STATE INSTITUTE OF HEALTH AND FAMILY WELFARE, UTTAR PRADESH

A BOOK FOR GOVERNMENT MEDICAL OFFICERS OF UTTAR PRADESH

INVESTIGATOR'S GUIDE TO MEDICO LEGAL PROCESSES & FORENSIC TOOLS

DEPARTMENT OF MEDICAL HEALTH AND FAMILY WELFARE,
GOVERNMENT OF UTTAR PRADESH

AKNOWLEDGEMENTS

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Processed and Realization

"Knowledge of forensic tools and services provides the investigator with the ability to recognize and seize on evidence opportunities that would not otherwise be possible."

MESSAGE

Shri Brajesh Pathak
Hon'ble Deputy Chief Minister
Hon'ble Minister of
Medical Health and Family Welfare
Department
Government of Uttar Pradesh

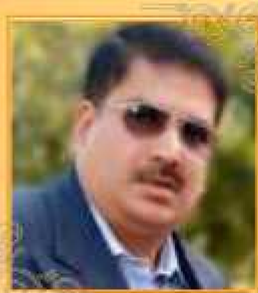
In the present civilized society, every crime ought to be punished and a criminal must be taken to task. Investigators and those who are engaged in the dispensation of justice require aid of an expert, who, by experience and knowledge, has acquired scientific term permanent and skill to unearth the crime. At the same time, with the aid of a forensic expert, an innocent can be saved from the gallows.

This book is intended for government medical officers working in the government medical facilities to provide evident based medico-legal practice with avante grade methods and tools including latest subjects such as forensic firearm, forensic medicine professionals and medico-legal practices and interdepartmental coordination with prosecution, defense attorney, enforcement agencies and judiciary.

This medico legal book is a key reading for Uttar Pradesh Provincial Medical Service's serving Medical Officers with a genuine interest in the links between the theory and practice of medico legal protocols to achieve justice within Indian Legal Systems.

(Brijesh Pathak)

MESSAGE



Shri Mayankeshwar Sharan Singh

Hon'ble State Minister
Medical Health and Family Welfare Department
Government of Uttar Pradesh

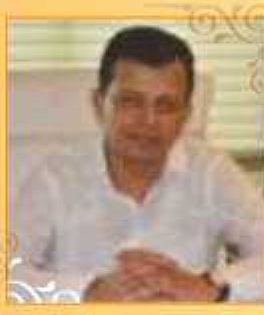
The common medico legal problems/mishaps that occur in major medical practices like anesthesia, gynecology and obstetrics practice, surgical practice and practice by physicians can be dealt with this book with exhaustive attempt to cover medico-legal protocols.

A major emphasis of this book is how to face common medico legal problems like refusal of treatment, arrival of dead body etc. Approaches on how to avoid medical malpractice suit/medical negligence are prescribed it is hoped that this book will help the medical officers working in medical services to discharge safe medical practice.

I thank team SIHFW for developing this guidebook for Medical Officer's of Utar Pradesh to conduct medico-legal at the best of their ablities and take part in the continuing contribution in the field of public health services.

(Mayankeshwar Sharan Singh)

FOREWARD



Shri Partha Sarthi Sen Sharma

Principal Secretary
Department of
Medical Health and Family Welfare
Government of Uttar Pradesh

The role of Medical Officers is crucial as investigator to cater justice in Indian legal system through optimum evidentiary materials produced from madico-legal findings.

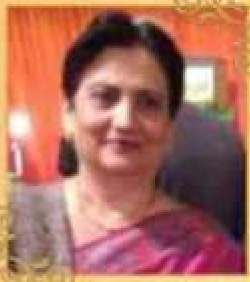
This present book prepared by SIHFW with elaborative division of contents into segments, viz, (i) Of the basics, (ii) Of the Dying and the Death, (iii) Of the Injured and the injuries, (iv) Clinical Forensic Medicine, (v) Legal and Ethical Aspects of Medical Practice and placement of illustrations, tables, flowcharts, etc. speak volumes of this book.

The descriptive approach in chapters on brain-stem death vis-avis sudden and unexpected deaths; custody related torture and/or death; deaths associated with surgery, anesthesia and blood transfusion; medico legal examination of the living; medical negligence; informed consent and refusal; deserve extreme applause. Exceptional features of this ensuring book have been the presentation of cases clinching to the text and updation of information in every segment. I am sure that this book would serve as a guiding light for all concerned government medical officers of Uttar Pradesh.

I believe this book will serve as a standard tool for the Government Medical Officers for years to come will help in expediting the process of Law.

(Partha Sarthi Sen Sharma

MESSAGE



Dr. Lilly Singh
Director General
Department of
Medical Health and Family Welfare
Government of Uttar Pradesh

Government Medical Officers in Uttar Pradesh often struggle to navigate the complexities of the medical legal system. It is Imperative that Medical Officer receive appropriate training and valuable guidance, helping them make informed decisions and avoid potential penalties.

This book deals with the Medico Legal aspect of law and details out the investigative procedures that are to be under taken while preparing relevant Medico Legal documents.

The State Medico Legal Experts and faculties at State Institute of health & Family Welfare, Uttar Pradesh have taken a great deal of care in preparing this guidebook to help Government Medical Officers to stay up-to-date with the latest regulations and best practices in the field, whilst ensuring that they are in compliance with all relevant laws and standards.

(Dr. Lilly Singh)

MESSAGE

Dr. Renu Srivastava Varma
Director General Family Welfare
Department of
Family Welfare
Government of Uttar Pradesh

The rapid exhaustion of the medico-legal and forensic tools reflects in the volumes of this book will surely widely accepted among medical officers, for its meticulous work.

This investigator guide explores the subjects in detail from sexual abuse and fetishism to necrophilia and sadomasochism, this unique chapters identifies fourteen classifications of unusual sexual pathologies.

This book also emphasizes on the physical and psychological aspects of sexuality itself, and presents detailed comparisons of legal and medical definitions, historical aspects, current incidence, and geographical prevalence of these offenses.

It also explores the potential causes, discussing etiological theories and reviewing psycho pathology. Highlighting the cross-cultural nature of the forensic aspects of human sexuality, the book examines various case studies in the context of international legislation.

(Dr. Renu Srivastava Varma)

PREFACE

Dr. Anita Joshi
Director General (Training)
Medical, Health & Family Welfare
Government of
Uttar Pradesh

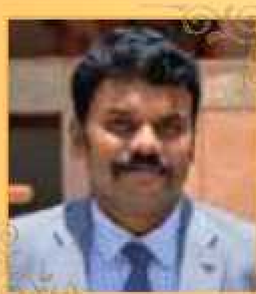
The integral thread of evidence-based description is seen running through the entire content of this book. Placement of precise information about the relevant legal provisions and forensic aspects of anatomical structures/findings at appropriate places promote interdisciplinary understanding of issues.

The guidelines, have specially been drawn up for rape cases, although the y could be used in other cases of sexual violence as well, Statistics pertaining to sexual and physical violence against women in this country are alarming as around one in three is likely to face this sort of violence in her lifetime.

This book caters to the prescribed guidelines laid down by competent authorities regarding investigating cases related to sexual violence on sound medico-legal background. I congratulate the team SIHFW for developing such a comprehensive document.

(Dr. Anita Joshi)

ACKNOWLEDGMENT



Dr. Rajaganapathy R.
Director
State institute of
Health & Family Welfare
Government of Uttar Pradesh

I deem it a great honor to contribute this acknowledgment to the Investigator's guide to Medical officers of Uttar Pradesh to get updated methods and tools of Medico Legal Cases of

With the publication of this compact document a long felt need to bring about a certain degree of uniformity in approaching, treating and documenting cases of medico-legal, mainly against women and girls should get fulfilled. Even so, there still maybe some gaps in this book which need to be plugged and through feedback received from various quarters further improvements can be effected in them.

Thus, the exercise of drawing up these guidelines has to be treated as an iterative one and the process would need to continue till such time as a reasonable level of definitiveness can be brought into them.

I Put my sincere thank to Mr. Partha Sarthi Sen Sharma, Principal Secretary as Head of the Department for his valuable guidance and direction to incept this book. My immense gratitude to Dr. G. Khan, Additional Director and State Medico Legal Expert and his accomplice Dr. Kirti Vardhan Singh, Senior Medical Officer for their valuable input in development of this book.

Lastly, I would like to thank Dr. Manish Singh, Assistant Professor, Training for his immense effort in drafting and editing this guidebook with illustrations and reader friendly shape.

(Dr. Rajaganapathy. R.)

INDEX

CHAPTER-1

INTRODUCTION TO FORENSIC TOOLS/ MEDICO LEGAL PROCESSES AND INDIAN LEGAL SYSTEM

In 1822, the first medical school was established in Kolkata and converted into Medical College in 1835. The first chair in Medical Jurisprudence was instituted in Calcutta Medical College in 1845, and Dr. CTO Woodford was the first Professor of Medical Jurisprudence in the country. It is obvious that the subject was born as a concrete separate branch of medical discipline by dint of its own merit, until it reached its present status. The history of the subject is the 'key to the past, explanation of the present and/or signpost for the future.'

While introducing the subject of Forensic Medicine, the natural and obvious query that appears in one's mind is about the meaning and scope of the words 'forensic' and 'medicine'. The word 'forensic' has been derived from the Latin word 'forensis', which implies something pertaining to 'forum'. In Rome, 'forum' was the meeting place where civic and legal mat ters used to be discussed by those with public responsibility. Thus, the word 'forensic' essentially conveys any issue related to the debate in the courts of law. The word 'medicine' carries wide import. Broadly, it may be considered as a science for pre serving health and effecting cure. From the interaction of these two professions, medicine and law, has emerged the discipline/ subject of Forensic Medicine, i.e. application of medical and allied knowledge and expertise towards the administration of justice. Forensic Medicine was earlier known as 'Medical Jurisprudence'.

It was also termed as 'State Medicine'; this term was recommended by Dr. Stanford Emersion Chaille (1949) and was developed to regulate the code of conduct for registered medical practitioners, to guide and regulate the pro fessional activities of the doctors and to standardise and supervise the medical practice in the country. In Europe and United States, the term 'Legal Medicine' (application of medical knowledge for solution of legal problems) is often preferred. However, in most parts of the world, the description 'Forensic Medicine' is widely accepted. In short, it denotes 'medical aspects of law', whereas the term 'Medical Jurisprudence' (Juris law, and Prudentia knowledge) denotes application of knowledge of law in relation to practice of medicine.

Whatever may be the name, the subject spreads into almost every branch of medicine and is certainly not confined to criminal matters. It covers responsibilities of doctors towards the State, patients and towards each other. With the enormous advances in knowledge and technology during the past decades, the fields like Forensic Odontology, Forensic Osteology, Forensic Biology, Forensic Ballistics, Forensic Psychiatry and Forensic Serology, etc. have come to be recognised as speciali sations in themselves. Forensic Pathology essentially deals with interpretation of autopsy findings in a medicolegal investigation of death. It still rests largely on the principles of morbid anatomy.

Forensic medicine plays a remarkable role in guarding safety of each individual and also in ensuring that any accused is not unjustly condemned. Instances may be legion, but a single illustration would be sufficient at this juncture: a man may die of coronary thrombosis while walking on a road and sub sequently be run over by a vehicle and the driver charged with 'culpable homicide not amounting to murder'. Histochemical and biochemical studies of the injured tissue would establish the postmortem origin of the injuries and the examination of the coronary vasculature will reveal the presence of disease; thereby clearing the issues and helping in the disbursement of justice when the concerned doctor is called upon to depose in a court of law. It is obvious that if the medical aspects of such cases are not interpreted in a proper forensic perspective, pans of justice may remain ill balanced.

Although the terms 'Medical Jurisprudence', 'Legal Medicine' and 'Forensic Medicine' are commonly used to denote the branch of medicine that deals with the application of knowledge of medicine for the purpose of law, yet they bear different implications. Medical Jurisprudence embraces all medical issues affecting social rights/obligations of the individual as well as the doctors and brings the medical practitioner in contact with the law. Thus, medical jurisprudence deals with the legal aspect of medical practice, whereas Forensic Medicine deals with the application of medical knowledge towards administration of justice. It is, therefore, essential for a medico legal expert to have a fair knowledge of all the branches of medical and ancillary sciences. It is often required to invoke the aid of these subjects in the elucidation of various problems of medicolegal interest. Forensic Medicine is a practical subject. Class lectures should, therefore, be illustrated with practical examples and students should get ample opportunities to observe and discuss cases of varied magnitude. They should be carried to the courts to observe lively debate of the opposing counsels.

INQUEST

Inquest (in; quasitus to seek) means legal or judicial inquiry to ascertain a matter of fact. In forensic work, an inquest implies an inquiry into the cause of death that is apparently not due to natural causes. Such an inquiry/investigation into sudden/ suspicious/ unnatural death is obviously necessary to apprehend and punish the offender.

POLICE INQUEST

The inquest is held by a police officer (called Investigating Officer) not below the rank of Senior Head Cons..

Procedure

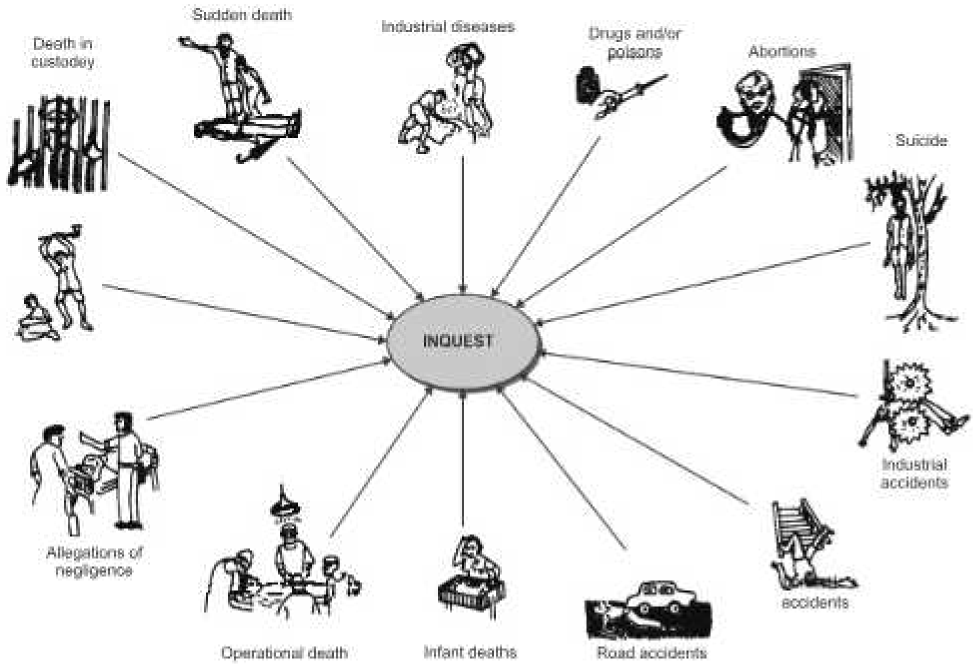
- Police officer, on receipt of information of death, proceeds to the place of occurrence and holds an inquiry into the matter in the presence of men of the locality.

- He takes all reasonable steps to investigate the case and writes a report describing the appearance of the body, wounds (how were they caused and by what weapon).

- The witnesses are called panchas (Panch witnesses or Panchayatdars). He obtains the signatures of the witnesses there and then. (Witnesses should preferably be some respected persons of the locality/area.) The inquest report so prepared is known as panchnama.

- If no foul play is suspected, the dead body is released to the relatives of the deceased for disposal.

In every case where death appears to have been due to suicidal, homicidal, accidental or suspicious causes, or where it appears to the officer conducting the investigation (whether under Section 157 or 174 CrPC) expedient to do so, the body is to be sent for the postmortem examination to the nearest medical officer of the government hospital/dispensary.



Magistrate Inquest

Section 176 CrPC concerns with the inquiry by a magistrate into the cause of death. This appears to have been based on the assumption that it is not always safe or advisable to rely upon the inquest/inquiry made by the police there a Magistrate can order an inquest either under Criminal Procedure code or Juvenile Justice Act 2015.

Categorizations of Courts in India

MEDICAL EVIDENCE

Medical evidence may be defined as the legal means to prove or disprove any medicolegal issue in question. It may be of two types:

- Documentary
- Oral

DOCUMENTARY EVIDENCE

It comprises all documents written or printed to be produced before court for examination during the course of trial. It may include the following documents:

- Medical Certificates (in relation to ill health, death, insanity, age, sex or pensioned disabilities, etc.).
- Medical Reports (injury report, postmortem report, report on sexual offences, pregnancy, abortion or delivery etc.).

Court	Powers
Supreme Court: Highest judicial tribunal of India, situated in New Delhi	Can pass any sentence. Usually considers appeals from lower courts. It can sustain or alter the punishment approved or awarded by the High Court
High Court: Highest judicial tribunal of the State, usually situated in the capital of the State	Can pass any sentence. Usually exercises appellate jurisdiction. Confirmation of death sentence passed by the Sessions Court
Sessions Court (Sessions Judge): Highest judicial tribunal of the District, usually situated at the district headquarters	Can pass any sentence. However, death sentence has to be confirmed by the High Court
Additional Sessions Judge: High Court may appoint Additional Session Judges to exercise jurisdiction in a Court of Session	Same as Sessions Court
Assistant Session Judge: High Court may also appoint Assistant Session Judges depending upon the demands. Such court may be situated at district headquarters or any other place considered sui.	Can pass any sentence except death sentence, life imprisonment or imprisonment exceeding 10 years

Chief Judicial Magistrate/Chief Metropolitan Magistrate: In every district, High Court shall appoint a Judicial Magistrate of first class having sufficient experience to be the Chief Judicial Magistrate (in the Metropolitan area, it is called as Chief Metropolitan Magistrate)	Can pass any sentence except a sentence of death or of imprisonment for life or of imprisonment exceeding 7 years. Fine without limit. However, Section 63 IPC lays down that where no sum is expressed to which the fine may extend, the amount of fine to which the offender is liable is unlimited, but shall not be excessive; that is to say that the amount of fine imposed should be within the means of the accused to pay though he must be made to feel the pinch of it. Imprisonment in default of fine should also be long enough to induce the accused to pay the fine rather than suffer the imprisonment
Judicial Magistrate (First Class)/Metropolitan Magistrate	Can pass sentence of imprisonment for a term not exceeding 3 years or of fine not exceeding ₹ 10,000, or both
Judicial Magistrate (Second Class) (In every district, as many courts of Judicial Magistrates of first class and of the second class may be established as the state government may, after consultation with the High Court, specify by notification)	Can pass sentence of imprisonment for a term not exceeding 1 year or of fine not exceeding ₹ 5000, or both
Special Judicial Magistrates: Government may, after consultation with the High Court, establish one or more special Courts of Judicial Magistrate of first class or the second class to try any particular case or particular class of cases. Such magistrates may be appointed for any term, not exceeding 1 year at a time	High Court may empower such Special Judicial Magistrates to exercise the powers of a Metropolitan Magistrate in relation to any metropolitan area outside its local jurisdiction

- Dying declaration.
- Miscellaneous (expert opinion from books and deposition in previous judicial proceedings, etc.).

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ORAL EVIDENCE

This means and includes all statements that the court permits or requires to be made in relation to matters of fact under inquiry. According to Section 60 Indian Evidence Act (IEA), the oral evidence whenever possible must be direct. It must be the evidence of that person who has personal knowledge of facts in relation to the particular incidence, i.e. it must be the evidence of an eyewitness. Accordingly, if the oral evidence refers to a fact that could be seen, heard or perceived in any other manner, it must be the evidence of that person who has himself seen, heard or perceived it. If it refers to an opinion, it must be the evidence of that person who holds that opinion. Hearsay or indirect evidence is the evidence of a witness who has no personal knowledge of the facts but repeats only what he has heard others saying.

Oral evidence is more important than documentary evidence because it admits of cross examination for its accuracy. While it is desirable that oral evidence must always be direct and subject to cross examination, there are circumstances when this is either not possible or strictly necessary. In these cases, the report/observation or statement of the person who has actually heard or perceived a thing or witnessed/examined the particular incidence is accepted as such. These exceptions are enumerated as follows:

- Dying declaration: Although this is hearsay or indirect evidence, this is accepted in court as legal evidence in the event of the victim's death, as it is presumed that dying people will speak the truth during the last moments of their life.

- Expert opinions expressed in a treatise: According to Section 60 IEA, expert opinions printed in books commonly offered for sale, are generally accepted as evidence on the production of such treatise without oral evidence of the author.

- Deposition of a medical witness taken in a lower court: Under Section 291 CrPC, this is accepted as evidence in a higher court when it has been recorded and attested by a magistrate in the presence of the accused or his lawyer who had an opportunity of cross examining the witness. The medical witness is, however, liable to be summoned again if his evidence is deficient in any respect or needs further elucidation.

- Evidence given by a witness in a previous judicial proceeding: Under Section 33 IEA, this is admitted as evidence in a subsequent judicial proceeding or in a later stage of the same judicial proceeding when the witness is dead, untraceable or incapable of giving evidence or cannot be called without unreasonable delay or expense to the court.

- Statements by persons who cannot be called as witnesses: Under Section 32 IEA, these are admissible as evidence when the person who made them is either dead, untraceable or has become incapable of giving evidence or cannot be called without unreasonable delay or expense to the court.

- Report of certain government scientific experts: Under Section 293(1) CrPC, reports of certain government scientific experts are usually admitted in the court as evidence without their oral examination. However, under Section 293(2) CrPC, the court is given discretionary power to summon and examine them if their report is found inadequate or there is some specific request from the prosecution or the defence. Under 293(3), where any such expert is summoned by a court and he is unable to attend personally, he may, unless the court has expressly directed him to appear personally, depute any responsible officer with him to attend the court, if such officer is conversant with the facts of the case and can satisfactorily depose in court on his behalf. The names of the Government Scientific Experts whose reports are admissible as evidence as such in inquiry, trial or other proceeding mentioned under 293(4) are (i) Chemical Examiner or Assistant Chemical Examiner, (ii) Chief Controller of Explosives, (iii) Director of Fingerprint Bureau, (iv) Director of Haffkine Institute, Mumbai, (v) Director/Deputy Director/Assistant Director of a Central Forensic Science Laboratory or a State Forensic Science Laboratory, (vi) Serologist and (vii) any other Government Scientific Expert specified by notification by the Central Government for this purpose.

- Public records: A record kept in the public office, for example, birth and death certificates, certificates of marriage, etc.

- Hospital records: Routine entries such as date of admission, date of discharge, pulse, temperature, etc. are admissible without oral evidence. However, the nature of disease, the treatment given or the diagnosis accomplished, etc. are not accepted without oral evidence.

Forensic science, sometimes referred to as criminalistics, applies the knowledge of science to the definition and enforcement of laws. Criminalistics is a branch of forensic science that is involved in the collection, analysis, and interpretation of physical evidence produced by criminal activity. This field of study involves several scientific disciplines: biology, chemistry, and physics. Forensic science is not a branch of law enforcement, and forensic scientists are not law enforcement officers. Despite how they are portrayed on television, forensic scientists do not interrogate and arrest suspects and do not usually investigate crime scenes. The main duties of a forensic scientist are to analyze physical evidence, interpret the results and testify in a court of law. Forensic scientists are expert witnesses who express opinions as to the significance of laboratory findings.

Forensic science plays a role in criminal and civil law. Forensic scientists help determine cause of death, identify perpetrators of crimes, identify bodily remains, track the electronic transfer of money, investigate internet fraud and identity theft, and reconstruct vehicular accidents. Laws regulate the safety and quality of our food and water, the potency of medications, motor vehicle emissions, and pesticides used on crops. It would be impossible to monitor compliance with laws if not for accurate laboratory testing. Forensic science is becoming increasingly broad in its application to law and criminal investigations.

Crime laboratory analyses are only relevant if the specimens received are properly collected, transported and preserved. Crime scene evidence is often collected and transported by trained police officers.

We examine various forensic sciences and the application of forensic sciences as practical tools to assist police in conducting investigations. The book is not intended to be a comprehensive dissertation of the forensic sciences available. Rather, it is intended to be an overview to demonstrate the broad range of forensic tools and medicolegal processes available.

It is not necessary for an investigator to be an expert in any of the forensic sciences and medico legal processes; however, it is important to have a sound understanding of forensic tools and medicolegal processes to call upon appropriate experts to deploy the correct tools when required. The forensic and medicolegal analysis topics covered in this book include various types of physical evidence that can be found at almost any crime scene. The types of evidence and where it is found can assist investigators to develop a sense of how the crime was committed. Tool marks where a door was forced open can indicate a point of entry, shoe prints can show a path of travel, and blood stains can indicate an area where conflict occurred. Each of these pieces of physical evidence is a valuable exhibit capable of providing general information about spatial relationships between objects, people, and events. In addition, the application of forensic examination and analysis could turn any of these exhibits into a potential means of solving the crime.

A physical match from the torn edges of one piece of wadding paper to the original sheet from which it was torn, we can appreciate that physical matching is a forensic technique that can be applied, to some extent, by the investigator personally viewing and studying details of the evidence. At this level, physical matching can be used by investigators to do on site analysis of evidence. That said, the more sophisticated aspects of physical matching do require the expertise of a person trained in the techniques to form and articulate an opinion that the court will accept as expert evidence.

During a crime investigation, physical matching is typically conducted on items, such as fingerprints, shoe prints, tire prints, glove prints, tool impressions, broken glass, plastic fragments, and torn edges of items, such as paper, tape, or cloth. In these physical matchings, there are two levels of examination that are typically considered; an examination for class characteristics and an examination for accidental characteristics.

A Level One examination determining class characteristics takes place in relation to items, such as shoe prints, tire prints, glove prints, and tool impressions. At the first level of examination, these items can be classified and sorted based on type, make, model, size, and pattern. For example, if a shoe print is found at the scene of a crime and is determined to be a left shoe of a size 9, Nike brand, Air Jordan model, running type shoe with a wavy horizontal sole pattern, these class characteristics collectively provide a description of the suspect's shoe based on five defined descriptors.

In turn, these class characteristics may allow the investigators to narrow their focus to suspects having that class description of shoe. It is not a positive identification of the shoe to any particular suspect, but it does allow the potential elimination of suspects who wear different sizes, brands, and sole patterns of running shoe. Using this Level One examination, an investigator at the crime scene may find a suspect shoe print showing a distinct size and sole pattern. If a suspect with a matching size and sole pattern is found near the crime scene, this Level One observation would provide strong circumstantial evidence to assist in forming reasonable grounds to suspect that this person was involved in this crime.

A Level Two examination may be able to produce a conclusive match. Positive identification requires this next level of examination, namely the examination for accidental characteristics.

Accidental characteristics are the unique marks and features that develop on any item resulting from wear and tear. Looking back at the Nike Air Jordan Running Shoe, to make a positive match of a suspect's shoe to the impression found at the crime scene, the crime scene impression would be examined for nicks, gouges, and wear patterns typically present on a worn shoe. These features would then be compared to a rolled impression of a suspect's shoe, and if the same nicks, gouges, and wear patterns could be shown in all the same locations on the suspect's shoe, a positive match could be made.

This Level Two method of comparison for things, such as shoes prints, tire prints, glove prints, and tool impressions, is the practice for physical matching. Investigators can often use these physical matchings to link the suspect back to the crime scene or the victim. Finding a suspect in possession of a shoe, a tire, or a tool that is a positive match to an impression at the criminal event is a powerful piece of circumstantial evidence.

With items, such as broken glass and plastic fragments, the process of physical matching requires significantly greater levels of expertise. At Level One, these items are first matched for general characteristics, such as material colour and thickness; however, the process for making the comparison of broken edges requires microscopic examination and photographic overlay comparison of broken edge features to demonstrate a positive match. For investigators, these kind of comparisons can be called upon where there is broken glass at a crime scene and fragments of glass have been found on a suspect's clothing, or in cases where glass or plastic fragments are left at the scene of a hit and run car crash and a suspect vehicle is found with damage that includes similarly broken items. Glass fracture analysis can also be used to demonstrate which side of a piece of glass received the impact that caused the fracture. This can be a helpful tool in confirming or challenging a version of events, such as insurance fraud, break in reports, and motor vehicle crashes where the damage has been exaggerated or staged. Glass fracture analysis can also be used to demonstrate the sequence and order in which a series of bullets have passed through the glass of a window. This can be helpful for an investigator to establish the origin location of the shooter, and, in cases of a drive by shooting, the direction of travel.

The forensic science of fingerprints has a longstanding history in policing. Fingerprints have been accepted as being individually unique to each person. The courts frequently accept positive fingerprint matches conducted by an expert witness, as proof of identity beyond a reasonable doubt (Jain, 2010).

Prior to the modern advent of DNA analysis and biometric scanning technologies for positive identification, fingerprints and dental record x rays were the only truly positive means of making a conclusive identification.

Fingerprints are unique patterns of lines and ridges that exist on the areas of our hands and fingertips, known as the plantar surfaces. These unique patterns have been classified in categories and features since the late eighteenth century. The various categories and features allow each digit of a person's fingers to be catalogued in a searchable system or database. These unique categories and features do not change throughout a person's life, unless they are subjected to damage through physical injury or intentional abrasion. The impressions of our fingerprints are often left on items we touch because the oils our bodies produce act like an invisible ink adhering to smooth surfaces we touch, thus transferring these fingerprint impressions to those surfaces. These virtually invisible image transfers are commonly called latent fingerprints, and they are easily made visible on most surfaces through the application of coloured fingerprinting powder that adheres to the oils left by our fingers. The powder sticking to the oil reveals the image of lines and ridges that make up the fingerprint. It is also possible for a fingerprint impression to be exposed on surfaces, such as plastic, dry paper, or paint though a process of chemical fuming that reacts with the oils of the fingerprint changing their colour, thereby exposing the image. Fingerprints are sometimes also visible when they are transferred to an object because the finger has some foreign material on it, such as ink or blood. Other forms of visible fingerprints can be found as an actual moulded impression of the fingerprint when a person touches a malleable surface, such as clay or cheese.

The unique lines and ridges of an unknown fingerprint can be searched in a database of known criminal fingerprints for identification. Today, this type of search is done electronically using a biometric scanning process known as Automated Fingerprint Identification System (AFIS). For smaller partial prints, identification of a suspect requires sorting through possible suspects and conducting specific searches of print characteristics to make a match. If the person who left the print does not have a criminal record or their fingerprints are not on file, the only way a comparison can be made is to obtain a set of fingerprint impressions from that person. When this is done, the print examination will be conducted by a trained fingerprint expert who will search the print to establish as many points of comparison between the suspect print and the known print as possible. The general accepted standard for accepting a match is to find ten points of comparison.

The location and identification of a suspect's fingerprint at the scene of a crime, or on some crime related object, is strong circumstantial evidence from which the court can draw the inference that the suspect is, in some way, connected to the crime. The investigative challenge of finding a suspect's print is to eliminate other possible ways that the print may have been left at the scene, other than through involvement in the crime.

In considering once again "Locard's Theory of Evidence Transfer," it was suggested that a person cannot be at the scene of a crime without leaving something behind, and cannot leave the scene of a crime without taking something with them.

Exhibits of hair and fibre fit support this theory well. As humans, we are constantly shedding materials from our bodies and our clothing. We enter a room and we leave behind strands of hair that fall from our heads, oily impressing of our fingerprints as we touch objects, and fibres of our clothing materials. As we leave a room, we take away hairs from other occupants of the room or fibres from the carpet and furniture adhering to our clothing. The analysis of hair and fibre, although not an exact science, can provide corroborative evidence. Hair samples can be compared taking a shed sample at the crime scene to the hair from a suspect to establish a similarity within a limited degree of certainty. If the hair happens to have been pulled out and still has root tissue, there is a possibility for more positive identification using DNA analysis. Somewhat more identifiable than hair samples, fibre samples can often be narrowed down to make a higher probability comparison using microscopic examination for size, colour, and type between an unknown sample and control sample.

Given the number of gun related crimes, the understanding of ballistic analysis is important for investigators. Ballistics is the study of all things that are launched into flight, how they are launched, and how they fly. In most cases, investigators find themselves dealing with several common types of firearms.

1. Handguns as either semi automatic pistols or revolvers

2. Long rifles that are single shot bolt action, automatic, or semi automatic

3. Shotguns that are breach loading or chambered pump action

There are techniques in ballistic science that address the unique aspects of firearms and bullets. Because ballistic comparisons seek to determine if a particular gun was the originating source of an unknown bullet or cartridge casing, this examination process is sometimes referred to as ballistic fingerprinting. The analogy being that if a particular gun touched a particular bullet or cartridge casing. It will leave behind some unique identifiable marks or a ballistic fingerprint.

When a modern day firearm is being loaded to fire, the cartridge loaded into the gun is composed of several components. The bullet portion of the cartridge is tightly pressed into a brass tube, called the casing. At the bottom of this brass casing is a round, flat base slightly larger than the casing, and this base prevents the casing from sliding completely into the cartridge chamber of the gun when being loaded. On the bottom of this flat base of the cartridge is the primer. When the trigger is pulled, the primer is the portion of the cartridge that will be struck by the firing pin of the gun. When struck, the primer ignites the gun powder contained inside the brass casing with an explosion that causes the bullet to leave the casing, travel down the gun barrel, and exit the gun.

Each of the components of the cartridge casing can be examined forensically and comparisons can be made to suspect guns. In some instances, it is possible to determine if a cartridge has been fired from the chamber of a specific gun. This can be done by examining the unique and identifiable marks left by four aforementioned components of the gun. Like the process of physical matching, this is also a two level process.

At Level One, cartridges are classified by the calibre, which is the size of the bullet, the maker of the cartridge, and the primer location; either a centre fire or a rim fire cartridge on the cartridge base.

For ballistic purposes, guns are classified by their calibre, chambering and ejector mechanisms, and firing pin, namely either centre fire or rim fire. Eliminations of suspect weapons can often be made at Level One. For instance, a .38 calibre bullet removed from a crime scene cannot have been fired from a .22 calibre weapon. Or, that same .38 calibre bullet showing marks from an ejector mechanism could not have been fired from a .38 calibre revolver that does not have an ejector mechanism.

At Level Two, the more decisive ballistic fingerprint comparisons are often made using the following methods:

1. Striations Matching;
2. Chamber Markings;
3. Firing Pin Comparison; and
4. Ejector markings.

Striations Matching: Bullets fired from either a handgun or long rifle, other than a shotgun, fire a single projectile each time. This fired projectile is a lead or lead composite bullet. When fired, this bullet travels down the barrel of the gun and begins to spin because the inside of the gun barrel has been intentionally machined with long gently turning grooves, called rifling. These grooves catch the soft lead sides of the bullet spinning it like a football, and this spinning makes the bullet travel more straight and true to the target. As a result of these grooves designed into gun barrels, every bullet fired will arrive at its target with markings etched into the bullet material from contact with the grooves in the barrel. These etched markings are call striations, and they are uniquely identifiable back to the gun they were fired from. For an investigator, these striations create an opportunity to match the bullet to the gun that fired it. Recovered bullets can be recovered and compared to test bullets fired from a suspected gun. When striations of a recovered bullet are compared to known samples fired from a suspected gun, a side by side microscopic technique is used to match striation markings. An expert ballistic examiner can sometimes identify and illustrate matches in the striations to make a positive match.

Cartridge Chamber Markings: When a cartridge is loaded into the chamber of a gun, the shiny brass casing comes into contact with the hard steel sides of the chamber. This chambering of the cartridge can leave unique and identifiable scratch marks on the side of the casing. A cartridge casing ejected or unloaded from a weapon and left at the crime scene can sometimes be matched to the suspect gun by comparing these markings.

Firing Pin Comparison: When the firing pin of any gun strikes the primer on the bottom of a cartridge, it leaves an indentation mark. This firing pin indentation can sometimes be matched to the firing pin of a suspect weapon. This requires microscopic examination that looks for the unique characteristics of the firing pin that become impressed into the soft metal of the primer when the firing contact happens.

Ejector Mechanism Markings: Methods for loading and unloading weapons have evolved considerably due to different gun designs. The simplest guns allow the user to open the breach of the gun exposing the cartridge chamber to manually insert the cartridge and close the breach to make ready for firing. There is no ejector mechanism for these guns, so there will be no ejector marks left on the base of a cartridge when it is unloaded from the weapon. Other guns have a variety of different ejector methods, including ejectors that catch the base of the cartridge casing to physically pull it from the breach and eject them away from the gun. In cases where a gun does have an ejector mechanism, these mechanisms leave very distinct and unique marks on the soft brass cartridge base. These markings can sometimes be compared and matched back to the ejector of a suspect weapon. With this broad variety of ballistic comparison techniques, an investigator has a significant number of tools that can be deployed and strategies that can be engaged to assist in matching a bullet to the gun that fired it. Considering these tools, the cartridge casing left at the scene of a shooting can be as important as a bullet removed from the body of a shooting victim. An investigator needs to keep this in mind when seizing cartridge casings as evidence. Great care needs to be exercised to document the location where each individual casing was found, and to preserve each casing in a manner that does not degrade the possible markings that could enable a match to be made. Damage can be done by placing casings into a common bag where they can rub against each other causing more characteristics and obliterating existing marks.

In addition to the ballistic fingerprinting examinations, another area of ballistic science is known as trajectory analysis. The trajectory of a bullet is the path it travels from the time it leaves the barrel of the gun to the point where it finally loses the propulsion energy of the gunpowder and comes to rest. The flight of a bullet can be very short, as in the case of a point blank shooting, where a victim is shot at very close range, or it can be very distant where the target is one mile away or more, as in the case in some sniper shootings.

When the bullet is travelling a longer distance, it travels that distance in an arched path or trajectory of travel as it is pulled towards the ground by gravity. When the bullet arrives at its destination, it will have a distinct angle of entry into the target. This angle of entry can sometimes be calculated as trajectory to estimate the geographic location of the originating shot. In cases where a bullet passes through several objects, such as two walls of a house, the trajectory of the bullet can be used to determine where the shooter was located. In cases of drive by shootings, for example, where several shots are fired, the pattern of trajectories can show if the shooter was moving and, if so, demonstrate the direction of travel.

Blood spatter analysis, also known as blood stain pattern analysis, is a relatively new forensic specialty. The purpose of this analysis is to determine the events of a crime where blood has been shed. This is accomplished through the careful examination of how blood is distributed inside the crime scene. Studies have shown that when blood is released during an attack, certain patterns of distribution can be expected (National Science Forensic Technology Center, 2012). For instance, a person being struck with a baseball bat will begin to bleed, and blood will be distributed in a droplet spatter pattern in the direction of the strike behind the victim. These droplets of blood will have a direction of travel that will be indicated by the directional slide of each droplet as the bat hits objects in its path. Blood from the victim adhering to the bat can also be distributed when the bat is on the upstroke for the next strike. This blood will be distributed in an upward directional slide pattern, for example, up a wall, onto a ceiling, or behind the attacker. Calculations of how many strikes were made may become evident from the tracking of multiple streams of droplets behind the victim and behind the attacker. Given this developing science, blood spatter analysis can be useful in criminal event reconstruction.

DNA, or deoxyribonucleic acid, is a molecule that holds the genetic blueprint used in the development, functioning, and reproduction of all living organisms. As such, it carries the unique genetic information and hereditary characteristics of the cells from which living organism are formed. Except for identical twins, the DNA profile of each living organism is unique and distinct from other organisms of the same species. There are some rare cases where one person may carry two distinct types of DNA, known as Chimera (Rogers, 2016) where paternal twin embryo merge during gestation, or in cases where a bone marrow transplant enables the production of the marrow donor DNA in the recipient's blood. In these rare cases, a person may test for two distinct DNA profiles for different parts of their body.

In human beings, DNA comparison can enable high probability matches to be made between discarded bodily substances and the person from whom those substances originated. Bodily substances containing cellular material, such as blood, semen, seminal fluid, saliva, skin, and even hair root tissue can often be compared and matched back to its original owner with high statistical probabilities of comparison (Lindsey, 2003). Sometimes, even very old bodily substances, such as dried blood, dried saliva, or seminal stains, can be analyzed for a DNA profile. The introduction of DNA analysis has allowed investigators for advocates to re examine historical evidence and exonerate persons wrongfully convicted and imprisoned for criminal offences.

DNA is a very powerful tool for investigators and can be considered anytime discarded bodily material is found at a crime scene. Even very small amounts of material can yield enough material for DNA comparison. Importantly, DNA data banks of known criminals and unsolved crimes are now becoming well established in North America (Royal Canadian Mounted Police, 2006). When a person is convicted of certain criminal offences, DNA is collected and submitted to these databases.

Forensic Pathology is the process of determining the cause of death by examining the dead body during an autopsy. An autopsy generally takes place in the pathology department of a hospital. In the case of a suspicious death or a confirmed homicide, police investigators will be present at an autopsy to gather information, take photographs, and seize exhibits of a non medical nature, such as clothing, bullet fragments, and items that might identify the body. These items would include personal documents, fingerprints, and DNA samples.

During an autopsy, a forensic pathologist dissects the body carefully examining, documenting, and analyzing the body parts to determine the cause of death. In the first stage of an autopsy, the pathologist examines the body for external injuries and indicators of trauma that may provide a cause of death. In this first stage of examination, the pathologist will make an estimate of the time of death by observing evidence of four common post mortem (after death) indicators. These are body temperature, the degree of rigor mortis, post mortem lividity, and progress of decomposition.

Algor Mortis is the scientific name given to the loss of body temperature after death which can sometimes be used to estimate the time of death (Guharaj, 2003). This is a viable technique in cases where the body is being examined within 24 hours following death. This method of estimating time of death can vary significantly dependent upon many possible variables, such as:

- Ambient room temperature being within a normal range of approximately 22° Celsius
- Pre death body temperature of the victim not being elevated by illness or exertion
- Thickness of clothing that might insulate the body temperature escape
- The temperature and conductivity of the surface the body was located on that could artificially increase or decrease temperature loss

Considering a normal body temperature of 37° Celsius at the time of death, it can be estimated that the body will cool at a rate of 1° – 1.5° Celsius per hour. This calculation is known as the Glaister Equation. So, taking an internal rectal temperature and subtracting that from 37° Celsius will provide an estimate of the number of hours that have passed since the time of death. For example, a dead body with a measured temperature of 34° Celsius would provide a time range of 3 to 4.5 hours since the time of death.

Rigor mortis is a term used to describe the stiffening of the body muscles after death. A dead body will go from a flaccid or limp muscle condition to one where all the muscles become contracted and stiff causing the entire body to become constricted into a fixed position. After being in a constricted and fixed position, the muscles eventually become flaccid again. In normal room temperatures, this stiffening of muscles and the relaxing again has a predic. time progression of approximately 36 hours. In this progression, the stiffening of muscles will take approximately 12 hours, the body will remain stiff for 12 hours and will progressively become flaccid again over the next 12 hours.

Stiffening of muscles begins with the small muscles of the hands and face during the first 2 to 6 hours, and then progresses into the larger muscle groups of the torso, arms, and legs over the next 6 to 12 hours. These are general rules; however, the rate of rigor mortis can be different for infants, persons with extreme muscle development, or where extensive muscle activity precedes death, such as a violent struggle (Cox, 2015).

In determining the time of death in average environmental temperatures, Cox (2015) recommended that:

1. If the body feels warm and is flaccid, it has been dead for less than 3 hours

2. If the body feels warm and is stiff, it has been dead for 3 to 8 hours

3. If the body feels cold and stiff, it has been dead for 8 to 36 hours

4. If the body feels cold and is flaccid, it has been dead more than 36 hours

Post mortem lividity refers to a discoloration or staining of the skin of a dead body as the blood cells settle to the lowest part of the body due to gravity. This discoloration will occur across the entire lower side of a body; however, in places where parts of the body are in contact with the floor or another solid object, the flesh compresses and staining will not occur in that area. The staining is a reddish purple colouring, and it starts to become visible within 1 hour of death, and become more pronounced within 4 hours. Within the first 4 hours, lividity stains are not fixed and, if the body is moved, the blood products will shift and stain the part of the body that has become lower. In most cases, these stains become fixed between 12 and 24 hours. As such, they can be viewed as an indicator of how the body was left at the time of death. Importantly, if a body is found with post mortem lividity stains not at the lowest point in the body, it can be concluded that the body has been moved or repositioned after the 12 to 24 hour stain setting period.

This is the final indicator a pathologist can look at to estimate the time of death. Sometimes, dead bodies are not discovered in time to use body temperature, rigor mortis, or early lividity indicators to estimate a more exact time of death. In these cases, assessing the progress of decomposition becomes important. Decomposition starts as soon as the body ceases to be alive. Subject to environmental conditions of extreme heat or cold, the readable signs of decomposition will become apparent 36 to 48 hours after death (EnkiVillage, 2017). These signs include bloating of the body and a marbling discoloration of the skin in a spider web pattern along surface blood vessels. As the body continues to decay, the skin surface will open and body fluids will begin to seep out. In advanced stages of decomposition, the body is often no longer identifiable by facial recognition, and DNA testing or dental records become the tools to determine identity. At very advanced stages of decomposition, flies and maggots begin to emerge, and the number of life cycles of the maggot to fly can be estimated by a forensic entomologist to provide the amount of time that has passed since these insect life cycles began.

Once these preliminary examinations have been made, the pathologist will cut the corpse open to conduct a detailed internal examination of each organ to look for signs of trauma, disease, or external indicators that might explain the cause of death, such as water in lungs or toxins in blood.

Causes of Death

There are a wide range of possible causes of death and pathologists are trained to look for these indicators, gather the evidence, and develop an expert opinion regarding the cause of death. Causes of death can include:

- Laceration or Stabbing
- Shooting
- Blunt force trauma
- Asphyxiation
- Toxic substances
- Electrocution
- Depriving necessities of life

In cases of laceration or stabbing, wounds are inflicted by a sharp weapon or pointed object. The pathologist will attempt to determine if the death was caused by damaging a vital organ or by blood loss. The distinction here is that a person may be cut or stabbed in a way that causes them to bleed to death, which will be indicated to the pathologist by only a small amount of blood remaining in the body. Alternately, a laceration or stab wound may penetrate the heart, lungs, or the brain in a way that causes the organ to stop functioning and causes death. In these cases, the pathologist will make a determination and render an opinion of fatal organ damage.

In cases of stabbing, the pathologist can sometimes illustrate the entry point of the wound and trace the wound path to determine an angle of entry indicating how the stab wound was inflicted. The size, depth, and width of the wound may indicate the size and type of weapon used to create the injury. Similarly, examining the characteristics of the wound can provide information to allow the pathologist to offer an expert opinion on the direction of a laceration or cut wound by illustrating the start point and the termination point. This information can be helpful for investigators in reconstructing or confirming the actual actions and weapons used in a criminal event.

In cases of shooting, the pathologist will make a determination of whether death was caused by the fatal destruction of a vital organ or by blood loss. Recovery of a bullet or fragments of a bullet from inside the body can be helpful in ballistic analysis. Examining the entry wound can sometimes indicate the distance from which the wound was inflicted. In cases of point blank or direct contact shootings, gunshot (burned gun powder) residue will be present at the entry point of the wound. As with stab wounds, the pathway that the bullet travelled from the entry point into the body to where it came to rest can sometimes be identified by a pathologist to determine the angle of entry. For investigators, this information can be helpful in reconstructing the criminal event and determining the location of the shooter. In cases of self inflicted gunshot wounds, a point blank entry point and a bullet path indicating a logical weapon position in the hand of the victim can provide some confirmation or contradiction of the self inflicted wound theory.

In cases of blunt force trauma, the pathologist will look for indications of organ destruction or massive internal bleeding causing death. Blunt force trauma can be inflicted in many ways, such as massive sudden trauma from a fall from a great height, or a high speed car crash that can immediately damage the brain, the heart, or the lungs to the point where they cease to function resulting in death. Other blunt force traumas, such as a strike to the head with a weapon, may not immediately cause death, but result in massive bleeding and internal accumulation of blood that can cause death. In cases of head injuries pathologists will sometimes be able to determine the contact point where the injuries were inflicted, and they will be able to point to the contrecoupe injury effect, which happens when the head is struck on one side and the brain is so traumatically moved inside the skull that it also become damaged on the opposite side and bleeding occurs at the top of the brain. This bleeding inside the skull can sometimes cause death.

In a similar effect, Shaken Baby Syndrome (SBS), occurs when an infant child is violently shaken by a person and the baby's brain moves back and forth traumatically inside the skull causing bruising and sometimes fatal bleeding at the front and back of the brain. An examination by the pathologist for the contact points and internal bleeding can provide valuable clues to the manner in which the blunt force trauma was inflicted. According to An Investigator's Manual for Shaken Baby Syndrome, studies indicate that SBS is the leading cause of death in children under two years of age and research studies the United Kingdom and the United States indicate that SBS may occur each year in as many as 24 to 30 per 100,000 children under two years of age.

In cases of asphyxiation, a pathologist will look for indicators of how the body was deprived of oxygen. Several common means include strangulation, suffocation, smoke inhalation, or drowning. For strangulation, the pathologist will look for bruising around the neck inflicted by choking hands or by a ligature. A ligature is any item, such as a rope or a belt, which could be used to restrict breathing and stop oxygenated blood going to the brain, thus causing death. If a ligature has been used and removed, it will leave a distinct abrasion line. If a dead body is found with a ligature in place, investigators should take great care to not untie the ligature, but cut it off of the victim, as this allows the ligature size to be measured and compared to the size of the neck to determine the amount of breathing that was restricted. Once the ligature is removed from a dead body, a distinct ligature mark or a groove in the flesh will sometimes be visible.

To determine strangulation, the pathologist will examine the eyes of the victim for the presence of small ruptured blood vessel that appear as red spots on the white of the eyeball. These spots are known as petechial hemorrhage, and will often be visible in victims of strangulation (Jaffe, 1994).

Suffocation as a cause of asphyxiation occurs when a victim's breathing is stopped by an object, such as a pillow or a plastic bag, which restricts the ability of a victim to breath, thus causing death. Unlike strangulation, suffocation has fewer indicators of violent trauma. Suffocation deaths are sometimes accidental and are harder for pathologist to conclusively determine. The presence of a suffocation device at the scene of the death is sometimes a first clue to this cause. Other contributing causes can be the limited ability of a victim to remove the device that accidentally obstructs their breathing, as may be found with a very young child, a handicapped person, or a frail elderly victim.

Another unique type of asphyxiation death is Auto Erotic Asphyxia (AEA). This occurs when a person is attempting to enhance their sexual arousal or pleasure while masturbating and apply self strangulation with a ligature device. Their goal in AEA is not suicide but rather to reach a state of extreme oxygen deprivation and euphoria at the time of orgasm. This strategy can go wrong when the individual passes out and their ligature does not release causing continued strangulation and death. These cases can resemble suicide; however, they are really death by misadventure because the victim had no intent to kill themselves. AEA can sometimes be distinguished from suicide by the existence of apparent masturbation, pornography at the scene, and ligature devices that have releasable controls.

In cases where asphyxiation is caused by smoke inhalation, a pathologist can find signs of soot blackening in the lungs and, if the air containing the smoke was sufficiently hot, the lungs will also show signs of burn trauma. Because arson is sometimes used as a means of disguising a homicide, finding a dead body in a burning building, and not finding signs of smoke in the lungs, is a red flag for possible death by homicide.

In cases where asphyxiation is caused by drowning, a pathologist will find signs of water present in the lungs. If there is a question as to the location of the drowning, it is possible to have a diatom test conducted on the victim's tissue. If the victim was drowned in fresh water, the diatom material, which is microscopic algae, will have migrated from the water in the lungs to the blood and tissue of the victim. These microscopic algae are species unique to a particular body of water. Diatom material found in a victim's lungs should match the diatom sample from the water where the body was found. If it does not match, this suggests that the victim drowned elsewhere.

In cases of toxic substances, a pathologist will test the stomach contents, the blood, eye fluid known as vitreous humor, and tissue samples from various organs in the body for poisons, drug overdose, the ingestion of toxic chemicals, or toxic gas inhalation. Any of these substances can cause death if ingested or inhaled in sufficient quantities.

In cases of electrocution, a person dies because of an electrical current passing through their body that stops the heart. A pathologist will look for signs to confirm that a current passed through the body, including contact burns where a person has touched a source of power that entered their body and existed to a grounding point. This grounding point is often at the ground through the feet, but can be through a shorter contact pathway, if another hand or part of the body was in contact with a grounded object. Burns will also be visible where the electrical current exited the body.

Cases where the necessities of life have been deprived generally occur where there is a dependent relationship between a caregiver and a victim. The victims in these cases are typically very young or very elderly persons who are unable to take care of their own needs. These cases often take place over and extended periods of time and may include other types of physical neglect or abuse. Failing to provide necessities of life is such a significant issue that the Criminal law in India makes provision for this as an offence.

Duty of persons to provide necessaries

(1) Everyone is under a legal duty

(a) as a parent, foster parent, guardian or head of a family, to provide necessaries of life for a child under the age of sixteen years;

(b) to provide necessaries of life to their spouse or common law partner; and

(c) to provide necessaries of life to a person under his charge if that person

(i) is unable, by reason of detention, age, illness, mental disorder or other cause, to withdraw himself from that charge, and

(ii) is unable to provide himself with necessaries of life.

Marginal note: Offence

(2) Every one commits an offence who, being under a legal duty within the meaning of subsection (1), fails without lawful excuse, the proof of which lies on him, to perform that duty, if

(a) with respect to a duty imposed by paragraph (1)(a) or (b),

(i) the person to whom the duty is owed is in destitute or necessitous circumstances, or

(ii) the failure to perform the duty endangers the life of the person to whom the duty is owed, or causes or is likely to cause the health of that person to be endangered permanently; or

(b) with respect to a duty imposed by paragraph (1)(c), the failure to perform the duty endangers the life of the person to whom the duty is owed or causes or is likely to cause the health of that person to be injured permanently. (Justice Laws India, 2017)

Marginal note: Punishment

(3) Every one who commits an offence under subsection (2)

(a) is guilty of an indic. offence and liable to imprisonment for a term not exceeding five years; or

(b) is guilty of an offence punishable on summary conviction and liable to imprisonment for a term not exceeding eighteen months.

If the death of a person is found to be the result of failing to provide the necessities of life, the responsible caregiver can ultimately be charged with criminal negligence causing death.

There are a wide range of chemicals and usages that can be used in the commission of a crime or found at the scene of a crime. In addition to general chemical analysis, there are several sub areas for analysis in cases of:

- Accelerants used in the crime of arson;
- Explosive analysis in cases of conventional crimes and terrorism;
- Toxic chemicals and biological agents used in cases of murder, industrial negligence, and terrorism;
- Drug analysis in the cases of trafficking and drug overdoses;
- Gunshot residue analysis; and
- Analysis and chemical matching of paint transfer in cases of hit and run motor vehicle crashes.

Relatively new in the forensic world, forensic archaeology is the use of archaeological methods by experts to exhume crimes scenes, including bodies. These forensic experts are trained to methodically excavate and record their dig. They document the recovery of artifacts (evidence), such as human remains, weapons, and other buried items, that may be relevant to the criminal event. Forensic archaeologists will often work in concert with other forensic experts in DNA, physical matching, forensic entomology, and forensic odontology in the examination of evidence.

Forensic entomology is a very narrow field of forensic science that focuses on the life cycle of bugs. When a dead body has been left out in the elements and allowed to decompose, the investigative challenge is not only to identify the body, but to establish the time of death. Once a body has decomposed, the process of determining time of death can be aided by a forensic entomologist. As discussed in a previous chapter, these experts look at the bugs that live on a decomposing body through the various stages of their life cycle. From these life cycle calculations, scientists are sometimes able to offer and estimate relative time of death.

To paraphrase the description provided by Dr. Leung (2008), forensic odontology is essentially forensic dentistry and includes the expert analysis of various aspects of teeth for the purposes of investigation. Since the advent of dental x rays, dental records have been used as a reliable source of comparison data to confirm the identity of bodies that were otherwise too damaged or too decomposed to identify through other means. The development of DNA and the ability to use DNA in the identification of badly decomposed human remains has made identity through dental records less critical. That said, even in a badly decomposed or damaged corpse, teeth can retain DNA material inside the tooth, allowing it to remain a viable source of post mortem DNA evidence.

Beyond the identification of dead bodies, forensic odontology can sometimes also provide investigators with assistance in confirming the possible identity of a suspect responsible for a bite mark. This comparison is done by the examination and photographic preservation of the bite mark on a victim or an object, and the subsequent matching of the details in that bite mark conuration to a dental mould showing the bite conuration of a known suspect's teeth. Although bite mark comparison has been in practice for over fifty years there remain questions to the reliability for exact matching of an unknown bite mark to a suspect.

Forensic engineering is a type of investigative engineering that examines materials, structures, and mechanical devices to answer a wide range of questions. Often used in cases of car crashes, forensic engineers can often estimate the speed of a vehicle by examining the extent of damage to a vehicle. They can also match damage between vehicles and road surface to determine the point of impact and speed at the time of impact. Many police agencies now have specialized traffic personnel trained in accident analysis and accident reconstruction. These officers utilize a variety of forensic engineering techniques to examine and document the dynamics of car crashes to establish how and why a crash occurred.

In cases of building collapses, forensic engineers can conduct analyzes to determine the cause of a structural failure and, in the case of an intention explosion, such as in acts of terrorism, this can point to the location of the planted explosive device. The investigative possibilities for forensic engineering are too extensive to elaborate here, but if damage to a building, an object, or a piece of equipment poses an investigative question, the tools of forensic engineering should be used to seek answers.

Criminal profiling, also referred to as psychological profiling, is the study of criminal conduct to develop the most likely social and psychological profile of the person who may have committed the crime based on the actions of known criminals who have committed that same type of crime in the past. Criminal profiling draws on information from many sources, including historical criminal statistics of known criminals. Additionally, other information is collected about violent criminals and their modus operandi. This kind of information can shed light on details, such as preferences for luring victims, taking trophies, abduction methods, bondage preference, torture methods, means of killing, and displaying a dead body after death. With information and specific data collected from a wide assortment of offenders, psychological profilers work with investigators to examine the details of a criminal investigation, and, based upon the known historical criminal conduct data, they determine probable descriptors and characteristics that might be expected in a current suspect's profile. For investigators, this kind of profiling can be helpful in focusing the investigation on the most likely persons.

Geographic profiling is similar to psychological profiling in that it seeks to focus on the possible conduct of an unknown criminal based on the data collected from the known past criminal conduct of others. Unlike psychological profiling, geographic profiling is focused specifically on where a suspect might reside relative to the location where his or her crimes are currently being committed.

In today's digital world, criminal conduct frequently includes evidence in the form of digital data. The collection of data from cellular phones as proof of a criminal conspiracy, or the message tracking of images passed in the distribution of child pornography, all require significant levels of specialized technological knowledge to collect, preserve, and analyze the exhibits. Some crimes, such as identity theft and the subsequent fraudulent misappropriation of funds, are almost entirely digital data crimes, and they cross over several fields of technological expertise. It is now incumbent upon ordinary investigators to understand the basics of how to preserve digital evidence, and to know when and if digital evidence may be present. An ordinary investigator without forensic data skills and qualifications should never attempt to recover digital data evidence without help. The destruction of evidence would be like an untrained investigator trying to lift fingerprints at a crime scene.

Forensic document analysis is typically done by certified forensic document examiners working as independent contractors or as employees within the service of government funded crime detection laboratories. Most often tasked within the scope of fraud investigations, these specialists examine items, such as wills, land titles, contracts, deeds, seals, stamps, bank checks, identification cards, handwritten documents and documents from photocopiers, fax machines, and printers. These documents are often examined to authenticate them as genuine or unaltered original documents where an allegation of misrepresentation or fraud has been made. Original signatures are also sometimes called into question, and these examiners can make a determination of authenticity by comparing the signature sample to samples known to be genuine. Forensic experts are also called upon to analyze threatening letters, ransom letters, or hold up notes to make a connection to an identified suspect.

Forensic identification sections are the frontline forensic specialists typically working within their own police agency. Usually, these specialists are experienced police officers who have taken forensic training in photography, fingerprint examination, physical matching, evidence collection, and crime scene management to work within this type of section. The daily work of forensic identification sections involves attending crime scenes, and conducting a variety of examinations using special fingerprint dusts, chemical fuming agents, and ultraviolet light sources to uncover impressions of fingerprint, shoeprints, tool marks or even body fluid stains not visible to the naked eye. Once the stain or the image of a forensic impression is found, these specialists can record, preserve, and recover the exhibit using photography and specialized tools for lifting the exhibit from a surface or removing the entire imprinted surface as an exhibit.

Crime Detection Laboratories across India, provide a range of specialties, including;

- Biology – Comparison of the suspect's and victim's body fluids and hair; most often DNA analysis

- Chemistry — Identifying non biological substances found at a crime scene, such as paint, glass, liquids, fuels, and explosive substances
- Toxicology — The examination of body fluids to determine the level of alcohol present in the body, and providing expert opinions in relation to the extent of intoxication
- Documents Examination — The analysis of documents to determine authenticity for fraud allegations. Can also provide handwriting comparison
- Firearms Ballistics — Matching shells, casing, and fired bullets to a weapon and making a determination of bullet trajectory
- Tool mark examination — Matching tool impressions to an originating suspect tool

Scientists hired to work in these crime detection laboratories require a four year specialized degree in the field of their choice. Once hired, they undergo an understudy period of 12 to 18 months in a laboratory with an expectation that they will become proficient enough in their chosen field to achieve expert qualification from the court. This expert status will allow them, on a case by case basis, to render expert opinion evidence on their examination of forensic exhibits.

For an investigator wishing to engage the services of the Crime Detection Laboratory, it is necessary to complete a request for analysis of the exhibit they wish to have examined and deliver that exhibit, either in person or by double registered mail, directly to the Crime Detection Laboratory to ensure continuity of the exhibit. Once examined, the analyst will return the exhibit again either by calling for a personal pick up or by double registered mail along with a certificate of analysis detailing the result of the examination. The certificate of analysis can become an exhibit for disclosure to the defence in a criminal case, and, if uncontested, will be accepted by the court as evidence. If contested, the Crime Detection Laboratory Scientist will be called to attend court and provide testimony of the examination and the results as an expert witness. They are generally cross examined by the defence to validate their expert qualifications and analyzes.

However this book outlines a wide variety of forensic tools and medicolegal processes services available for criminal investigations and fact findings. For any Medical Officer as investigator, knowledge of forensic tools and medicolegal processes & services provides him/her with the ability to recognize and seize on evidence opportunities that would not otherwise be possible. The picture of physical evidence found at any crime scene only has face value as a collection of objects to be viewed and considered in their existing connection to the event. Analysis of those same objects using forensic tools can add significant information, making a circumstantial connection between the players and the event, and adding new insights. Forensic and medicolegal analysis can make the difference between solving a crime and it becoming a cold case.

Medical Jurisprudence

Medical Jurisprudence in itself is a heterogeneous science, admixing two different streams of studios Medicine & Law. Both are vital for wellbeing of society and both represent the epitome of human intellect and wisdom. Both are as old as the mankind itself, and both strive to maintain their authenticity in an ever evolving social edifice. White or Black, they both manifest inevitability of struggle, pragmatism of action and compulsiveness of survival in a complex matrix of truth and surreal. Forensic Medicine is a confluence of clinical subjectivity and judicial objectivity. It illustrates man's righteousness and ingenuity, his desire to seek just and punish guilty, and his native sense of maintaining balance.

It's also one of the most difficult branches of Medicine to practice. It's a backdrop science, offering minimum returns. It's one of the lesser researched subject and at the last count, least popular among the medical students and profession.

In our setup, practitioner of Forensic Medicine bears a plethora of responsibilities. He is answerable to a host of agencies his own superiors, local administration, police, Judiciary, media and public. He is least trained and minimally motivated. He is expected to perform miracles from obsolete resources. He has to often negotiate a tightrope of Utopian expectations and insane realities. He has to successfully sustain an atmosphere of maximum accountability and minimum security.

To many it's a thankless job, but certain privileges are priceless. Practice of Medical Jurisprudence involves a peculiar expertise. Unlike other sciences, space to fallback here is less, and chances to tumble are more. In this venture, he is often alone. Collective wisdom tells only five things

- Maintain your neutrality at all costs.
- Never falsify or manipulate evidence.
- Always remember that scales of justice often hang from the tip of the pen of Medical Jurist.
- We are neither judge nor jury; we are a mere professional in aid of Justice.
- We have to go back home, safe and sound at the end of day

CHAPTER-2

DYING DECLARATION

The Legislature in its wisdom has enacted in Section 32(1) of the Evidence Act that "when the statement was made by a person as to the cause of his/her death or as to any of the circumstances of the transaction that resulted in his/her death in cases in which the cause of that person's death comes into question, such a statement (written or verbal) made by the person who is dead is itself a relevant fact". This provision has been made by the Legislature, probably, on two grounds—(i) the victim being generally the only eyewitness to the happening/transaction, the exclusion of his/her statement would tend to defeat the ends of justice and (ii) the sense of impending death that creates a sanction equal to the obligation of an oath. The provision has been laid as a matter of sheer necessity by way of an exception to the general rule that hearsay is no evidence and the evidence that has not been tested by cross examination is not admissible. That being the importance of dying declaration, as far as possible, dying declaration should be recorded in the manner pro vided in the rules, i.e. Rules 3 to 10 of Chapter 13 A of Rules viz.:

- Fitness of the declarant to make the statement should be got examined.

- The statement of the declarant should be in the form of a simple narrative.

- Signature or thumb impression of the declarant to be obtained in token of the correctness of the statement.

- When death is imminent in the opinion of the doctor, the statement may be recorded by the doctor or the police officer without losing time in waiting for the magistrate. In such a case, the police or the doctor concerned must note down why it was not considered expedient to apply to the magistrate for recording the statement or to wait for his arrival.

- When the statement is recorded by a doctor or a police officer, it shall, so far as possible, be got attested by one or more of the persons who happened to be present at that time.

- Fitness of the declarant to make a statement to be certified by the magistrate or other officer concerned, at the conclusion of the statement.

- The statement should be free and spontaneous without any prompting, suggestion or aid from any other person.

- The magistrate, the doctor and the police officer must all realise that the welfare of the injured person should be their first consideration and in no circumstances proper treatment be impeded or delayed simply to obtain the statement.

(Such procedure of recording dying declarations should not be deviated and it is only in emergent and unavoidable circum stances that the departure from these rules may still not vitiate the authenticity of the statement.)

ADMISSIBILITY OF DYING DECLARATION— DIFFERENCE BETWEEN ENGLISH AND INDIAN LAW

death, also is it not restricted to the cases of homicide only. Before the dying dec Under the English law, it is essential to the admissibility of dying declaration that declarant must have entertained a settled hopeless expectation of death, but he need not have been expecting immediate death. Indian Law does not put any such restriction. It is not required under the Indian law that the maker should be expecting imminent laration may be admitted, it must be proved that its maker is dead. If the maker survives, it may be used to corroborate or contradict his statement in the court.

ELIGIBILITY OF STATEMENTS

There are certain pre requisites to the admissibility of statement under this Section. The court has to be convinced that the witness, whose statement is offered, is dead, or cannot be found, or has become incapable of giving evidence or unreasonable delay or expense is involved in producing him. What is unreasonable delay or expense is in the discretion of the court.

STATEMENTS: WRITTEN OR VERBAL

'Verbal' means by words. It is not necessary that the words should be spoken. The words of another person may be adopted by a witness by a nod or shake of the head. If the significance of the signs made by a deceased person in response to questions put to him/her shortly before his/her death is established satisfactorily to the court, then such questions, taken with his/her assent to them, constitute a verbal statement as to the cause of his/her death (Pandian Kumar Nadar vs. State of Maharashtra, 1993 CrLJ 3883).

CIRCUMSTANCES OF TRANSACTION THAT RESULTED IN DEATH

The word 'death' appearing in the Section is inclusive of suicidal or homicidal death. The statement must be as to the cause of declarant's death or as to any of the circumstances of the transaction that resulted in his death. The statement admissible under this clause may be made before the cause of death has arisen, or before the deceased has reason to anticipate being killed. The expression 'any of the circumstances of the transaction that resulted in his death' is wider in scope than the expression 'caused his death'.

PROXIMITY BETWEEN TIME OF STATEMENT AND THAT OF DEATH

The problem of proximity was for the first time raised before the Supreme Court in Sharad vs. State of Maharashtra. A married woman had been writing to her parents and other relatives about her critical condition at the hands of her in laws. She lost her life some 4 months later. Her letters were sought to be proved as a dying declaration. The court held that the statements were not so remote in time as to lose their proximity with the cause of death.

PERSON TO WHOM DYING DECLARATION SHOULD BE MADE

It is immaterial to whom the dying declaration is made. The declaration may be made to a magistrate, a police officer, a public servant or a private person. It may be made before a doctor, indeed he would be the best person to opine about the fitness of the dying man to make the statement and to record the same, where he found the life was fast ebbing out of the dying man and there was no time to call the magistrate or the police. In such a situation the doctor was justified, indeed he was duty bound to record the dying declaration. The declaration may take the form of first information report, or a statement before the police (Section 162 CrPC not declaring it inadmissible by reason of its having been made in the course of investigation by the police) or it may be in the form of a complaint, or a statement under Section 164 CrPC or a deposition before the committing magistrate in which case it may also become admissible under the next Section. The declaration should be taken down in the exact words that the person uses, in order that it may be possible from those words to arrive at precisely what the person making the declaration meant.

MORE THAN ONE DYING DECLARATIONS

When there are more than one dying declarations of the same person, they have to be read as one and the same statement for proper appreciation of the value and, if they differ from each other on material aspects, efforts should be made to see if they could be reconciled. If there was a reasonable explanation for the difference, the statement may be taken at par with an omission covered by explanation to Section 161 CrPC and be considered as a matter of fact in each case on its own strength (Radhy Shyam vs. State of UP 1993 CrLJ 3709).

INCOMPLETE DYING DECLARATION

An incomplete dying declaration is inadmissible. When the person making the declaration dies before completion of his statement, no one can tell what the deceased was about to add. But where all the necessary questions had been asked by the magistrate, or the doctor and replied by the deceased, and a couple of concluding questions were not answered by the deceased on account of becoming semi conscious or unconscious, the dying declaration may not be regarded to be incomplete (Kusa vs. State of Orissa 1980 SC 559).

DYING DECLARATION NEED NOT BE EXHAUSTIVE

Under the law, a dying declaration need not be exhaustive and need not disclose all the surrounding circumstances. Indeed, quite often, all that the victim may be able to say is that he was beaten by a certain person or persons. That may either be due to suddenness of the attack or the conditions of visibility or because the victim was not in a physical condition to recapitulate the entire incidence or to narrate it at length. In fact, many a time, dying declarations that are copiously worded or neatly structured, excite suspicion for the reason that they bear trace of tutoring (Munnu Raja vs. State of MP 1976 SC 2199).

EVIDENTIARY VALUE—NEED FOR CORROBORATION

The human mind is so constituted as to be inclined to attach high degree of importance to dying declarations, and it is necessary that the court should attach due weight to the points for and against the declaration. Although declarations made under a solemn sense of impending death and the concerning circumstances wherein the deceased is not likely to be mistaken are entitled to great weight, it should always be recollected that the accused has no opportunity of cross examination and that when the witness has no deep sense of accountability, feelings of anger or revenge (or in case of mutual conflict, the natural desire of screening his own misconduct) may affect the accuracy of his statements and give a false colour to the transaction. Moreover, the particulars of the violence to which the deceased had spoken are likely to have occurred under circumstances of confusion and surprise and leading both to mistakes as to identity of the person and to the omissions of facts essentially important to the completeness and truth of the narration.

PROCEDURE FOR EXAMINATION OF A WITNESS IN THE COURT SUMMONS

Summons (plural: summonses) literally implies an authoritative call to appear in a court. It is a written document issued by the court in duplicate (original copy) bearing signature of the presiding officer of the court or of such an officer as the High Court may, from time to time, direct. It also carries the seal of the court. The service of the summons may be effected by the following means:

- Through the police officer within whose jurisdiction the person summoned resides or an officer of the court issuing it or some other public servant (where the summons are to be served on a government servant, summons are ordinarily sent to the Head of the Office in which the person is employed, who causes the summons to be served to the concerned person and returning the copy carrying endorsement in the form of a receipt from the person summoned).

- As far as practicable, summons should be served on the person summoned, by delivering or tendering to him one of the duplicates of the summons and obtaining his signatures in the form of a receipt upon the other.

- Where a person summoned cannot, by exercise of due diligence, be found, the summons may be served by leaving one of the duplicates with some adult male member of his family residing with him and obtaining signatures on the other copy in the form of a receipt.

- If, however, service of summons cannot be effected by any of the above means, one copy of the summons should be fixed on some conspicuous part of the house or homestead in which the person summoned ordinarily resides.

- Court issuing summons to a witness may, in addition to and simultaneous with the issue of such summons, direct a copy of the summons to be served by the registered post addressed to the witness or his agent empowered to accept the service at the place where he/agent ordinarily resides or carries on business or personally works for gain.

- In the event of receiving a refusal of the witness to take delivery of the summons (whether through the acknowledgement purporting to be signed by the witness or through an endorsement purporting to be made by a postal employee), the court may declare that the summons has duly been served.

- Where the defendant resides outside India and has no agent in India empowered to accept service, the summons may be sent through post or by courier service or by fax message or by electronic mail service or by any other means as pro vided by rules made by the High Court. Alternatively, sum mons may be sent through Ministry of Foreign Affairs.

- Where the defendant is, in the opinion of the court, of some high rank as needing consideration, the court may "substitute a letter" for the summons signed by the Judge or such officer as he may appoint in this behalf. Such a letter shall be treated as summons in all respects and may be sent either through post or special messenger or in any other manner that the court may think fit.

Willful disobedience or willful departure before lawful time (i.e., departing without waiting for a reasonable time for the arrival of the presiding officer) has been made punishable. The punishment prescribed is imprisonment for a term that may extend to 1 month, or with fine that may extend to | 500, or with both (Section 174 IPC). The court may also issue a war rant of his arrest and production in the court (Section 87 CrPC). (As per latest amendment in the Civil Procedure Code, the limit of fine has been extended to | 5000 for the reason of decrease in the money value.)

Attendance in Response to Summons

If a witness is summoned to attend both a civil and a criminal court on the same date, he should attend the criminal court and inform the civil court the reason of his absence. Higher courts should have priority over the lower. If the two courts are of same status, he should attend the court who served the sum mons first and informing the other accordingly. After arriving at the court on scheduled date and time, the witness should report to the presiding officer of the court and should not leave the court without permission of the presiding officer.

Civil Procedure Code deals with the expenses to be paid to the witnesses. It requires that the party applying for summoning a witness shall pay/deposit into the court such sum as appears to the court to be sufficient to defray the travelling and other expenses of the person summoned in passing to and from the court, and for one day's attendance. If the witness to be summoned is an expert, the court may allow reasonable remuneration for the time occupied for both giving evidence and in performing any work of an expert character necessary for the case. The witness then shall withdraw the amount from the office of the court after receiving 'refund document' from the court. This is popularly called as conduct money. In the event where the summons is directly served by the party on a witness, the expenses referred above shall be paid to the wit ness by the party or his agent.

However, where it appears to the court or to such officer/ expert that the sum deposited into the court by the party is not sufficient to cover such expenses or reasonable remuneration, the court may direct further sum to be paid to the person/expert summoned as appears to be necessary on that account. And, where the witness is required to stay for a longer period than one day, the court may, from time to time, order the party at whose instance the person/expert had been summoned to pay/deposit into the court such sum as is sufficient to defray the expenses for the extended period. In criminal cases, no conduct money is paid at the time of service of summons, but witness is bound to attend the court and give evidence. The witness is paid TA and DA by the Government/Institution as per rules.

OATH TAKING

When called, the witness stands in the dock and takes the oath by reading or quoting, "The evidence that I shall give to the Court shall be the truth, the whole truth and nothing but the truth. So help me God". If the witness desires to give evidence on solemn affirmation, he will take the oath by saying, "I solemnly affirm that the evidence that I shall give in the Court shall be the truth, the whole truth and nothing but the truth". The witness will be liable to prosecution for 'perjury' under Section 193 IPC if he fails to state what he knows or believes to be true or deliberately gives false evidence.

Perjury

Sections 191 and 192 of the IPC deal with the 'giving' and 'fabricating' of false evidence and reflect that the law ought to make a distinction between the kind of false evidence that pro duces greater evil and the kind of false evidence that produces comparatively lesser evil. The offence is designated as 'perjury' under the English law. The salient features of the offence of giving false evidence are intentional making of a false statement or declaration by a person who was under a legal obligation to speak the truth. The word 'statement' in this Section is not limited to a statement by a witness but includes a statement

made by an accused too. It comprises, at least, three essential factors: (i) legal obligation to state the truth, (ii) making of false statement and (iii) belief in its falsity. (A statement recorded in the course of investigation under Sections 161 and 162 of the CrPC ordinarily would not provide a sound foundation for a charge of perjury as the statement under such situations is not being made under oath. However, it may be punishable for the offence of giving false information to the police.)

It is necessary that in order to make a person liable for per jury, his earlier statement regarding the facts must be on oath and his subsequent statement also must be on oath and if both the statements are opposed to each other and they cannot be reconciled, then the person may be liable to be proceeded against for perjury.

Section 193 of the IPC deals with the punishment for giving or fabricating false evidence. Giving false evidence in a stage of judicial proceeding falls within the first part of Section 193, and giving false evidence in the course of a statement (which is not evidence in a stage of judicial proceeding) falls within the second part of the Section 193. The punishment prescribed in the former case is imprisonment extending up to 7 years along with fine and in the latter case, imprisonment up to 3 years along with fine. This clarifies that the offences committed at any stage of a judicial proceeding are more severely punishable than when they are committed in a non judicial proceeding.

RECORDING OF EVIDENCE

Having been sworn or affirmed in the court, the witness is first examined by the prosecution counsel of the party who has summoned him to give the evidence. In government prosecution cases, the public prosecutor examines the witness. This is known as examination in chief. This is followed by cross examination by the opposing counsel, after which the witness may be re examined by the prosecution counsel. Questions may be put by the presiding officer of the court to clear any doubt at any stage of the proceedings.

Examination in Chief

In the private cases, this consists of questions put to the witness by the counsel for the side that has summoned him. In government prosecutions, the public prosecutor commences this examination. The object is to elicit from the witness the principal salient facts bearing on the case, and if the witness hap pens to be an expert, then interpretation of these facts. A medical witness in his examination in chief narrates his findings on examination of the case under consideration. He testifies the report to be prepared by him after the examination and was also duly signed by him. He has to answer queries of the prosecution counsel for clarification of points in connection with the case. At this stage of the examination, no leading questions are allowed except in those cases in which the presiding officer is satisfied that a witness has turned hostile. A leading question

Examination in chief:

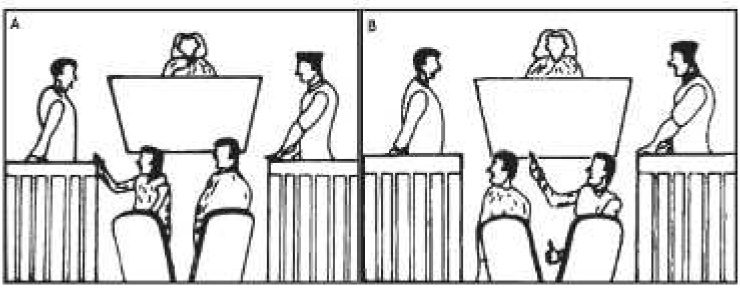
Doctor states the various facts as recorded in the postmortem report and his opinion. Prosecution counsel puts some queries like:

Q. What kind of weapon was involved and what could be the approximate distance?

A. Probably, it was rifled firearm and the distance within the range of 'tattooing'.

Cross examination:

To be conducted by the defence counsel to shake the evidence of prosecution.



Q. Could you name the specific weapon and the 'bore'?

A. No.

Q. You stated that the distance was within the range of 'tattooing', i.e. it was within 2 to 3 feet. Is not it?

A. Not necessarily.

Re examination:

To be conducted by the prosecution counsel to clarify some points that might have crept during the cross examination having bearing upon the case.

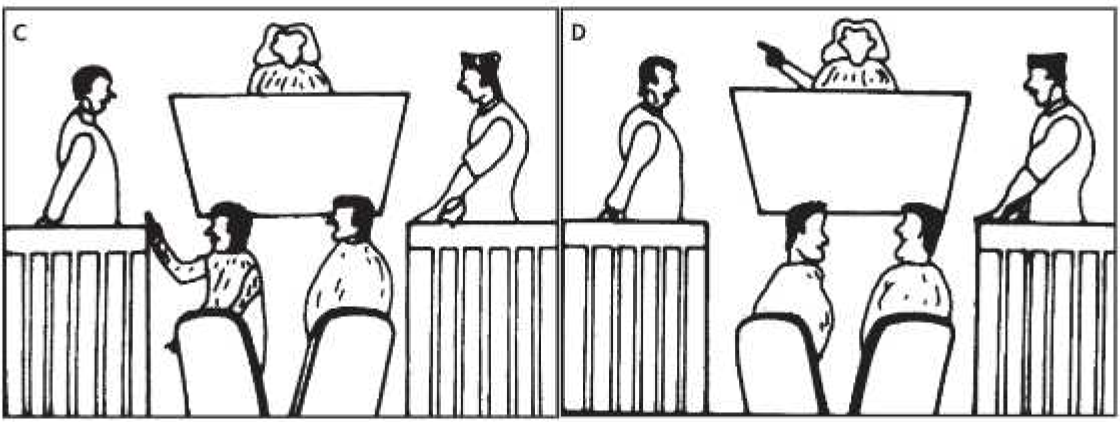
Q. What could be the usual length of the arm of an ordinary adult male?

A. Could be 2 to 3 feet.

COURT QUESTION:

May be put by the presiding officer of the court at any stage of the proceedings to have a distinct clarity about some finding?

Q. Could it be possible that a bullet traversing the chest of one victim, enters the other through the head and kills the latter?



A. Could be possible.

When did the incident occur?

A witness is generally disposed to state in favour of the per son producing him. He will be mostly not inclined to state any thing favourable to the opponent. However, occasions may be there when the witness, who has been called in the expectation that he would speak to the existence of a particular state of facts, pretends that he does not remember those facts or deposes entirely differently to what he was expected to depose or changes/contradicts his previous statement given to the police or to any other authority or in some judicial proceeding. Such witnesses have sometime been called 'adverse', 'unfavourable' or 'hostile' witnesses. In such cases, the party producing the witness is given permission by the court to test veracity and to impeach the credit of the witness. It is not correct to say that when a witness is cross examined by the party calling him, his evidence cannot be believed in part and disbelieved in part but must be excluded from the consideration altogether. The correct rule is that either side may rely upon his evidence and that the whole of the evidence so far, as it affects both the parties favourably or unfavourably, must be considered for what it is worth.

A witness may not be treated as hostile merely because his evidence does not suit the party on whose behalf he is deposing. It needs be shown that such a witness is suppressing the truth and exhibits hostile animus that has to be judged on the basis of answers given by him and to some extent from his demeanour. There must be some material to show that the witness has resiled from his earlier statement, or is not desirous of disclosing the truth, or has exhibited an element of hostility, or has changed sides etc. Section 154 of the Indian Evidence Act deals with such type of witnesses wherein it is laid down that the presiding officer of the court may grant permission to the party producing the witness to put any questions as may be put to him (to the witness) by the adverse party during cross examination. The conduct, attitude and mannerism of such witness may lead the court to feel that by providing an opportunity to the party producing/calling the witness to put questions in a more pointed, penetrating and searching way, his evidence (evidence of the hostile witness) will be more fully demonstrated/displayed, the truth more effectively extracted and the credit more adequately tested.

Cross Examination

Here the witness is examined by the counsel of the opposite party (defence counsel). In this stage of proceeding, the defence counsel tries to extract out of the witness any fact or facts in favour of defence such as some discrepancies, inaccuracies, contradictions, etc. that could have crept in during the examination. Cross examination helps to test the reliability of the evidence given. The purpose of cross examination is to weaken, qualify or destroy the case of opponent and also to establish the contention of defence through the witness of the prosecution. From this viewpoint, the witness will be asked not only as to facts in issue or directly relevant thereto, but also about questions tending to test his means of knowledge or even tending to impeach his credit or character. The court can, however, forbid any question that appears to it either insulting, annoying or needlessly offensive in form (Section 152 IEA).

Leading questions are allowed during this stage of deposition. The witness should be careful and vigilant in answering questions during this stage. The defence counsel during this stage may put forward many irritating, vague, conflicting questions to the witness, which are well calculated to disparage his skill and integrity. He should face the cross examination coolly and intelligently, should on no account loose his temper. The witness can appeal to the court for ruling against insulting and disparaging remarks of the counsel. Self incriminating statement, given by the witness under compulsion during cross examination, does not make him liable for arrest or prosecution subsequently.

There is no time limit for cross examination. It may last for hours or days. The witness may have to answer hypothetical questions having some bearing on the fact in issue, but he need not answer when he thinks that the subject is beyond his purview. The author is aware of a case where cross examination lingered on for about a year or so, of course on different dates, the case was of the suicide/homicide nature of drowning.

At times, cross examination may act as a double edged weapon, damaging the prosecution and the defence alike, especially where the counsel is not well adept with medical science and the witness happens to be a well experienced and honest medical expert.

Re examination

During this stage, the counsel who has conducted examination in chief, re examines the witness to clarify any discrepancy or obscure points or to rectify any ambiguity that has crept in during the cross examination. The witness should not bring any new point without permission of the presiding officer or the consent of the opposing counsel. In the event, if some new point is introduced, the witness will be liable to be cross examined on the point that has lately been introduced. Re examination is allowed only when the presiding officer thinks it proper.

Question(s) by the Court

The presiding officer can put any question during any stage of the deposition to clarify any doubt, discrepancy or ambiguity. The medical witness can also be asked by the court to explain things so that it can be well understood by the non medical people.

On conclusion of the evidence, the witness should read over his own deposition very carefully before he signs it. He should draw the attention of the court for correction or any inaccuracy or discrepancy in recording of the evidence. Subsequent to discharge, the witness is liable to be recalled if his evidence needs further elucidation.

Kinds of Witnesses

A witness is a person who gives sworn testimony in a court of law as regards facts and/or inferences that can be drawn there from. They are of two kinds described as follows.

COMMON/ ORDINARY WITNESS

A common or ordinary witness is one who testifies as to facts,

i.e. what he actually saw or heard or perceived in any other manner. He is not able to draw any inference from observations made by him or express any opinion from the observa tions made by others.

AN EXPERT WITNESS

Section 45 of Indian Evidence Act defines an expert wit ness. It says that an expert witness is one who has acquired special knowledge, skill or experience in any science, art, trade, or profession. Such knowledge may have been acquired by practice, observation, or careful studies. It implies that the value of an expert does not depend upon his qualifications; rather it depends upon the soundness of reasoning advanced by him based upon his experience. Putting in the words of the Apex Court, "In order to be a competent witness, an expert need not have specialised in certain branch of science or art. It is sufficient, so far as admissibility of evidence goes, if he or she has acquired a special experience therein" (Baldeo Raj vs. Urmila Kumari, AIR, 1979 SC 879).

The opinion by an expert is of advisory nature and is not a binding upon the court. It is not substantive evidence, and the doctor has to depose in the court and to undergo cross examination to prove his point. Keeping in view the limitations of present knowledge of medical science, courts usually do not encourage dogmatic expression of opinions.

It may be reiterated that the credibility of expert witness depends upon reasons stated in support of his/her opinion and the data and material produced before the court that form the basis of his/her opinion. Mohd. Jahid vs. State of Tamil Nadu (AIR 1999 SC 2416) is an important case on this point. In this case, the credibility of the doctor's opinion as to the 'cause of death' narrated in the postmortem report vis a vis a statement found in some textbook was compared. The prosecution put forward a suggestion to the doctor on the basis of statement found in the textbook. The doctor disagreed with the statement of the authoritative textbook without giving any reasons. No other authority was produced by the doctor in support of his opinion as to the 'cause of death' of the victim. Doctor's opinion was not relied upon, and she earned wrath of the court. (A doctor may act both as an ordinary as well as an expert witness. When he states his observations on the injuries examined by him during the course of medicolegal examination of the victim, he is acting as an ordinary witness. When he draws inference or extends his interpretation about the injuries as to the kind of weapon involved or suicide/accident/homicide nature of the injuries, he is acting as an expert witness.)

A medical witness, seeking to testify in the court, should bear in mind the solemnity of the occasion and adhere to some basic principles while giving evidence.

PUNCTUALITY AND DEMEANOUR

When a summons is served on a witness, he must attend the court punctually and produce documents and/or other articles as required by the court. His demeanour should be that of a professional man, sui. to the occasion. Generally, the evidence of the expert is taken as early as possible, but if there occurs some delay, he may request the court for early disposal. While in the premises of the court, he should avoid any indis criminate talk of discussion of the case or otherwise too.

BE FAIR AND FRANK

A medical person must remember that although called by one party, his evidence should be impartial. He must answer the questions fairly and truly, according to his knowledge and experience. He should be prepared to admit any alternative explanation of the facts that appears reasonable to him, though it had not struck his mind prior to that.

CLARITY OF THE SUBJECT MATTER

Words can both confuse and clarify an issue, and their careful choice is of great importance in the field of forensic medicine. Competence in medicolegal matters lies not so much in the acquisition of facts, as in the ability to arrange them in orderly way, to draw sound conclusions and to apply these to the needs of law. Medical observations carry somewhat limited concept being primarily confined to diagnosis and treatment, whereas medicolegal observations should take much wider.

DOCTOR IN THE WITNESS BOX

All evidence, whether oral or documentary, falls into two categories—fact or opinion. The law generally gives more importance to facts than to opinions. In science, however, and in medical sciences particularly, it is always difficult to separate fact from opinion and, therefore, any doctor attending to testify to a medical or scientific fact cannot escape extending opinion arising out of the fact range and be directed to all the surrounding facts. The witness may refresh his memory from the 'notes' actually written at the time of examination. The opposing counsel, however, can inspect such notes and cross examine the witness on the same. Hence, the notes must be 'bona fide notes' and nothing be added to or rephrased in the light of any subsequent happening(s).

Many experts feel that they benefit by holding conference with their counsel, or even more from discussion with fellow experts on the matters at issue. An opinion should be considered and criticised as if it were of an adversary and one should endeavour to seek explanations from that point of view.

SPEAK CLEARLY AND COOLLY, BUT NOT COLDLY

He should speak coolly and calmly in a clear, loud voice that should be audible to the judge, counsel of both sides and, of course, to the clerk/steno who is taking down the evidence on the typewriter. He must restrict himself to simple words and avoid technical terms and phrases. A master in his art may be incompetent as a witness.

As a rule, a witness should turn towards the presiding officer of the court to give his replies. It is, of course, courteous to turn to the counsel while a question is being put but never under any circumstance, should he adopt discourteous attitude by gazing out of a window or turning to something else.

GIVE DIRECT ANSWERS WHEREVER POSSIBLE, AND ANSWER ONLY THE QUESTION ASKED

Brief and precise answers are effective. Many of the questions put by the opposing counsel in cross examination will admit of an answer, 'Yes' or 'No'. However, if the question is framed in an ingenious manner and the witness feels that simple affirmative or negative might mislead the court, he should qualify his answer or give an explanation that is relevant to the case. If a question is not understood, doctor should say so and request for it to be repeated.

Medical science being very vast, the doctor is not expected to be conversant with everything. Therefore, if the witness does not know the answer to any particular question, he should say at once, 'I do not know'. This is definitely better and once he has used this expression, he should adhere to it, and not be pressed by cross examination into agreeing some unsounded proposition.

If some passage from a book is quoted or an authority is produced and the witness is asked whether he agrees with the author, he must go through the passage and assess its contents and also look for the 'year' of edition of the book. The lawyer usually reads that portion of the paragraph that is favourable to his case, while the meaning may become completely different on reading the whole passage as well as the preceding and the succeeding ones. It is always better to agree that the author of the book is an expert; this does not mean that one has to agree with everything he has written. There is often some room for a polite but firm difference of opinion. Therefore, if he disagrees, he should stand firm on the opinion already given. Everything written in the book may not be accepted as gospel truth, especially when the expert's own long experience in the field does not corroborate it.

There may be occasions when the witness is asked about some secret information in his possession. If the court directs him to do so, he must answer any such question. Nevertheless, he should on no occasion volunteer such secrets but should divulge them under protest to show his sense of moral duty. The information can be written and handed over to the court. Professional secrecy is not recognised by a Court of Criminal Law.

USE ADJECTIVES WITH CARE

He should avoid exaggerations in his evidence. He should give precise dimensions while describing injuries or fractures or swelling, etc. Whenever anything has dimensions or details of character descriptions of which would clarify one's conception of it, these details should be given.

NEVER LOSE TEMPER

A lawyer often tries to make the witness lose his temper in order to tempt him while in such a condition to make a rash or hazardous statement. There may be occasions when the medical witness must remain firm and contradict strongly any false/ unpleasant statement imputed against him by the defence counsel. The law stresses that the questions put to the expert witness must be relevant and couched in terms that are not bullying or abusive. The judge can always be depended upon to stop either. However, this does not prevent a skilled lawyer from introducing a note of bias or even of biting sarcasm into his questions, and the doctors must try to tolerate such attitudes.

VOLUNTEERING A STATEMENT

It is obvious that the court has no special medical knowledge, and it relies upon the opinion of the medical expert as far as it is founded on scientific facts as presented before the court. Therefore, it is proper for the witness to volunteer a statement if he feels that there is danger of justice being miscarried owing to the court having failed to elicit an important issue.

IN CASES OF MALPRACTICE

It may be hard to criticise a fellow practitioner, but it would be wrong to ignore the public interest and to conceal something that one knows to be true or to suppress something that one honestly believes to be true. This is usually done under the mis guided notion that by doing so, they would be doing disservice to the profession. On the contrary, such persons who ignore the public interest bring the profession to disrepute. The golden rule, 'Do unto others as you would wish that they should do unto you' should be strictly observed on these occasions. Medical experts in all such cases should always be men of acknowledged reputation in the profession. Teachers in the medical colleges who, from the nature of their duties, must keep themselves abreast of the developments of advancing medical science and the experienced practitioners are best suited for testimony under such circumstances. Much higher and rigorous ethical standards are required in India, because there are few legal regulations for the professional service and the public gives almost unlimited authority to the therapist. A mechanism of inner control has to be evolved summoning a doctor to maintain a high standard of practice and to develop public confidence. Equally significant, of course, is the consideration that the ethical practices are largely assimilated by a kind of 'diffusion' or 'osmosis' and as such, it is mandatory that the teachers of the young medicos should themselves put up exemplary models.

Under Section 132 of IEA, the witness (including medical witness) is duty bound to answer any question relevant to the matter at issue. This is so even when the answer is likely to incriminate himself directly or indirectly. However, such incriminating answer of the witness cannot subject him to any arrest or prosecution or be proved against him in any subsequent criminal proceeding, except that for giving false evidence.

Some lawyers may obtain the services of doctors or scientists to advise them on the best method of cross examining medical witness. This may work well in some cases by curbing convictions or moulding opinions; it is liable to be abused. Doctors must not agree to lend help merely to make difficulties for their colleagues. However, where medical views diverge, or there are reasonably tenable alternatives, doctors should be available for 'either side'. But an honest and well informed witness will often admit readily as to the existing/ available alternative, and the need to introduce opposition expert(s) usually does not arise.

Criminal justice process—usual steps for trial of an offender of a cognisable offence

Commission of a cognisable offence (all offences punishable with imprisonment for not less than 3 years aregenerally considered serious and therefore, made cognisable. Arrest can be effected

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Information to the police, i.e. lodging of first information report (FIR). Intentional omission by a person legallybound to inform is punishable under Section 202 IPC

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Where the police officer has reason to suspect the commission of a cognisable offence, he initiates the investigationunder information to the magistrate having jurisdiction to take cognisance of the offence under reference (such a magistrate has a power to order an investigation in cases where the police officer declines to

↓

The police can secure attendance of persons who can give necessary information (a person willfully or intentionallyomitting to attend is liable to be punished under Section 174 IPC)

↓

Recording of statements of witnesses (including the accused and the suspects) by the police during the course of investigation. No oath or affirmation is required in such recording of statements and the same are not required

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Collection and obtaining of all available evidence by the police (including as obtained from medicolegal examinationof the accused and the victim)

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When the evidence is sufficient,* the accused is forwarded to the concerned magistrate empowered to take cognisance of the offence upon the police report (this report is commonly called the "charge sheet" or

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Court frames the charges and summons the witnesses

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Examining of witnesses by the public prosecutor (examination-in-chief) and cross-examination by the defence

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Guilt or innocence of the accused is determined depending upon the evidence

↓

Sentenced, if found guilty

*Where the investigation against the accused cannot be completed within 24 hours of his arrest and there are reasonable grounds for believing that the accusation against him are well founded, the officer in charge of the police station or the investigating officer not below the rank of sub inspector forwards the accused to the magistrate for remand, who may either refuse or direct his detention in police custody (for a term not exceeding 15 days) and thereafter, judicial custody (the maximum period of remand in case of offences punishable with death, imprisonment for life or imprisonment for a term not less than 10 years is 90 days and for any other offence, it is 60 days).

CHAPTER-3

MEDICO LEGAL AUTOPSY

Autopsy/necropsy implies examination of the dead body (postmortem examination) with a view to searching primarily for the cause of death. The necessity for this procedure was evident to our ancestors. Records from Roman times narrate the examination of the wounds of Gaius Julius Caesar by the physician Antistius in 44 BC. In 1302, a court in Bologna ordered the examination of one Azzolino, who had died under suspicious circumstances of alleged poisoning. This procedure was carried out by two physicians and three surgeons, including Bartolomeo da Varignana. Though conventions and legal pro visions vary from country to country, there are generally two types of autopsies:

- The Clinical or Academic Autopsy, which is performed with the consent of the relatives of the deceased to arrive at the diagnosis of cause of death where diagnosis could not be reached during the treatment or to confirm diagnosis where it was doubtful.

- The Medicolegal or Forensic Autopsy, which is per formed on the instructions of the legal authority in circum stances relating to suspicious, sudden, obscure, unnatural, litigious or criminal deaths, and the information so derived is applied for legal purposes to assist the course of justice. In the medicolegal autopsy, the body belongs to the State for the protection of public interest until such time as a complete and thorough investigation into the circumstances attending the death has been completed. Any or all portions of the body may be taken and kept for detailed examination as well as preserved for later trial purposes.

PRELIMINARIES TO A MEDICOLEGAL AUTOPSY

For conduction of a medicolegal autopsy, certain preliminary formalities have to be observed:

- A medicolegal autopsy is to be carried out at the behest of the appropriate legal authority. The request/order may move from the police officer (usually the station house officer or sub inspector of police) or from magistrate or from Coroner under whose jurisdiction the incidence/ event leading to death occurred. Ordinarily, this protocol is not disturbed unless under compelling circumstances.

- With the requisition, a copy of the Inquest or 'Preliminary Investigation Report', prepared by the investigating officer at the scene of death; a dead body challan; hospital record (where there has been a period of treatment between an act of violence or between the accident and the death) and any other relevant paper are necessary as to enable the doctor to concentrate on the organ or the part of the body most suspected and likely to serve as a guide to retain and send the appropriate to the forensic science laboratory (FSL). In the urgency of forensic work, however, at times, during weekends, the autopsy may have to be proceeded without the hospital record, as there may be none to furnish the same and the attendants/relations of the deceased may not be subjected to harassment merely due to non availability of history in spite of the best efforts to procure the same. Where the death has occurred during or shortly after the operation, the surgeon/clinician who operated/treated/ anaesthetised the deceased prior to death should be present with the clinical notes to discuss the case as the autopsy is being performed. This aspect has enormously been stressed in the chapter 'Death Associated with Surgery and Anaesthesia'. However, with all such information at hand, the doctor must approach the case with an open mind. Any preconceived notions can adversely influence, consciously or otherwise, the efficiency of examination. There may be occasions when the information may have been supplied by the person who will eventually turn out to be the suspect.

- Medicolegal postmortem examination can be performed only at the authorised centre and preferably be done by a person of experience and knowledge in that particular field. Unfortunately, either from shortage of staff and resources or owing to apprehension inherent in the subject, the medicolegal autopsies are often being performed by the doctors inexperienced in the forensic procedures. However, occasionally, the autopsy may have to be conducted at the site, particularly when the body is in advanced stage of putrefaction and materials of evidentiary value may be lost during its transportation or where the District Magistrate desires it to be conducted at the site due to some law and order problem.

- All Registered Medical Practitioners in Government Service are authorised to conduct the medicolegal autopsy. However, even the private medical institutions can under take the medicolegal examination of the living as well as of the dead, provided they possess resources and approval of the concerned government.

- The examination should preferably be conducted under natural sunlight. However, under circumstances of urgency, it may have to be carried out at night with the help of the adequate quantity and quality of artificial light.

- Before beginning the autopsy, the formal identification of the dead body must never be omitted. In a mortuary where several autopsies are done in a day, the chances of performing an autopsy on a wrong body do exist. This can be pre vented by appropriate identification by a police officer or by the relatives/friends of the deceased whose names and signatures should be recorded. In case of unknown bodies, photographs in the mortuary be obtained (it may well have already been photographed at the scene) and skin from the finger tips should be removed and given to the police pre served in 10% formalin in separate vials. Fingerprints are taken by the police in cases of unknown bodies. Doctor must scrutinise the body for features of identification under such situations, including clothing and other articles/ documents/ornaments, etc., on the person of the deceased.

Some other guidelines that need to be adhered to:

- Avoid delay as far as possible.

- No unauthorised person should be permitted to enter the mortuary.

- No police official should be present while the autopsy is being conducted.

- All the details should be noted there and then in the post mortem register. If there is an assistant, it may be better to dictate the notes to him as the autopsy proceeds step by step and then to read, verify and attest the report. All corrections should be initialed. Nothing should be erased or mutilated or left to memory.

- Always hand over the report and other specimens/tissues/ articles, etc., immediately after conducting the postmortem. Never indulge in delaying the things.

- A doctor should better not take up the autopsy, which he does not feel competent to carry out. He should not be too proud or too ashamed to suggest more skilled and experienced doctor, since a poor opinion is often worse than no opinion.

CLOTHING

The doctor must take notice of the clothing and other articles/ property on the deceased in criminal as well as traffic, industrial or other accident cases. In some cases, the clothing might have been removed in the Emergency Wing by the Emergency Medical Officer, especially in criminal assaults like firearm cases, stabbing, etc., to preserve as an evidence (if the deceased had an opportunity of undergoing treatment prior to death) and in such cases a note to that affect may be recorded in the report itself, which will obviate any harassment in the court about any questioning in relation to clothing when a case is launched after about a year or so. Clothing and their contents need detailing (style, fabric, colour, print/pattern and labels/marks, etc.), retaining and handing over to the police in a sealed packet after putting signatures (especially in the cases of criminal assaults). The contents of the pockets, documents, articles, ornaments, etc., all provide clue towards identification.

Clothing should be removed gently, taking care to avoid contamination or loss of any trace evidence. All such evidence as hair, fibres, fragments of paint, glass must be collected and handed over to the police after due sealing, mentioning all the particulars of the case and source and site of the material so removed. If there is any necessity to cut the clothing, a note should be made to the sites of cutting, which should avoid passing through any area that is stained or where there is any tears or rents. The presence of grease or tyre marks in the road traffic accidents and any other special feature may be of significance.

In deaths due to criminal assaults, damage upon the cloth ing may be matched with the injuries/wounds upon the body, which may to some extent give an indication as to the position or posture of the deceased at the time of sustaining the injury. The damage upon clothing may not necessarily be compatible with the location and dimensions of the injuries/wounds upon the body owing to the movements/displacements ordinarily expected in the scuffle during life and also due to nature, texture and foldings/crumpling of the clothing. In firearm deaths, the residues upon the clothing may form vital evidence regarding the range of discharge of the firearm and identity of the ammunition. A descriptive note should be made of each garment and photographs be obtained to demonstrate stains, tears, cuts or other effects upon the clothing. If clothing is wet or smeared with mud/soil, etc., it should be air dried and not heat dried. When all the clothing have been removed and examined, they must be handed over to the police in sealed packets to be carried to the Chemical Examiner's Laboratory or FSL for further examination or merely to be stored and produced in the court as and when required.

EXAMINATION OF THE BODY

The examination of the body in the mortuary must be thorough and exhaustive. Deficiencies may well be exposed later in the court to the discomfort of the doctor. Every case must receive same degree of care and skill, as any case may turn out to be the basis of a civil suit or a case for the insurance claim and so on. Relevant sketches, photographs and radiographs may be preserved wherever desirable.

External Examination

The external examination is a ritual full of meaning and com mon sense. It needs to be performed in as orderly a fashion as a pilot's pre flight instrument check up. The importance of external examination in case of medicolegal autopsy is far greater, as it is often from the outer evidence that inferences may be drawn about the nature of the weapon, direction of application of force and possible determination of inlet/outlet wounds and distance of discharge in case of firearm injuries. Therefore, the doctor must spend sufficient time in careful evaluation of the body surface and should not be too impatient in running towards dissection in an attempt to arrive at the cause of death. The routine for the external examination may vary depending upon the nature of the case, but it may be preferable to proceed from head to foot so that nothing escapes notice.

In all cases, general description like build, height, weight, age, sex (changes in the skin, eyes, hair, etc., to assess age) should be noted. Description of teeth deserves special mention. In infants, circumference of the head and crown heel length should also be noted. Congenital or acquired external marks may be noted.

After the body has been undressed, the wounds upon the body should be photographed. Before starting the examination properly, samples like hair from the head and pubic region and swabs from mouth, vagina, anus, glans, etc. may be collected in the appropriate cases. This will avoid contamination with the body fluids or other stains. The hair must be plucked out by the roots and never cut. Fingernail clippings, if desired, may be secured at this stage.

Sequential changes after death like degree of rigor mortis, postmortem hypostasis, postmortem cooling and extent of putrefactive changes should then be assessed. They will help a great deal in ascertaining the time since death, position of the body at the time of death and whether the position has been tampered with after the death as discussed in the chapter 'Death and its Medicolegal Aspects (Forensic Thanatology)'.

All wounds upon the body must be meticulously described that should include site, length, breadth, depth, orientation to the axis of the body and their relations to the fixed anatomical landmark. The shape and condition of the margins should be noted down wherever appropriate. The injuries may also be marked on the body diagrams provided for this purpose in the postmortem report.

As stated already, the body must be systematically examined, preferably proceeding from head to foot. Wounds of the scalp may present difficulty in location in a thick and long haired head. The hair may be shaved and wounds described. Some may be revealed when the scalp is reflected during the dissection. A note about the scalp hair as to the length, colour, use of dye, presence of dust, mud, stains and baldness may also be given. The eyes need careful observation, both upper and lower lids and conjunctivae for the petechiae, the cornea and lens for the opacities, the pupil and iris for the irregularities and the periorbital tissues for the extravasation of blood. The blood may be exuding from the nose, mouth or ears. The mouth should be inspected for any foreign body, drug, damaged teeth, injured gums, lips and the bitten tongue of epilepsy. In case of unidentified bodies, teeth should always be charted, preferably with the assistance of the dental surgeon. Lacerations and/or bruises inside the lips, cheeks and of the gums might have been produced by the crushing of soft tissues against the teeth by blows or stretching or gagging. Corrosion of the lips, mouth and the surrounding region may be seen in irritant poisoning. Frothy fluid, sometimes blood tinged, may be seen exuding from mouth or nostrils or both, in cases of deaths due to drowning. The state of beard, moustaches as to their length, colour, trimming, shaving, etc., should also be noticed that may carry importance in identification and sometimes in appreciating the distribution of the ligature mark around the neck in cases of hanging or strangulation.

In the neck, both the front and the back should be examined for any bruises, fingernail abrasions, ligature marks or other abnormalities. Such injuries deserve detailed description, preferably with photographs. The circumference of the neck should be recorded in all cases of alleged strangulation. The method of tying the ligature should be photographed and described before removal as the nature and position of knots may carry evidentiary value. Attempt should be made to pre serve the knot by cutting the ligature away from it and binding the cut ends with the thread so as to prevent their fraying. The ligature mark, if present, is to be described meticulously.

The thorax and abdomen should be inspected for any injury or deformity. The axillary regions should not be over looked. The possibility of needle puncture marks in the arms, buttocks, etc. must not be forgotten. In case of body of new born infants where the issue of live birth or viability creeps in, it may be necessary to examine the umbilical cord and shape of the chest and to look for certain ossification centres.

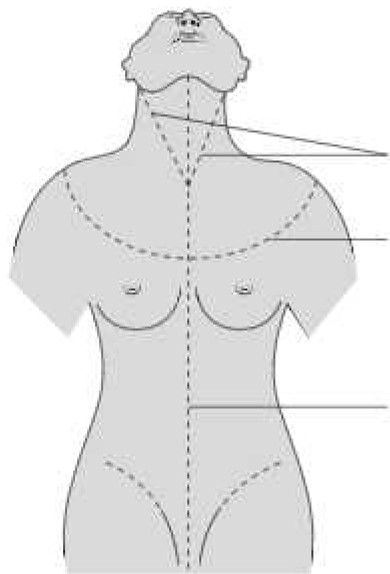
The external genitals require careful examination as does the anus. Any evidence suggestive of sodomy or indulgence in recent sexual intercourse must be looked for. Collection of swabs has already been described at the outset. Examination of vulva and vagina may be carried out to exclude any injury and disease, etc., but if the nature of the case suggests some sexual intervention, a more detailed external as well as internal examination is warranted including collection of swabs from different levels of the genital passage and the appropriate specimens for histopathology, bacteriology, venereology, etc. Routine examination of the male genitalia including scrotum and testes should never be omitted.

Lastly, the extremities, i.e. upper and lower limbs, should be inspected. Arms and hands for any defence wounds and for any deformity; legs for their respective lengths (shortening being suggestive of fracture), presence of varicose veins (which may arise suspicion of thrombosis and pulmonary embolism for which confirmatory evidence may be sought).

It is prudent to get the whole body X rayed in cases of multiple fractures, bomb blast, firearm injuries, suspected infanticide or battered baby syndrome and in deaths due to criminal violence where the identity of the deceased is obscured by the attempts of the assailant and/or by the advanced state of putrefaction.

Internal Examination

It is neither possible nor advisable to lay down any hard and fast rule regarding the procedure to be followed for the internal examination. In general, it is convenient to commence with the cavity chiefly affected and the incisions adapted to suit the circumstances of the case. All the three major cavities, i.e. skull, thorax and abdomen, should be opened and examined. The spinal cord need not ordinarily be examined except where desirable. Any of the following incisions may be followed to open the body . The usual incision is drawn from just above the thyroid cartilage to the pubic symphysis avoiding the umbilicus and any injuries in the line of incision (I shaped incision). This method is mainly followed as a routine on account of its simplicity and convenience. In the second method, two incisions are made, commencing on either side of the chest from anterior axillary fold, curving under the breasts/nipples to meet at xiphisternum and to be continued as a single vertical incision down to pubic symphysis (modified Y shaped incision). This is desirable in those cases (especially females) where it is customary to restore the body in a reasonable cosmetic condition for view for some time after death. In the third method, the two incisions commence on either side of the neck from 2 to 3 cm behind the lobe of each ear to meet at manu briumsterni and then continued as a single incision down to pubic symphysis (Y shaped incision). This method is specially



suited when a detailed study of neck organs is desired.

The choice of opening the skull or the other body cavity first is left to the dissector. In cases of head injury, it is a common practice to open the skull first and then the thorax and the abdomen. In deaths due to compression of neck, it is preferable to open the skull first. The draining out of blood from neck vessels due to prior removal of skull and brain pro vides a comparatively clearer field for the study of neck structures and will avoid congestive artefactual haemorrhages in the neck structures as cautioned by Prinsloo and Gordon.

Skull and Brain

- To examine the brain, it is usual practice to make an incision through the scalp from behind one ear, passing just behind the vertex and ending behind the other ear . Reflect the two flaps forward as far as supra orbital ridges and back wards as far as the occiput. This may reveal any further injury to the scalp. Note any injury, petechial haemorrhages, or oedema; in presence of fracture, record its dimensions and contour.

- Incise the temporalis muscle about its middle on each side.

The cranium is to be opened by saw cut, the line of severance following a point just above the superciliary ridges in front and through the occiput behind . A mallet and chisel should never be used, and every care must be undertaken to keep the meninges and brain intact. The risk of extending or even causing fractures by excessive hammering is not unknown. The removal of skull cap is facilitated by gently inserting and twisting the chisel at various places through the cut. Inspect the skull cap for fractures by holding it against the light or tapping it on the ..

- Examine the dura from outside for extradural haemorrhage, and superior sagittal sinus for antemortem thrombus. Determine the weight and volume of extradural haemorrhage, if present.

- Cut the dura along the line of severed skullcap and pull it gently from front to back while cutting falxcerebri and examine for subdural and subarachnoid haemorrhage. It may be difficult, in cases of subarachnoid haemorrhage, to demonstrate a ruptured berry aneurysm, and dissection under a gentle stream of water may facilitate the examination.

The whole of the circle of Willis should be exposed and all the major vessels traced as far as practicable and examined for any obstruction of thrombus or atheromatous material.

- External assessment of brain is made from the point of view of flattening of the convolutions and asymmetry with displacement to either side.

- The frontal lobes should then gently be lifted from anterior fossae of the skull together with the olfactory and optic nerves, and pituitary stalk should be cut along with cranial nerves, allowing a free length and not cutting them too close to the brain. Cut the tentorium along the superior border of the petrous bone. Cut the cervical cord, first cervical nerves and vertebral arteries as far below as possible, supporting the brain throughout with the left hand. Remove the brain along with the cerebellum. Weigh and transfer to a clean tray for subsequent examination.

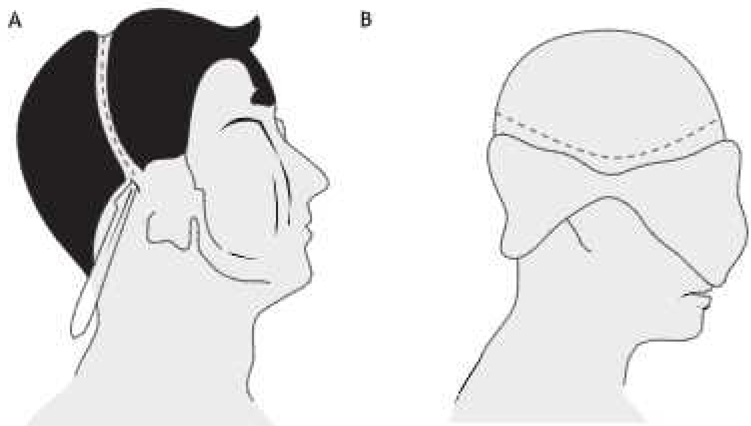
- Examine the remaining venous sinuses and the cranial cavity for antemortem thrombi. Then the dura mater should be stripped from inside and dried out with a sponge and examined for fractures.

- Remove the pituitary by chiseling the posterior clinoid processes and incising the diaphragm of the sellaturcica around its periphery. Do not squeeze the gland with forceps while removing.

- The middle ears and the mastoid processes can be examined by chiseling out wedge shaped portions of petrous temporal bone. The orbits may be examined by removing the orbital plates in case of skull.

- Cut the brain in serial coronal sections at regular intervals from front to back or cut obliquely at the intracerebral fissures exposing basal ganglia, lateral ventricles and white matter, and examine for haemorrhage or other abnormality. Shrinkage of cerebral cortex (grey matter) is common in chronic alcoholics. If there are injuries to the brain, successive sections parallel to the wounded surfaces should be made till the whole depth of the lesion is revealed. If possible, it is better to fix the brain before cutting as changes are much more clearly delineated and distortion due to softening can be avoided. For fixing, brain must be suspended, floating free by the basal vessels or in a muslin bag.

- Cut the cerebellum through the vermis to expose the fourth ventricle.



Spine and Spinal Cord

The spinal cord is better examined by posterior approach. Make a midline incision from the base of the skull to the sacrum. Reflect the paraspinal muscles and fasciae from the spinous processes and the laminae. Carry out laminectomy by sawing through the entire length of spine on each side of the spinous processes, and the laminae are then removed with the help of bone shears that exposes the spinal canal. It is important to obtain a wide exposure of the canal to allow the cord to be removed without difficulty.

Examine the dura for any pathological condition, such as inflammation, haemorrhage, crushing, infection, etc. Transect the nerve roots and dural attachments from below upwards as they pass through the spinal foramina. Separate the cord at the foramen magnum, carefully lift it from vertebral column, and place it on . for examination. The dura is then opened with the help of forceps and scissors to examine the cord itself. Samples may be taken for histology, if needed.

Neck

For exposing the structures of the neck, ordinarily, the I shaped incision serves the purpose, which extends from symphysis menti to the pubic symphysis. The structures are examined layer by layer as they are being dissected. However, when wider view is necessary, neck structures should better be exposed by a Y shaped incision. The incision commences from behind the lobe of each ear, runs forward to meet at the upper border of the manubrium sterni and then a vertical incision being made through the thorax and abdomen. The V shaped area of the skin at the front of the neck should then be reflected upwards as far as the level of jaw. Soft tissues are separated from their attachments, and tongue is made to visualise. Now the pharynx and palate can be examined for any foreign body or any other abnormality. The soft tissues may be cleared away as high and as far back as the base of the skull, exposing carotids, soft palate, etc. In case of death due to alleged pressure upon the neck, carefully examine the carotids, hyoid bone and the thyroid cartilage for any injury or abnormality.

Thorax

After the routine midline incision, reflect the skin and muscle mass from the thoracic cage laterally, and examine them for any injury or surgical emphysema. Examine ribs and sternum for fracture. Fractured ribs may give a flattened contour or asymmetrical appearance to the thorax.

It is convenient to test for the presence of pneumothorax at this stage, which may be suspected by bulging of the chest wall and confirmed by inserting a 16 gauge needle attached to a syringe filled with water through an intercostal space into the pleural cavity when air bubbles will appear in the syringe if air is under pressure. Alternatively, an X ray can help.

Cut the rib cartilages on either side obliquely to avoid cut ting the lungs and disarticulate the sternoclavicular joint care fully avoiding injury to the vessels below; cut the diaphragm from the sternum and lower ribs; and remove the wedge shaped piece formed by the sternum and cartilages.

Inspect the pleural cavities. Normally, the pleural cavities do not contain any appreciable quantity of fluid. Record the quantity of blood or any other fluid, if present. Examine the fluid for any foreign body. If pleural adhesions are present, clear them gently or strip the pleura from the chest wall and the diaphragm. Open the pericardial sac by an anterior midline cut with a pair of scissors. Inspect the coronary vessels for segmentation. Over distension of the right side of the heart is suggestive of air embolism. Inspect the pericardial sac for its contents and any abnormality. If haemorrhage is present, determine its origin. If fat or air embolism is suspected, as may be in case of suspected abortion or in an open wound of the neck, the pul monary artery should be dissected under water, when the fat droplets may be seen escaping. In case of doubt or when the emboli are minute, microscopic examination of the frozen sections of the lungs stained for fat will be helpful. In pulmonary air embolism, the pericardial sac may be opened anteriorly, filled with water and the edges of the sac being grasped with haemostats on each side. The right side of the heart is then punctured when the bubbles of air may be seen to be issuing. The intrathoracic organs should then be removed along with the structures of the neck, i.e. larynx, trachea, oesophagus and tongue also. The structures are examined individually.

Heart:

Dissection The heart is held at the apex, lifted upwards and separated from other thoracic organs by cutting the vessels entering and leaving it (inferior and superior vena cava, pulmonary vessels, and ascending aorta) as far away as possible from the base of the heart, by applying double ligatures over each vessel and dissecting in between the two ligatures.

The isolated heart is then inspected as regards its size and weight. It is cut along the direction of blood flow—right atrium, right ventricle, pulmonary arteries, pulmonary veins, left atrium, left ventricle, and aorta. The right atrium is cut between the openings of the superior and inferior vena cava. An additional cut opens the right auricle. Look at the tricuspid opening. The knife is then directed through the tricuspid valve to incise the right ventricle along its lateral border up to its apex. The incision is then carried along 1 cm lateral to the ventricular septum on the right side, passes through the pulmonary trunk and pulmonary arteries. The left atrium is exposed by cutting between the openings of the pulmonary veins. An additional incision opens the left auricle. Inspect the mitral opening. The knife is then directed through the mitral valve to cut the left ventricle along its lateral border up to its apex.

Note the condition of the valves and presence of atheroma in the large vessels. Observe the state of myocardium and endocardium. Any ischaemic lesion, old or new, should be searched for. The patency of the coronary arteries deserves special attention. Any intravascular clotting in the coronaries must be looked for. Controversy exists about the methods of opening the coronaries, but the balance of opinions weighs towards cutting serial interrupted cross sections about 2–3 mm apart. Difficulty may arise where severe calcification exists, as the knife may either fail to cut through the artery or may shat ter it owing to the excessive force required. In such cases, the vessels may be decalcified. Postmortem angiography is the other alternative. In traffic accidents, the presence of ladder tears at the junction of aortic arch and descending aorta may be looked for.

Lungs They should be separated from the mediastinal structures. By ligating the vessels, examine the cut surface of the lungs and cross sections of the bronchi, their ramifications for consolidation, oedema, emphysema, atelectasis, congestion, petechiae, etc. The diagnosis of pulmonary fat emboli can be confirmed by microscopic examination of the frozen section of the lung stained for fat with Sudan

III or other stain for fat. In asphyxial deaths, the surface of the lungs, especially the interfaces of the lobes, should be looked for presence of Tardieu spots. In cases of drowning, there will hardly be any Tardieu spots but the lungs may show the findings of emphy sema aquosum or oedema aquosum. Punctured or lacerated wounds cause collapse of the particular lobe. In case of any pathology, tissue may be preserved for histological examination. Thoracic cavity should again be examined after removal of the viscera for evidence of any fracture or deformity.

Abdomen

Abdomen is opened by a midline incision as described earlier, care being taken not to injure the intestines underneath. To accomplish this, a small puncture may be made in the peritoneum and a finger inserted to lift it away from the intestines. The knife then may be directed outwards cutting along the length of abdomen and preventing penetration into the intestines. The cavity as such should be examined for any pus, blood, exudation, etc. Then the individual organ should be examined as under.

Stomach

Ordinarily, the stomach is examined by making a cut while in situ for the contents as regards their quantity and quality and the degree of their digestibility. But in suspected poisoning, the stomach is removed after tying a double ligature just above the cardiac end and the pyloric end. It is then opened along the greater or lesser curvature in a clean con tainer and the contents may be poured in a special glass bottle for being sent to the Chemical Examiner. Mucous surface should be examined carefully noting its appearance, and any suspicious particles found adherent thereto, picked off and placed in a separate small phial for chemical analysis. The con tents of the stomach should also be measured and examined as regards their smell, colour and character.

Intestines

Both the small and large intestines should be removed by cutting the mesentery and freeing other attachments after ligaturing at both ends and should be cut longitudinally along the mesenteric border to examine the inner surface for the presence of congestion, inflammation, erosions, ulcers, perforation or any other lesion. In cases of suspected poison ing, a portion of small intestine with its contents be preserved and sent for chemical analysis.

Liver

The surface of the liver should be examined as to its smoothness or roughness. In case of any injury to the liver, its nature and dimensions should be noted. The weight and size also needs to be noted. The organ should be cut open by deep incision at several places, and the colour and consistency noted. The gallbladder should be opened, and the presence or absence of bile stones and the character and quantity of the bile should be noted. In some cases, bile may be required for analysis as in morphine or chlorpromazine poisoning.

Pancreas

Pancreas should also be examined and looked for fat necrosis.

Spleen

The size, colour, weight and consistency of the organ should be noted as well as the condition of its capsule.

Kidneys

Kidneys are exposed by incising their capsules after gaining over the thick layer of perirenal fat. Its capsule should be examined as to whether it is adherent or strips off easily. The internal cut surfaces should be examined for the presence of nephritis or degenerative changes; the pelvis should be examined for calculi. Adrenals should be removed and examined.

Bladder

The bladder is to be examined for congestion, haemorrhage, inflammation and ulceration of its mucous membrane. It may be opened in situ and its contents noted, but in a suspected case of poisoning, the urine should be drained by catheter and preserved for chemical analysis.

Prostate and Testes These should also be sectioned and examined wherever necessary.

Uterus In female bodies, the uterus should always be examined for its size and shape. The usual size of a nulliparous organ is 7.5 ○ 5.0 ⊠ 2.5 cm3; but the size and weight varies considerably during pregnancy or in case of any growth. It should be opened longitudinally, and mucous membrane and walls should be examined. In old age, it becomes atrophied, and paler and denser in texture. If the uterus contains a fetus, the age of its intrauterine life should be determined. The ovaries and fallopian tubes should also be examined. The vaginal canal should be opened from below upwards and examined for the presence of a foreign body or marks of injury. The condition of the cervix and any marks from instruments should be noted.

ANCILLARY INVESTIGATIONS

A wide range of samples may require to be obtained either before, during or subsequent to the examination. The nature of such ancillary investigations, obviously, will depend upon the nature of the case and the attending circumstances.

Histological Examination

Sections of various internal organs and body tissues, which need to be histologically examined, are to be preserved in 10% formalin.

Microbiological Samples/ Specimens

Fredette (1916) suggested that 'agonal invasion' accounts for a large proportion of positive cultures recovered at autopsy. This is suggested to be due to decline in viability occurring during a variable period preceding death rendering the individual susceptible to invasion by endogenous microorganisms. However, Carpenter and Wilkins (1964) suggest that endogenous bacteria multiply and migrate throughout the body only after death, a phenomenon called as 'postmortem invasion'.

Despite the controversies, the proper taking of samples for microbiological examination may be of utmost value in confirming a presumptive antemortem diagnosis. Some general precautions and guidelines are furnished below (a discussion with microbiologist will prove highly rewarding):

- Early refrigeration of the body after death and restriction of its movement will go a long way in preventing passive recirculation of blood from contaminated areas and thus decreasing the potential for false positive blood cultures.

- Postmortem should be performed at the earliest in order to minimise any bacterial overgrowth and death of some sensitive microorganisms.

- Blood should be taken from some large vessels such as femoral vein or artery using sterile syringe and needle. Before sampling, skin needs to be cleaned with an alcoholic iodine preparation. Direct culture of the blood is advocated.

- For taking sample of the tissue, surface of the organ in an area of 2 ○ 2 cm2 should be seared to dryness and a portion removed for examination. Alternatively, a sterile swab can be forced through the seared area or fluid aspirated using a sterile needle and syringe.

- Tissue fragments should be suspended in sterile saline solution to prevent desiccation.

- Samples need to be sent to the laboratory without any delay. Clinical details should accompany the specimens. A copy of 'autopsy report' should also be sent.

Biochemical Examination

Blood from femoral vessels, heart or even liver and cerebrospinal fluid of the cadaver may be collected for various biochemical examinations.

Enzymatic Studies

Small pieces of tissues are collected into a thermos flask containing liquid nitrogen.

For Suspected Virus

A piece of appropriate tissue is collected under sterile conditions and preserved in 50% sterile glycerine.

Vaginal/ Anal Swabs and Smears

These need to be examined in cases of alleged sexual assaults.

Urine and Faeces

Urine may be collected direct from the bladder and be exam ined. Faeces may be examined for detection of blood, protozoa, helminths, etc.

Selection of Viscera in Cases of Suspected Poisoning

Since most of the poisons are ingested, the poison is expected to be found in the stomach and small intestines. After absorption, all poisons pass through the liver that acts as metabolising and detoxifying organ and possesses the power of concentrating many poisons. Kidneys being the organs of excretion are expected to show the presence of the poison. The need for preserving different specimens/materials under different circumstances.

Instructions for Packing and Transmission

The stomach and its contents are preserved in one wide mouthed glass bottle; intestines with contents are preserved in another bottle. Detection of poison in the stomach and intestines will have a bearing upon the time of survival. For this reason, it is not advisable to preserve the stomach and intestines in one bottle. The stomach and intestines are opened before packing to see the state of mucosa. Pieces of liver, spleen and kidney are preserved in another bottle. These should be cut into pieces to ensure penetration of the preservative. The preservative used should be filled up to two thirds of the bottle(s) so as to prevent bursting of the bottle, in case the decomposition ensues.

The stoppers of the bottles should be well fitting, covered with a piece of cloth and tied by tape or string and the ends sealed using a personal seal. Each bottle should be suitably labelled, the label containing the autopsy number, date, the name of the deceased, the name(s) of the organ(s), followed by signature of the doctor who performed the autopsy. A sample of the preservative used, either 100 ml of rectified spirit or 25 gm of sodium chloride, is separately preserved and sent for analysis to rule out any poison being present as a contaminant. The sealed bottles are placed in the viscera box having well padded compartments into which the bottles fit snugly. The box (if wooden) should be locked, and lock should be sealed. If them box is of cardboard or some other material, it must be secured with some thick durable cloth and adequately sealed. Particulars of the case must be mentioned on the box also with due sig natures. Such precautions are necessary to ensure that no tampering with the contents of viscera box occurs during its transit to the FSL/Chemical Examiner's Laboratory.

The sealed box and the envelope containing the key (in case of wooden box that has been locked) is then handed over to the police cons. authorised to transport the same to the FSL/ Chemical Examiner's Laboratory. Along with the box, another sealed envelope containing police papers (Inquest Report), a copy of the postmortem report, brief facts of the case, a copy of the hospital record (if available) and the forwarding letter addressed to the Chemical Examiner requesting him to exam ine the viscera is also handed over to the cons.. A separate piece of cloth bearing sample seals and signatures of the doctor is also given. Due receipt for all these is obtained.

Embalming

Chemical preservation methods of the cadaver had a great measure of success with the Egyptians for over three millennia. The main preservative used was 'natron'— a naturally occurring mixture of sodium carbonate and bicarbonate in varying proportions and obtained from the dry alkaline lake beds or shores. This was used to be supplemented with aromatic compounds like aloes and balsams to preserve the dead body, and also to mask the putrid odour. The use of balms and balsams to impregnate the body for preservation has gained the name 'embalming', and the term presently signifies the treatment of the dead body with antiseptics and preservatives to prevent putrefaction . By this process, proteins are coagulated, tissues are fixed, organs are bleached and hardened. Embalming produces a chemical stiffening similar to rigor mortis, and normal rigor does not develop. It is better to perform embalming within 6–12 hours of death in summer and 24–48 hours of death in winter.

Methods Basic consideration rests in forcing the chemical fluid into the tissues through arterial injection. Diffusion occurs into the cells and tissues for preservation at the capillary level. Methods usually include:

- Gravity injector, wherein the gravity bottle containing arterial fluid/embalming fluid is raised above the body level and fixed at a height (a rise of 1 m gives a fluid pressure of 0.6 kg/cm2). The bottle carries plastic tubing to the other end, of which the needle and cannula is attached that is inserted into the femoral artery.

- Electric pump, wherein fluid from an injection tank is forced into vascular system through electric pump. The injection pressure is much better in this method than the gravity injector method, and therefore, less time is required.

- Injection method, wherein multiple sites of injection are required as in cases of traumatic death, autopsied cases and postmortem mutilations.

Medicolegal Considerations In India, it is the common law of the land that is applied in the disposal of the dead. The dictates of the various castes and communities determine the time interval between death and disposal. However, the disposal is usually quick and rarely causes any major public health problem. Embalming is resorted to the following circum stances: (i) in medical colleges to preserve dead bodies for the purpose of dissection, (ii) when the dead body has to be trans ported from one country to another or from one part to the other remote part of the same country for burial or cremation and the time taken in transit is such as would ordinarily lead to decomposition and (iii) necessity to preserve the dead body of some important personality for public view, etc.

Embalming alters the appearance of the body, tissues and organs, making it difficult to interpret any injury or disease and detect certain poisons (especially alkaloids and organic poisons). Further, most embalming fluids contain methyl or ethyl alcohol, making the detection/identification of such sub stances and of other volatile poisons extremely difficult. Hence, removal of specimens from such bodies should be completed before embalming.

Embalming incisions made for injection and drainage may be mistaken for non existent antemortem stab wounds. Some blood may be forced out of the injured or disrupted blood vessels and may accumulate in the tissues with the appearance of haemorrhage. Skin bruises may be markedly accentuated due to factors like (i) forcing of additional blood into the injured areas by pressure used in injecting the embalming fluid, (ii) increased transparency of the overlying skin resulting from perfusion with fixative and (iii) reaction between some constituent in the embalming fluid and blood tissue fluid with resultant formation of dark pigment complex.

DISPOSAL OF THE BODY

After the postmortem examination including removal, collection and preservation of various samples/specimens of tissues/ fluids/blood/swabs/smears, etc., the body should be properly sutured and washed and handed over to the police, under a receipt. The doctor should note that the body is present, and its appearance should not in any way hurt the sentiments of the relations of the deceased.

In India, Hindus cremate, Muslims and Christians bury the dead body. In common law, a dead body is not a property, but the right of the custody of the dead body for the purpose of disposal is of the next of kin or an appointed executor of the deceased. However, any disrespect or undue mutilation of the corpse invites applicability of Section 297 IPC. This Section punishes a person who commits trespass in any place of worship, or any place of sepulcher (burial) or any place set a part for the performance of funeral rites, or as a depository for remains of the dead; or offers any indignity to any human corpse. According to Punjab Anatomy Act 1963 (adopted by Chandigarh Administration in 2000), an unclaimed body means the body of a person who dies in hospital, prison, or public place that has not been claimed by any of his near rela tives within 96 hours. The authority in charge of hospital or prison should report the fact to the police and they will take possession of the body. If there is some doubt as to the cause of death, investigation/inquest under Section 174 CrPC needs be conducted by the police. After excluding such procedural necessity and adopting all reasonable steps to secure identification, the body should preferably be handed over to the authority in charge of the teaching institution for conducting anatomical examination/dissection/research, etc. However, in the event where the body is not required by such institution the police may hand it over to any charitable society that is willing to accept it. If no such society comes forward, the body should then be buried or burnt (Rule 25.38 of PPRs).

As far as voluntary donation of the dead body for anatomical examination/ dissection/research, etc. is concerned, no specific provision has been provided in the Act. However, the usual practice being followed is that the individual wishing to donate his/her body after death to some institute for such purpose can write a "will" in the presence of two witnesses (one of them prefer ably being the next legal heir/claimant).

EXAMINATION OF DECOMPOSED BODIES

Decomposed bodies, though esthetically unpleasant, but are still human bodies that deserve thorough examination. There is an understandable tendency to dispense with examination of decomposed tissues as un necessary or unproductive activity, especially at the peripheral hospitals/dispensaries. At occasions, it may be challenging, especially when the state of the decomposition is advanced. However, making an attempt may prove worthwhile as cases have been reported where the brain tissue decomposed to the consistency of soft paste has yielded useful information in toxicological screening. Skeletal muscle is another useful tissue in such circumstances, as this will provide drug and/or alcohol level that will generally approximate to that of blood levels. Specimen of vitreous fluid may also be collected for screening drug(s) or electrolytes. It is therefore advisable that Medical Officers working in the peripheral hospitals/dispensaries should endeavour to conduct such cases at

Routine viscera and body fluids to be preserved in suspected poisoning

• Stomach and its contents: If the stomach is empty, the wall should be preserved	• In one container
• Upper part of small intestine and its contents (approximately 30 cm in adults and whole of it in infants)	• In separate container
• Liver: About half kilogram (preferably the portion containing the gallbladder) • Spleen: Half of it • Kidney: Half of each kidney (both kidneys in children)	• In another container
• Blood: 10–20 ml • Urine: 50–100 ml	• Sterilised glass/plastic tubes

(preferably collected through syringing)	

Peculiar circumstances necessitating additional specimens/materials	
Suspected criminal abortion	Vagina, uterus, fallopian tubes, ovaries, urinary bladder. Abortion stick or foreign body in the genital tract to be preserved separately
Firearm injuries	Skin around the entrance and exit wound (at least 2.5 cm of skin around and 5 mm beneath the wound should be preserved)
Suspected Rabies	Haffkine Institute, Mumbai recommends sending pieces (1–2 cm3) of hippocampus, cerebral cortex, cerebellum and medulla in 50% glycerol-saline for Negri bodies and isolation of virus
Snake bite/injected poisons	Aqueous washings from the area. 2.5 subcutaneous tissue and muscles in and around the site. Similar material from the other side to serve as control
Inhaled poisons	One lung (preferably in efficiently sealed metallic can)
Corrosive poisons	Skin and subcutaneous tissue (at least 2.5 cm2) from the affected area and similar portion from opposite side to serve as control
Pesticides, insecticides, etc.	Fatty tissue and myoneural junction, if possible. Portion of brain and lungs
Spinal poisons	Spinal cord, one half of brain
Cerebral poisons like alcohol, anaesthetics, barbiturates, opiates, carbon monoxide, cyanide, hallucinogens, etc.	Half of brain
Poisons likely to be excreted in the bile	Bile is best removed by puncturing the gallbladder in situ. Examples may include narcotic drugs, cocaine, methadone, glutathione, and some tranquilisers
Heavy metals (chronic poisoning by arsenic, antimony, lead, copper, mercury, etc.)	About 10 cm of shaft of long bone, 15 – 20 strands of plucked scalp hair, finger or toe nails, and a wedge of quadriceps muscle before opening the abdomen (to avoid contamination)
Decomposed bodies	Insect eggs, maggots, pupa, and about 500 gm of muscle tissue
Exhumed bodies	Soil samples from above, beneath and sides of the coffin and control samples from some distance away. Hair, nails, bones or other materials as available
Personal effects	Stained as well as surrounding unstained portion of the clothing (after drying). Suspected packet of the poisonous substance/strip of .ts (or a part thereof), etc.

Preservatives for viscera and body fluids	
Viscera	Rectified spirit* or saturated saline

their own level (may be under the supervision/guidance of seniors/more experienced colleagues), since the referral involves further time allowance for progression of decomposition, rendering findings surprisingly hopeless till the time is squeezed by the expert at the institute to conduct examination out of his/her busy schedule.

Different Specimens/Materials to be Preserved Under Different Circumstances

Blood	For every 10 ml, use 30 mg potassium oxalate and 100 mg sodium fluoride**
Urine	100 mg sodium fluoride for every 10 ml

Typical Embalming Coposition

Functions	Ingredients	Proportion
Preservative	Formalin	1.5 L
Buffer	Sodium borate	600 gm
Anticoagulant	Sodium citrate	900 gm
Wetting agent/humectants	Glycerine	600 ml
Crystalloids	Sodium chloride	800 gm
Dye	1% Eosin	30 ml
Perfume	Soluble winter green	90 ml
Vehicle	Water	Up to 10 L

CHAPTER-4

EXHUMATION

Exhumation means lawful disinterment or digging out of a buried body from the grave. There is no time limit for exhumation in India. However, some countries like France, Germany, Scotland, etc. have fixed time limits for the exhumation. As the Hindus, who form a majority of population of India, cremate the dead as early as practicable, exhumation is quite rare in India.

PRECAUTIONS

- Exhumation is to be carried out under the orders of the appropriate authority. District Magistrate/Sub-Divisional Magistrate/Executive Magistrate are empowered to order for the exhumation.

- Body is exhumed under the supervision of a magistrate in the presence of a doctor. The presence of a police officer is required for providing witness to the identity of the grave, the coffin and the dead body as well as maintaining law and order.

- Exhumation should preferably be carried out during early morning hours before the cemetery is open to the public so that there remains some degree of privacy and the whole process of digging and autopsy can satisfactorily be completed during the natural light.

- Identification of the grave is important. It should be formally identified by the warden of the cemetery from the records and by the relatives, friends, etc. who may have been present at the time of burial.

- Autopsy may have to be done at the spot for which a tarpaulin screen may be erected around the grave or the body/ skeleton may be shifted to a close-by mortuary.

- It is advisable to be conversant with the nature of the geological layout of the cemetery and direction of any water drainage. If the grave is water-logged, samples of water should be collected.

PROCEDURE

- The identified grave should then be dug carefully to avoid damage to the coffin and its contents. Notes should be made about the condition of the soil, water content and nature of vegetation.
- After the dirt has been removed from above and around the corpse, it needs to be photographed. A drawing of the grave and body or skeleton should be made noting all the details.
- Identification of the coffin should be carried out by the undertaker. Any fluid or debris in the coffin should be collected. A portion of the coffin and burial clothes must be removed for further examination/analysis, if necessary.
- Identification of the body is confirmed by the relatives and friends, which is supervised by the magistrate or coroner and assisted by the police.
- Disinfectants should not be sprinkled on the body. If decomposition is not advanced, a plank or a plastic sheet should be made to spread under the body and the body be gently shifted onto plank or sheet and then removed from the grave.
- If skeletonisation is advanced, then it may become necessary to dig down beside and beneath the body and the skeleton (including some soil from beneath and sides) be lifted on some plank or sheet and transported to a mortuary. The soil must be carefully screened for smaller objects like teeth, bullet(s), hyoid bone, thyroid cartilage, etc. If necessary, X-ray examination of the body with surroundings should be undertaken before transporting the body and the materials surrounding it.
- Injuries, if discernible, should be noted carefully. Since soft tissue injuries may disappear or get distorted/dis.ured due to decomposition, fractures should be especially looked for. However, possibility of such fractures having been produced during the process of digging should be excluded.
- In a case of suspected poisoning, viscera (if present and identifiable) should be preserved for chemical analysis. If viscera are not distinguishable, masses obtained from the areas of these organs should be preserved. If viscera/ masses are not present, then hair, nails,

teeth, bones and skin should be preserved.

In such a case of suspected poisoning, samples of earth (about 500 gm) from above, below and sides of the coffin and control samples at some distance from it, should be collected in separate clean, dry, wide mouthed glass bottles/jars for chemical analysis.

SECOND AUTOPSY

There may be circumstances where the body is buried after due autopsy but discrepancy arose after sometime, may be due to public hue and cry or some political overtones. The doctor may then be required to perform second autopsy. Before launching on to conduct second autopsy, the doctor must obtain all the available documents relating to the case especially the first autopsy report, photographs of the scene of death and of the body taken during the first autopsy, hospital records in case of hospital-death and police investigative reports/papers, etc.

Here, it must be focused that decomposition causes merger of contusions with blurring of their patterns. Other injuries too are made ambiguous with the development of decomposition. Therefore, the interpretation of findings of a second autopsy, performed on a previously autopsied exhumed body, is extremely difficult due to various artefacts of burial and exhumation and the alterations resulting from the first autopsy. The findings should be documented meticulously with photography. It is possible that valuable results may be discovered. Even if no new information is unearthed from the second autopsy, it will help in putting an end to rumours or suspicions and will go a long way in maintaining public tranquility.

OBSCURE AUTOPSY

Several surveys in various countries have shown that in cases where a doctor offers a cause of death without the benefit of autopsy findings, the error rate is of the order of 25–50%, even in hospital deaths. Thus, the importance of autopsy in improving the value of death certification is undoubted. But, it still has to be conceded that the autopsy is by no means infallible in revealing the definite cause of death. These may be called as cases of obscure autopsy. In many of these cases, cause of death can be made out after detailed laboratory examination of different materials/samples from the body. However, at rare occasions, the cause of death may still remain unknown even after detailed laboratory investigations. Such cases may be termed as cases of negative autopsy. There may be no adverse medical history, the gross examination may reveal nothing abnormal and histological, toxicological, microbiological and virological screening remains unrewarding. In such a situation, as Professor Alan Usher of Sheffield points out, the case needs to be labelled as 'unascertainable'.

The rate may also vary according to the competency, personality and seniority of the doctor conducting the autopsy. (The younger doctor is often hesitant to show failure in pro- viding a cause of death, feeling that it reflects upon his ability; whereas the more experienced and seasoned doctor is less inhibited towards admitting something sour.) At times, the death may be due to interaction of multiple factors, as in case of anaesthetic deaths, when it may become difficult to apportion the correct liability to each. The common obscure causes of death may include the following.

CONCEALED TRAUMA

Concussion, blunt injury to the heart, blast effect without any external injury and electrocution without any external mark.

POISONING

Delayed subtoxic or narcotic poisoning, anaesthetic overdosage or maladministration, neurotoxic or cytotoxic poisons and plant poisoning, etc.

MISCELLANEOUS

Reflex vagal inhibition, incompatible blood transfusion, air embolism, allergic reactions including drug idiosyncrasy (anaphylactic deaths), etc.

A negative autopsy may help to explore the possibility of natural death, even though there might have been an initial suspicion of foul play as to the cause of death. Ancillary investigations may not provide any help, but they must be carried out in order to exclude such causes and to prevent allegations that the death was not investigated as fully as it should have been. It can be added, however, that the absence of injuries, poisoning, lethal infection or wellrecognised natural disease is in itself significant evidence negating such causes. The use of terms like 'heart failure' or 'cardiorespiratory arrest' is pointless and merely confuses the issue. A 'mode of death' is useless in lieu of a 'cause of death'. The more the autopsy surgeon knows about the total scenario, the more he/she can contribute from the autopsy. Conversely, the less the autopsy surgeon knows about the history and circumstances surrounding death, the greater is the likelihood of overlooking useful findings.

- Pathological process causing death is not conspicuously evident.
- The morbid changes cannot be detected by histopathological and other investigations due to lack of such facilities at the place of autopsy.
- Death having been precipitated by emotional stress and strain, sudden flight of temper and anger, sudden shock, work stress, etc., acting on a previously diseased heart or any other organ, the existence of which might even have been unknown to the victim himself/herself.
- Death occurring from functional failures, e.g. epilepsy, strokes, etc.

BIOCHEMICAL DISTURBANCES

Biochemical disturbances include uraemia, hyperglycaemia, hypokalaemia (potassium deficiency), hypocalcaemia, electrolyte imbalance as in potassium deficiency, etc. Respiratory disorders as may be seen in severe anaemia, porphyria, etc.

ENDOCRINE DYSFUNCTION

Adrenal insufficiency and thyrotoxicosis or myxoedema.

ANAPHYLACTIC DEATHS

The word 'anaphylaxis' (coined by Portier and Richet in 1902) appears attractive to pronounce but is misunderstood in the realm of medicine both because of poor data and relevant clinical research. It literally implies 'altered reactivity' as a result of previous exposure. The term 'Allergy' is now-a-days used indiscriminately as a general term for reactions of discomfort of unknown origin. The term 'Hypersensitivity' is defined as a state of exaggerated immune response to an antigen. Depending upon the rapidity and duration of the immune response, two distinct forms of hypersensitivity reactions are recognised as follows:

- Immediate type in which, on administration of antigen, the reaction occurs immediately (within seconds to minutes). Immune response in this type is mediated largely by humoral antibodies . (After reactions with allergens, mast cells release several biologically active substances including histamine, heparin and serotonin as well as arachidonic acid, which are converted by other cells into prostaglandins and leukotrienes responsible for later phase inflammatory reactions.) Subtypes include the following:

  - Type I (anaphylactic, atopic reaction) like systemic anaphylaxis due to administration of antisera, drugs, stings, etc., and local anaphylaxis like hay fever, bronchial asthma, food allergy, cutaneous, angioedema, etc.

  - Type II (cytotoxic) like autoimmune haemolytic anaemia, transfusion reactions, drug-induced reactions, etc.

  - Type III (immune-complex) like injection of antitetanic serum (ATS), farmer's lung, skin diseases, collagen diseases, etc.

- Delayed type in which the reaction is slower in onset and develops within 24–48 hours, and the effect is prolonged. It is mainly mediated by cellular response. (The later acting prostaglandins and leukotrienes cause infiltration of affected tissues with polymorphonuclear leukocytes, eosinophils and other hallmarks of acute inflammation 6–12 hours after allergen exposure.)

  - Type IV reaction like tuberculin reaction, tuberculosis, tuberculoid leprosy, contact dermatitis, transplant rejection, etc. are delayed hypersensitivity reactions.

ANAPHYLACTOID REACTIONS

Any event causing histamine release may cause atopic symptoms that may be confused with a true allergic reaction. Anaphylactoid shock is produced in normal (non-immune) animals by injection of a variety of agents capable of releasing histamine or activating arachidonic acid metabolism without the mediation of an antigen–antibody reaction. The resulting clinical, physiological and pathological picture is virtually indistinguishable from true phylaxis but is not produced by immune reaction. Physical agents (heat, cold), trauma (dermatographia), emotional disturbances or exercise may evoke pharmacology mechanisms that mimic allergic reactions. However, there are increasingly convincing data that most of these reactions are IgE mediated. An important difference between anaphylactic and anaphylactoid reaction is that anaphylactoid reaction is dose dependent and may be halted by removing the antigen. Fortunately, these reactions are rarely serious.

AUTOPSY FINDINGS

If death is suspected to be due to anaphylactic shock, an accurate history needs to be obtained as regards the possible cause. Autopsy should be conducted as soon as possible as laryngeal oedema recedes after death and may not be observed. External examination forms an important feature. The site of injection or sting should be sought, photographed and excised with a 5 cm area of skin and underlying tissue for laboratory examination of antigen (allergen). There is usually local swelling of the involved tissues. There may be oedema of face, eyelids, conjunctivae and lips. Asphyxial changes may include subconjunctival haemorrhages and froth from the mouth and nostrils. Generalised petechial haemorrhages in the skin may be present due to vasodilatory and increased permeability effects of the mediators. Internal examination may show oedema of the glottis and epiglottis spreading to the vocal cords. This oedma recedes soon after death. Visceral pleura and pericardium often show scattered petechial haemorrhages. Detailed photograph of laryngeal apparatus may be taken. In cases with a history of clinical bronchial obstruction, the lungs show marked hyperinflation on gross and microscopic examination. Focal pulmonary distension alternating with collapse and bronchiolar constriction may be seen. The microscopic findings in the bronchi may be limited to luminal secretions, peribronchial congestion, sub- mucosal oedema and eosinophilic infiltration. Victims dying of vascular collapse without antecedent hypoxia from respiratory insufficiency may show visceral congestion but no major shift in the distribution of blood volume. Brain may show congestion with petechial haemorrhages in the white matter. Hyperaemia and occasional haemorrhages may be seen in the Peyer's patches of the small intestine, lymph nodes of the porta hepatis and lymph nodes of the mesentery. The quality and extent of ther- apy may modify some of the findings.

DIAGNOSIS AT AUTOPSY

Availability of an accurate history (including details of therapy during hospitalisation, if any) lends significant help towards further investigations. (Individuals differ in the time of appearance of perception of symptoms and signs, but the 'hallmark' of the anaphylactic reaction is the onset of two life-threatening clinical features, i.e. laryngeal oedema and severe hypotension, which may be available to the autopsy surgeon through the 'clinical history/notes' and through 'inquest papers'.) Meticulous autopsy negating pathological, toxicological findings and investigating blood samples for radio-allergosorbent testing (RAST for IgE) and serum tryptase levels should form an integral part to reach at a diagnosis. (Studies have shown that RAST tests and tryptase levels can be performed on serum collected postmortem. There are conflicting reports of the effect of postmortem interval, with some reports of artefactual elevation of tryptase with a postmortem interval (PMI) of 14 hours or more, and other reports that PMI does not affect the tryptase level. How- ever, the peak level of tryptase occurs 1–2 hours after anaphylaxis, and then declines under first-order kinetics with a half-life of approximately 2 hours. Therefore, tests for this protein should better be performed on samples taken during or shortly after the reaction. If death is delayed for more than a few hours, tryptase levels measured in postmortem blood may not be helpful). Some interpretational factors may be as follows:

- Tryptase is sensitive measure of mast cell activation, and
- Unless grossly elevated, a high tryptase level in postmortem serum should, therefore, be interpreted with some caution if there is no suggestion of an allergic reaction in the clinical history. However, in the presence of a suggestive history and
- a lack of specific autopsy findings, elevated serum tryptase may be used as confirmatory evidence of an anaphylactic death.

MEDICOLEGAL CONSIDERATIONS

While occurring most frequently with intravenous or intramuscular administration in highly sensitive persons, it can also occur after ingestion or inhalation of the antigenic substance. The common offending agents capable of eliciting the systemic anaphylactic reaction in the human include heterologous proteins like hormones, enzymes, bee or wasp stings, serum or drug therapy in highly sensitised persons, injection of penicillin or local anaesthetics, pollen extracts and foods. Common diagnostic agents and drugs such as antibiotics and even vitamins may sometimes be responsible for such reactions. The type of lesion observed depends upon the dose of antigen, the route of contact with the antigen, the frequency of contact with the antigen, the tendency for a given organ system to react (shock organ) and the degree of sensitivity of the involved individual. This final factor may be genetically controlled or may be altered by environmental conditions, unrelated inflammation (presence of a viral upper respiratory infection) or the emotional state of the individual. The treating doctor and the paramedical staff usually become the target of criticism. There is often an immediate complaint or rumour of ill-treatment/negligence by the relatives or the media. The autopsy surgeon also faces a difficult task in ascertaining the 'cause of death' because such deaths do not leave much fingerprints on the organs or tissues. Drug attributed anaphylaxis has been recorded by the Boston Collaborative Drug Surveillance Program as occurring in 8 of 11,526 consecutively monitored patients (0.6 per 1000). Death has been known to occur within 15 minutes after the development of initial signs and symptoms, which are those associated with circulatory collapse, bronchospasm and laryngeal oedema. Intervention must be carried out in the first few minutes, as it is an acute medical emergency requiring efficient management. If the doctor does not get the patient over the immediate effects, he should refer that individual to a facility that can handle continued shock. During transportation too, due care needs to be arranged. high levels will be found after severe anaphylactic reactions,

Medicolegal Autopsy or Forensic Autopsy is learnt only through extensive practical experience, and the doctor conducting the autopsy carries great responsibility over his shoulders. It is obvious that if he is unable to furnish proper interpretation of the findings, the pangs of justice will be disturbed and, therefore, it is imperative that all unusual findings must be meticulously examined and photographed and if need be, some experienced, better qualified colleague may be approached there and then since, as stated earlier, a poor opinion is worse than no opinion at all. The doctor should learn to draw conclusions logically and rationally instead of forming hasty judgement. Further, if he misinterprets the findings, he will have to face rough time in the court during the cross-examination, if the defence counsel incidentally being aware of these pitfalls attempts to discredit the evidence.

THERAPEUTIC ARTEFACTS

The task of performing autopsy may sometimes become difficult in cases where the victim has sustained serious injuries and has survived for a fairly long time, undergoing surgical and other treatment; these may affect the interpretation of findings at the time of conducting autopsy, if the autopsy surgeon is not conversant with their origin and significance. This focuses the necessity of going through all the records of the antemortem treatment and if needed, a discussion with the doctors who attended the victim during hospitalisation. The following are a few examples:

- Vigorous external cardiac massage may result in fractures of the ribs and sternum.
- Injection marks against the cardiac region and ring-like bruising caused by a defibrillator may be the other sources of confusion.

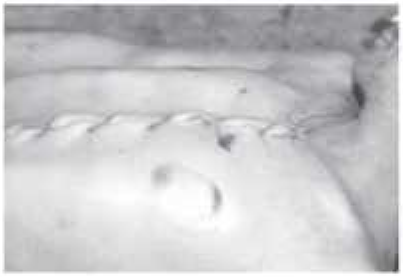
- Administration of fluids or multiple blood transfusions may introduce changes in the blood alcohol concentration or concentrations of other toxic agents.

- Shape and size of the injury/injuries may be altered by the surgical intervention . The appearance of entrance and/or exit wounds may be distorted by surgical interference or during washing/cleaning the wounds. Bullet or especially those causing severe shock. Levels are not raised in local allergic reactions such as rhinitis, and may not be significantly elevated in purely asthmatic reactions.

- Tryptase levels may be slightly raised in non-anaphylactic deaths. This may result from disruption of tissues containing mast cells, particularly in deaths due to trauma, non- anaphylactic mast cell degranulation by opioids, or from postmortem release.

ARTEFACT

Artefact may be regarded as any change caused or feature introduced in the natural state of the body that is likely to be misinterpreted at autopsy. Such artefact may be introduced before death, at the time of death or after the death and, there- fore, may accordingly be labelled as therapeutic artefacts, agonal artefacts and postmortem artefacts.

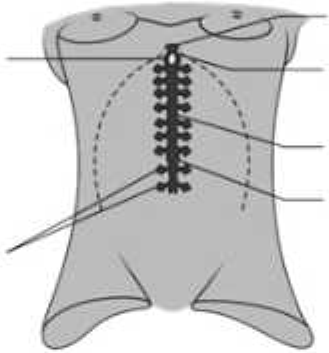


AGONAL ARTEFACTS

Absence of appreciable haemorrhage does not necessarily indicate its postmortem origin nor does the presence of extravasated blood into the tissues always suggest its antemortem origin. During the terminal moments of life, the victim may pass rapidly into vascular collapse or shock that may prevent any significant bleeding to occur. An individual may collapse and die along the roadside and may subsequently be run over by some vehicle, leading on to collection of blood in the body cavities and some into the tissues too. Agonal spillage of the gastric contents into the respiratory passage has been discussed in the chapter 'Sudden and Unexpected Deaths'.

POSTMORTEM ARTEFACTS

Postmortem artefacts imply any alteration, modification, addition or subtraction of some postmortem features due to certain Curved portion of the incision on (stab wound) the right limb of the main surgical wound, presenting against the small horizontal incision (remaining part of the stab wound) on the left limb Tubes secured by stitches at either end



- Horizontal part of the stab wound joining the left limb of the surgical wound
- Main midline surgical wound
- Umbilicus factors originating after death. These may be classified as following:
- Artefacts induced by transportation/storage/ handling, etc.
- Artefacts induced by embalming, decomposition, etc.
- Artefacts induced by predators or deliberate mutilation/ dismemberment by the criminals.
- Artefacts induced by improper autopsy procedures.

Artefacts Induced by Transportation/ Storage / Handling, etc.

These are as follows:

- Postmortem lividity is usually purplish in appearance. However, this lividity appears pinkish in refrigerated bodies or bodies exposed to cold environment.
- Postmortem collection of blood in the occipital region due to bumping of head.
- Protruding areas of the body may get abraded due to dragging of the body.
- Rigor mortis may be broken during lifting or handling of the bodies giving wrong clues towards time since death.
- Rarely, fractures of the long bones may be caused particularly in debilitated, elderly dead bodies with osteoporotic changes.
- During transportation, dead body may be contaminated

with dirt, soil, grease, etc., which may give wrong impression about the place of occurrence of death.

- Tearing of the clothing during transportation may appear to be due to some scuffle during life.

- Attempt to remove ornaments from the body parts like nose, ears, neck, etc., may cause injury to these parts and may send wrong impressions.

Artefacts Induced by Embalming, Decomposition, etc.

These are as follows:

- The embalming technician may pass trocar in any of the wounds already present upon the body or may make a fresh cut. Embalming fluid used may pose problems in chemical analysis of viscera.

- Decomposition of the body may lead to production of most common artefacts, i.e.:

  - Bloating, discolouration and blistering of a decomposing body may not be mistaken for disease or injury. Dark bluish areas of discolouration must be distinguished from bruising.

  - Distension of parts of the body having loose tissues like lips, eyelids, breasts, penile and scrotal regions and protrusions of tongue may impart false sense of obesity.

  - Expulsion of blood-tinged fluid from the mouth and nose may be mistaken as bleeding originating during life.

  - If the deceased were wearing tight clothing or having a neck-tie, a groove may appear around the neck and this along with bulging of the eyes and protrusion of the tongue may be mistaken for strangulation .'Case' at the end of the chapter).

  - Fissures or splits formed in the skin during decomposition may simulate incisions or lacerations.

  - Expulsion of semen or vaginal discharge due to pressure of putrefying gases may wrongly suggest involvement of sexual activities with the cause of death.

- Marked bluish discolouration of the loops of intestines, especially in the pelvic cavity, may not be mistaken for infarcted bowel.
- Autolytic rupture of stomach can occur postmortem with release of the stomach contents into the peritoneal cavity.
- Pancreas too may undergo autolysis due to proteolytic enzymes within it. This autolysed organ may appear haemorrhagic and mistaken for pancreatitis. However, histology will be helpful in resolving the issue.

Artefacts Induced by Predators or Deliberate Mutilation/ Dismemberment by the Criminals

Common terrestrial creatures attacking the dead body in and around the mortuary are rats, rodents, ants, cockroaches and crows, etc. Ants and insects mostly attack the exposed parts and moist areas such as face, arms, genitals, groins and axilla, etc. Rats, cats and dogs usually destroy the soft tissues of the exposed parts. All these are devoid of evidence of haemorrhage and vital reaction and their edges appear nibbled. Bodies recovered from jungle or open space may be attacked by dogs, cats, vultures or jungle animals, and the bodies recovered from water may show gnawing by fish, crabs and other aquatic animals. Flies, maggots, larvae, etc. may alter the wounds.

Sometimes, mutilation or dismemberment of the corpse may be done by the criminals for easy disposal and removal from the scene of crime. Injuries may also be inflicted after death merely to mislead investigations. Often, persons may be killed and thrown in water or the dead body may be set on fire. Occasionally, the victim may be poisoned and hanged after death and so on. This has substantially been discussed under appropriate chapters.

Artefacts Induced by Improper Autopsy Procedures

- In usual practice, the vault of the skull is sawn and then removed gently by inserting and twisting the chisel at various places through the gap generated by sawing. Any vigorous sawing or using chisel and hammer may result in extension of the existing fractures, or fresh fractures may be caused.

- In deaths due to compression of the neck, it is preferable to open the skull first. The draining out of the blood from the neck vessels due to prior removal of skull and brain provides a clearer view for the study of the neck structures and will avoid occurrence of congestive artefactual haemorrhages in the neck structures as cautioned by Prinsloo and Gordon.
- When the neck structures are pulled forcefully or improperly, air may enter the vessels of the neck or there may be seepage of blood into the tissues or there may occur fracture of the hyoid bone especially in the elderly.
- During removal of the sternum, damage to the heart or internal mammary vessels may lead to seepage of blood in the pleural or pericardial cavities.
- While abdomen or peritoneum are being cut open, coils of intestines may get involved.
- Improper pulling apart of the liver may cause tears in the diaphragm and denudation and laceration of the bare area of the liver.
- Collection of viscera in a single container or use of contaminated dirty bottles/jars or preservatives may result in wrong conclusions for visceral analysis.

Heat Effects

When the body is exposed to intense heat, the skin becomes tense, leathery, hard and frequently exhibits splits that may be mistaken for wounds. Heat fractures may also be encountered. In conflagrations, when the head has been exposed to intense heat, scalp may show splits, and the skull cap may present fissured fractures that may be mistaken for fractures due to trauma. Furthermore, 'heat haematoma' within the burnt skull can resemble an extradural haemorrhage of antemortem origin. The frothy brown appearance of the false clot along with heating effects upon the adjacent brain helps in differentiation. The details have been discussed excellently in the chapter 'Thermal Deaths'.

Case: Dead Bodies Recovered from Railway Track? Appreciation of Artefacts

During mid-February, 1998, two dead bodies were allegedly recovered by the police from the side of railway track on the information furnished by the watchman on duty and were transported to the local hospital concerned for the postmortem examination. The days were of 'General Elections' and the political parties got involved, possibly aiming to encash some favour of the masses. The District Magistrate of the area, on the request of the parties and smelling some ensuing law and order problem, referred the dead bodies to the General Hospital, Chandigarh, which were received in the General Hospital at about 7 p.m. The authorities of the General Hospital, in view of attaining firm-footing as to the issue of the jurisdiction, further asked for the orders of the local SDM.

The postmortems showed the faces of both the dead bodies as swollen and suffused obviously owing to their slanting position in which the bodies were lying alongside the railway track with the heads at the lower level than the rest of the bodies. One of the bodies was also presenting some diffuse punctate haemorrhages distributed along the lower part of the neck and the adjoining inner two-thirds of the area against the clavicular regions. This, along with slightly protruded tongue and suffused face, initially conveyed erroneous impression of something concerned with some assault involving neck . But such appearance was the result of prolonged posture in which the body was lying (probably for the entire night), coupled with round-necked clothing which the deceased was wearing, namely: Camel-coloured jacket with a central zipper, blue-coloured full sleeves round-necked T-shirt, black- coloured full sleeves round-necked warm vest.

CHAPTER-5

IDENTIFICATION

Identification means determination of individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means the absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity while others remain unknown . The most successful approach utilises close co-operation between the investigating experts and other interested parties (family and friends) with pooling of efforts and information. Experts who can make contributions towards solving identity include pathologists, physicians and dentists, anatomists, physical anthropologists and experts in evaluation of various trace evidences.

Accurate identification is mandatory for the establishment of corpus delicti after homicide since unclaimed bodies, portions of dead body or bones are sometimes brought to the doctor to support a false charge.

The term 'Corpus Delicti' means the body of offence or the body of crime. In a charge of homicide, it includes the following:

- Positive identification of the dead body (victim)
- Proof of its death by criminal act of the accused

MedicoLegal Aspects of Identity

Identification of the living is usually carried out by the police. However, where medical knowledge is needed for elucidation of disputed facts, a medical person may be consulted. In Civil Courts, identification may be required in cases such as insurance, pension, inheritance claims, marriage, disputed sex and missing persons. In Criminal Courts, it is essential in cases such as persons accused of assault, rape, murder, etc.

A medical person is mainly concerned with the identification of a dead body. It is required in cases of fire, explosion, travel accidents and other mishaps. Further, it is also required when an unknown dead body is found on/along the road or field, or in a railway compartment or in water. Identification in cases of decomposed/mutilated bodies and of skeletal remains is another problem encountered by the medical person.

physical evidence. This invites the 'Law of Multiplicity of Evidence' to play its role wherever called for. The Supreme Court has laid down that in law, a conviction for an offence does not necessarily depend upon the 'corpus delicti' being proved. The cases may be conceivable where the discovery of the dead body, from the very nature of the case, is impossible. Such, for instance, was the case of the mariner who was inducted for the murder of his captain at sea and then throw- ing him overboard, as to which there was an eyewitness whose testimony was corroborated by the prisoner's clothing being found stained with blood, and the judges unanimously accepted the verdict of the jury and the prisoner was executed. Therefore, it may be said that the existence of the dead body of the victim is no doubt a proof positive of the death but its absence not fatal to the trial of the accused for homicide. Indeed, any other view would place in the hands as a means of identification, identification of the living almost exclusively depended upon recognition by personal impressions. It is still being employed as a part of the investigation of crime to hold 'identification parades'. The suspect or the accused is included in a group of persons of approximately similar build.

IDENTIFICATION IN THE LIVING

As mentioned earlier, identification in the living is warranted for a variety of reasons. Until the value of fingerprints was recognized age and appearance, etc. and witness/witnesses are invited to point out one of them as the alleged criminal. Alternatively, a witness in the court may be asked to look around and see whether there is any person present whom he can identify as the offender. However, the unsatisfactory nature of identification by personal impressions has long been of common knowledge. A few of us, relying on personal impressions, might have made some honest mistakes in recognising a person. These errors in private rarely have importance except for causing a little embarrassment. It is otherwise, if they give rise to false accusations.

Handwriting, gait, speech, etc. constitute other means of identification in the living. However, such methods require the services of different experts with reasonable experience. Finger, palm and toeprints are unique as means of identification both in the living as well as in the dead. There may be included tests like testing of mental calibre and educational standard in the living that, for obvious reasons, cannot be applied to the dead.

Photography is a valuable aid in identification of the living but may be of not much use in the identification of the dead. Appreciable change, exaggerated by decomposition can occur in features after death. However, it will also be wrong to assume that excellent photographs never lead to an error in the identification of the living.

IDENTIFICATION OF THE DEAD

It is obvious that problem of identifying a recently dead person whose features, clothes and fingers are intact is totally different from identifying the same person, dying in the same fashion but whose naked body is discovered in a field and that too in the peak of summer/rainy season. The longer the interval between death and examination of the body/remains, the greater creeps the need for one or more of the different experts in establishing identification. Under such situations, sight recognition of the body for positive identification must be accepted with a caution, and the investigator should never relax his/her vigilance.

AGE

External inspection of the dead permits only an estimate of age. Age, however, is a primary characteristic in the identification, and its estimation is of considerable importance. The skeleton and the teeth are the principal sources of information towards the age estimation. Krogman (1960) reviewed the reliability of the identification of human skeletal remains. Where the age exceeds 25 years, there occurs great variability due to intrinsic and extrinsic factors, but it is possible to attain accuracy to ± 1 year in the first two decades. After 25 years, reliability is only within a decade. Here, the pubic symphysis is of best value and with other parts of the skeleton, better range of accuracy may be achieved.

It is convenient to discuss the evidence of age in the following three phases:

- The foetus and the newborn infant

General Data/Points for Identification of Dead

- The children and young adults under the age of 25 years
- The adults over the age of 25 years

• Age May be considered as primary • Sex characteristics • Stature
• Features May be classed as secondary • Personal effects characteristics (pocket contents, clothes including any mark/defect/stitching, jewellery, etc.) • Hair • Scars • Tattoos • External peculiarities including deformities, whether natural or due to disease • Occupational stigmata • Race, religion and nationality
• Dental patterns or These are the comparative data/ restorations techniques for identification. • Finger-, foot- or Though these techniques/ hand-prints procedures are capable of • Superimposition affording clinching evidence of technique identification yet each of these • Neutron activation techniques requires premortem analysis specifically comparable material • Anthropometry from those thought to be • Other fortuitous of the victims with which to comparisons match the material collected • Trace evidence in the postmortem state. This comparisons restricts the application of such techniques for making these dependent upon availability of such comparable material.

Age of the Foetus and the Newborn Infant

The main problem with this group is to decide whether the infant was viable, i.e. it was born after 210 days of gestation, and if viable, whether it was capable of leading an independent existence. All these queries have been dealt with at length in the chapter 'Infanticide and Foeticide'.

Age of the Children and Young Adults Under 25 Years

The times of union of the epiphyses are only approximate because there are regional as well as individual variations, but even so they carry value in assessment of age. Data for ascertaining age include the following:

- General physical examination
- Dental examination
- Radiological examination (ossification of bones)
- Miscellaneous particulars in the form of birth record, school certificates, horoscope, etc.

Difference between Temporary and Permanent Teeth

Temporary teeth	Permanent teeth
1. Smaller in size usually, except in case of temporary molars, which are larger than the permanent bicuspids replacing them	Longer and larger than temporary teeth except permanent bicuspids replacing temporary molars
2. They are lighter and more delicate than the permanent ones except molars	More strong, broad and heavy; temporary molars are bigger and longer than premolars replacing them
3. The anteriorly placed milk teeth are vertical	Permanent incisor teeth are more or less inclined forwards
4. Neck is more constricted	It is less constricted
5. Crowns are China white in colour	Crowns are usually ivory white in colour
6. A ridge or thick edge is present at the junction of the crown and the fangs	No such ridge is noticed
7. Temporary molars have their cusps flat, roots smaller and more divergent	Bicuspids replacing temporary molars have bigger and less divergent roots with prominent cusps
8. Presence of tooth germ beneath the tooth if seen in X-ray will suggest that the tooth is temporary	No such thing is visible in X-ray in case of permanent tooth

General Physical Examination

General conuration and bodily development do not need any elaboration for it is common knowledge that certain degree of development of these would indicate a certain age within broad limits as detailed below:

- In males, pubic hair usually grow by 13–15 years, axillary hair by 14–16 years, beard and moustaches by 15–17 years and hair on other parts of the body by 17–20 years. Greying of scalp hair, beard and moustaches usually start by 40 years. Greying of pubic hair starts by about 55 years of age.
- In females, pubic hair usually grow by about 13–14 years, axillary hair by about 14–15 years. Greying of scalp hair usually starts by about 40 years and greying of pubic hair by about 55 years. Development of breasts occurs progressively between 13 and 20 years.

Height and Weight Commencing from intrauterine life up to a certain age of extrauterine life, the height (body length), and to a lesser extent weight, of a person bear some relationship with age.

Dentition in Determining Age

Every individual has two sets of teeth in his/her life time, called as temporary/deciduous/milk teeth and permanent teeth. Temporary teeth are 20 in number, namely: four incisors, two canines and four molars, i.e. ten teeth in each jaw. They begin to erupt at about sixth month after birth and begin to shed off by the sixth year. These deciduous teeth are replaced by permanent incisors, canines and premolars. Hence, these permanent teeth are known as 'successional permanent teeth', whereas the permanent molars that appear independently of their own and have no predecessor milk teeth are known as 'super-added teeth'. They are six in each jaw. Temporary teeth can easily be differentiated from the permanent teeth.

Development and Eruption of Teeth The alveolar cavities for tooth buds are formed at about the 4th or 5th month of intrauterine life. Tooth development begins with formation of cellular tooth germ within the alveolar cavities of the jaw in the shape of the crown. Within this tooth germ, apposition and calcification of enamel and dentin take place, and before any change of position of tooth occurs, the crown gets formed and calcified. At birth, the rudiments of all the temporary teeth and first permanent molars are found in the jaws. After completion of the crown, root formation begins; with the roots getting longer, the crown erupts through the soft tissues of the gum and protrudes out inside the oral cavity. The roots get completed sometime after the teeth are in full functional occlusion.

As the permanent tooth erupts, the overlying root of its temporary predecessor undergoes simultaneous resorption, until only the crown remains. The unsupported crown then falls out. X-ray examination will reveal the stage of development of unerupted teeth

Spacing of Jaw After eruption of second molars, the ramus of the jaw grows behind when the body of the jaw increases in length to make room for the eruption of the third molar teeth. Hence, while examining the teeth, the space behind the second permanent molar is to be felt; if space is present, it is to be seen if it is hard in feel or not.

Calcification and Eruption of the Deciduous Teeth

Tooth	Eruption	Calcification of root completed
Central incisor Lower Upper	6–8 months 7–9 months	1.5–2 years - do -
Lateral incisor Upper Lower	7–9 months 10–12 months	- do - - do -
1st molar	12–14 months	2–2.5 years
Canine	17–18 months	2.5–3 years
2nd molar	20–30 months	3 years

Usually the permanent tooth erupts first in the lower jaw, then after a short interval, in the upper jaw, but this may not be always regular. Usually permanent teeth appear a few months earlier in girls than in boys.

The eruption of third molar is very irregular. This usually erupts by 17–25 years. Hence, presence of all the four third molars indicates that the subject is over 18 years of age, but their absence gives no certain idea about age. If the X-ray shows no calcification of the roots of third molars, it is to be presumed that the age is below 25 years. If calcification is found to be complete, then the age can be presumed to be at least 25 years. In general, complete calcification of the roots of the teeth takes place within 3–4 years of their eruption.

Period of Mixed Dentition Starting from the day of eruption of one permanent first molar till before the day of eruption of last permanent canine, there will be both temporary and permanent teeth in the jaws. This period when both per- manent and temporary teeth are present in the jaws is known as period of mixed dentition. This period of mixed dentition is the age interval between 6 and 11 years; may sometimes persist until 12–13 years of age. The description given in . will be helpful in illustrating number and nature of teeth at various ages.

Calcification and Eruption of the Permanent Teeth

Tooth	Eruption	Calcification of root completed
1st molar	6–7 years	**9–10 years**
Central incisor	6–8 years	**10 years**
Lateral incisor	7–9 years	**11 years**
1st bicuspid	9–11 years	**12–13 years**
2nd bicuspid	10–12 years 11–12 years	**12–14 years** **12–13 years**
2nd molar	12–14 years	**14–16 years**
3rd molar	**17–25 years**	**22–25 years**

Estimation of Age (Beyond 25 Years) from Teeth In elderly subjects, age can be ascertained by application of Gustafson's formula (based on the aging and decaying changes in teeth). Most of the criteria or changes (except attrition and periodontosis) used in this formula are useful only while examining a dead subject or skeletal remains because for examination of such changes, teeth have to be extracted from their sockets.

After about 20 years of age, the changes that occur in the teeth are shown in . 3.6.

Based upon the changes, each change is ranked arbitrarily and allotted scores such as 0, 1, 2, 3, etc. according to the degree of structural changes as detailed ahead in . 3.7.

Other Information from Teeth Apart from helping in the determination of age, teeth carry extreme medical importance towards establishing identity as will be obvious from the following.

- Sex from teeth: Seno and Ishizu reported (in 1973) on the use of Y chromosome in dental pulp to determine sex differences. In 1984, Mudd reported on the use of the Y chromosome in hair. Such studies involve the detection of the Y chromosome using quinacrine and fluorescent microscopy. More recently, successful isolation of sex-specific banding patterns in the DNA-profiles of the X and Y chromosomes developed from fresh and degraded specimens have been reported.

- Race from teeth: According to St. Hoyme and Iscan (1989), the most useful racial clue in dentition is 'shovel- shaped' incisors found in most Asiatic Mongoloids and Amerindians and in less than 10% of Whites and Blacks. Tooth size and shape, Carabelli cusp or tubercle, enamel pearls and dental pulp shape (taurodontism vs. cynodontism) have been listed as racial determinants. In general, there are large-toothed and small-toothed races. Aboriginal Australians, the Melanesians and the American Indians including Eskimos tend to be large-toothed with wide crowns. The Lapps and Bushmen are small people with small teeth. American Blacks tend to have large crowns.

- Occupation and habits from teeth: Cobblers, tailors or electricians usually show notched upper incisors from wear and tear due to constant weaning. Betel nut chewing will lead to blackish brown or reddish stains over the teeth and gum margins. Dark brown stains on the back of incisors in 'cigarette smokers' or yellowish brown discolouration, striations or mottling on the enamels in 'fluorosis' are highly suggestive.

- Social status from teeth: From the general cleanliness of teeth, dental fillings by gold or other metal, from the dentures, the idea about the social status of the individual can be gathered.

Number and Nature of Teeth at Various Ages

Age	Number and nature
2–5 years	20 (all temporary)
At 6th year	21–24, due to eruption of 1st permanent molars
7th–12th year	Remains 24, though there is eruption of more permanent teeth other than molars because they erupt by replacing the temporary teeth
12th–14th year	Between 25 and 28, due to eruption of 2nd permanent molars
14th–17th year	28, as there is no eruption of any other tooth during this period
17th–25th year	Between 29 and 32, due to eruption of 3rd permanent molars
After 25 years	Should be 32, due to eruption of all permanent teeth

Teeth as victim of assault and weapon of offence: Tooth or teeth fracture or dislocation/subluxation is/are designated as 'grievous hurt' under Section 320 IPC. Even breaking of enamel constitutes grievous hurt. However, if there are injuries in the form of abrasions, contusions and/ or lacerations surrounding tooth/teeth but the tooth is intact, it forms 'simple injury'. As far as the injuries produced by teeth are concerned, they essentially produce abrasions and/or lacerations.

Age from Ossification

Activity of the Bones

The bones of human skeleton develop from a number of ossification centres. At 11–12th week of intrauterine life, there are 806 centres of ossification, at birth there are about 450. The adult human skeleton carries only 206 bones. The time of appearance of centres of ossification and the process of union of the epiphyses with the diaphyses have a sequence and time period, which is generally utilised towards age determination. However, differences may be noticed in the appearance and fusion activities of ossification centres depending upon race, sex and geographical distribution. The process of ossification may also be influenced by food, habit, nutritional status, and presence of some disease, physical activity and hormonal and metabolic disorders. Generally speaking, ossification activities occur earlier in Indian population than in Western population. The activities are generally earlier in females than in males. If all the epiphyses of the long bones are found united, the subject is most probably over 25 years of age. X-rays of the elbow, wrist and shoulder joints in case of upper extremity and of the hip, knee and ankle joint in case of lower extremity are usually recommended. X-ray of the jaw(s) will be of added advantage.

Age Determination in Adults Over 25 Years

After the age of 25 years, estimation of age becomes more uncertain, whether in the living or in the dead. Premature aging may be produced by illness, malnutrition, sufferings and anxiety. White hair may appear in quite young persons due to grief or shock. It is difficult to achieve an accuracy of even 5 years in estimating the age after the full permanent dentition and fusion of all the centres of ossification of long bones. The ossification of cartilage in the hyoid, the fusion of the greater horns of the hyoid to the body and of manubrium and xiphisternum with the body of the sternum, the lipping of the vertebrae, etc. all occur somewhere between 40 and 60 and may be suggestive of advancing age but give no precise evidence. Hence, a careful consideration of all the factors must be taken to reach an approximation under such situations.

Symphyseal Surface in Estimation of Age

The changes occurring on the articular surface of the symphysis pubis are considered a reliable index for aging male skeletons. In female skeletons, parturition has modifying effect on these changes. When the changes in the symphysis pubis are correlated with other skeletal criteria, Krogman ventures an accuracy of ± 2 years. The changes may be summarised as follows:

Below 20 years, the symphyseal surface has an even appearance with a layer of compact bone over its surface. Between 20 and 30 years, it looks markedly ridged and irregular—the 'ridges' or 'billowing' run transversely and irregularly across the

articular surface. Between 25 and 35 years, the 'billowing' gradually disappears, and the articular surface in macerated bone presents granular appearance with its well-defined anterior and posterior margins. Between 35 and 45 years, the articular surface looks smooth and oval with raised upper and lower extremities. Between 45 and 50 years, narrow beaded rims develop in and around the margins of the articular sur- face, showing some erosion. Above 50 years, the symphyseal surface presents varying degrees of erosion with breaking down of the ventral margins. All these changes as to the age limits are rough approximates and, as stressed earlier, should be considered in conjunction with other skeletal changes.

Skull Sutures in Estimation of Age

For many years, the closure of the skull sutures used to be considered a reasonably reliable index of age determination between 25 and 40 years of age. Recent literature casts doubt as to its reliability in the forensic work. However, the closure of sutures usually occurs as follows:

Fontanelle Posterior fontanelle closes between birth to one and a half months after birth. Anterior fontanelle closes by the second year. The two posterolateral fontanelles close within a short period after birth and the anterolateral fontanelles close within the first 6 months after birth.

Metopic Suture The metopic suture between the two frontal bones closes between 2 and 8 years, but sometimes may remain intact even in adults.

The basi-occiput fuses with the basi-sphenoid by about 18–20 years in females and by about 20–22 years in males.

Suture Closure in the Skull Closure of the sutures begins on the inner aspect by 5–10 years earlier than on the outer aspect. In contrast with other ossification centres, fusion of sutures occurs comparatively early in males. Endocranially, puberty; with the onset of puberty, ossification of intervertebral discs starts from below upwards and the fusion of the sacral segments become complete by 20–25 years.

In many skulls, fusion of sutures at the ectocranial surface may remain incomplete. This is called 'lapsed union' and occurs most often in the sagittal suture. On the outer side, the fusion occurs in the following order:

- Posterior one-third of sagittal suture at about 30–40 years.
- Anterior one-third of sagittal and lower half of coronal at about 40–50 years.
- Middle sagittal and upper half of coronal at about 50–60 years.
- In the lambdoid suture, fusion activity starts late and the progress is also slow. The closure starts around 25–30 years near the asterion, and the peak or maximum closure occurs at about 55 years.

Estimation of age by sutural closure of skull is not reliable. It can be given only in the range of a decade. The usual reliability falls in the order of sagittal, lambdoid and then the coronal.

Sternum in Estimation of Age

Sternum carries importance in estimating age because of appearance and fusion of various components at different age range.

Baldness or greying of hair does not carry much value in indicating age. Hair may turn grey usually after 40 years and silvery white in advanced old age. But greying of the hair may also occur in young age due to hereditary, climatic and other factors. Extreme grief, sufferings, grave shock, long protracted illness, malnutrition and anxiety, etc. can be a factor in turning the hair grey. Circumscribed patches of grey hair on the scalp may be due to trophic changes resulting from neuralgia and other causes. Usually pubic hair do not turn grey before 50–60 years of age.

Arcus Senilis

An opaque zone around the periphery of cornea may be noticed after 40 years of age; it is seldom complete and circular before 60 years. Its formation is attributed to deposition of lipids—cholesterol, phospholipid, neutral fat and is considered to occur more in males (by 45–50 years) than in females (by 55–60 years). Width of arcus does not have positive correlation with age. Arcus Juvenilis appears as white lines around cornea in young adults suffering from hyperlipaemia.

Skeletal Changes

- Thyroid and cricoid cartilages tend to ossify by about 45–50 years.
- The greater cornu of the hyoid fuses with the body by about 40–50 years.
- The xiphisternum and manubrium unite with the body of the sternum respectively around 40 years and above 50 years usually.

Number and Nature of Teeth at Various Ages

Age	Number and nature
2–5 years	20 (all temporary)
At 6th year	21–24, due to eruption of 1st permanent molars
7th–12th year	Remains 24, though there is eruption of more permanent teeth other than molars because they erupt by replacing the temporary teeth
12th–14th year	Between 25 and 28, due to eruption of 2nd permanent molars
14th–17th year	28, as there is no eruption of any other tooth during this period
17th–25th year	Between 29 and 32, due to eruption of 3rd permanent molars
After 25 years	Should be 32, due to eruption of all permanent teeth

- Lipping of bones frequently occurs around margins of the bodies of the lumbar vertebrae around 40–50 years, and atrophic changes occur in the intervertebral discs with diminution of joint space at about 50–60 years.
- The skull bones, with advancing old age, tend to become

lighter and thinner due to absorption of diploe, increase in inorganic constituents and hence they become more liable to fracture even after light trauma.

- The long bones show extreme thinning of the cortical layer with corresponding increase in size of the medullary canal with advancing old age. In youth, the compact cortical layer is much thicker in comparison with the comparatively nar- rower medullary canal. 'Medullary index', therefore, may give some idea about the age of the subject.

Medicolegal Importance of Age

Age-related changes in a foetus, and lists medicolegal implications of various ages.

SEX

Sex determination may be required in forensic work for the following reasons:

- For the purposes of simple identification in a living or dead person.
- For deciding whether an individual can exercise certain civil rights extended to one sex only.
- For deciding questions relating to legitimacy, divorce, paternity, affiliation and also some criminal offences.

Sex of a person can be determined from:

- Physical morphology
- Microscopic study of sex chromatin.
- Gonadal biopsy.
- Other recent advanced methods.

Microscopic Study of Sex Chromatin (Nuclear Sexing)

Of the 46 chromosomes present in each of our body cells, 44 (22 pairs) are autosomes and 2 are sex chromosomes. In a nor- mal male, the pattern of sex chromosomes is XY and in a normal female, it is XX. In 1949, Barr and Bertram noticed a nodule in the nuclei of some cells of the female cat. Later investigations revealed that this nodule was normally found in a percentage of all normal women's cells. When the nodule is found, the person is said to be chromatin positive. Microscopically, this is seen as a condensed material towards the nuclear membrane in the nucleus of the cell. This is called the sex chromatin or Barr body. They are better appreciated in the cells of buccal mucosa, skin, cartilage, nerve, amniotic fluid, polymorphs and lymphocytes. In a buccal smear from the normal female, sex chromatin is demonstrable as a small planoconvex mass, lying near nuclear membrane inside the nucleus. To diagnose sex as female, buccal smear must show at least 20–30% Barr bodies as against 0–4% Barr bodies often detected in normal male.

In neutrophilic leucocytes, the sex chromatin often presents in the form of a nuclear attachment to one of the nuclear lobes, resembling a drumstick. This is known as Davidson body. To diagnose sex by this, the peripheral smear must show a minimum count of 6%.

Gonadal Biopsy

This is a confirmatory method of determining sex. In all the disputed sexual identity cases, gonadal biopsy is called for. Biopsy from primary gonads, i.e. testes in case of male and ovaries in case of female, can indicate definitely about the actual sex of an individual.

Concealed Sex

Criminals may try to conceal sex to avoid detection by the police by wearing costumes of opposite sex and other means. Simple undressing of the person may be rewarding in some cases, whereas in the others investigations may be carried out to reach a satisfactory conclusion.

Intersex States

Intersex is an intermingling of sexual characters of either sex in one individual to a varying degree including the physical form, reproductive organs and sex behaviour. Davidson divides the congenital intersex states into four groups:

Gonadal Agenesis In this condition, sexual organs (testes or ovaries) have never developed. Nuclear sex is negative.

Gonadal Dysgenesis In this, the external sexual characters are present but at puberty, testes or ovaries fail to develop. These conditions are known as Klinefelter syndrome and Turner syndrome, respectively.

- Klinefelter syndrome: Anatomically male, but nuclear sex is female (chromatin positive). Sex chromatin pattern is XXY (47 chromosomes).
- Turner syndrome: Anatomically female, but nuclear sexing is negative. Sex chromatin pattern is XO (45 chromosomes).

True Hermaphroditism This is the state of bisexuality. Both ovarian and testicular tissues are present. External genitalia of both the sexes exist in one individual. Sex chromatin may be of either male or female pattern.

Pseudo hermaphroditism May be classified as male or female according to the presence of testes or ovaries and independent of anomalies of the external genitalia, which may be the reverse of normal.

Sex from Skeletal Remains

Occasionally, police may bring objects that falsely resemble bones. The mistake may be more obvious when these objects are mixed with actual bones (may be of animal origin), which may be found buried or mingled with rubble. Recognition is usually easy by morphology, texture, weight and other charac- teristics. If need be, services of an anatomist may be called for.

Medicolegal Implications of Various Ages

Age	Medicolegal circumstances/implications
From fertilisation till the end of 8th week (56 days) of IUL	• Fertilised ovum gets impregnated and is called embryo. Issues like surrogacy, oocyte donation/selling, cryo- preservation and implantation of embryos, etc. deserve consideration in the present scenario. It is not far when one may log on to some 'uterus.com' or 'rent-a-uterus.com' and get access to willing surrogates.
From 57th day following fertilisation till birth	• It is called foetus (PC and PNDT Act). Sections 312 to 316 of IPC punish those who indulge in causing miscarriage (foeticide) in defiance of provisions of the law. Age of the 'conceptus' (i.e., duration of pregnancy) carries significance in view of the enhanced punishment for the crime after pregnancy has advanced beyond the stage of 'quickening'.

12th week of pregnancy	• MTP Act allows termination of pregnancy on the basis of opinion of one registered medical practitioner where the length of pregnancy does not exceed 12 weeks. Importance of this gestational age needs specific mention from the angle of PC and PNDT Act also. At 12 weeks' gestation, foetal gender can be determined ultrasonographically (since during embryologic development, the male and female genitalia are identical till the 11th week of gestation).
12th–20th week of pregnancy	• Opinion of not less than two registered medical practitioners is necessary to carry out MTP where the length of pregnancy exceeds 12 weeks but does not exceed 20 weeks.
7 lunar months (28 weeks) of IUL	• A foetus who has been issued forth from its mother after this period but did not breathe or show any other sign of life is termed as still born.
7 calendar months (210 days) of IUL	• A foetus at this stage is considered to be viable. "No specific limit can be assigned to the period when chance of life begins, but it may, perhaps, be safely assumed that under 7 months, the great probability is that the child would not be born alive"—Barriman Cox.
From birth till 1 year of life	• Baby is called infant and killing of such a baby is infanticide. (In India, due to non-existence of Infanticide Act, the crime is considered as murder).
5 years	• Custody of minor who has not completed the age of 5 years shall ordinarily rest with the mother.

7–12 years	• A child below 7 years of age is exempted from criminal liability because he is incapable of having a criminal intent (82 IPC). • A child above 7 years and below 12 years may/may not be held guilty depending upon presence/ absence of maturity and understanding (83 IPC). • A child under 12 years cannot give valid consent to suffer any harm that may result from any act done in good faith for the benefit of the child [consent of guardian or the person having lawful charge of the child is required (89 IPC)]. • Consent given by a person who by reason of immaturity of age (i.e., a child below 12 years) is incapable of understanding nature and consequences of the act is not valid in the eyes of law (90 IPC). • Exposure and abandonment of a child below 12 years of age by the parent or the person having care of the child is punishable (317 IPC). • Kidnapping or abducting a child below 10 years of age with intention of robbing any moveable property from the person/body of such a child is punishable (369 IPC).
14 years	• A child less than 14 years cannot be employed in a factory. • Between 14 and 15 years of age, a person can be engaged in non-hazardous factory jobs for a limited period during day hours.
15 years	• Above 15 years of age, one can be employed in a factory like an adult subject to the production of fitness certificate for the particular employment. • A police officer cannot compel attendance of a male person below 15 years (or any woman) at any place other than the place in which such male person (or woman) resides (160 CrPC). • A decree of divorce can be procured by the wife if her marriage (whether consummated or not) had been solemnised before she attained the age of 15 years, and she repudiates the marriage after attaining that age but before attaining the age of 18 years—Section 13(2) (IV) of HMA.
16 years	• Sexual intercourse with a girl below 16 years of age is termed as 'statutory rape', i.e, consenting age for sexual intercourse for a girl has been prescribed as 16 years and above (375 IPC).
Age	• Medicolegal circumstances/implications Kidnapping of a minor under 16 years of age (if male) and under 18 years (if female) is punishable (361 IPC). • Kidnapping or obtaining custody of a minor below 16 years (if male) and below 18 years (if female) and the maiming of a minor for employing him/her for begging are punishable (363-A IPC).
17 years	• A candidate seeking admission to MBBS course must complete the age of 17 years on or before 31st of December of the year of admission (MCI regulation on graduate medical education).

18 years	• Qualifying age for marriage has been prescribed as, "The bridegroom should have completed the age of 21 years and the bride, the age of 18 years"—Section 5(iii) HMA. • On completion of 18 years of age one becomes 'major'. • No pregnancy of a woman who has not attained the age of 18 years shall be terminated except with the consent of her guardian in writing—MTP Act Section 4(a). • A person under 18 years of age cannot give valid consent to suffer any harm that may result from an act not intended or not known to cause death or grievous hurt, e.g. consent for an operation. • Abetment of suicide of a child below 18 years of age is punishable to the extent of life imprisonment or imprisonment up to 10 years and fine. • Inducing a minor girl under 18 years of age to go to any place, or to do any act, with the intention or knowledge that such minor may be forced or seduced to have illicit intercourse with another person is punishable under 366-A of IPC. • A person (boy or a girl) who has not completed 18 years of age is a juvenile and in case of any offense, Juvenile Justice Board may advise or warn the juvenile, or to be released on probation for good conduct, or to pay fine, or to make an order directing the juvenile to be sent to reformatory/correctional school. • A person of and above 18 years of age can authorise the removal of organ from his/her body for therapeutic purposes [Transplantation of Human Organs Act, 1994; Section 2 (f)]. • A person of and above 18 years of age can exercise the right to cast vote. • A person of and above 18 years of age and having a sound disposing mind can make a 'valid will'. • No court shall take cognisance of an offence under Section 376 IPC where such offense consists of sexual intercourse by a man with his own wife, the wife being under 18 years of age, if more than 1 year has elapsed from the date of the commission of the offense—CrPC (Amendment) Act, 2008.
20 years	• A person selling, letting to hire, distributing, exhibiting or circulating obscene objects to any person under 20 years of age has been made punishable (293 IPC).
21 years	• Qualifying age for the marriage has been prescribed as, "The bride groom should have completed the age of 21 years and the bride, the age of 18 years"—Section 5(iii) HMA. • Procuring girl(s) from outside the country or from Jammu and Kashmir for illicit intercourse with another person is punishable under 366-B IPC. • For those under guardianship of court, one is not deemed to attain majority until completion of 21 years of age.
25 years	• Minimum age for contesting for the membership for the parliament or other legislative bodies. • Maximum age for entering into some government services.

35 years	• Minimum age for appointment as the President, Vice President of India and Governor of a State. • No prenatal diagnostic technique shall be used or conducted unless the age of pregnant woman is above 35 years—PC and PNDT Act Section 4(3)(i).
55–60 years	• Age for retirement from service under some government, statutory, or autonomous bodies.
60–70 years	• 60 years is the usual age of retirement for the Central Govt. employees. • A member of the District Forum can hold office for a term of 5 years or up to the age of 65 years, whichever is earlier. • A member of the State Commission can hold office for a term of 5 years or up to the age of 67 years, whichever is earlier. • A member of the National Commission can hold office for a term of 5 years or up to the age of 70 years, whichever is earlier. • MCI allows a medical teacher to work in a private institution till completion of 70 years of age.

Age	Medicolegal circumstances/implications
Approximate age— an important link to identification data	• When a person suddenly appears after many years (Bhowal Sanyasi Case) and claims to be the missing person. • When a dead body is produced as that of the missing person. • When a few days old child is alleged to be newborn, etc.
No age limit prescribed for deposing in the court	• Every person is competent to testify provided he is able to understand the questions put to him and giving rational answers to those questions (118 IEA). It may be worth mentioning that in the Mumbai Terror Attack, a girl of 10/11 years of age (who herself had received bullet injury in her leg) deposed in the court and her evidence was taken on record including identification of the accused.
No age limit	• "The possession of virility and procreative power neither requires to be nor can be proved to exist by
prescribed for	any physician, but is rather, like every other normal function, to be supposed to exist within usual limits
possession of virility	of age"—Casper.
and procreative power	

Determination of Sex from Physical/Morphological Features

Features		Male	Female
General built		Muscular, strong and stout	Less muscular, delicate and slender
Wearing apparels, ornaments, etc. Scalp hair Eyebrow hair Facial hair Pubic hair Adam's apple Shoulders Waist	Presumptive evidence of sex	Suggestive Short and coarse Coarse and thick Present Thicker, coarser, extends upward with apex at umbilicus Prominent Broader than hip Not well-defined	Suggestive Long and fine Fine and thin Absent Thinner, finer, does not extend upward, triangular in distribution with baseline at mons veneris Less prominent Hip broader Well-defined

Breasts		Not developed, nipples and	**Well-developed after puberty**
		areolae small	
Distribution of subcutaneous	Highly probable	—	**Present**
fat and vagina	evidence of sex		
Uterus		Absent	**Present**
Penis		Present	**Absent**
Ovaries, fallopian tubes and		Absent	**Present**
uterus, etc.	Certain evidence		
Scrotum with testes and	of sex	Present	**Absent**
prostate, seminal vesicle, etc.			

if present, their nonhuman shape may be more readily identifiable but in case of cylindrical segments of the central shaft, difficulty does arise in distinguishing. Burnt bone fragments offer similar problems. Here, the advice of the forensic anatomist and/or osteologist may be needed. Histological examination may be helpful in species differentiation or at least to exclude human origin. If the bones are too fragmentary to provide any anatomical data, then serological investigations are the answer. These depend upon species-specific proteins being extracted from the bone that can be tested against specific antisera prepared by immunising animals against a range of animal proteins. In the present scenario, DNA can identify human tissue, if not the alternative species. However, the bones that have no extrac. proteins (e.g., burnt or cremated bones and the bones that have been dead for some years) pose real problem. The duration for which the identifiable proteins persist is variable. However, DNA techniques may be more sensitive in such cases too.

The accuracy of determination of sex from the skeleton varies with the age of the subject, the degree of fragmentation of the bones and biological variability. Obvious sex differences do not become apparent until after puberty, though specialised measurements on the pelvis can indicate sex even in foetal material.

Features Diagnostic of Sex from Skeleton

Features	Male	Female
	SKULL	
General appearance	Larger, heavier, rugged, more marked muscular ridges	Smaller, lighter, smoother and less marked muscular impressions
Capacity	1500–1550 cc	1350–1400 cc
Frontal surface	Irregular and rough	Smoother
Glabella	Prominent	Less prominent
Supra-orbit ridge	Prominent	Less prominent
Frontonasal junction	Distinct angulation	Smoothly curved
Orbits	Squarish with roundish margins, set lower on face	Roundish with sharp margins, set higher on face
Frontal eminence	Less prominent	More prominent
Parietal eminence	Less prominent	More prominent
Occipital area	Muscular impressions and protuberance prominent	Muscular impressions and protuberance not prominent
Mastoid process	Medium to large, round, blunt	Small to medium, smooth, relatively pointed
Base	Sites of muscular insertions more marked	Less marked
Digastric groove	Deep	Shallow
Condylar facet	Long and narrow	Short and broad
Foramen magnum	Relatively large and long	Relatively small and round
Palate	Larger, tends to be U-shaped	Smaller, tends to be parabolic
	MANDIBLE	
General appearance	Larger, thicker	Smaller, thinner
Chin (symphysis menti)	Square or U-shaped	Rounded
Anatomical angle of body with the ramus	Less obtuse	More obtuse
Angle of mandible Condyles	Everted larger	Not so smaller
General appearance	Heavy, rough with prominent sites for muscular attachments	Light, comparatively smooth

Pre-auricular sulcus (attachment of anterior sacroiliac ligament lying just lateral to the sacroiliac joint)	Infrequent, when present it is narrow and shallow	**Frequently present, broad and deep**
Greater sciatic notch (Harrisons and Hrdlicka felt that the greater sciatic notch was one of the best determinants for sex, the latter claiming a 75% success rate using this criterion alone.)	Narrow and deep	**Broad and shallow**
Obturator foramen	Larger and oval	**Small and triangular**
Ileopectineal line	**Well-marked and rough**	**Rounded and smooth**

(Contd.)

STATURE

The third primary character for the identification of a person is the stature as outlined earlier. Stature or height of a person increases progressively and becomes maximum at the age between 21 and 25 years. Later, for every 25 years, it is short- ened by 2.5 cm due to thinning of intervertebral discs and some stooping posture as a result of decreased tone of muscles. Further, the height varies in the various hours of the day, being maximum in the morning and less by 1.5 to 2.00 cm in the evening due to reduction of elasticity of intervertebral discs. In a dead body, soon after death due to primary relaxation of the muscles, the body length may be more by 2–2.5 cm. Later, when rigor mortis develops, it may be shortened. With the passage of rigor mortis and onset of putrefaction, the length may change due to secondary relaxation.

Stature from a Dismembered Body Part

- When both side arms are outstretched in a straight line, the distance between the tips of the two middle fingers of the hands is approximately equal to the stature of the person.
- Stature is approximately equal to twice the length from vertex to symphysis pubis or equal to twice the length from symphysis pubis to one side heel, with the hip and knee extended and ankle dorsiflexed.

- Stature is about 3.3 times the length from the sternal notch to the symphysis pubis.
- Stature is about 3.7 times the distance between the tip of olecranon and tip of middle finger of the same side.

Stature from Bones

Stature is 2.5–4 cm more than the length of the whole skeleton (total thickness of the soft tissues in between the bones at different joints from heel to vertex is about 2.5–4 cm). When the whole skeleton is not available but one or the other long bones are available, anyone of the following formulae can be used to get the stature of a person (due consideration may be given to the racial or geographical origin, sex and condition of the bone).

- Karl Pearson's formula (1899): This formula was in use worldwide for a long period. It gives different calculating factors for bones from males and females of European subjects, depending on whether the bones are wet with intact cartilages or are dried and devoid of cartilage. For each long bone, there is a separate multiplying factor. A constant factor (different for each bone) is to be added to the product of the length of the bone with the multiplying factor 2.5–4 cm is to be added for the soft parts (. 3.14).
- Trotter and Glesser's formulae (1952, 1958): They succeeded in finding out more dependable formulae for determination of stature for males and females of White and Negro origins. They considered the lengths of the long bones separately and in combinations. The subjects of their study were between 28 and 30 years of age. Therefore, due consideration should be given while using their formulae for elderly subjects in whom there occurs some decrease in the stature. The formulae discovered by Trotter and Glesser were sui. for the people on whom and for whom these were worked out. As such these cannot be satisfactorily used for Indian subjects. Further, people from different regions of India bear different morphological features depending on their geographical distribution and primary racial characters. For this reason, a single formula cannot suit all parts of the country.

In taking measurements of the bones, their maximum lengths are to be considered. Use of Hepburn type osteometric board gives most accurate measurements. To get the maximum length of the bone, it is placed lengthwise in between the two vertical planes of the board. The maximum length of the bone is the distance between these two planes. For femur, overall maximum length from the head to the medial condyle is measured. For tibia, the maximum length from the lateral condyle to the tip of the medial malleolus is measured. For fibula, the length between tip of the head and tip of the lateral malleolus is measured. For radius, the greatest length from the medial margin of the head to the tip of the styloid process and for ulna, the length from the top of the head to the tip of the styloid process is measured. Wet or humid bones are slightly longer than the dry ones. While measuring humid bones, some authors have recommended deduction of 7 mm in case of femur, 5 mm in case of tibia, 5 mm in case of humerus and 3 mm in case of radius to bring the lengths of the bones at par with the lengths at their dried state. To maintain a uniform standard, some authors recommend use of right side bones only. However, the right side bones may not always be available. Therefore, to reach some authentic results, one should examine as many of these long bones as available and the average of all should be recorded as the estimated stature of the individual.

SECONDARY CHARACTERISTICS IN IDENTIFICATION

A number of secondary characteristics can be considered while identifying a person. These are as follows:

Facial Appearance

During life, the general expression of face can readily be altered and, therefore, mistakes can easily be made. After death, such alteration is, of course, impossible; but death so speedily alters facial appearance that too much reliance need not be made upon this mode of identification. Nearly every person might have seen another who is more or less like him, and occasionally this resemblance is so startling that it may become impossible to recognise the difference between the two people when seen apart. A remarkable example reported in literature is of two men, quite unrelated to each other, were in the same prison at the same time, bore the same name and had practically the same Bertillon measurements. All this serves to observe caution by sight recognition in criminal matters.

Personal Effects

It includes clothing, pocket contents, laundry marks, peculiar stitching/repair and jewellery, etc.

Clothing may be distinctive, and a detailed description may be obtained from the relative or someone who had last seen the deceased. Moreover, there may be clues in the clothing itself such as laundry mark, maker's tag or dyer's mark(s), etc. The clothes should better be examined under ultraviolet light so as to appreciate apparently invisible ink-marks.

Clothing may also provide a clue to the social status and occupation of the individual. Bullet holes/defects (with or without deposits of soot, powder grains, etc.), cuts or tire impressions may yield information regarding the cause and manner of death. Disarranged clothing, missing button(s), stains due to poison, vomit, faecal matter, blood, semen, saliva, etc. suggest nature of assault that can be helpful in further identification.

Pocket contents like papers, letters, keys, license/identity card, diary, passport, etc. often provide the initial evidence that usually leads to positive identification. In a series of exhumations of allied war crime victims following the Second World War, over one-third of the bodies were identified by laundry marks and personal effects; although in several cases efforts had been made to conceal the identity of the deceased.

However, caution may be exercised in accepting laundry marks as evidence of identity on small articles like handkerchiefs, etc., as these are easily transferred or misplaced.

Cigarette packages bear code symbols that indicate the date and place of manufacture. Watches frequently have private marks inside the cases made by the watch makers who have carried out repairs.

However, a person might have been clothed in borrowed garments or second-hand clothes and rarely, a body may be deliberately clothed in another's attire and documents/articles, etc. placed in the pockets in order to mislead the investigative agencies. All the pocket contents must be carefully recorded, preserved and handed over to the police in a sealed parcel.

Hair

Examination of hair is of considerable help in crime investigation, as it is one of the most decay-resistant identifying features, sometimes lasting for years in favourable circumstances. Hair is frequently found at the scene of crime or upon the victim and/or suspect as contact/trace evidence. It may also be found in the hand(s) of the victim and/or suspect in an assault; in cases of rape, pubic hair may be transferred from the assailant to the victim and vice versa. In hit-and-run accidents, some of the victim's hair may be found upon the vehicle involved in the accident. In chronic poisoning by metals, examination of hair provides essential data. However, it must be clear that examination of the hair is the province of the forensic biologist. In this context, the following basic information may be considered:

Nature (whether material is hair or some other fibre): Hair is an appendage of skin that grows from hair follicle. It has a root (bulb or knob), a shaft and a tip. The portion of the hair that lies in the follicle is known as the root. It is surrounded by the loose connective tissue known as root sheath. The root lies in the dermis. The shaft grows and projects out of the skin. Distal end of the shaft is known as tip. Hair consist of three zones: (i) cuticle, (ii) cortex and (iii) medulla.

The cuticle is outer covering of the shaft of the hair consisting of scales of keratin and forming a certain pattern. The scale pattern of different animals is characteristic and differs from that of human hair. In human hair, the scales are flattened. (Moritz described seven types of scale-pattern. Type I is the elongated variety of imbricate type. Type II is the serrated or dentate variety of the coronal type. Types III, IV and V are not much elongated and there is gradual decrease in vertical length in them. Type VI is the flattened variety with smooth free margin and Type VII is the flattened variety with serrated margins. Type VII is the human type.)

The cortex is the intermediate zone of varying thickness and forms the bulk of the thickness of the hair. The cortex consists of longitudinally placed non-nucleated elongated cells. Diffuse and/or granular pigmentation occurs in the cortex, which may be distributed all around the cortex or may be limited near the central or the peripheral zone, depending upon the species. In human beings, the pigment is usually distributed

near the periphery. The pigment may be present uniformly all along the length of the cortex or may be present in segments. In some animals, more than one pigment may be present in different segments of the cortex. The cortex contains abundant of keratin. This is responsible for the repulsive smell when the hair is burnt.

Hair may be artificially bleached by applying chemicals. Prolonged exposure to sunlight may partially bleach the hair. Malnutrition may discolour the hair to smoky red. However, such changes in the colour of the hair are temporary and when the cause is removed, the hair usually resumes its original colour. Bleaching of the hair can be done by treating it with alkalised hydrogen peroxide. However, the bleached hair is brittle, dry and straw-yellow. The bleaching colour will not be uniform, the roots are of different colour and the hair is rough, brittle and lustreless. The length of extra-follicular part of uncoloured zone may be used to determine the time of the colour last applied. Dyed hair shows characteristic fluorescence with ultraviolet light. With polarised light microscope, the undyed part appears much brighter than the rest.

As such, hair is resistant to ordinary mechanical deforming

forces. However, on application of moist heat or certain chemicals, hair can be softened to change the conuration from straight to curly or curly to straight.

The medulla is the central core of the shaft of the hair. The diameter of the medulla varies. In some varieties where the medulla is narrow, the space at some places may even be obliterated. Therefore, the medulla may be continuous, interrupted (obliterated intermittently for short distances) or fragmented (obliterated intermittently for greater lengths). It is also known as medullary canal or central shaft. Medullary index is the ratio of the diameter of medulla to the diameter of the shaft. The tip of the hair is usually tapering and non-medullated. In recently cut hair, the tip is sharp and flat. But when old, the cut end becomes smooth and roundish. The tip end of the hair gets split or frayed, if it is subjected to continuous friction as in case of axillary or pubic hair.

If the hair is singed, the affected part is swollen and appears bulbar due to gain in medullary space that gets occupied with trapped air and the gas produced by the burned keratin, and this may impart ballooning appearance to the affected part.

Differentiating Features of Human and Animal Hair

Age, Sex and Race from Hair

The lanugo hair on the shoulders appear around the fourth month and scalp hair around the fifth month in the foetus. The lanugo hair are fine, soft, downy, non-pigmented and with smooth flattened

Features	Human hair	Animal hair
Texture	Fine and thin	**Coarse and thick**
Cuticle	Scales are small, flattened (Moritz Type VII), serrated, and surround the shaft completely (coronal)	**Scales are large, polyhedral, wavy and do not surround the shaft completely (imbricate)**
Medulla	Narrow. May be absent, fragmented or discontinuous	**Broad. Always present, continuous and shows characteristic pattern**
Cortex	Thick, 4–10 times as broad as medulla	**Thin, rarely more than twice the breadth of medulla**
Medullary index	Less than 0.3	**More than 0.5**
Distribution	More towards the periphery of pigment	**Uniform, peripheral or central of cortex**
Precipitin test with root portion	**Specific for human**	**Specific for animal**

scales. The age sequence of appearance of pubic and axillary hair has already been given. With extreme variations, scalp hair start greying by 40 years, pubic by 50 years and body hair by about 60 years.

Sexing of the human hair is possible by studying sex chromatin from the hair root cells of the scalp. Barr bodies are demonstrable in hair follicle in a proportion of 29 ± 5% in females and 6 ± 2% in males. Male hair are generally thicker, coarser and darker. Female hair are generally fine, long and gently taper to an end. Blood grouping and other serological criteria can be determined from the hair root cells. The cells of the hair root can also be used for DNA-profiling.

Negro head hair are dark and have a spiral twist with a flattened, elliptical cross-section. Mongoloid hair are less pigmented and are straight with a cylindrical cross-section. Hair of white people are round or ovoid in cross-section. Though head hair in the white people are round to ovoid in section, eyebrow hair tend to be triangular and pubic hair flattened.

Situation/ Site of the Body

Hair from different parts of body sometimes present differentiating characteristics as given below:

- Scalp hair are long with a tapering end. They show more constant distribution of pigment than hair on other parts of the body. Periodical cropping shows well-pointed tips that become blunt and round about a week later. Presence of dye, oil, etc. is suggestive of scalp hair. On cross-section, scalp hair appear oval/circular in outline.

- Pubic and axillary hair are short and stout with unevenly distributed pigment. They are wary and curly due to varying diameter of shaft along its length. Axillary hair are more or less reddish/brown or bleached in appearance due to greasy sudorific secretion.

- Beard hair are coarse and curved. On cross-section, they are more oval and more flattened than scalp hair.

- Moustache hair are nearly triangular on cross-section.

- Limb hair taper from base to tip, have a granular medulla and usually form an arc.

- Hair from eyebrow, eyelid, nose or ear, etc. are short and stubby with a wide medulla.

Evidences about Crime

- If a female pubic hair is detected on the glans or the surrounding area of the suspect of a case of rape or if a male pubic hair is available on or near private parts of the victim of rape, then relationship between the crime, the suspect and the victim can be established by studying the sample hair recovered from the male or female. Similar is the position in cases of sodomy (pubic hair of the active agent and anal hair of the passive agent) and bestiality cases (pubic hair of the accused found near the anus or vagina of the animal and the animal hair on or near the private parts of the accused). In a case of mechanical assault, hair may be present in or on the weapon recovered from the accused that may be compared with the hair of the victim to establish relationship between the accused and the victim.

- A naturally fallen hair due to decay or disease will show distorted, shrunken and atrophied root. Sheath will usually be absent. In case of forcible extraction of hair, the sheath will get ruptured and the bulb will show irregularities on its surface.

- Occasionally, in the event of assault/homicide, some portion of the hair belonging to the assailant may be found firmly clutched in the hand(s) of the victim/deceased. It will be helpful in linking the victim and the accused.

- Careful search need to be made for any stain(s) present upon the hair. One should especially look for stains of mud/dirt, blood, semen, saliva, etc.

- In case of chronic poisoning by heavy metals (arsenic, antimony, mercury, lead, etc.), the hair retain traces of poison for a considerable period. Chemical examination of hair in such cases will reveal the presence of poison in the living as well as in the exhumed bodies. Hair must be plucked with roots intact and a minimum of 10–20 hair are desirable. The analysis of successive short lengths of hair from the base to the tip gives an idea of the metallic dosage or intermittent period of such administration. Examination of the hair proved Napoleon's death to be due to chronic arsenic poisoning.

- Hair may get scorched or singed due to burns or close-range firearm injuries. Singed hair are swollen, black, fragile, twisted/ curled/clubbed and has peculiar disagreeable odour due to burning of keratin. Carbon may be found deposited on them. The tip of the burnt/singed hair swells out to resemble a bulb in shape. Microscopically, the width of the singed hair is more than that of normal and it shows vacuolation.

Time Since Death from Hair

Hair cease to grow after death but due to shrinkage of skin, there is an apparent growth of hair on the face. The rate of growth of hair is about 0.4 mm per day. An approximate idea about the time since death may be obtained from this, if the time of last shave is known. Decomposition causes loosening of the hair in 48–72 hours after death in summer.

Case: Neutron Activation Analysis (NAA) of Hair The first murder case in which neutron activation analysis (so- called atomic evidence) played a decisive role was the one that occurred in 1958 wherein a 16-year-old girl named Gaetane Bouchard left home for shopping. As she did not come back till late evening, her father started calling her friends. A few mentioned the name of John Vollman, a 20-year-old saxo- phonist. Girl's father went to Vollman who denied having seen the girl recently. Then he informed the police. The police found the stabbed dead body of the girl in some dark ground outside the town. A pool of blood and tire prints were located some distance away. Two slivers of green paint were also noticed. Police interviewed Vollman. They checked his vehicle, which was in good condition except for some bare area beneath the passenger door where the paint was chipped off. The paint found at the crime scene matched finely with the paint of the Vollman's vehicle. Some half-eaten pieces of lipstick- stained chocolate were found in the vehicle (the girl had bought some chocolates from a particular shop a few hours before her death). The most clinching evidence came from a single hair found entwined in the dead girl's fingers. Hair from the girl and Vollman were compared through NAA for the trace elements present in them. Girl's hair showed

2.02 radiation in the sulphur to phosphorus proportion, while the sample hair from Vollman and the single hair recovered from the girl's fingers . This was enough to demonstrate that the single hair did not belong to the murdered girl. Scientists put the likelihood of two individuals having the same concentration of nine different elements at one in a million. With the advent of other techniques for identification, this method has fallen out of gear (Dr. AK Perkons, Director of the Toronto Laboratory, was able to solve a case almost about a century after its occurrence. Through NAA, he could demonstrate widely varying amounts of arsenic in the fingernails: at the tip of the nail 24.6 parts per million and at the base 76.7 parts per million. Assuming a nor- mal growth rate of 0.7 mm per week, Perkons concluded that the victim had received a massive amount of arsenic in the last two weeks of his life). [Derived from The Case Book of Forensic Detection (1996) by Colin Evans.]

Scar

A scar or cicatrix is a fibrous tissue covered by epithelium formed as a result of healing process of a wound. It is devoid of hair follicles, pigment and sweat glands. A known scar on a particular part of a person's body may help in identification, though multiple scars are more convincing. Scars being formed of fibrous tissue with less vascularity resist decomposition and as such can help in identification of grossly decomposed body. Probably, the best known instance of identification by scar is the Crippen case of 1910 in which much forensic controversy was generated over the distinction between a surgical scar and a skin crease on a piece of abdominal wall. In any injury where the dermis has been entered, healing occurs by organisation of blood clot and/or granulation tissue thereby resulting in formation of scar. Injuries involving only epidermis heal without any scar formation.

Examination of Scar

Scar must be examined under adequate lighting. The description should include number, site, size and shape, its particular location upon the body, fixed or free, smoothness or irregularity of the surface, colour and the presence/absence of glistening and tenderness. The condition of the ends (whether tapering or not) and the probable direction of original wound may be determined. The application of heat, filtered ultraviolet light or surface friction is helpful in making faint scars readily visible. A magnifying glass is very useful. Suspected scar in a dead body can be proved by microscopy by examining for the presence/absence of elastic tissue that is absent in a scar.

(Scar evidence of identity must be taken in conjunction with other points for identification, but where a scar/cicatrix is unusual or even unique in nature or position, its value gets greatly enhanced.)

Characters of Scar

- A scar generally assumes the shape of the wound causing it. A scar resulting from an incised wound (which has healed by primary union) is usually linear and straight. However, a scar following an incised wound of axilla or upon the genitals may be irregular on account of loose folds of the skin and may also be smaller than the original wound.
- Lacerated wounds result in broad and irregular scars.
- Suppurated wounds also produce irregular and large scars, which are attached to the deeper tissues.
- In a case of stab wound, depending upon the shape of the blade of the weapon, scar may be elliptical, oval or irregularly shaped.
- Large irregular scars accompanied often by keloid patches result from extensive burns and scalds.
- Scars resulting from bullet wounds are generally irregular, depressed and adherent to the underlying tissues. (Occasionally, bullet-wound scar may become matter of controversy as happened in 1989 over the identity of Nazi war prisoner Rudolf Hess, who was alleged to have been an imposter because he had no scar from an old rifle bullet wound through the chest.)
- Vaccination scars are circular or oval, flat or slightly depressed.
- The old scars of wrist- or throat-slashing indicate previous

attempts at suicide.

- Scar causing permanent disuration of head or face amounts to grievous hurt.
- Scar causing contracture at or around a joint restricting the movements or functions of the joint amounts to grievous hurt.
- Scar over cornea amounts to grievous hurt by way of causing permanent (total or partial) loss of vision.
- Scars at cubital fossa or dorsum of hand may indicate drug addiction.
- Striae gravidarum indicate past or present pregnancy.

Age of the Scar

It is difficult to assess the exact age of a scar as it will vary according to the nature, size and position of the wound, the presence or absence of sepsis, the method of healing and the vascularity of the part. The latter factor is influenced by age, physical status and pathological conditions of the blood vessels. Therefore, a medical witness must be careful in answering this question. The age of the scar becomes materially important towards ascertaining the time elapsed since infliction/ sustaining of injury in an assault or otherwise. A rough idea about the age of the scar may be gathered from the following:

- An uninfected superficial cut (as for example, a shave-cut) usually heals with formation of a scar by 5th or 6th day. In case of clean aseptic wound as produced by a surgical knife and heals by first intention, the scar usually appears in a fortnight while in a suppurating wound, it may take from 2 weeks to 3 months or more.
- Freshly formed scar appears reddish or bluish but is tender and soft. The age of such a scar is up to a couple of weeks.
- As the vascularity diminishes, the scar becomes pale but is still tender and soft. The age is up to a couple of months.
- With age, the scar contracts but still little tender and soft. The age is between 2 and 6 months.
- As the scar further contracts, it becomes tough, white and

glistening. The age probably is not less than 6 months to an indefinite number of years.

Erasure/ Disappearance of Scar

- Scars resulting from wounds or skin diseases involving whole thickness of skin are always permanent, but superficial linear scars involving epidermis may disappear in a few years.
- A scar may be removed by plastic surgery or its shape and size may be altered by surgical operation.
- Tattooing and infliction of incisions on the scarred area to efface it can sometimes be practiced.

Tattoo Marks

The word 'tattoo' comes from the Polynesian 'ta tau', meaning 'to mark'. Deliberate ornamentation of the skin by introducing pigments under the epidermis has been practiced in all parts of the world. Some races such as the Ibans of Sarawak may be tattooed over much of their body surface but many men and some women in most countries have localised tattoos that can be of considerable help in identification.

Tattoo marks are the designs effected by multiple small puncture wounds made through the skin with needles or similar penetrating tools dipped in colouring matter (dye). Permanency of the tattoo marks depends upon the type of dye used, its depth of penetration and the part of the body tattooed (.. 3.6). Commonly used dyes are indigo, cobalt, finely divided carbon, China ink, cinnabar, vermilion, cadmium selenide and Prussian blue, etc. Unusual substances such as soot or gunpowder have also been used. Colours such as blue, green or red may be scavenged by the tissue cells and leached into the lymphatic system after a number of years or even decades. Black pigments (usually carbon particles in the form of Indian ink) are so resistant as to be virtually life-long, though some may be transported into the regional lymph nodes.

The optimum depth of penetration is up to superficial layers of dermis. If the dye is deposited in the epidermis, it will slowly become fainter and disappear in due course of time due to wear and tear of superficial epithelium. If the dye is deposited into deeper layers of dermis, it will be removed by phagocytes. A tattoo disappears early from the parts of the body subjected to constant friction and remains for a longer period over the parts of the body protected by clothing.

The patterns are so diverse as to defy classification.

Varieties of patterns reflecting personal details, religious beliefs and sexual fantasies are available. Designs of all sorts varying from initials to Gods of worship and even those indicating emblems of moral depravity may be encountered. In the notorious German Concentration Camp at Auschwitz, prisoners had their prison numbers tattooed upon their arms. The blue bird design on the back of hand between basis of the thumb and forefingers is commonly used by homosexuals. Some persons have their blood group/social security number/ date of birth/date of marriage, etc. tattooed on them.

Natural Disappearance of Tattoo Mark

If the pigment has been deposited just below the epidermis, it will slowly become fainter and certain pigments such as vermilion, cinnabar and ultramarine may eventually disappear after a minimum of ten years. However, even when the less persistent dyes have disappeared from the skin, they may be demonstrable in the regional lymph glands.

The marks are indelible if pigments such as Indian ink, gunpowder or powdered charcoal have been used and have penetrated deep into the fibro-elastic tissue of the skin. Such marks may be recognised even in the decomposed body after the skin has peeled off.

Revealing Latent Tattoo Mark

A faded tattoo mark may be revealed by the use of ultraviolet light or may be rendered visible by rubbing the part and examining it with a magnifying glass in strong light. As already stated, even when the tattoo marks have disappeared from the skin, evidence of this may be obtained at autopsy by examining the regional lymph glands.

Artificial Removal or Alteration of Tattoo Mark

A tattoo mark may be altered or eliminated or a second one may be superimposed in an attempt to conceal identity. The design may be altered by over-tattooing with titanium oxide (a white pigment) causing reduction in intensity of the original colour. Various methods/devices that may be employed for removal of tattoo marks include the following:

- Surgical removal and skin grafting
- Electrolysis that releases and dissolves the pigments to be washed out
- Applying carbon dioxide snow
- By derm-abrasion
- Application of caustic substances
- Exposure to laser beam, etc.

Medicolegal Importance of Tattoo Marks

- The tattoo mark could be helpful in giving clue towards identity in the form of race, religion, nationality, occupation, name of the person or of his beloved ones, date of birth, date of marriage, etc.
- The design could be of an idol, obscene figure, a flower, etc., representing the mental make-up, desire/inclination, etc.
- Tattooing at times may cause infection and keloid formation, etc.
- Drug addicts, especially intravenous drug users, may conceal the site of infection by a tattoo design.
- They may indicate behavioural characteristics—erotic tattoos of the sexual fanatic, blue bird design on the extensor surface of the web of the thumb in homosexuals.

One of the most remarkable cases of identification from tattoo marks is the so-called Sydney Shark Case: A man called James Smith disappeared on 8th April, 1935 and was never seen again. On 22nd April, a shark was caught off the beach at Coogee and was sold to an aquarium, where after 3 days, it vomited out a quantity of material including a human arm. The arm, which belonged to an adult male, was in a fairly good state of preservation. Medical evidence showed that the arm had been severed from a dead body by some sharp instrument. A tattoo design of 'two men boxing' was there on the forearm. Smith's wife and brother both definitely identified the arm as that of Smith and fingerprint experts were able to support the identification.

A couple of interesting cases have been reported in the newspapers. In one, the words 'yeh chor hai' were inscribed on the back of a jail inmate and the board of doctors who examined the inmate opined that the tattoo was branded in the past 2–3 days and scars were burn injuries. While the victim was complaining that 'the words' were inscribed on his back by the jail authorities, while the authorities were asserting that the victim was a drug addict and was trying to blackmail them. He may have got written the same on his back with the help of other inmates. In another case, which was reported during 1995–1996, the foreheads of some women had been branded with 'jebkatri'. Later, the marks were removed by plastic surgery and expenses were born by the Police Department and the State Government.

Occupational Stigmata

Occupational marks are characteristics that result from adaptation to work. Distinctive physical marks of occupation have decreased in incidence and importance. Victorian days of pen callosities in clerks and shoe maker's kyphosis have gone but many other occupations have their stigmata and may be of use at occasions. They may be recent and temporary and permanent or semipermanent.

Recent and temporary include paint spots on painters, grease on mechanics, flour on bakers and millers, dyes on dye- workers, etc. Microscopic examination of dust or debris on the clothing, in the pockets and trouser turnups, under the finger- nails and in the ear, nostrils, etc. is important in identification of unknown bodies. It may also show presence of a person at a particular place.

Permanent or semipermanent may include callosities on the outer side of the distal phalanx of the middle finger of the right hand of a clerk, thickening of the palmar skin in butchers, horny and rough hands in manual labourers, etc.

- Tailors may have marks of needle punctures on left index finger.
- Coal miners usually have multiple 'blue scars' (involuntary tattooing) caused by dust entering on the hands and face producing minute lacerations.
- Workers in the chemicals and photography usually have discoloured distorted fingernails.
- Carpenters may have callosities on the thumb and index finger.
- Bricklayers have flattening of the thumb and index finger of the left hand due to constant picking up of bricks.
- Steel workers and foundry men may have tiny burn scars on exposed areas from the spattering of the hot metal.

Congenital malformations such as supernumerary or webbed fingers/toes, hare-lip, cleft-lip, cleft-palate, dental peculiarities, birth marks, moles, etc. may help in identification to some extent. Some of these may be remedied by proper treatment. If, however, wounding or loss of tissue is involved in the remedying of the malformation, the resulting scar will testify to the possibility of its presence in the past. While noting birth marks or moles as identification marks, full description as to their site, size, shape, colour and other characteristics such as raised or flat, hairy/non-hairy, etc. should be noticed.

Race, Religion and Nationality

The question of determining race may assume importance in cases of mass disasters when fatalities occur simultaneously in persons of different races travelling together as in case of rail- way accidents, air crash, etc.

Race

Race can be determined from the following:

Clothing Traditional Indian dress is different from traditional Western dress although tendency of wearing Western dress by the Indian people is being noticed increasingly. Even within India, people can be identified of their place of origin from the nature and manner of wearing clothing.

Complexion The skin is black in Negroes, brown in Indians and fair in Europeans. Decomposition readily produces changes in the external appearance. This is therefore of limited value.

Eyes Indians have dark or brown iris. Europeans have blue or grey iris. Variations in colour, however, are common.

Hair Colour, length, appearance and arrangement of hair may be helpful in determining race. The hair of the Indians are generally black, long and fine; of Negroes wooly, short and curly; and of Europeans fair, light brown or reddish. Mongolian hair is coarse and dark and usually circular on cross-section and has a dense uniform pigmentation and dark medulla.

Religion

Hindus and Mohammedans form the largest proportion of the population of India. Traditionally speaking, certain external peculiarities of dress and religious markings may serve to distinguish them. Hindu males are normally not circumcised. Sacred thread, necklace of wooden beads and religious marks on the forehead, if present, are helpful. Hindu females generally put on saris and apply vermilion on their head. They may have a nose ring in the left ala of the nose. Mohammedan males are normally circumcised. They may have marks of corns and callosities on lateral aspects of knees and feet due to their attitude during prayer. Mohammedan females normally put on trousers and have no vermilion mark on their head. The nose ring is usually in the septum.

Case: Peculiar clothing and ornaments helping towards identification (alleged abduction with murder): On 21st November, 1998, an FIR was lodged in the police station by the husband of the deceased that about a couple of months back his wife had gone with some persons but never returned home. Initially he tried to locate her but when all efforts went futile, he approached the police when a rickshaw-puller, while sitting at a session of drinking, disclosed that she had been taken by some persons to a place near Sukhna bridge. The police registered a case under Section 365 IPC and took one suspect under custody. The suspect on interrogation allegedly revealed that they had killed the lady by strangulating her. Remains were discovered from the bushes alongside the Sukhna bridge as per disclosure and were presented for post- mortem examination. The degree of putrefaction had reached skeletonisation except some intact portion of thoracic and abdominal walls on the posterior aspect. This, possibly, was due to posture of the body that was having its back towards the upper side and face downwards and almost completely covered by the bushes. The peculiar features of the case, which travelled a long way in ascertaining identity of the deceased, were:

- Atypical clothing, namely one short shirt with sleeves, collar and two pockets. (One pocket on the left side of front-flap and other on the right side in line with the axillary seam from which a key was recovered.) The flaps for the arms were in a folded position up to some distance near the terminal portion, possibly suggesting that she had been taken by the suspects while she was at work. (The husband revealed that she had been taken by the suspects while she was selling vegetables as usual.) The second was the sari (dhoti) of multicolour and the third was a petticoat of purple colour.

- A 'mangal sootra', discovered from the space between the skull and middle portion of the remains. It was in the form of a double black strong thread carrying a boat-shaped metallic ornament, appearing to be of gold. This is something that is usually worn by women in Uttar Pradesh (UP) and is vernacularly called as 'Jaun dana'. The deceased belonged to UP and the suspects plus the rickshaw-puller also belonged to UP.

COMPARATIVE DATA/ TECHNIQUES FOR IDENTIFICATION

Dental Patterns and Restorations

Historically, the earliest recorded case of dental identification dates back to the fifteenth century. A classic in the history of forensic odontology was the Parkman Webster Case in 1849. Professor Webster of the Harvard Medical School murdered his friend Dr. Parkman and incinerated the body. Charred jaw bones and dental structures retrieved from Webster's laboratory furnace were identified by Parkman's dentist as being those of the murdered man. He recognised the artificial teeth, taken from the furnace, by certain peculiarities and also by their fitting the original plate and moulds. The gold plates attached to them had been melted but the greater part of this gold was recovered and the artificial teeth to which the gold plates had been fastened had acquired pink colour showing that they had been submitted to a high temperature. The testimony of the dentist led to conviction.

Fingerprints and dental means represent the most scientifically reliable methods of identification. On exposure to physical injury and putrefactive change, the human dentition (the enamel of which is the hardest part of the body) outlasts all other tissues. The preservation of teeth in ancient human relics buried for centuries attests to this fact. The adult dentition is comprised of 32 teeth, each tooth possesses five surfaces. The innumerable combinations of missing teeth, filling materials, carious lesions and prostheses involving these 160 surfaces form the basis for dental identification. Specific morphological patterns of individual restorations further enhance the characterisation. Considering additional identifying features incorporated within root canals, periapical, and surrounding bone and soft tissues, it may be realised how specific the oral structures can be in terms of identification. The concept that no two dentitions are alike is the basic premise of dental identification.

The fundamental principles of dental identification are those of comparison (when the antemortem records of the proposed deceased are available) and exclusion (when antemortem records of other persons only are available). Unfortunately, all too often dentists maintain poor records, resulting in inconsistencies and thereby restricting the utility of this method. In terms of probability, the more the dental work performed in a given individual, the greater the number of surfaces altered and hence, the higher the available points of comparison. However, occasionally even a single filling, if specific enough in location, morphology and material, may be sufficient to establish identity.

Carr et al. in 1986 reported a case in which Scanning Electron Microscope (SEM) was used to confirm dentition in recovered remains from the burned wreckage of a gasoline truck involved in a transportation mishap. Identification of the specimens as dentition was based on the presence of dentinal tubules. The investigators noted that in addition to dentinal tubules, SEM provided evidence of tool marks and other defects. Use of SEM with energy dispersive X-ray (EDX) could also provide evidence of a particular type of dental material. Fairgrieve in 1994 reported a similar case involving SEM on incinerated teeth to evaluate parallel striations in tooth enamel and dentin as evidence of previous dental restorations.

Forensic odontology may be considered as an art and sci- ence of dental medicine as applicable in resolving issues per- taining to the law. It is a discipline in itself and requires special knowledge and experience in dentistry. It is therefore impera- tive that problems relating to teeth and jaws be referred to Forensic Odontologist at the earliest. The assistance that den- tistry can render may be considered under two headings:

(i) Identification, which can further be studied under two cat- egories, i.e.

(a) general or reconstructive identity, which attempts to clas- sify the unknown person by age, sex, race, occupation/ habit, etc. and

(b) comparative methods that indicate or exclude the per- son against antemortem dental records. These aspects have already been dealt adequately in this chapter.

(ii) Bite mark evidence, interpretation of which is the job of the expert, and the autopsy surgeon should not attempt to replace or dispense with a good odontological opinion.

Circumstances where such evidence may be encountered may include the following:

- In violent crimes, such marks may be encountered where the attacker may bite the victim or the victim biting the attacker during defensive responses (in sexual offence cases, common sites for such bites being face, breasts, abdomen, thighs, pubis, shoulders, etc. Differentiation from the so-called 'love bites' must be carefully carried out because such bites may be a part of the accep. sexual intercourse).

- In child abuse cases, bite marks may be present in any area of the body. However common sites being the arms, hands, cheeks, buttocks, trunk and shoulders. It becomes vital to determine whether it is of a size consistent with adult dentition, or whether it is small enough to have come from another child or is of different shape, indicative of an animal.

- Bites may also be inflicted/suffered during sporting events and during other assaults when the victim manages to bite the assailant.

- Some bite marks may be self-inflicted or self-suffered to fabricate injuries for a variety of motives.

- Bites may be encountered on an inanimate object like food stuffs or fruits, etc., left at the scene. This is mainly within the province of forensic scientists where dental evidence is used to identify the perpetrators of a crime who happen to have left their teeth marks on the substance left at the scene.

Nature of Bite Mark

Teeth, acting as tools, leave marks that carry class characteristics (such as the type of tooth that inflicted the bite, for exam- ple, incisor, cuspid, etc.) and individual characteristics (such as rotations, fractures, or missing or extra teeth and size relation- ships of the bite marks, etc.). A human bite mark may present only a small part of the dental arcade, caused by the front teeth from canine to canine, with an almost invariable gap at either side representing separation of jaws. It may be near circular or a shallow oval. Sometimes, teeth may cause separate marks or they may run into each other to form a continuous or intermit- tently interrupted line. Occasionally, the bite may be in a more linear fashion, especially when the upper incisors are scraped down the skin causing a series of parallel tracks. The clarity of marks depends upon factors like:

- whether the contour of the surface/part is irregular or curved, receiving proportionate part of the bite;
- degree of application of force during biting;
- whether one or more operations have been inflicted;
- the fact of missing teeth or grossly displaced teeth or substantially damaged teeth imparting peculiar architecture/ pattern to the mark that may suggest a match with someone or altogether exclude/eliminate a person; and
- age of the bite, i.e. healing/aging of the bite will leave progressively less details (ultraviolet or infrared light can be helpful in the visualisation of suspected healed skin injuries. These light sources can penetrate the skin surface and bet- ter document the bite or patterned skin mark evidence photographically. It may be added here that photographing bite mark evidence needs a skilled hand and it is advocated that photographs need to be taken from different angles, but especially from directly perpendicular viewpoint with an accurate scale lying adjacent to the lesion).

Medicolegal Considerations

The basic concept of forensic odontology centres around the recognition and comparison of dental patterns. The investiga- tor's knowledge of testing methodologies and experience con- tribute to successful evidence evaluation and assessment. There may often be a query as to the number of points of concordance necessary to render an authentic decision on a dental identification. However, this need not be pursued unduly, as there have been cases where singular feature was peculiar enough to point strongly towards identification. In addition, when all of the points of concordance are considered as a set of aggregate data, "positive identification within rea- sonable scientific certainty is quite often achieved".

Further, one can also go for taking swabs/washings from the bite area to recover saliva. This can be important in helping to identify or exclude the assailant, if he/she is one of the 80% of people who are 'secretors', i.e. who exude their blood group substances in saliva. For this purpose, plain cotton-wool swabs may be gently rubbed onto the bite as such or after moistening with distilled water or saline. In the present scenario, this can also be a source of DNA for analysis and comparison with a suspect.

Presently, the following categories are being forwarded by the experts for use in communicating the results of a forensic odontological identification.

- Positive identification: Where antemortem and postmortem data match in sufficient detail to establish that they are from the same individual.

- Possible identification: Where the antemortem and post-mortem data have consistent features. However, due to some infirmities in the quality of either the postmortem remains or the antemortem evidence, it is not possible to go in for positive identification.

- Insufficient evidence: Where the available information is insufficient to constitute the basis for a conclusion.

- Exclusion: Where the antemortem and postmortem data are clearly inconsistent.

A couple of cases are being cited where dental evidence went a long way in establishing identity.

Baptist Church Cellar Case: In July 1942, some workmen while demolishing a Baptist church in the Vauxhall district of London found a partly dismembered body lying under a cellar floor. It was thought that the body had been lying there for 12–18 months. Lime had been strewn over the body, preserv- ing a fracture of the larynx that suggested death due to stran- gulation. Parts of arms, legs and lower jaw were missing. A minute fragment of scalp with some hair lying stuck to the back of the head was also available. A wartime fire-watcher, named Dobkin, was suspected since he was the only person with access to the cellar in question. About 15 months earlier his wife had disappeared after attempting to obtain arrears of maintenance from him. Four days after her disappearance, a fire had been seen in the said place by two passing consta- bles.) Examination had revealed that the remains were those of a woman aged 40–50 years, 5 ft. 1 inch in height, and the womb/uterus showed presence of a fibroid (Mrs. Dobkin was 49 years old and 5 ft. 1 inch in height. Interestingly, records of two London

Hospitals showed that she was carrying a 'fibroid' and had refused operation). The dental surgeon who had attended on her was traced and comparison of features of upper jaw with the available antemortem records showed con- sistency as regards number and position of teeth, the situation of filling, marks of fittings of denture, the remains of root, etc. The dental surgeon later identified the skull saying: "That is Mrs. Dobkin's jaw and those are my fillings".

Fiery Crash—Identification through dental records thereof: Two white males speeding on a highway met a fiery crash. Gathering clue from the registration of the vehicle, owner/driver was tentatively identified. The other passenger remained to be identified. Witnesses gave some indication about that passenger. Dental records were requested from the dentists of the victims. The identity of the driver was estab- lished beyond doubt through comparisons. However, the den- tal records of the other passenger did not match. Further investigations revealed that this victim had loaned his Medical Card to a friend so that the friend could receive dental treat- ment at no charge. Ultimately, another set of dental records was located that did indeed match the passenger victim. (Derived from 'Legal Medicine', 6th Ed., by American College of Legal Medicine).

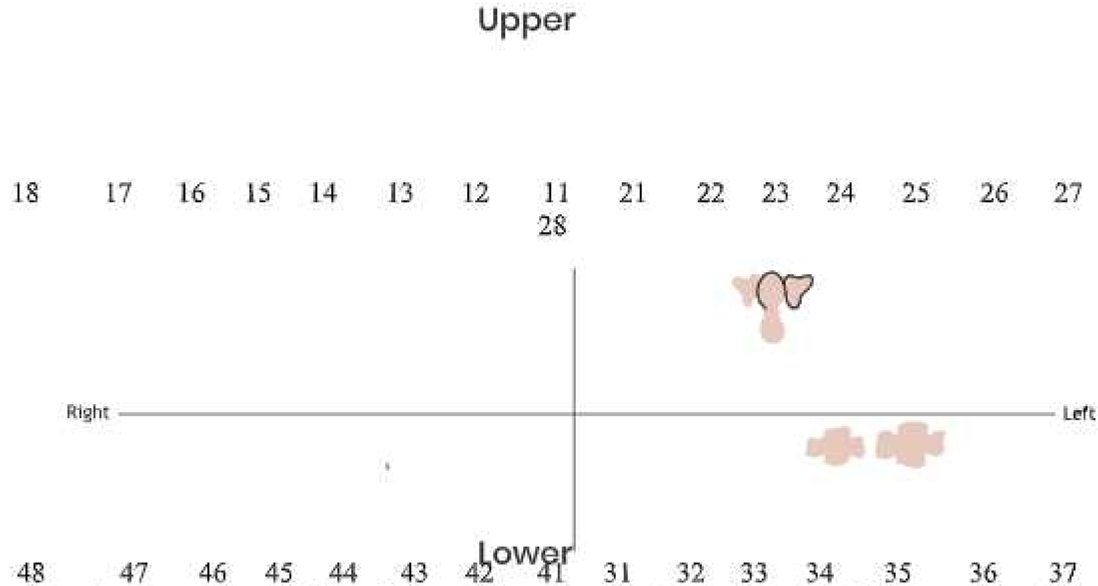
Dental Charting

There are a host of different methods of charting the contents of the jaws. However, any careful record of the number, position and state of the teeth can be useful at a later stage. All systems have a notation describing the position of the teeth almost always in four quadrants: right upper, left upper, right lower and left lower . Unfortunately, there is considerable variation in the sequence of numeration in various systems. However, a good graphic representation can always be turned

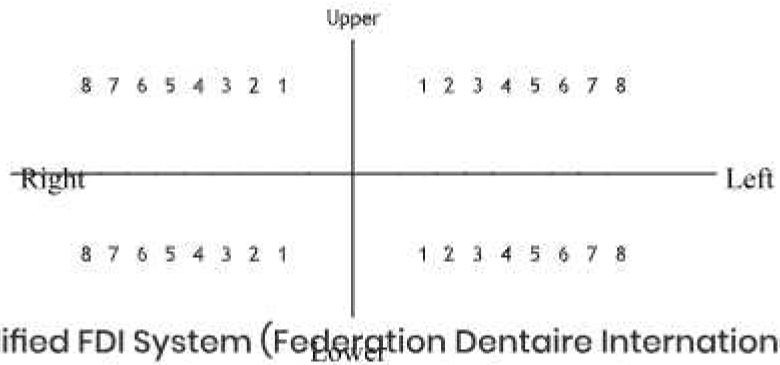
into any system, when required at a later stage. The following features need to be recorded on the chart:

- Extractions (recent or old)
- Fillings—their number, composition and position
- Artificial teeth—metal to be mentioned, if discernible

- Other prosthetic work such as bridge-work or braces
- Broken teeth
- Crowned teeth
- Pathological conditions, if any
- Congenital defects like enamel pearls, Carabelli cusps, etc.
- Malpositioned teeth



'Odontogram' designed for Interpol. The chart displays each surface of each tooth, including the deciduous teeth.



Modified FDI System (Federation Dentaire Internationale) or Modified International System of numbering teeth.

- Racial pointers like shovel-shaped upper central incisors or multicusped molars
- General condition of care and hygiene.

Dactylography (Dermatoglyphics/

Galton System/ Fingerprint Study, etc.)

History

Dactylography is the process of taking impressions of the pulp of fingers and thumbs on an unglazed white paper and exam- ining them with a magnifying lens. The system was discovered by Sir William J Herschel, ICS, who introduced it in Hoogly District of Bengal in 1877. It was systematised in 1892 by Sir Francis Galton, an English anthropologist, whose name it bears. It was further elaborated and improved by Sir Edward Henry of Scotland Yard. It is, therefore, also known as the Henry–Galton system of identification. The first recorded instance of a fingerprint having been used to prove the identity of a murderer was in Argentine in 1892 (the case of Francesca Rojas). In Great Britain, the first case was R vs. Stratton.

Principle

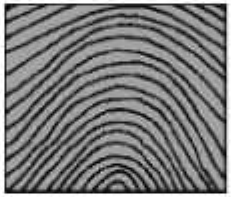
It is based on the principle that skin of the balls of the fingers and thumbs is covered with characteristic ridges, the arrange- ment and distribution of which remains constant and persists throughout life and that the patterns of no two hands resemble each other. Even the fingerprints of the twins are not similar. It has been estimated that the chances of two persons having identical fingerprints is about one in sixty four thousand mil- lions. (Quetelet's rule that every nature-made object shows infi- nite variations of forms, and in the world's crime records no two identical fingerprint patterns have been reported.)

Primarily, there are four types of ridge patterns. According to the percentage of their distribution, these are as follows (..3.8):

Loop – about 65%

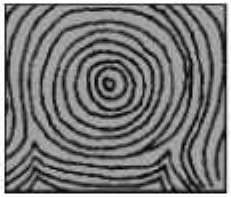
Classification

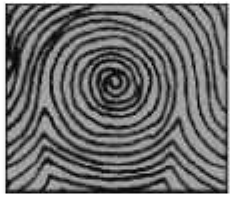
A B



Arch Loop

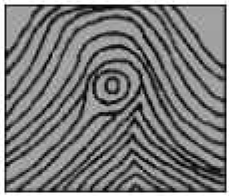
C1 C2

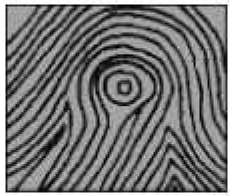




Whorl Whorl

D1 D2



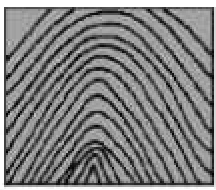


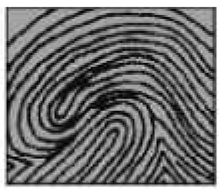
Pocket loop

E F

Tented arch Composite

Core Delta





Whorl– about 25%

Arch – about 7% Composite – about 2–3%

A considerable amount of finer details of branching and sub-branching and coalescence of ridges, island, core and delta arrangements permitting sub-grouping and an unlimited quantity of extremely fine pore details makes the system absolutely peculiar towards identification.

Recording of Fingerprints

Dactylography is a progressing science and new methods for the recording, lifting and developing of prints under different field conditions, including those from the decomposed body, appear regularly. For recording fingerprints, hands are washed, cleaned and dried to ensure clear prints. The print is taken by using printer's ink on an unglazed white paper. A plain impression is obtained by gently pressing the inked surface of the tip of the finger or thumb on the paper while a rolled impression is taken by rolling the inked finger or thumb from side to side. A rolled impression recording the complete pattern of the whole ball of the finger or thumb is much more complete and desirable than a plain one, which is only partial. In case of criminals, impressions of all the digits of both the hands are taken and preserved by the police for future identification. [Under the Identification of Prisoners Act, the police are legally authorised to take the measurements, finger impressions, footprints and photographs of persons convicted or arrested due to some crime. Also, Section 73 of the IEA empowers a court to direct any person including an accused, to allow his finger impressions to be taken and the Supreme Court has held that being compelled to give finger or thumbprints does not violate the constitutional safeguards under Article 20(3).] However, it is customary to take usually the left thumb impression of an illiterate person in lieu of signature on legal and other documents. In practice, 16–20 points of fine comparison are accepted as proof of identity.

In a dead body, if the fingertips are dried up, the prints can be taken after soaking the fingers in an alkaline solution for sometime. If the skin has peeled off as a result of putrefac- tion, burns or drowning, etc., the prints can still be recorded either from the dermis or from the peeled-off skin hardened by formalin.

Advantages

The practical applications of this method include the following:

- Recognition of chance impression left at a scene of crime.
- Criminals often leave their fingerprints at the site of crime, unknowingly or unconsciously, which, though not appar- ently visible, can subsequently be developed and studied successfully.
- As stated earlier, they can be taken even from a decom- posed body, either from the peeled-off epidermis of the fingers or from the dermis when the epidermis is lost.
- To apprehend internationally operating criminals, details of fingerprints can be sent from one country to another by telecommunication.
- Prevention of impersonation.
- As an extra precaution on cheques, bank notes and other legal documents that may bear a fingerprint in addition to manual signature.
- In case of unknown dead bodies, skin from finger tips should be removed and preserved in 10% formalin and handed over to police in a sealed packet for onward trans- mission for evaluation.
- As with fingerprints, the skin pattern of palms, soles and even lips, are said to be unique and have been used in identification, but again, this is the job of the concerned expert.

Removal or Alteration of Fingerprints

Criminals sometimes attempt to mutilate the fingerprint pat- tern by inflicting injuries such as wounds or burns on the bulb of their fingers or thumbs, but there still may exist definite delineation unless the true skin is destroyed. However, it has been reported that by derm- abrasion, identification by finger- prints can be circumvented. According to TJ David et al. in coeliac disease, the fingerprints may be temporarily modified or obliterated. Ridge alteration usually occurs in eczema, acan- thosis nigricans, scleroderma and dry or atrophic skin. Permanent impairment of fingerprint pattern can occur in lep- rosy, electrical injury and after exposure to radiation. In rickets and acromegaly, though the pattern is not altered, distances between the ridges can be changed.

Superimposition Technique for Identification

Where potential candidate(s) for the identity is/are in the knowledge of the investigating agencies and the photographs taken during life are available, photo superimposition tech- nique may be carried out for identification. In this method, photographs of the skull are taken in exactly the same orienta- tion as the available life-time photograph of the missing person. Transparency (negative) of the skull photograph and the trans- parency of the life-time photograph are focused on the same sensitive printing paper. The focussing is so adjusted that dif- ferent anatomical landmarks of the face (from both the trans- parencies) should have maximum alignment, after giving due consideration to the thickness of the soft tissues in the trans- parency of the life-time photograph. (It is presumed that inter-pupillary distance is always the same in all directions.) Then, from the positive print thus obtained that now possesses shadows of the outer surface of the face (from the transparency of life- time photograph) and skull bone (from the transparency of skull), attempt is made to study the matching, non-matching of major anatomical landmarks, which include (i) eyes within the orbit with two pairs of canthuses properly aligned; (ii) the nasion; (iii) the prosthion in the central line; (iv) the nasal spine in the centre that is little above the tip of the nose; (v) the lower border of the nose; (vi) the lower border of upper jaw; (vii) the zygoma below the eyes; (viii) supra-orbital ridges; (ix) angle of the jaw; (x) external auditory meatus; and (xi) the teeth.

The test mainly carries exclusory value in that, if the match- ing cannot be made then the skull is not that of the person in the photograph. If the match is good (or even excellent), then it can at best be said that the skull could be that of the person in the photograph.

A more modern variant of the photo superimposition tech- nique is with the use of video cameras, where two images— one of photograph and other of skull—are mixed on one video display unit. By altering the camera angles and the degree of magnification of the images, superimposition can be tested quickly without the need for laborious photographic process- ing. This method was used in 1994 to identify a number of the 12 victims of the notorious 'House of Horror' in Gloucester.

Reconstruction of Facial Contour from the Skull

The method depends upon a pre-knowledge of the usual tissue thickness at various points on the normal skull, which now has quite a large database. Modelling clay is laid on to the unknown skull in layers corresponding to these standard thicknesses and some more imaginative modelling added through the informa- tion obtained from the acquaintances. The obvious defects include lack of knowledge about the eyes, lips, nose, ears, head hair, etc., all of which contribute to the individualistic charac- teristics. Such information may be gathered from the persons who knew the suspect and then, facial curves, creases, shape of the chin, eyebrow, shape of the lips may be mapped out.

Similar methods have been used by the graphic artists who use their portraiture talents to create a face on the two-dimensional base provided by the skull profile plus knowledge of the tissue thickness at many anatomical points. The method was used with success in 1988 in the investigation of murder of Karen Price in Cardiff, skeletonised after being buried for 8 years in a carpet beneath a garden. A medical artist rebuilt her face on a skull with sufficient accuracy for its display on public television to be recognised by her parents.

Neutron Activation Analysis

This method is very helpful in identifying minute traces of ele- ments present in the hair, nail, drugs, soil, glass particles, gunshot residues, paints, etc. This will be helpful when comparison samples are available. It has been found that levels of trace elements in the body hair remain uniform in an individual, and this differs from person to person. This method is also helpful for detect- ing abnormal amounts of metallic elements in the hair even in a highly decomposed or in an exhumed body.

In this method, hair is bombarded with neutrons in a cyclo- tron and the emission of spectrum therefrom is analysed. The spectrum depends upon the mineral content of the hair, which varies from person to person and hence considered to be individualistic. However, the mineral constituents of the hair may vary depending upon the dietetic and environmental conditions. Moreover, there are not many institutions in India that can undertake this precision work.

Anthropometry (Bertillon System)

'Anthrops' means man and 'metron' means measure, i.e. it deals with the measurements of various parts of the human body. It is also called the Bertillon System or Bertillonage after the name of Alphoso Bertillon, a French Criminologist who introduced it in 1882. It is based on the principle that measurements of various parts of the body do not alter after adult age (21 years) and that no two persons show the same measurements in all respects. The system is, therefore, applicable to adults only.

It comprises of registration of characteristics of the individual under three heads: Descriptive Data such as colour of the hair, eyes, complexion, shape of nose, ears, chin, etc.; Body Marks such as birth marks, tattoo marks, scars; and Body Measurements, namely, the standing and sitting heights, length and breadth of the head, breadth of the face, length of right ear, the span of the outstretched arms, length of the left foot, length of the left middle finger, length of the left little finger, and the length of the left forearm and hand. The photographs of the full face and side profile are also taken.

Drawbacks of the system are following:

- Applicable to adults only.
- Personal factor in measurements introduces many errors.
- Requires delicate instruments and well-trained operators.
- Photographs in themselves not being reliable means of identification.

Hence, it has been replaced by fingerprint system and the only measurements still made as a routine are the height and weight.

Other Fortuitous Comparisons

Sometimes, identification can be effected by the presence of some previous disease or any surgical condition, and compar- ing the same with the findings available at autopsy or in the skeletal remains. Examples may include finding of gall stone/ kidney stone, horse-shoe shape kidney, uterine fibroids, etc. Surgical devices like peculiar wire-sutures; pacemakers (each pacemaker bears not only the manufacturer's name but also a model and serial number); bullet recovered from the body and compared with the bullet fired from the alleged weapon; protheses like implanted heart valves, hip or knee joints, plates in the skull and other devices may be used as a means of effecting identification.

Trace Evidence Comparisons

Edmond Locard, Head of the Institute of Criminalistics in the University of Lyon in France, coined in Manual of Police Techniques his 'theory of interchange' at the scene of crime (Locard, 1923, 1928, 1930). His postulation was proved when on his advice, three suspected persons linked with dealing with counterfeit coins were examined and found to carry in their garments the particles of the metals used in the counterfeit coins. The suspects were arrested and all confessed commission of the offence. Similarly, a foreign body (may be a portion of hair or piece of glass or traces of paint or of vegetation, etc.) may be found in/around the wound and/or upon the body/clothing of the victim that may provide important clue towards the circumstances. Such evidence is termed as 'trace evidence' (also see in the Chapter "Transportation Injuries").

Blood as Trace Evidence

Blood itself is an extremely important entity in the medicolegal practice, which alone or along with other trace evidences can play a clinching role to unfold different criminal problems. It is the task of the police to collect such evidence from the scene and of the autopsy surgeon to collect such evidence from the victim's body/clothing, etc., which may help the police in locat- ing matching materials from the suspect(s) in order to provide objective evidence of their presence at the scene. Following are the steps in the examination of blood/blood stains:

- Whether the stain is of blood or not.
- If of blood, whether human or of animal origin.
- If human, then one should try to find out
  - Age of the stain
  - Arterial or venous origin
  - Whether of antemortem/postmortem origin
  - Source of blood
  - Distribution pattern of the blood (.s. 3.9A–C)
  - Sexing of the stain
  - Blood group of the stain

Whether the Stain is of Blood or Not Benzidine test and phenolphthalein test (Kastle–Meyer test) are used to find out if a stain is of blood or not. These chemical tests are based upon the presence of enzyme peroxidase in the red blood cells. The action of the peroxidase is demonstrated with change in colour of the reagents used in the tests. Hydrogen peroxide is used in tests. This, when acted upon by the peroxidase, liber- ates oxygen that acts on the reagent that changes in colour (blue colour changes in case of benzidine test and pink colour changes in case of phenolphthalein test). Benzidine test is very sensitive (positive with 1 in 1000,000 dilution). But benzidine powder is a known carcinogen. The negative test is of more value as it rules out blood but the positive test suggests that further steps be taken to confirm the nature of the stain because vege. stains, salivary stains, pus, rust, etc. can also give positive reaction with this test. Phenolphthalein test is more specific for blood but comparatively less sensitive.

Confirmatory tests for blood include the following:

- Microscopic examination

- Microchemical tests, namely:
  - Haemochromogen crystal test (Takayama test).
  - Haemin crystal test (Teichmann test).
- Spectroscopic examination.

Microscopic examination: When frank blood is available, it can be examined as such under the microscope. In case of stain, the extract should be prepared. The stain may be scraped out with the help of a blunt pointed blade and dissolved in normal saline solution before examination. If the stain is on the cloth, the piece of cloth may be left overnight dipped in normal saline to get the stain extract. The stain extract thus obtained may be placed on the glass slide and covered with a cover-slip and observed under the microscope. Intact red blood cells confirm the stain to be of blood. Human red blood cells are circular, biconcave, non-nucleated and are of average diameter of 7 उm. All mammalian red blood cells are circular, biconcave and non-nucleated except that of camels. In fish, avians and amphibians, the red blood cells are oval, biconvex and nucleated.

Staining of the film of the extract with Leishman stain will provide added information about white blood cells also, which may help to know the sex of the origin of the blood by counting Davidson bodies in the polymorph cells.

Microchemical tests: Of both the tests named above under this head, haemochromogen crystal test (Takayama test) is more dependable but is comparatively more time con- suming. These tests are based on the property of haem (iron) part of the haemoglobin to form characteristic coloured crys- tals with certain reagents, and these crystals can be appreciated microscopically. (Pink feathery crystals of haemochromogen and dark brownish rhomboid-shaped crystals of haemin are diagnostic of blood.) False negative results may be obtained in both the tests (i) if the stain extract is contaminated with some chemical, (ii) if the stain is very old or decomposed or (iii) if the reagents are very old/defective.

Spectroscopic examination: It is more reliable both for the recent and old blood stains. Less than 0.1 mg blood is suf- ficient. The blood stain is dissolved in normal saline or dilute ammonia and is placed in a small glass test tube, which is then kept between the spectroscope and the source of light. The solution of blood has the property of absorbing some of the rays from the spectrum of light producing characteristic dark absorption bands that vary with the type of the blood pigment present.

Whether the Blood is of Human or Animal Origin This includes Serological Testing of the blood. Various methods in use are gel diffusion, antiglobulin consumption test, isoenzyme methods and precipitin electrophoresis.

Age of the Stain Colour and nature of the stain can help in ascertaining the age of the stain:

- Fresh stain on light-coloured cloth appears bright red, is moist and sticky.
- Turns reddish brown in 24 hours.
- More than 24 hours—it is dark brown and black on longer duration.

Source	Appearance
Stomach or gastric bleeding	Chocolate coloured due to presence of acid haematin and is acidic in reaction
Nasal bleeding	Blood mixed with nasal mucus and hair, etc.
Haemoptysis	Bright red (being oxygenated in the lungs) and frothy (due to some churning effect with the inspired and expired air). Reaction is alkaline
Menstrual blood	Dark coloured fluid blood with foul smell and often with endometrial debris. Acidic in reaction. Vaginal epithelial cells may be present
Abortion	Dark clotted blood. Endometrial and placental debris with some foetal remnants present

Whether Arterial or Venous Recently shed arterial blood is bright-red and venous blood is dark-red. Bleeding from arteries has a sprouting effect (jet like ejection/spurting), while bleeding from a vein occurs passively.

Whether of Antemortem or Postmortem Origin Ante- mortem bleeding causes coagulation when the blood partly solidifies with separation of serum. The clot can be taken out en masse from the spot, and the stained area after removal of the clot usually retains the impression of fibrinous network owing to the process of clot formation. On stretching, the clot can be separated in scales due to presence of fibrin. Postmortem solidification occurs without proper coagulation change and the clot cannot be taken out en masse.

Diagrammatic representation of types of blood spots commonly encountered at a scene showing:

(A) Drops of blood falling vertically on the flat surface. Depending upon the distance of the fall and the recipient surface, they may have scalloped edges at shorter distances or more secondary spatters with a lon- ger fall; the peripheral spatters growing finer and larger in num- ber with the increase in length.

(B) Jetting or spurting of blood.

(C) The splashes caused by striking the surface at an angle usually appear like spears or exclamation marks depending upon velocity and angle of the fall; the 'dot' of the mark points towards the direction of path of the drop of blood. On removal from the spot, it does not leave the impression of fibrinous network. On stretching, the clot becomes powder.

Distribution Pattern of Blood The pattern of distribu- tion of blood at the scene may give an insight into the actions and activities of the victim and the assailant and may be of particular value in evaluating direction of travel of blood spots, the distance travelled, etc.

Sexing of the Blood Stain As written earlier, Leishman staining of the extract of the stain can help in ascertaining the sex by studying the presence of drumstick bodies (Davidson bodies) in the polymorph cells.

Grouping of the Blood Stains Whether the blood or blood stain belongs to group A, B, AB or O can be known by testing for antigen (agglutinogen) present on the surface of blood cells if the cell structure is intact or indirectly by testing for the antibody (agglutinin) present in the serum. According to the antigens present on the surface of red cell membranes, blood can be classified into four major groups, i.e. Group

A, B, AB and O. The serum contains antibodies known as anti-A and anti-B. Red cells with antigen A will react with serum con- taining anti-A antibody and will result in clumping of red cells and this is known as agglutination, which forms the basis for blood group testing. Similarly, the red cells with B group anti- gen will react with anti-B antibody. The red cells containing A and B antigens will be agglutinated by both anti-A or anti-B antibody. The blood in which red cells have neither A nor B antigen is known as Group O. This group, therefore, is not agglutinated by either of the antibody. That is why Group O blood can be transfused to any person, and the person having blood Group O is known as Universal donor. Similarly, Group AB is called the Universal recipient because there are no antibodies in the serum and, therefore, the person belong- ing to this group can receive blood of any group.

Methods for determining blood group

- When the red cells are intact, then direct agglutination test with the help of known antisera can be undertaken either by the tube method or by the tile method. In the tube method, red cells are washed with normal saline and suspended for sometime. One drop of cell suspension is added to equal volume each of anti-A, anti-B and O-group serum in separate tubes and left for an hour or two at room temperature. Presence/absence of agglutination is appreci- ated to know the blood group as mentioned earlier. In the tile method, one drop of cell suspension and one drop of each antisera are mixed separately in different well of the tile, shaken by rod and observed for clumping (agglutina- tion). The results are mentioned in . 3.18.

- When the red cells' structure is damaged and they can-

not be subjected to agglutination test, then the techniques like absorption inhibition, mixed agglutination and absorp- tion elution are the proper techniques for determining blood group.

Medicolegal applications of blood groups: The knowl- edge of manner of inheritance of blood groups carries an obvi- ous application in cases of disputed paternity and maternity. Blood groups are inherited as per Mendel Laws of Heredity. The two important principles in this context are:

(1) A blood group antigen cannot appear in a child unless it is present in one of the parents.

(2) If one of the parents is homozygous for a particular blood group antigen, that antigen must appear in the child's blood.

Thus, from the above first point, we get that if the blood cells of child contain A antigen, then at least one of its parents have A antigen in his or her blood cells. From the second point, we get that if father or mother has homozygous A anti- gen (AA), then it must be present in the blood cells of the child . (The only chance of exception of the above two theories is the chance of mutation that may occur in 1 in 50,000 newborns.)

Blood group evidence has been accepted by the courts in cases of disputed paternity for more than 50 years, but it is only in the last few years that a legal framework has been recognised in this direction. The courts can give directions for the blood testing if one of the parties involved in the proceed- ings made an application and if, either party refuses to comply with the directions, the court is empowered to draw any infer- ence from this failure, if it thinks proper to do so under the circumstances.

The question of disputed paternity may arise in the fol- lowing circumstances:

- Alleged adultery and suits for nullity of marriage. When the child is born in lawful wedlock and the husband denies that he is the father of the child and seeks divorce on this ground.
- Blackmailing: When a child is born out of lawful wedlock and the mother accuses a certain man as the father of the child but the man denies the accusation.
- Suits for maintenance of illegitimate children.

The question of disputed maternity may arise in the fol- lowing circumstances:

- When two women claim the same child.
- When there has been an allegation of interchange of a child with another in the maternity home or hospital.
- In case of a kidnapped child, when the woman who has kidnapped the child claims to be the mother. She may name a friend as alleged father.

- In case of suppositious child, when a woman pretends pregnancy and delivery, and brings forth a suppositious child to pass it off as her own.

Exclusion of Paternity: Exclusion of paternity falls into two classes:

- First-order exclusion: Where the child possesses a blood group antigen that is absent in both the mother as well as the putative father. As for example, supposing the child's blood group gene is B and that of mother's and putative

Non-exclusion of Paternity: Where no exclusion of paternity is obtained, it is of value to the court to be provided with some indication as to the likelihood of paternity. False conclusions may be reached if blood relative of the alleged father is involved or the parties hail from an isolated community in which inbreeding may have occurred, resulting in a gene uncommon in the general population being more frequent.

With the present range of tests, over 90% of falsely impli- cated men can be excluded from paternity so that a non- exclusion result in itself carries significant evidentiary value to the mother. Blood group systems commonly employed for the purposes of exclusion of paternity are listed in . 3.20 and another important system, HLA system, has been described below:

The HLA System consists of a series of antigens present on the lymphocytes. The chance of excluding a falsely accused man using a comprehensive range of HLA genetic markers is about 96%. This high exclusion rate makes it the most important system for use in paternity problems, but a number of practical difficulties limit its usefulness. A particular difficulty is due to short life-span of the lymphocytes so that many samples may become unsui. for testing. Others are the cost factor and lack of well-equipped laboratories and well-trained experts.

Medicolegal Importance of Blood Examination In Civil Cases like paternity/maternity issues, divorce and nullity of marriage, compensation cases related to workmen's welfare considerations or civil negligence issues arising in hospital or medical practice. In Criminal Cases like identification of the victim or the offender of a crime of assault, homicide, sexual offences or where death occurs due to rash or negligent act of the offender, etc. (In case of homicide, if the blood stain pres- ent on a lethal weapon matches with the blood stain present on the wearing apparel of a suspect on the one hand and blood of the victim on the other, then relationship between the offence of homicide, the victim, the offender and the offending agent gets authenticated.)

Mass Disaster

Every accidental death is a disaster to the individual family involved and (to them) is of the same dimension irrespective of how many others were similarly affected at the same time. Every accidental death has its preventive aspects and, often, these lie in the hands of the pathologist (Mason, 1989). WHO has defined disaster as an occurrence that causes damage, ecological disruption, loss of human life or deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected community or area. A 'Mass Disaster' is considered to have occurred when the number of casualties occurring in a single event exceeds 12. (This .ure may be modified in accordance with local criteria as applicable in a country or a city.)

CLASSIFICATION

A. Natural:

(i) Non-biological—earthquake, cyclone, flood, drought, heat wave, volcanic eruption, landslide, and most recently, 'the sunami'.

(ii) Biological—disease epidemic, mass poisoning (food/ liquor).

B. Man made:

(i) Accidental—transportation (road, rail, sea, river, and air), building collapse, mining accidents, dam bursts, food poisoning, fires, football tragedies like Ibrox Park, Heysel, Hillsborough, crush tragedies, etc.

(ii) Industrial—fires, explosions, leakage of toxic substances/

gases.

(iii) Civil disturbances—riots and demonstrations.

(iv) Warfare—conventional (bombardment, exchange of fire, shelling) and non-conventional (nuclear, biological and chemical warfare, terrorism).

Objects usually include:

(i) Retrieval, reconstruction, examination and early disposal of the bodies [it may be worth focussing that the medico- legal expert may become open to criticism (or even to action) for pain and suffering brought about by the delay in releasing a body to its next of kin].

(ii) Establishing identity.

(iii) Conducting autopsy, wherein practicable, and to establish the cause of death [all necessary factual evidence needs to be obtained at the time of autopsy, including samples for histology, toxicology, odontology, radiology and DNA analysis (depending upon the case)].

(iv) Seeking evidence in the form of some foreign material/ fragment (of bomb or detonator) that may be embedded in the bodies.

MANAGEMENT

It is primarily a teamwork of the civil administration and its agencies (especially the police) on one hand and a multi-disciplinary medical task force usually comprising of clinicians, nurses, para-medical staff, odontologists, radiologists, forensic scientists, mortuary assistant, and funeral officials, etc., on the other hand, resources of the Armed Forces may be called-in to reinforce efforts. Over the past couple of decades, many countries have established protocols for the management of disasters, often with the setting up of Disaster Victim Identification (DVI) teams. Recently (after 'tsunami disaster'), Indian Government also constituted the National Disaster Management Authority under the Chairmanship of the Prime Minister with a Vice Chairman and five members. This authority aims at bringing about a change in orientation from a relief-centric approach to a holistic multi-disciplinary and multi-sectoral approach.

Because the circumstances differ so much from incident to

incident (as described above), it is impossible to try and anticipate every contingency and draw detailed plans to cope with them (Walsh, 1989). Hence, protocols need be 'simple and flexible'. Commonly involved considerations may be as under:

Isolation, Demarcation and Protection

Isolation, demarcation and protection of the site by the secu- rity cordon and entry of the team through some predetermined route. Involvement of by-standers and other officials need be checked. An experienced Lieutenant Commander of the New York City Police Department once remarked that the greatest problem he encountered in protecting the scene was the unauthorised attendance of police personnel and high- ranking officials coming along to help. This occurred particu- larly in the more 'high-profile' cases, which were attended by a great deal of publicity. Further, as remarked by Geberth, "such visitors either contaminated or destroyed valuable evidence or got in the way. They frequently left behind material, initially thought to be valuable trace evidence, which was consequently, needlessly examined". Other organisational features have been well canvassed and a vade mecum has been published by the Royal College of Pathologists.

Identification and Investigation

Identification and investigation are not different exercises but are complementary in at least two respects, viz.:

- In accidental cases, identification of the individual may contribute towards cause of the accident in case the deceased had the history/record of having some pre-existing disease or some toxicological problem (age and experience go hand in hand, as do age and atheroma).
- It may afford some explanation towards the pattern of

injuries (especially when sitting arrangements are available).

Some regard the exercise of identification as the major priority, as was the case at Mount Erebus. The Royal College of Pathologists places it first in the list of medicolegal expert's responsibilities. Others take the view that identification is ultimately the responsibility of the police and that the medico- legal expert's obligation to provide such information/evidence of identity as available stands ancillary to his/her responsibility towards investigation.

Visual recognition may not be helpful because of severe dis.urement (due to trauma, burning or decomposition, etc.). Further, the emotional factors involved in visual recognition make it unwise to accept either a positive or negative response in such circumstances. Major disaster usually involves an inter- national dimension, and it is imperative to be sensitive to cus- toms and traditions of each community in order to avoid future action.

Belongings can be helpful and may include clothing, jewel- lery, and personal documentation. Clothing found on a body can be of great value in establishing identity but must not be accepted as a positive proof in isolation. The corpse needs be searched and undressed very carefully (even the badly inciner- ated corpse may have a fragment of recognisable underclothing in the depth of the inguinal fold, axillary fold, natal clefts, etc.). Such clothing may also contain evidence of the use of a fire accelerant. Timperman (1991) in discussing the Zeebrugge ferry disaster put forward a proposition that the clothing need be removed by medical personnel, believing that the cadaver was entitled to privacy in the same way as is the living victim/patient. Jewellery being relatively fire-resistant can be very helpful, especially when some unusual and strongly identifiable frag- ment is available. However, it being secondary evidence must not always be assumed that the item belongs to the deceased or will be recognised by relatives (ACPO EP, 1999). Personal documents carry potential value but again, being secondary evidence, should not in their own be used to assume the iden- tity of the deceased. The compact and protective way of car- rying documents can often afford a great protection from fire and water, and every tiny fragment can be useful and therefore be handled with care.

Medical and X-ray evidence may contribute or confirm identification. Clearly, the more unusual the medical or post- surgical condition is, the more positive will be the identifica- tion of the body. Comparison of X-rays taken in life may be used when there is some abnormality. Alternatively, normal structures may be of such a variety that they can almost pro- vide proof of personal identification—the cranial sinuses and the pituitary fossa are good examples.

Odontology has proven to be very helpful, especially when fire or putrefaction has destroyed the soft tissues. Obviously, the method needs obtainable dental records. Seventy-three percent of the deceased were identified dentally in the Mount Erebus disaster that involved predominantly Western and Japanese people and included a high proportion of New Zealand adults who had notorious amount of dental work done on them prior to fluoridation.

Fingerprinting is another method of personal identifica- tion with well-established criteria for reliability. Obviously, fin- gers or fingerprints may be destroyed in the event of fire or severe mutilation. It is for this reason that some recommend retaining of heel print records too, the heel being relatively better pro- tected from fire or decomposition by shoes or boots. [In the Mount Erebus accident wherein all 237 passengers and 20 crew died, 1 passenger, though badly burnt about the face had a wallet in his hip pocket that contained a plastic identity card including fingerprints, which matched the fingerprints of the body.]

DNA-profiling has been shown to be of great value in identifying a wide range of human fluids and tissues, chiefly because DNA molecules remain highly s. in stains, are pres- ent in virtually all human cells and are extremely polymorphic.

Management of Survivors

In case of survivors, establishing a system of Triage to determine priority for evacuation is the need of the hour. Colour-coded tokens may be hung around the neck of the injured. The colours recommended are the following: Category I (Red)— requiring resuscitation and emergency lifesaving surgery, Category II (Yellow)—requiring possible resuscitation and early surgery, Category

III (Green)—less serious injury not endangered by delay and Category IV (Black)—survival not likely.

CHAPTER-6

DEATH AND ITS MEDICO LEGAL ASPECTS (FORENSIC THANTOLOGY)

Death is the end of dying. It is a process rather than an event except in the exceptionally rare situations where death may be almost instantaneous such as in case of crushing of the brain in a vehicular accident, death in a nuclear explosion or in a bomb blast, etc. Need usually arises to ascertain specific time of death whether in family or in business affairs. Inheritance of property and acquiring a business often revolves around this. Legal systems usually contain provisions regarding the 'Presumption of Death' and 'Presumption of Survivorship' depicting the importance of these aspects. Sections 107 and 108 of IEA lay down that if it is shown that a person was alive within 30 years, and there is nothing to suggest the probability of his death, it is presumed that he is still alive unless proof be produced that the same person has not been heard of for 7 years by those who would naturally have heard of him, had he been alive. The onus of proving that the person is dead is shifted to the individual who asserts such fact. An example in this context may be cited of the disappearance of the Prime Minister of Australia while swimming on a rocky, deep sea- coast near his home. It was followed by assumption of power by his successor after a few days when he was presumed legally dead, but uncertainty may prevail in certain circumstances where there is no obvious explanation for the disappearance in contrast to such factually based presumptions and hence the legal provisions.

Black's Law Dictionary defines death as, 'The cessation of life; the ceasing to exist defined by the physicians as a total stoppage of circulation of the blood and a cessation of animal and vital functions consequent there upon, such as respiration, pulsation, etc.' Here, the emphasis was placed on the cessation of respiration and circulatory function, but it was obvious that all systems would fail quickly after any of the vital functions had failed, viz., nervous system, circulatory system and the respiratory system. That is why these are known as atria mortis, death's portals of entry.

This unified or interdependent concept of death lingered on for centuries until recent times when the medical-care advances have made it possible to maintain respiration and circulation for long periods through heart–lung machines. However, the tragedy is that the irreversible damage to the brain often occurs during the short period when breathing/ circulation has been suspended. Serious permanent impairment can occur with only 4–6 minutes of oxygen deprivation, and total loss of function may often occur when deprivation exceeds 6–10 minutes. Hence, there appeared the development of concept of 'brain death'.

BRAIN DEATH

The first proposal to determine brain death by permanent loss of consciousness is generally assigned to Mollaret and Goulon in France in 1959. However, it was Ad Hoc Committee of Harvard Medical School that examined the definition of brain death in 1968. The Committee was composed of 13 members— ten were doctors representing various disciplines of medical science and three were non-doctors, i.e. a lawyer, a theologian and

a historian of science. It recommended three criteria for determining permanent non-function of the brain:

- Unreceptivity and unresponsivity
- No movements or breathing
- No reflexes

And an added confirmatory test proposed was 'a flat' or isoelectric electroencephalogram. The fact that EEG is an objective test, while all other require subjective clinical judgements by the doctors, substantiates its strength.

The criteria of Harvard Ad Hoc Committee have since been generally accepted throughout the world. Currently, brain-stem has been the focus of attention where vital centres are situated because various strata of brain behave differently in their response to oxygen deprivation. Therefore, circum- stances may be there, where cortex has been damaged but the lower brain including brain-stem is still functioning. In such a state, the victim will exist in a 'vegetative state', the so-called 'living cadaver'. The victim can remain in deep coma for a considerable period; may be for years. However, when brain death spreads below the tentorium, i.e. when base of the brain including midbrain, pons and medulla suffer damage, the loss of vital centres and consciousness will cause the victim not only to be irreversibly comatose but also to be incapable of spontaneous breathing. Without medical intervention, the car- diac arrest invariably follows within minutes and then the usual process of 'cellular death' progresses. Once irreversible dam- age to the brain-stem has been established, the victim is dead in the somatic sense, though not yet dead in the cellular sense. It is through this 'physiological gap' that the advances in removing the organs from the cadavers for the transplantation purposes have broken through.

With the passage of Transplantation of Human Organs Act, 1994 (the Act was enacted in July 1994 and notification was issued in Gazette of India on 4th February, 1995), India has also given statutory sanction to the concept of brain-stem death. The Act defines a 'deceased person' as one in whom permanent disappearance of all evidence of life has occurred by reason of brain-stem death or in the cardio-pulmonary sense, at any time after the live-birth. Brain-stem death has been defined as the stage at which all the functions of brain- stem have permanently and irreversibly ceased. The brain- stem death needs to be certified by a board of doctors consisting of the following:

- The registered medical practitioner in charge of hospital in which brain-stem death has occurred.

- An independent registered medical practitioner being a specialist to be nominated by a registered medical practi- tioner specified in clause (i) from the panel of names approved by appropriate authority.

- A neurologist or a neurosurgeon to be nominated by a reg- istered medical practitioner specified in clause (i) from the panel of names approved by an appropriate authority.

- The registered medical practitioner treating the person whose brain-stem death has occurred.

Certain preconditions to be fulfilled before certifying the brain-stem death are:

- The cause of irreversible brain-stem damage (either from a period of hypoxia, trauma, illness or toxic insult) producing non-responsive coma, must be clearly established. Following reversible causes must be excluded:
  - Intoxication
  - Depressant drugs
  - Muscle relaxants
  - Primary hypothermia
  - Hypovolemic shock
  - Metabolic or endocrinal disturbances
- The patient must be examined by a team of doctors at least twice, with a reasonable gap of time in between (say about 6 hours or so).
- None of the doctors who participate in the diagnosis of brain-stem death should have any interest in the transplan- tation of an organ being removed from the cadaver.

The structural and functional damage of brain-stem may be diagnosed depending upon the following observations:

- Dilated fixed pupils, not responding to sharp changes in intensity of incident light.
- Absence of motor responses within the cranial nerve distri- bution on painful stimulation.
- Absence of corneal reflexes.
- Absence of vestibulo-ocular reflexes.
- Absence of gag reflex or reflex response to bronchial stimulation by a suction-catheter passed down the trachea.
- Absence of spontaneous breathing.

TRANSPLANTATION OF HUMAN ORGANS ACT

For the purpose of retrieval of human organs from the dead body for therapeutic purposes, Section 5(1) and Section 5(2) of the Transplantation of Human Organs Act come into operation. In accordance with Section 5(1) of the Act, a dead body lying in a hospital or prison and not claimed by any of the near relatives of the deceased person within 48 hours from the time of the death of the concerned person, the authority for the removal of any human organ from the dead body which so remains unclaimed may be given by the person in charge of the management or control of the hospital or prison or by an authorised employee of such hospital or prison. However, in accordance with Section 5(2) of the Act, no authority shall be given under sub-section (1) if the person empowered to give such authority has reason to believe that any near relative of the deceased person is likely to claim the dead body even though such near relative has not come for- ward to claim the body of the deceased person within the time specified in sub-section (1).

MEDICOLEGAL CONSIDERATIONS OF BRAIN DEATH

For legal and medical purposes, an individual who has sustained an irreversible cessation of functioning of brain, including the brain-stem, is dead. A determination of death must be made in accordance with the criteria outlined earlier.

Another aspect that deserves consideration is the criteria to be followed in switching off the heart–lung apparatus. Sustaining life by artificial maintenance of circulation and respiration inherits some legal implications. Considering the death to be a permanent and irreversible cessation of functions of the three interdependent vital systems of the body (the 'tri- pod' of life)—the nervous, the circulatory and the respiratory systems—will not help in deciding as to when the artificial aids should be stopped as these systems are functionally inter- linked. It is obvious that artificial aids may be applied in the hope that natural circulation or respiration may be resumed after the 'aids' are continued for sometime. But natural respiration may not be resumed even after the use of artificial aids for considerable periods. Therefore, where lies the line of demar- cation, i.e. when the artificial aids to be stopped so that the doctor may not get involved in the offence of culpable homi- cide not amounting to murder or one of rash and negligent act, if he has removed the 'aids' indiscriminately. In such crucial affair, the decision for permanent withdrawal of the artificial aids should preferably be taken after consultation with another doctor. Ordinarily, it is sufficient to wait for 10–15 minutes. If no evidence of spontaneous functioning of respiration/circulation is available for such a continuous period, the doctor(s) is/are justified in disconnecting the artificial aids because the serious permanent impairment of brain cells can occur with only 4–6 minutes of oxygen deprivation and total loss of function generally supervenes when the deprivation exceeds 10 minutes.

have to be removed for the purposes of transplantation even before occurrence of somatic death by maintaining the donor on artificial aids after declaration of the brain-stem death because any lack of oxygenated blood-supply will soon make them unsui. for transplantation purposes.

SUSPENDED ANIMATION (APPARENT DEATH)

Ordinarily, the diagnosis of death does not pose any difficulty if the observations of cessation of respiration and circulation can be made with sufficient accuracy and for a sufficient period. Obviously, one should not make such decisions hurriedly as there are numerous accounts in the literature of premature pronouncement of death. Mullan et al. (1965) described two cases of barbiturate poisoning in patients who had been certified dead but were subsequently found to be alive. Polson et al. (1985) described a case of a young woman of 23 years of age, who was found on a beach near Liverpool and was declared dead by a local doctor. The pathologist who appeared later at the scene also agreed with the view. When the body was taken to the mortuary, one of the persons noticed the flickering of an eyelid and formation of a tear. She was immediately covered with clothing and shifted to the intensive care unit, and eventually recovered fully.

Such cases emphasize the importance of examining the body carefully before death is certified. Failure to detect heart beat or respiration by auscultation must be accompanied by the demonstration of electrocardiogram and electroencepha- logram. The condition where the person may appear to be dead due to the fact that the vital functions are at such a low pitch as to be minimum compatible with life is known as sus- pended animation or apparent death. It may be encountered under the following circumstances:

SOMATIC AND MOLECULAR DEATH

Two phases of death have been recognised, namely, the extinction of personality or the death of the body as a whole (soma means body) when there is cessation of vital processes of the body. This is referred to as somatic death (systemic or clinical death), which is followed by progressive disintegration of body tissues and is called as cellular or molecular death.

In the absence of circulation and respiration, different cells die their molecular deaths at different times after the somatic death. Death of the brain cells stand first that are most sensitive to oxygen deprivation and therefore usually begin to die within about 5 minutes of somatic death. Then may come the organs like lungs, liver, kidneys and heart, which need to be removed for transplantation at the earliest possible, maximally within about an hour. The striped muscles can survive for hours and tissues like hair and nails for days. Practically speaking, the organs like lungs, liver, kidneys and heart, etc. with temporary suspension of heart beat. The limit of tolerance will vary with the degree of oxygenation of blood at the time of suspension, metabolic rate and body temperature, etc. Under usual conditions, longer than 3–5 minutes arrest of heart beat is irrecoverable. But condition of suspended animation is practicable, and its practice is popular amongst the yogis who can maintain their vital processes to the mini- mum through their physical and mental exercises and restraint.

- In hypothermia: Operations are being undertaken after lowering the body temperature artificially and can be extended to an hour or so without heart beat, yet normal rhythm will return on warming.
- In bodies removed from water: Visible respiration may be

absent for some periods and doubt often may occur as to presence of life or not.

- In newborn infants: Infants, particularly in case of 'birth in a caul', may not show any obvious signs of life yet prompt resuscitation may bring them to life.
- In electric shocks: The individual may impart every appearance of death but continuous artificial respiration may be helpful in restoring life. In some jurisdictions of the United States, it is still mandatory that in such cases the resuscitative measures be continued till livor mortis becomes manifest.
- Vagal inhibitory reflexes: Narcotic poisoning, hanging, catalepsy, hysteria, sunstroke, concussion and severe 'synco- pal attacks' of various kinds are notoriously likely to cause conditions simulating death. On all these occasions, greatest care must be exercised in order to avoid the calamity of premature certification and the resuscitative measures should be continued until definite signs of death are evident.

MODE, MANNER, MECHANISM AND CAUSE OF DEATH

Confusion often arises in appreciating these terms and their proper interpretation, particularly amongst the doctors who are in infancy in the medicolegal work. This is extremely significant as one has to declare the 'cause of death' at the end of the 'autopsy report' and even otherwise in relation to the documentary certification of death.

The Mode of Death refers to the abnormal physiological state that existed at the time of death. According to Bichat, there are three modes of death depending upon the system most obviously involved, irrespective of what the remote cause of death may be. These are:

- Coma, i.e. failure of functions of brain.
- Syncope, i.e. failure of functions of heart.
- Asphyxia, i.e. failure of respiratory system.

Gordon postulated that vital body functions depend upon availability and utilisation of oxygen by the body tissues, and tissue anoxia of any type (anoxic, anaemic, histotoxic or stag- nant) finally leads to cardiac failure and death. Bishop's stand point is on mode of dying, i.e. on the three proximate causes of death, while Gordon lays stress on the pathogenesis. Thus, fundamental pathological changes though vary in degree but will be more or less uniform in all forms of death. Hence, essentially the two classifications do point to the same goal. Bishop's classification, providing a descriptive picture of the mode of dying, is useful to the lawyers and laymen for inter- pretation of medical evidence as to cause of death. Gordon's classification is useful to the forensic pathologist to understand the pathogenesis in different forms of death of medicolegal importance. In most cases, the mode is unhelpful in describing and understanding the underlying fundamental aetiological process. Therefore, the terms like 'cardiorespiratory failure' or 'heart attack' or 'syncope', etc. are undesirable unless further qualified by basic pathological condition.

The Manner of Death refers to the 'design'/fashion in which the cause of death came into being. If death results from some disease, the manner of death is 'natural' and if by injury, then the manner of death is 'violent'/unnatural. Violence may be accidental, suicidal or homicidal in origin, depending upon the circumstances attending the episode. The manner of death, here in India, is determined by the court after examining all aspects of the case including the evidence of the doctor and his interpretation of the findings. In the United States and some other countries where there is 'Medical Examiner System' the manner of death is also expected from the doctor after evaluating the scene of crime/incidence and the victim.

The Mechanism of Death refers to the physiological derangement or biochemical disturbance in relation to death. It includes such entities like metabolic acidosis and alkalosis, sepsis, toxaemia or paralysis, etc.

The Cause of Death:

The determination of cause of death following autopsy is an interpretive exercise depending upon the sound evaluation of the anamnestic data, circumstantial evidence (in India, it is furnished by the police), mor- phological evidence of disease and/or injury and the results of any additional laboratory studies (if need be).

Cause of death is the injury, disease, or combination of the two that initiates a train of physiological disturbances (brief or prolonged), result- ing in the termination of an individual's life. Immediate cause of death is the disease or injury present at the time of death that caused person's death, whereas the proximate cause of death is the original natural disease process, injury, or event that led to a string of uninterrupted train of events (time interval may be spread over weeks, months, or even years), that eventually led to the individual's death. However, this link/connectivity between injury and death gets weakened or broken if in the intervening period, the individual has com- pletely recovered from the injury or has died from an unrelated condition. Labelling cause of death as 'cardio-pulmonary arrest,' 'respiratory arrest,' or renal/hepatic failure, etc. is unac- cep.. Use of such seemingly inappropriate expressions invites scrutiny (such expressions may be used in clinical set- tings, not in the autopsy diagnosis).

It is not unusual that the information gathered at the time of autopsy is not enough to properly list 'the cause of death'. In such a situation, the opinion can be kept pending and the same is given when results of other investigations (such as toxicology, histology and/or some other test) become avail- able. It is, therefore, understandable that certainty as to cause of death depends on many variables. Some categorisation in this context may be as follows: (i) cases where the examination including laboratory studies reveal cause of death with a degree of 'probability nearing certainty'—the circumstances are not necessarily incompatible with life but the investigations including laboratory studies reveal no other reasonable expla- nation for death (e.g., advanced heart disease or poisoning deaths where the poisoning/drug demonstrates non-fatal range);

(ii) cases where cause of death approaches 'probability' as interpreted from the anamnestic facts, the postmortem and other findings being non-specific (e.g., deaths from electrocu- tion and epilepsy); (iii) cases where neither anamnestic data nor the findings or laboratory studies help in arriving at some sufficient evidence and cause of death merely remain 'conjec- tural' (e.g., most anaesthetic deaths behave in this manner); and finally (iv) cases where cause of death remains 'undetermined' from the circumstances (highly decomposed/skeletonised body), autopsy as well as laboratory studies. However, the negative anatomical and chemical findings carry significance in dispelling allegations of injuries or poisoning that might have been alleged to have caused or played some role towards death. may hinge upon this time of death. Other matters may revolve around insurance and compensation claims following acci- dents or assaults.

Before taking into account the various methods in estimating the time since death, once again it may be projected that from the medicolegal standpoint, it is unfortunate that the length of time, required to attain a particular degree or type of postmortem change, cannot be categorically furnished because the timings of onset and the rates of change are usually governed by unpredic. endogenous and exogenous factors. Neverthe- less, careful observations of all the varying phenomena/ sources of information, influencing the postmortem interval, can yield some reliable data within reasonable range of time.

The signs of death or changes after death or the methods of estimating time since death may traditionally be studied under the following heads: immediate, early and late.

Estimatiom of the Time Since Death

Most of the books have given the heading as 'Estimation of Time of Death' but I have specifically chosen the heading as 'Estimation of Time Since Death' because the experience shows the fallibility of all the methods and commands that a reasonable range of latitude be allowed for any of the meth- ods, whether considered individually or in concert, and the doctor should, therefore, wisely avoid making dogmatic state- ments regarding this duration of postmortem interval.

Fortunately, even the courts, for most practical purposes, require establishing a relatively broad time-range to surround the moment of death. It is very rarely that a more precise moment of death becomes necessary. It is further stressed that the longer the interval between the moment of death and the time of examination, the wider become these limits.

IMPORTANCE OF TIME SINCE DEATH

Determination of reasonably accurate time since death has a bearing on the issues of 'alibi' and 'opportunity'. If a suspect can prove that he was remote from the victim when the fatal incidence occurred and thereby his innocence may be implicit. Conversely, if it is shown that the lethal attack occurred when the suspect was known to be in the neighbourhood of the victim, he thereby had an opportunity for committing the crime.

When several suspects are being sorted out, the estimation of this postmortem interval may be extremely helpful in the screening procedure to exclude some putative killers, who could not be able to approach the victim at that particular time and may help in giving more weightage towards the others whose movements/activities happened to coincide with the estimated time. Therefore, any doctor, while reporting on such issues, must be wary of relying on any single observation so as to be able to withstand intense cross-examination in the courts, many months or may be many years after the reporting. In the civil cases also, it may have implications. As stated in the beginning, the matters concerning transfer of estate or property

IMMEDIATE SIGNS OF DEATH

Insensibility and loss of voluntary power are concomitants of death but may be found in cases where the death is merely apparent, a fact inviting sustained efforts at resuscitation, as has amply been stressed earlier.

Cessation of respiration and Cessation of circulation are the other immediate signs of death but again deserve caution as outlined under Suspended Animation (Apparent Death). If on careful auscultation by the stethoscope, heart sounds are not appreciated for a continuous period of 5–10 minutes, it is accepted evidence of death. Difficulty may arise if the sounds are feeble or chest wall is thick or in cases of emphysema. In case of doubt, ECG will settle the issue. A flat ECG for a continuous period of 5–10 minutes is accepted as an evidence of death.

Various subsidiary tests for testing presence or absence of circulation are Magnus Ligature Test, Icard Test, Diaphanous Test and Fingernail Test. Similarly, there are some tests for determining the presence or absence of respiration, namely, Mirror Test, Feather Test and Winslow Test. All these proce- dures are of historical interest only and of little academic importance presently. Prolonged listening with the stetho- scope over the trachea or lung fields is the time-honoured procedure.

EARLY CHANGES AFTER DEATH

Facial Pallor and Changes in the Skin

Due to stoppage of circulation after death, blood drains out of the small vessels to big ones and thereby face usually appears pale. The skin becomes lustreless, pale, ashy-white and also loses its elasticity. That is why that postmortem lacerations or incisions do not show gaping to any appreciable extent.

In cases of death associated with agonal spasm and where there has been obstruction to the venous return due to compression over the neck or in cases of traumatic asphyxia, face remains congested, bluish-black for sometime after death. Yellow discolouration of skin due to jaundice and reddish-pink colouration due to carbon monoxide or HCN poisoning usu- ally persist for sometime after death.

PRIMARY FLACCIDITY OF THE MUSCLES

Muscles lose their tonicity and become flaccid, loose and lax. The jaw drops, limbs fall flat and limp, thorax collapses, the sphincters relax, and there may be involuntary passage of urine and faeces, though the muscles are physically capable of responding to electrical/mechanical stimuli during this phase.

CHANGES IN THE EYE

They include the following:

- Loss of corneal reflex: After death, there is loss of cor- neal and conjunctival reflexes, but this may be noted in all forms of deep insensibility, e.g., narcotic poisoning, general anaesthesia, epilepsy, etc. and therefore should be inter- preted cautiously.

- Opacity of the cornea: The cornea loses its glistening appearance, becomes dull and opaque. The glistening appearance of cornea may get dimmed even before death, as in uraemia, cholera, narcotic poisoning, wasting diseases, etc., whereas the cornea may preserve its glistening appear- ance for sometime after death as in cases of death due to carbon monoxide or HCN poisoning.

The eyelids usually close after death due to primary flac- cidity of the muscle, but the flaccid muscles usually fail to produce complete occlusion and therefore where the sclera remains exposed, a film of cell-debris, mucus and dust set- tles steadily on each side of the cornea within a few hours, becoming reddish-brown and then occasionally almost black, to which the name 'Taches Noire De La Sclerotique' has been given.

- Flaccidity of the eyeball: Intraocular tension decreases rapidly after death as it depends upon the arterial pressure. The eyeballs feel progressively softer and tend to sink into the orbital fossa. This flaccidity may easily be appreciated by simple palpation. Nicati (1894) invented an instrument to measure intraocular tension. He estimated that during life the tension could vary between 14 and 25 gm. But when the heart ceased to beat, the tension fell to about half and fell as low as eighth after about half an hour of death and was nil by 2 hours after death. Reduction in intraocular ten- sion allows distortion of the pupillary shape by gentle pal- pation on the globe, which is not observed during life.

- State of the pupils: Though the iris responds to chemical stimulation for hours after death, the light reflex is lost as soon as the brain-stem nuclei suffer ischaemia. The iris contains a large portion of the muscular tissue, which loses its tone rapidly after death and the iris usually relaxes into a state of equilibrium, assuming a mid-dilated position, though the state may alter later on as a result of onset of rigor mortis. There may be unequal dilatation of the pupils, but this has no bearing upon the cause or manner of death.

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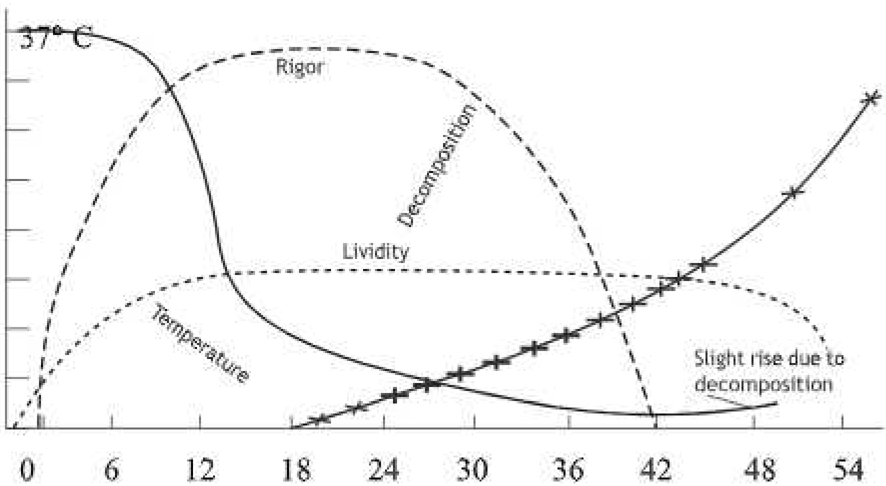
ı Changes in the retinal vessels: Ophthalmoscopic examination of retina provides one of the earliest positive signs of death. After death, the blood stream in the retinal vessels becomes segmented as the loss of blood pressure causes the blood stream to break up into segments. This condition of 'trucking' is considered a valuable early sign of death. The phenomenon occurs all over the body but the retina is only accessible for direct viewing.

Wroblewski and Ellis (1970) studied retinal and corneal changes in 300 patients. 'Trucking' was exhibited in one or both the eyes in about one-third patients within an hour of death. Clouding or haziness of the cornea was observed by them at 2 hours in three-fourths of their subjects. They con- cluded that static segmentation was a postmortem change and on the other hand, any obvious movement in the columns of blood might be due to persistence of circulation. They opined that static fragmentation and clouding of cornea were each indicative of death within previous couple of hours.

Algor Mortis (Postmortem Cooling)

It may be stated that the first recording of body temperature for confirming the death of a person was used by Dowler (1849–1850). Presently, recording of rectal temperature is often a quite useful step in the investigation of any death occurring in suspicious circumstances, unless where the external appear- ances indicate the body would have cooled to the temperature of surroundings. It must also be emphasised that the useful- ness of the temperature estimations resides only in the cold and temperate climates where the body loses heat so long as it is in equilibrium with the environmental temperature, whereas in tropical areas, the postmortem fall in body temperature may be minimal or even absent and in some torrid climates, the corpse may even warm up after death.

When life ends, after a short interval, the body starts losing heat. The usual temperature of a healthy adult at rest is about 98.4° F (37° C) when determined by mouth, whereas the tem- perature at the rectum under same conditions is about 99° F and in the axilla, about 97° F. Further, there are usually indi- vidual and daily variations up to 1–1.5° F. The temperature also shows variations during the different timings of the day. It will be less in the morning and higher in the afternoon. Exercise may also have influence upon the body temperature but this however drops to normal in about half an hour. Of all the changes that occur in a dead body, the cooling of the body to the temperature of its surroundings was the first to be used as an index of the time of death. A low body temperature is a sign of either death or hypothermia. It may be reasonable to assume that a rectal temperature of 21° C (70° F) is presump- tive evidence of death or a moribund state.



Graph showing some factors helpful in estimation of time since death. This graph shows the approximate rate of cooling of the body after death, the approximate time of onset and progress of postmortem lividity, the approximate time of onset, duration and offset of rigor mortis, and the approximate time of onset and progress of decomposition. All these times are approximations because all these changes are subject to a number of variations.

In 1958, Fiddes and Patten worked out a formula applying repeated observations of the difference between the rectal temperature and the surroundings, assuming that the rate of cooling of the corpse would follow Newton's law. However, Marshall (1962–1974), in an extended series of studies with many coworkers showed that the body does not follow Newton's law of cooling but rather that the curve of cooling exhibited 'sigmoid shape' with an initial plateau forming an upper flattened or slightly sloping part of the double exponential curve (.. 4.1). (Metabolic heat production does not cease uniformly and

Rates of Fall of Body Temperature in Subjects of Different Body Builts

Time passed since death	Thinly built subjects	Average built subjects	Fatty built subjects
Up to 3 hours	11/3° F	1° F	**5/6 F**
3–6 hours	12/3° F	2° F	**12/3 F**
6–9 hours	21/3° F	2° F	**11/3 F**
9–12 hours	12/3° F	11/2° F	**11/3 F**
12–15 hours	**11/3 F**	**11/3 F**	**11/3 F**

In tropical countries, where the difference between body temperature at about the time of death and the atmospheric temperature is not high, the determination of time since death by recording temperatures is not considered to be a good cri- terion. Therefore in our country, Marshall and Hoare formula is not advisable to be applied except in some hilly areas where the atmospheric temperature is low (nearing 60° F). Glaister (1962) in 11th ed. of Forensic Medicine and K Simpson in Taylor's (1965) 12th ed. have suggested that in an average adult, the overall rate of fall of temperature in air may be 1.5° F per hour for the first few hours in temperate climates but in tropical climates, it may be approximately 0.75° F per hour. But these are broad generalisations and should be used with great circumspection.

In cold or temperate countries where the difference between the body temperature at the time of death and envi- ronmental temperature is reasonable, hourly recording of temperature is of more value. For temperate countries, for- mula of Marshall and Hoare can be applied with some degree of satisfaction. The pre-requisites are (i) the atmospheric tem- perature should be around 60° F, (ii) body should better be uncovered, (iii) the limbs should be outstretched and (iv) body- built of the subjects should be taken care of. The formula provides different rates of fall of body temperature for corpses of different body-builts.

For recording the temperature of the dead bodies, the traditional method of measuring postmortem temperature is by inserting a mercury thermometer (chemical thermometer) with graduation from 0 to 50° C into the rectum. The bulb must be inserted at least 10 cm into the rectum. The reading should be recorded after sometime when it has become stabi- lised and it is to be recorded when the thermometer is in situ- ation. Multiple readings should be taken at an hourly interval without withdrawing the instrument. Alternative sites may be axilla, deep nasal passage or intra-abdominal (sub-hepatic) regions. While taking the temperature of the cadaver, the temperature of the surroundings should also be recorded. Joseph AEA and Schickele E (1970) prefer to use the term 'torso cooling' as the course of cooling varies from region to region of the same body.

Modern measuring devices include thermoelectric couple, which registers temperature accurately with least stabilising time. It may be connected to a computerised recorder, which can analyse some other sites at regular intervals.

Factors Influencing the Cooling of the Body

Although the rate of heat loss can be theoretically defined, there are a number of known and unknown factors that intro- duce variations into the cooling process. The factors may include:

- Temperature of the body at the moment of death: Uncertainty as to the temperature of the dead body at the moment of death is an important factor, which mitigates the accuracy of the calculations. Even during life, temperature varies from person to person and from time to time. In many cases, as in asphyxial deaths, fat or air embolism, heat-stroke, certain infections, drug reactions, cerebral haemorrhage or when the body has been left near the fire or body dying in an electric blanket or warm bath-tub etc., temperature at about the time of death may be raised. Conversely, in some wasting diseases like cholera, congestive cardiac failure, expo- sure to cold, massive haemorrhage, the temperature at the time of death may be lowered. Unless the temperature at the time of death is known (because all methods/formulae for calculating time since death depend upon the fact that body temperature being 37° C), all efforts to achieve accuracy in estimation of temperature loss get frustrated.

- Temperature difference between the body and the surroundings: The rate of cooling of the body is roughly proportional to the difference of temperature between the corpse and its surroundings. The greater is the difference between the two, the more is the rate of fall. That is why in cold or temperate climates the rate of fall of temperature is roughly 1.5° F per hour and in tropical climates the rate of fall is roughly 0.75° F per hour.

Depending upon the medium of disposal of the dead body, i.e. whether in air (atmosphere) or water or buried under the ground, the rate of cooling will vary accordingly. In case of water, the body heat is lost both by conduction and convection, both being efficient means of heat loss. In case of air, the heat loss is partly due to conduction (through the parts of the body touching the ground or some other material), partly due to convection (evaporation of body fluids) and partly due to radiation (through the nature of the substances lying in the vicinity). In case of burial, the only effective means of loss of heat is by way of conduction.

Furthermore, bodies buried in dry rocky soil will retain their heat much longer than when exposed to air and the bodies thrown in dung-heap or cesspool cool less rapidly than when kept in open air. The bacterial flora or maggots under such circumstances may even raise the body temperature.

- Clothing and coverings: Conduction and convection are markedly reduced by clothing. Clothing made of silk, wool- len or synthetic fibre exerts a great influence on cooling. The more minute air-spaces (in the clothing), the poorer will be the conducting properties and therefore slower will be the rate of cooling. Electric blankets left upon the body after death or some quilt left upon the dead body may add further problem. Wet clothing will accelerate cooling because of uptake of heat for evaporation.

- Body-built (the size factor): In relation to cooling, it is essential to consider the size-factor, i.e. the ratio of the surface area of body exposed to cooling to that of body mass. Thus, children and adults of small stature will undergo cooling more rapidly than the average adults. Further, in case of bodies lying in position with arms by the sides, only about 80% of the total external body surface loses heat whereas in crouched position the loss will be only through 60% of the body surface [Hardy GD et al. (1938) in J Nutt 15, 477 and Bedford T (1935) in J Hyg 35, 303]. In such positions, most of the body heat radiated by inner aspects of arms and legs is reabsorbed by the opposing body surfaces and hence the variations.

The amount of subcutaneous and abdominal fat opeates in the process of cooling due to its insulating proper- ties. Oedema and dehydration both exert influence because of high specific heat of water. In general, bodies of thin persons cool more rapidly because of both low mass–sur- face area ratio and lack of fat.

- Air current and humidity: Major skin cooling occurs by conduction and convection, the air adjacent to the body acting as a transporting medium. In still conditions, a layer of warm air usually embraces the body surface thus blocking the temperature differential. Better air movement over the body surface brings cooler air in contact with the body and encourages the heat loss. Damp air conducts heat more rapidly than the dry one.

- Postmortem caloricity: It is a condition where there is rise of body temperature after death instead of cooling of the body. Although the process of postmortem glycogenolysis, which occurs in all dead bodies soon after death, can produce up to about 140 calories that can raise the body temperature by about 2° C, yet the temperature shows further rise in all such conditions, e.g. asphyxial deaths, poisoning due to alco- hol/dhatura/strychnine, drug reactions, heat stroke, brainstem haemorrhage and deaths due to infectious diseases, etc.

Nomogram Method for Estimating Time Since Death

Two ways have been advocated for calculating time since death at the scene of death. These are based on application of the basic considerations achieved through mathematical modelling of the body cooling and experimental body and dummy coolings. The methods include hand-held computer and nomograms.

Nomograms introduced by Henssge constitute a very useful practical guide towards determining time since death from a single rectal and ambient temperature recording at the scene of death. However, it must be emphasised that all these experimental data have been conducted in the cold countries under their own environmental set-up and therefore, hardly of any application in India. However, those interested should consult the book entitled: The Estimation of the Time Since Death in the Early

Livor Mortis (Postmortem Hypostasis)

Livor Mortis is one of the most obvious postmortem changes. It has been variously named as postmortem hypostasis, post- mortem lividity, postmortem staining, suggillations, vibices, and so on. But out of all these, the term postmortem hypostasis or simply hypostasis sounds appropriate as it suggests the basic process involved in it. The word 'hypostasis' itself means 'passive congestion of an organ or part'. With the cessation of circulation at the time of death, the blood obeying the law of gravity gravitates into the toneless capillaries and venules of the 'rete mucosum' in the dependent parts of the body and settles into the lowest available parts of the body. This passive pooling of blood into the dependent areas of the body, imparting pur- plish or reddish-purple discolouration to those areas, is known as postmortem hypostasis.

Time of Appearance

Hypostasis generally starts appearing within an hour or so after death and manifests itself as purplish blotches. These blotches become increasingly intense and gradually coalesce during the next few hours to form a large area of reddish-purple discolouration. The phenomenon is usually complete in 6–12 hours. In Northern India, it begins to appear in less than an hour after death and usually becomes well-marked in 6–10 hours after death. Under certain circumstances, when the agonal period is prolonged or in persons dying of narcotic poisoning or where the circulation becomes stagnant prior to death, it may appear at about the moment of death. Conversely, its appearance and development may be unduly delayed in death due to anaemia, acute haemorrhage or introduction of huge saline transfusion prior to death.

Extent and Distribution

The extent of lividity depends upon the amount and fluidity of blood. As already stated, in deaths from wasting diseases, pro- found anaemia or haemorrhage, the staining may be so slight or faint or weak, as to be barely appreciable. Much debate has been encountered regarding fluidity of blood after death. Work of Mole and Mant, however, provides significant knowledge in this concern:

- Blood is spontaneously coagulable in all cases of sudden death where the autopsy is carried out within an hour or so of death.
- The spontaneous coagulability of blood may disappear as shortly as 1.5 hour after death.
- Fibrinogen is absent from postmortem blood samples that have lost their power of spontaneous coagulation.
- Fibrinolysin obtained from postmortem blood acts only on fibrin and not on fibrinogen.
- Fibrinolysin acts by becoming absorbed on to the clot as it is being formed and it is later released into solution when the clot lyses. It is not effective when added to a clot already formed.
- Fibrinolysin is probably produced by the endothelial linings of the vascular channels and body cavities.

The distribution of hypostasis depends upon the pos- ture of body after death. With the body lying on the back, postmortem staining will be pronounced over the posterior and dependent parts like area against the lumbar region, poste- rior aspects of the flanks of the abdomen, back of neck, extensor surfaces of upper limbs and flexor surfaces of the lower limbs, sparing areas that prevent pooling of blood as they are pressed against the surface of the ground. These areas are known as 'areas of contact flattening', which obviously include back of head, back of shoulders, buttocks, back of thighs and calves . Therefore, these areas will stand out depressed, flattened, pale and blanched amidst the areas of discolouration due to hypostasis. Similarly, it will not be seen in the parts that have been compressed by tight clothing like area against the collar, area of the waist, against the brassiere, area against the constricting terminal parts of the socks and so on. On these areas, it may occur as strips or bands called vibices.

In case of hanging, hypostasis will be more marked on dependent lower limbs, surrounding genitalia, hands and distal

Features	Postmortem staining	Bruise
Situation	On the dependant parts of the dead body	Anywhere
Surface	Not elevated	May be slightly elevated
Margins	Well-defined	Diffused/ill-defined
Colour	Bluish or reddish purple normally. Specific colour in some specific poisoning death cases	Reddish when fresh, which changes in colour with time
Cause	Due to capillovenous distension with blood	Due to extravasation of blood from capillaries
Effect of pressure	Pressed spot appears pale	No change on application of pressure
Cut section	Cut surface shows blood confined within the vessels, and minute drops of blood may be seen exuding from the divided ends of the distended capillaries/venules, which do not stain the tissues	Cut surface shows evidence of haemorrhage in the tissues with coagulated or fluid blood from the ruptured blood vessels
Microscopic study	Blood elements found within the blood vessels and no evidence of inflammation	Blood elements are found outside the blood vessels, and there may be evidence of inflammation
Enzymatic study	No change	Change in the level of certain enzymes in the affected area
Medicolegal importance	Suggests about the time of death and position of the dead body	Suggests about the nature of injury, weapon used, etc.

portions of the arms. If the suspension is prolonged, the accu- mulation of blood may create enough pressure to rupture sub- cutaneous capillaries and produce petechial haemorrhages in the skin. Rarely, if the body is suspended by the feet, development of such postmortem haemorrhages in the face and eyes may pose problem by simulating haemorrhages of asphyxial origin. In case of drowning, postmortem staining is usually found on the face, the upper part of the chest, hands, lower arms, feet and lower legs because in still water when the body floats, the abdomen being lighter in weight due to accumulation of gases remains at a higher level than the head and shoulders, which are heavier. The limbs will be hanging passively. This explains the distribution of postmortem staining upon the described areas.

If the body is constantly changing position due to forceful currents/waves of water, staining may not develop.

The So-called 'Fixation' of Postmortem Staining

Once the hypostasis is well-developed and gets fully established, it is generally believed that there will be no change in the distri- bution of hypostasis on altering the position of the body as the blood gets coagulated. However, practically speaking, this view is largely not tenable. The 'fluidity of blood' has already been discussed under the heading 'Extent and Distribution of Hypostasis'. The author's own experience also shows that the blood is almost always found fluid in the small capillaries and venules after death. However, clots may be encountered in the large vessels and chambers of the heart. This is probably due to liquefaction of postmortem clots in the smaller capillaries and venules due to the action of fibrinolysin liberated from vascular endothelium at about the time of death. It has been suggested that the liberation of fibrinolysin is due to some non-specific general reaction to injury. This fibrinolysin activity appears to be greatest in the capillaries and venules where there is highest ratio of endothelial area to the content of blood.

However, certain physical factors that may be playing a role in this so-called 'fixation of hypostasis' are as follows: firstly, inability of blood to flow in well-developed areas of lividity as compared to quick changes observed in change of position of the body during the first few hours of death. Secondly, by the time there has been total settling of blood, rigor mortis also makes the appearance in the body. This prevents the blood to pass through the big vessels (as they are being compressed by the process of rigor mortis) and to settle in the venules and capillaries of the new area.

From the above discussion, it may conveniently be advo- cated that the fixation of hypostasis is a 'relative term' and it is unlikely that the movement of body, though some hours after death, will completely displace the blood even though it is fluid. Hypostasis may decrease in intensity but evidence of its initial distribution can be appreciated with careful observation. However, secondary distribution may also occur in the then dependent parts on changing the position of the body. This has an important medicolegal bearing in the sense that if the body is found with the hypostasis in unexpected locations as related to the posture/position in which it is found, it should raise suspicion that the body might have been moved after death.

Colour of the Hypostasis

The usual colour is reddish-purple (.. 4.2A). The colour depends upon the state of oxygenation at about the time of death. That is why those dying of hypoxic states have darker tint due to presence of reduced haemoglobin in the cutaneous vessels, whereas when the death is due to hypothermia as in exposure to cold or drowning etc., the colour may be pink due to presence of much of oxyhaemoglobin as the tissues, due to reduced metabolism, are unable to take up oxygen from the circulating blood. Other such colour changes may include:

- Cherry-pink or cherry-red colouration in poisoning by carbon monoxide or hydrocyanic acid (.. 4.2B).
- Chocolate or coffee-brown colour in cases of poisoning by potassium chlorate, potassium bichromate or nitrobenzene, aniline, etc.
- Dark brown colour in poisoning by phosphorus.
- Bright pink patches: A refrigerated dead body may show bright pink patches probably due to retention of oxyhae- moglobin in the tissues.

Distinction between Hypostasis and Bruising

This rarely presents any difficulty in the fresh bodies but when the decomposition supervenes, the differentiation may be difficult as there occurs haemolysis of blood and diffusion of the pigment into the surrounding tissues due to the onset of decomposition. As decomposition progresses, the lividity becomes dusky in colour, turning brown and finally green before disappearing with the destruction of blood. Changes in the postmortem lividity appear when the putrefaction sets in. In early stages, there occurs haemolysis of blood and diffusion of blood pigment into the surrounding tissues, where it further undergoes secondary changes, i.e. formation of sulph-haemoglobin etc. The capillary endothelium shows lytic changes and on microscopic examination, the cellular outlines are obscured and capillaries are usually not identifiable. A contused area also shows similar putrefactive changes and it becomes extremely difficult to determine whether the pigment in a stained putrefied area originated from an intravascular (hypostasis) or/and extravascular localised collection of blood (contusion). As decomposition progresses, lividity becomes dusky in colour and turns brownish, greenish and finally to greenish-blue or greenish-black.

Differences between Postmortem Staining and Bruising Hypostasis in the Internal Organs

Just as the blood settles in the dependent-subcutaneous vessels after death, so it behaves in the other tissues and organs of the body. Therefore, under usual circumstances when the body is lying upon its back, hypostasis is frequently observed in the posterior cerebral lobes, lower posterior surfaces of lungs, posterior surfaces of liver, kidneys, spleen, posterior part of stomach and the dependent loops of jejunum and ileum. Often loops in the pelvis are the worst sufferer because of their most dependent position. The importance lies in differentiation of hypostasis from that of antemortem congestion with inflammation. Thus, hypostasis in the heart may not be mistaken for infarction, lungs for pneumonia, in gastric mucosa for some irritant poisoning and the dependent coils of the intestines may look as if strangulated.

Medicolegal Significance of Hypostasis

- The principal value lies in ascertaining whether a body has been moved from the position in which it originally lay when the life ceased.
- Degree of development may help in ascertaining the post-mortem interval.
- Characteristic distribution may suggest manner of death as in hanging.
- Colour may impart clues towards cause of death.
- A good indicator of occurrence of death.

Rigor Mortis (Postmortem Stiffening)

Alternatively called as cadaveric rigidity, it is the stiffening of the muscles after death. Following death, muscles of the body pass through three phases, i.e. primary flaccidity, which occurs immediately after somatic death as has been described earlier. Here the muscles are able to respond to electrical or chemical stimuli. The second stage is the development of rigid- ity known as rigor mortis during which there is no longer any response to the electrical or chemical stimuli and the third stage is the secondary flaccidity or stage of resolution when the rigor passes away that coincides with the onset of putrefaction.

Pathophysiology of Rigor Mortis

This is a physicochemical process involving both voluntary and involuntary muscles of the body following the period of pri- mary flaccidity. To understand the development of rigidity, it is better to study the mechanism of muscular contraction first and then the stages of development of rigidity.

Szent-Gyorgyi discovered that the essential contractile ele- ments in the muscle were the two proteins, which he named as actin and myosin. These two proteins form interdigitating thick (myosin) and thin (actin) filaments that build the sarcomere, the contractile unit of the muscle. The contraction of the muscle can be explained by the ATP-theory. The contraction in the muscle is achieved by the contrary motion of these interdigitating fila- ments. The driving force for this sliding motion comes from the myosin heads that bind the ATP and form myosin-ATP, which in turn has high affinity for actin, thus resulting in the actin–myosin complex. When the actin–myosin complex is formed, the low ATPase activity exhibited by free myosin heads is increased and ATP is hydrolysed. The energy released through the hydrolysis of ATP is used for dissociation of the actin–myosin complex.

During life, there is fairly constant concentration of ATP

in the muscular tissues and the balance is maintained between utilisation and resynthesis. The ATP used in the process of contraction is almost immediately resynthesised through the following processes:

- Through the hydrolysis of creatine phosphate (CrP) that supplies the rapidly available energy. The CrP used in this process is restored by means of the energy generated by anaerobic glycolysis.

- Through the transformation of glycogen into lactic acid by anaerobic hydrolysis. This process gets limited by the accu- mulation of sufficient lactic acid.

- Through the oxidative phosphorylation of glucose. Although it liberates great amount of ATP, it is relatively a slow process.

If this ATP is not regenerated as is the case after death, the actin–myosin complex is not split, it persists and the muscle remains inextensible. This s. actin–myosin complex is the basis for the development of rigor mortis after death (.. 4.3). After going through the above mechanism of muscular contraction, the process of development of rigor may be studied under the following phases.

- First phase: After somatic death, the muscle remains in a normal state for 'sometime' as long as there remains suffi- cient ATP to permit the dissociation of the actin–myosin cross-bridges. This fact was first established by Erdos (1943) and later confirmed by Bate-Smith and Bendall (1947). Obviously, the rate of ATP depletion will depend upon its content and on the rate of ATP hydrolysis at the time of death. This 'sometime' as mentioned above, therefore, rep- resents the time during which the dead body is capable of utilising the ATP already present and its resynthesis from the available glycogen stores, as the cellular death has not yet occurred. This explains indirectly the rapid onset of rigor in the circumstances where the stores of glycogen are depleted by vigorous exercise prior to death, say, death following epileptic attacks or tetanic spasms or electrocution or strychnine poisoning or any other violent activity prior to death.

- Second phase: When the ATP content of the muscle falls below a critical level, the cross-bridges remain bound and the muscles tend to turn into viscous, inextensible dehydrated stiff gel like state that accounts for the onset of rigor mortis. However, this state is still reversible by addition of ATP or O2. It has been reported that rigor is initiated when ATP concentration falls to 85% of the normal and the rigidity of the muscle is maximum when the level declines to 15%.

- Third phase: Rigidity becomes fully developed and irreversible.

- Fourth phase: It may also be called as 'Phase of Resolution' when the rigidity disappears and the muscle becomes limp and loose. The cause of the resolution is not definitely known. One view is that it is a denaturation process due to development of enzymes in the dead muscles, which dis- solve myosin by a process of autodigestion. The other view is that the process is pH dependent occurring due to solution of myosin by excess of acid produced during the con- tinuance of rigidity.

The fact that rigidity can be broken by forceful movements of a joint during a certain period after death while the rigor is still developing and it gets restored afterwards can be explainedby the observations of the various workers that the human skeletal muscle contains two sorts of fibres—Type I (red), which are rich in mitochondria with dominant oxidative metabolism, and Type II (white), which are relatively poor in mitochondria with dominant glycolytic metabolism. The rigor, as suggested, is expected to occur in these types of muscles at different times. The fibres that are still slack and some others that are not fully contracted retain capacity for reversible bind- ing of myosin heads to actin filaments. The contraction of such fibres causes re-establishment of rigor.

There has been some controversy regarding the point— whether rigor mortis only stiffens the muscles or shortens them too. Shortening is not a normal concomitant of rigor and is unlikely to cause any significant change in the attitude of the corpse at death. Forster was of the opinion that when a muscle was under tension, it did shorten. He also showed that the high atmospheric temperature and poisons, which enhance muscle tone, lead to shortening during rigor. However, as stressed ear- lier, the effects are negligible because flexor and extensor muscle groups oppose each other across most of the joints.

From the medicolegal viewpoint, rigor mortis may be considered under the following heads:

- Time of onset and duration.
- Order of appearance and disappearance.
- Rigor mortis in the involuntary muscles.
- Factors influencing onset and duration.
- Other forms of stiffening.

Time of Onset and Duration

The time of onset and duration of rigor is varied by multiple factors as will be discussed shortly but in general it is likely to be apparent in about 1–2 hours after death, gets well-established in the entire body in about 9–12 hours. It is maintained for about 12 hours and then gradually passes off in the same order as it appeared. In the Northern India, the usual duration of rigor mortis is 18–36 hours in summer and 24–48 hours in winter.

Order of Appearance and Disappe arance

In 1811, the French Physician and Chemist PH Nysten pub- lished the first scientific description of rigor mortis. He stated, "Cadaveric rigidity affects successively the masticatory mus- cles, those of the face and neck, those of the trunk and arms, and finally those of the lower limbs". It is often added that resolution occurs in the same order. Even today, almost the same holds good, and it is considered to appear first in the muscles of the eyelids by 1–2 hours of death and then pro- gresses on to muscles of face, neck, lower jaw, muscles of the chest, upper limbs, abdomen and lower limbs. The proximodis- tal progression is only apparent one. The process responsible for bringing about rigor mortis being a physicochemical pro- cess, it affects all the muscles of the body simultaneously. As Shapiro (1950) pointed out, "Although the changes are more easily detected in the smaller muscle masses than in the larger ones, they take place in all the muscles simultaneously. The order of onset and passing off of the rigor mortis may be determined by the quantum and kind of the muscle involved." Nevertheless, from the practical angle, corpses may be divided into three categories depending upon the progression of rigor mortis: (i) those that are still warm without showing any rigor indicating death within about a couple of hours pre- viously; (ii) those in which the rigor is progressing but not established in the entire body, suggesting death within about 4–12 hours previously; and (iii) those in which the rigor is well-developed in the entire body suggesting death beyond 9–12 hours. To bring better approximation, degree and extent of rigor in the various parts of the body should be determined.

The disappearance of rigor follows the same fashion as its appearance. Hence, it may be observed that while being well-established in the upper limbs, it may not be seen in the lower limbs and conversely, rigor mortis may be observed in the lower limbs while it has already disappeared from the upper limbs depending upon the time since death. It has been described earlier that the lower limbs are the last to be affected by rigor and last to exhibit disappearance too.

Rigor Mortis in the Involuntary Muscles

Rigor mortis involves the involuntary muscles also, where it makes its existence earlier than the voluntary muscles. It may be due either to their small mass or more speedy loss of irrita- bility. It appears in the heart usually within an hour of death and may stay for 10–12 hours. Left ventricles contracted by rigor may not be deemed hypertrophied.

In connection with the involvement of various muscles by the rigor mortis, some peculiar effects having some medi- colegal bearing may be as follows:

- When the iris gets involved, the antemortem dilatation or constriction gets modified. It may affect the eyes unequally making the pupils unequal.
- Contracted, stiff, left ventricle may be mistaken for left ventricular hypertrophy.

- Rigor in the dartos muscle of scrotum can compress the testes and epididymis and this associated with contraction of muscular fibres in the seminal vesicles and prostate may be responsible for postmortem expulsion of semen.

- Rigor of the erector pili muscles attached to the hair folli- cles causes goose-skin or pimpling appearance with the erection of hair.

Factors Influencing Onset and Duration

There are many extrinsic and intrinsic factors that may significantly influence the onset and duration of rigor mortis. These may be summarised as follows.

- Temperature: As rigor mortis is a biochemical process, it is understandable that its overall development is affected by the temperature of the body at about the time of death and that of the surroundings. This fact was noticed long ago as Nysten (1811) stated that 'rigidity persists longer in cold, wet air than in fresh, dry air'. In one of the Forster's cases, a corpse kept at 4° C exhibited strong rigidity even after 234 hours. This is why onset of rigor is slow and duration longer in cold countries or cold weather, whereas the onset is rapid and duration is short in hot weather. It is due to early and increased breakdown of ATP in the hot weather and an early setting of the putrefaction.

- Influence of nature of death: It has been observed that the bodies of those who are emaciated or who die of wast- ing diseases pass rapidly into the state of rigidity, which is usually of shorter duration. Further, it may frequently be absent in persons dying of septicaemia, particularly in the limbs or areas of the body that are affected by purulent inflammation of the muscles. In one reported case of enteric fever, rigor mortis appeared as early as by three and a half minutes after death and disappeared in a quarter of an hour and in less than an hour, putrefaction had set in. In deaths from asphyxia, severe haemorrhage, apoplexy, pneu- monia and nervous diseases with paralysis of the muscles, the onset is delayed.

- Condition of the muscles before death: The onset of rigor mortis is slow and duration is longer in cases where muscles are healthy and robust and are at rest prior to death. The onset is rapid if the muscles are exhausted or fatigued. In persons where death occurs while running, rigor may develop rapidly in their legs as compared to other parts. Similarly, in deaths due to electrocution, lightning, convulsant poisons, epilepsy or in the soldiers dying after severe muscular exercise, etc., onset and duration is hastened.

- Influence of central nervous system: As already stressed, rigor mortis is dependent upon chemical changes occurring in the muscles after death as a result of cellular and enzy- matic activity. Obviously therefore, division of the nerves supplying the muscles or even removal of the brain does not exert any influence on its onset. Rigor mortis occurs in amputated limbs too, whether amputated traumatically or surgically.

- Age: Rigor usually does not occur in foetus of less than 7 months but may be found in stillborn infants at full term. It is earlier to appear and also to disappear. Rigor mortis has no value as a sign of live-birth. In healthy adults, it develops slowly but is well-marked whereas in children and old peo- ple, it is weak and rapid.

Other Forms of Stiffening

Heat Stiffening All muscle proteins in the body get coagulated at temperature above 149° F (65° C). Therefore, whenever a body is subjected to intense heat as by burning or exposure to high voltage electric current or immersion in a hot liquid, rigidity develops due to coagulation of muscle proteins, which is usually more intense than the rigor mortis. Changes in the posture, particularly of the limbs, may occur due to con- traction of the muscles (Pugilistic or Boxer's attitude). This heat stiffening cannot be broken down by extending the limbs as in rigor mortis and will persist until disintegration supervenes. Further, unlike rigor, heat-stiffening is associated with considerable shortening of muscle fibres. These changes have nothing to do with the life or the cause or manner of death in any way.

Cold Stiffening As the term applies, it is the stiffening of body due to cold environment. Any reduction of the tempera- ture of a corpse below 3.5° C (40° F) will result in significant solidification of subcutaneous fat and muscle. The process of rigor mortis is suspended in such cases until thawing takes place. When the body is subjected to thawing, true rigor mortis appears with great rapidity and passes off very quickly. Hardening of the subcutaneous fat, particularly in infants, may render the skin-folds rigid and may be mistaken for ligature marks. However, they coincide with the skin creases, are deepest at the front and do not exhibit any petechiae, abrasions or patterning as might be expected in the seat of the groove of the ligature. In extremely cold environments, even the adult body may freeze rigid. The body fluid gets frozen including that of the joints and on bending the joint, crepitus may be felt due to breaking of frozen fluid in the joint spaces.

Cadaveric Spasm (Instantaneous Rigor)

Cadaveric spasm is a well-recognised but quite rare phenomenon. Ordinarily, the muscles become loose and lax immediately after death (primary flaccidity), which is followed by rigor mor- tis after about couple of hours or so. This period of flaccidity does not occur in case of cadaveric spasm, and the muscles exhibit stiffening at the moment of death. It may be that the changes are extremely accelerated so that the usual state of flaccidity of musculature at the time of death does not occur or is of such a short duration that it escapes notice. The condi- tion frequently involves only a group of muscles of hand or limb or rarely whole body. This state persists until true rigor develops.

The nature of the cadaveric spasm is obscure but can be explained, like that of rigor mortis, on the basis of exhausted ATP stores in the affected muscles. Adrenocortical exhaustion, which interferes with the resynthesis of ATP, may be the pos- sible cause. It is usually associated with the violent deaths occurring under circumstances of intense emotions. Hence, the obvious circumstances may be:

- In routine medicolegal work, it may be encountered in cases of drowning, hence the proverb, 'drowning man clutching at a straw'. In these cases, twigs or vegetation may be firmly grasped in the hand. It may be virtually impossible to extend the fingers when they are in cadaveric spasm.

Differences between Rigor Mortis and Cadaveric Spasm

Features	Rigor mortis	Cadaveric spasm
Onset	This is due to changes in the muscles after the molecular death of their cells and is preceded by primary flaccidity of muscles. 2–3 hours are therefore usually necessary before stiffening occurs	This is continuation of state of contraction of the muscles after death in which the muscles were at the instance of death. The stage of primary flaccidity is absent. The stiffening is therefore instantaneous
Muscles involved	All muscles of the body are affected gradually	Selected muscles, which were in a state of contraction at the time of death
Intensity	Comparatively moderate	Comparatively very strong
Duration of stay	About 12–24 hours	A few hours, until replaced by rigor mortis
Predisposing factor(s)	Nil	Excitement, fear, fatigue, exhaustion, nervous tension along with contraction of muscles during death
Mechanism of formation	Breakdown of ATP below critical level	Not exactly known
Medicolegal bearing	Mostly helps to know the time since death	It helps to suggest the manner of death, i.e. whether suicide, accident or homicide

The importance lies in the fact that it indicates presence of life at the time of submersion. Though it is not a proof of drowning but does impart corroboration towards this cause of death.

- More likely to be seen when death precedes great muscular exertion and intense emotions. It is reported that on one occasion a soldier was found in the kneeling posture appar- ently taking aim with his rifle. As it was dark, he was told to get up and when he failed to obey the orders, someone pushed his shoulder. He fell over and proved to be dead.

- Death from violent disturbance of nervous system (firearm wounds of head involving brain) may also be another ele- ment in its production.

- Certain poisons may predispose to instant rigor. Tidy (1882) described a couple who were found dead rigidly locked in each other's arms after taking cyanide. Experiments by Brown- Sequard (1861) with strychnine produced instant rigor.

- In a small proportion of suicidal deaths when some weapon such as razor in case of cut-throat or pistol/revolver in case of firearm injury is found clenched tightly in the hand of the deceased.

- In certain cases of homicides when some portion of clothing or hair belonging to the assailant is found in the deceased's hand(s), which may help in identifying the assailant.
- In certain cases of accidents such as mountain fatalities, when branches of shrubs or trees are seized by the deceased.

Medicolegal Significance of Instant Rigor

The condition, though well-recognised, yet is extremely rare. Polson admits to having seen only two cases in his extensive practice but gives references to other reported cases. The author has encountered only one case during medicolegal work of about 19 years. This was a case of an elderly teacher, riding on a cycle and speeding hastily for going to teach tuition early in the morning at about 4.30 a.m. He was carrying a torch in one hand to make his way through darkness. It was winter season. All of a sudden, he was shot by some unidentified assailants and the bullet pierced the head, creating a distinct tract through the brain. He fell down the very moment. The torch was found intensely clutched in the hand, when examined at the scene.

The practical importance lies in the fact that it helps in drawing certain conclusions as it records the last moment of death and also that the person was alive at that time. When some agent or weapon causing the fatal wound is found held firmly, it is strongly suggestive of self-infliction. Taylor (1965) adds an important caution. If the weapon be held lightly, it may not follow that suicide is excluded because the instant rigor is not an invariable consequence of violent death.

Then question may creep up that the condition may be imitated by someone having the knowledge of the above facts by placing the weapon in the hand postmortem. But ordinary rigor does not produce the same grip as produced by instant rigor, and considerable force will be required to extract the weapon from the grip. Moreover, in haste, the weapon may be placed in the hand in a way in which the suicide could not be able to use;

e.g. the blade could be facing the wrong way or the weapon be placed in the right hand of a left-handed victim and so on.

LATE CHANGES AFTER DEATH

The time of onset and rate of decomposition like most of the other changes that throw some light on the time since death are subject to considerable variations (.. 4.1). As already stressed in the very beginning of this chapter, the death is the end of dying and it is a process not an event. Therefore, while the cells of some tissues are still alive and may respond to chemical or mechanical stimuli (muscles) the other cells may be dying or dead. The process of decomposition may involve some tissues/cells earlier and others later, as it is dependent upon a host of intrinsic and extrinsic factors. This overlapping may continue for several days and therefore one must be cautious in pronouncing too rapidly that the decomposed condition of the body is inconsistent with the time interval alleged.

Putrefaction or Decomposition

It is the final stage of dissolution of body tissues resulting in breaking down of complex organic body constituents into sim- pler inorganic ones. Two processes contribute to this decom- position, which are described as follows.

Autolysis

This is the softening and liquefaction that occurs in a tissue even under sterile conditions as it is brought about by the digestive action of the enzymes released from the cells after death and can be prevented by freezing the tissues. The earliest autolytic changes may be noticed in the parenchymatous and glandular organs. Intrauterine maceration of foetus in the uterus occurs from aseptic autolysis. Softening and even rupture of the stomach and lower end of the oesophagus may occur from autodigestion by the gastric juice in some newborns after death. In adults too, such extreme changes may be observed.

Bacterial Action

The second but the dominant process contributing to bring about putrefaction is the action of microorganisms, both aerobic and anaerobic. Bacteria, normally inhabiting the body, soon invade the tissues after death. Most of these bacteria come from the bowel, the Clostridium welchii being chiefly instrumental. Some may come from the respiratory tract and some from the open skin wounds. Should death have been due to bacterial dis- ease, putrefaction will obviously be rapid. As blood is an excellent medium for the growth of the organisms, therefore the organs receiving richest blood supply and those nearest the source of bacteria naturally will receive most bacteria and putrefy first.

Bacteria produce a large variety of enzymes that act on carbohydrates, proteins and fats and break down the various tissues. One of the most important enzymes is the 'lecithin- ase' produced by the Clostridium welchii, which hydrolyses the lecithin present in all the cell membranes including blood cells and thus is responsible for producing haemolysis of blood postmortem. This enzyme also helps in postmortem hydroly- sis and hydrogenation of body fat.

Putrefactive activities are optimal at temperatures between 70° and 100° F and are retarded when temperature falls below 70° F or when it exceeds 100° F. Below 70° F, propagation is almost at a standstill, though most enzymes produced by bacte- ria will continue to act even at much lower temperature. There- fore, initial spread of putrefaction is mainly governed by two factors: the cause of death and the period of time during which the internal temperature of the body remains above 70° F.

Site of Appearance and the Colour Changes

It is a usually held notion that putrefaction follows disappearance of rigor mortis, but this may not hold true in all the cases because in extreme hot and/or humid months, it may make its appearance before rigor has completely passed off from the body. In India, climatic conditions vary so much in different parts and therefore wide variations can be expected in the time frame of the putrefactive changes.

The first visible sign of putrefaction is the appearance of greenish discolouration of the skin of the anterior abdominal wall, usually manifesting in the right iliac fossa. The reason has amply been explained earlier because the area is against the cae- cal region, which is rich in bacteria and fluid contents. This discolouration is due to the conversion of haemoglobin into sulphmet-haemoglobin by the action of sulphuretted hydrogen diffusing from the intestines into the tissues. The patch of dis- colouration usually appears between 12 and 18 hours in summer and 1–2 days in winter and is more appreciated upon the fair skin. Green patches then spread over the entire abdominal wall and adjoining parts of the external genitalia, spreading over to chest, neck, face, arms and legs. The sequence is probably governed by extent and distribution of fluid/blood in the various parts of the body at the particular time. Such a distribution involving entire abdomen and other areas may be observed by about 24 hours in summer. These patches gradually deepen in colour, becoming purple and dark-blue and ultimately coalesce together.

At about the same time, the bacteria that largely originate from the intestines get infested in the venous system, the blood acting as nutrient for them. The blood in the vessels is haemo- lysed, which stains the vessel walls and the adjacent tissues, giv- ing rise to marbled appearance. The marbling of the skin becomes prominent in about 36–48 hours after death in summer and distinctly appreciable in the superficial veins of abdomen, shoulders, chest and inguinal region (.. 4.4, photograph B).

Development of Foul-smelling Gases

Side by side with exhibition of greenish patch of discoloura- tion on the abdomen, the body begins to emit a nauseating smell owing to gradual development of gases of putrefaction. The composition of the gases varies according to the postmor- tem interval and environment of the body. The gases are non- inflammable in the initial stages but as the decomposition progresses, enough of hydrogen sulphide is formed that can be ignited with blue flame.

In summer, gases accumulate in the intestines during 12–24 hours after death and consequently abdomen swells up; from 24 to 48 hours after death, gases collect in the tissues, cavities and hollow viscera under enormous pressure with the result that the features become bloated and distorted

Subcutaneous tissue becomes emphysematous, breasts, scrotum and penis, markedly distended. Eyes may be forced out of their sockets, the tongue gets protruded between the teeth and the lips become swollen and everted. A reddish, frothy fluid or mucus may be forced out from the mouth and nostrils as the lungs are forced upwards due to the pressure of the gases. Ultimately, the features may become obliterated to the extent that they become hardly recognisable. The abdomen gets greatly distended and on opening the cavity, a loud, hissing noise may be experienced. The contents of the stomach may be forced into the mouth and larynx and seen running out of the mouth and nostrils. The sphincters relax and urine and faeces may escape. The anus and uterus may prolapse after 2–3 days and postmortem delivery of foetus may occur. The cel- lular tissues get inflated throughout the body, so that the body appears stouter and older (.. 4.5).

Gas collection between the dermis and epidermis results in formation of blisters. These blisters may contain red-colouredluid, expressed out of the blood vessels due to pressure of gases. Blisters are usually formed first on the under surfaces, where tissues contain more fluid due to hypostatic oedema. The epidermis gets loosened producing fragile sacs of clear or pink-coloured fluid. This loosening of the epidermis has been termed as 'skin slippage' and may be seen in 2–3 days. The sacs so formed, generally enlarge, coalesce and ultimately rup- ture, leaving bare areas of dermis. Shifting of areas of postmortem staining is another peculiar effect owing to the pressure of gases in the blood vessels. Hence, no plausible inference can be drawn regarding the position of the corpse since death, at this stage.

Between 3 and 7 days, ever increasing pressure of the putrefying gases associated with colliquative changes in the soft tissues may lead to softening of the abdominal parietes resulting in burst- ing open of the abdomen and thorax. Teeth become loose and may be pulled out easily or may even fall. Skin of the hands and feet may come off in a 'glove and stocking' fashion. Hair and nails may turn loose and may be easily pulled out.

By 5–10 days or more after death, colliquative changes (liquefaction) are prominent. Soft firm tissues change into thick, semi-solid black masses. They may be separated from the bones and fall off. The cartilages and ligaments are soft- ened in the final stage.

Skeletonisation

Skeletonisation of the body takes varying time as it is dependent upon multiple intrinsic and extrinsic factors and also whether the body lies in air or in water or buried shallowly/deeply in the grave, particular atmospheric variables to which it is exposed and so on. Ordinarily, a body exposed to air may get skeleton- ised in about 2–4 weeks but even this time may be reduced to a few days if the body is attacked by ants, flies, dogs, jackals, etc. or may be prolonged if the body remains relatively protected/ concealed by some means as when lying covered with leaves or vegetation or in bushes or some other shelter, etc.

Here, it must be remembered that decomposition may dif- fer from body to body, from environment to environment and from one part of the same body to another. Sometimes, one part of the body may be mummified, while the rest may show liquefying putrefaction. Further, a body lying exposed on the outskirts of village and that too in the hot humid atmosphere of rainy season is likely to be attacked by animals as mentioned above. Animals nibble and destroy soft tissues in a very short time and may, occasionally, skeletonise the body even in less than 24 hours. These aspects must receive proper recognition while assessing the time since death.

Putrefaction of Internal Organs

Changes of discolouration also appear in the internal tissues and organs though it proceeds more slowly than the surface, and sometimes the internal organs may be encountered in a better state than the external appearances would suggest. Thenmore vascular and the softer the organ, the more early will it putrefy. A brownish red discolouration of the inner surface of aorta and other vessels is the earliest change to appear. Internally too, the same mode operates, i.e.

haemolysis of blood and diffusion of pigments that stains the surrounding tissues/organs, imparting them dark red discolouration that later on becomes black instead of greenish. The organs subsequently soften, become greasy, pulpy and finally liquefy into semi-liquid grumous masses. The rate of putrefaction of an organ, apart from vascularity as written above, also depends upon its architecture, abundance of microorganisms, fluid contents and enzyme/ferment contents, etc.

The usual order of appearance of putrefaction in the internal organs is show in . 4.5.

- Circumstances Influencing the Onset and Progression of Putrefaction

- Postmortem Changes and Postmortem Interval (Usual Summer Season)

- Exogenous Factors Certain exogenous factors that warrant details are enumerated as under:

- Temperature of the atmosphere: High atmospheric or environmental temperature promotes decomposition. As stated earlier, putrefactive activities are optimal at tempera- tures between 70° and 100° F and therefore get retarded when the temperature is either below 70° F or exceeds 100° F. Below 70° F, the propagation will come to a standstill, though the enzymes produced by the bacteria may continue to work even at lower temperatures. A dead body may thus be preserved for considerable periods in refrigerators, snow, etc. It is well-known that the hot and humid atmo- sphere is most notorious in bringing about putrefactive changes at an extremely accelerated pace. Under such con- ditions, particularly in the months of rainy season, it is not surprising to notice greenish patches over the body within about 6–12 hours.

- Access of air and light: Air exerts its effects mainly through its temperature and moisture, which have been highlighted above. Flies and insects usually avoid those parts of the body that are exposed to light, tending to lay eggs in the cervices like the eyelids, nostrils, etc.

- Immersion in water: Certain factors influencing the pro- cess of decomposition are peculiar to immersion. Still or running water, polluted water or sea water, temperature of water, deep or shallow water, etc. all have bearing upon the subsequent rate of putrefaction.

Ordinarily, putrefaction is delayed in water to the entire exclusion of air. Casper's dictum is that the time and rate of putrefaction in air, if denominated as 1, it will be 2 in case of submerged ones and 8 in case of bodies buried in deep graves. This dictum must be taken in the spirit of stressing a time honoured fact that the rate of putrefaction is slower in water and much slower in buried corpses, rather than fol- lowing the dictum literally. However, putrefaction is acceler- ated in a body lying in water contaminated with sewage. Further, presence of fish, crabs or other animal and/or bac- terial contents that may happen to be present in the particu- lar water may destroy the soft tissue and expose the bones in a short period. Water also exerts its influence on the usual process of decay in the way that the epidermis gets macer- ated due to imbibition of water and eventually detached. Detailed effects helping to estimate time since death have been discussed in the chapter on 'Drowning'.

Floatation of the body in water primarily depends upon the production and accumulation of gases in the body tissues and cavities. The specific gravity of a cadaver is slightly greater than that of water and therefore the body will have a tendency to sink unless sufficient gases are produced to make it buoy- ant. Therefore, the evolution of sufficient gases will help the body to rise to the surface unless the body is entangled in weeds, stones or any other impediments. In India, a sub- merged body may usually come to the surface by 24 hours in summer and 2–3 days in winter. The factors like age, sex, clothing, condition of the body, season of the year and nature of water (whether polluted or otherwise, stagnant or running, sea water or ordinary, etc.) all influence this period of floatation owing to playing their role upon the rate of putrefying process and consequent production of gases.

The order of appearance of colours of decomposition upon the surface of the body is usually deranged when the body is immersed in water as the usual posture of a floating body is head and face at a lower level than the rest of the body as the head is relatively heavy and dense and, consequently, even while under water, the body tends to assume a char- acteristic posture—the trunk is uppermost and head and limbs hang passively at lower level. This favours gravitation of blood into the head and face and hence more marked decomposition. The order of appearance may be summarised as given in . 4.7.

Submersion of the bodies with injuries upon the surface may prevent the differentiation between antemortem and postmortem wounds as the water will lyse the blood in the wounds. Once the body has been removed from water, the putrefaction is much enhanced because the body has imbibed much fluid, which accelerates the process.

- Burial under earth: In this context, it is usual that the bod- ies buried under deep graves will putrefy much slowly than those in the shallow grave, as in shallow graves, the body will be subjected to constant variations of temperatures and

ı further, in bodies buried in damp, marshy, clayey soil, the putrefaction will be hastened. Putrefaction is, however, retarded if body is buried in dry, sandy or gravelly soil on high ground or in a deep grave. Presence of chemicals around the body, especially lime, may retard the putrefaction. Bodies buried without clothes or coffins in a porous soil rich in organic matter will show hastened putrefaction. Bodies placed in air-tight lead or zinc coffins resist putrefaction for a considerable period.

Time elapsed between death and burial and the environ- ment of body during this period exert profound influence upon the putrefaction. The longer the body remains on the ground before burial, the more enhanced is likely to be the state of decomposition, especially if the body has been kept under warm atmosphere. This was obvious from a series of exhumations carried out in Germany after the 1939–1945 War, where the bodies of aircraft crew, who all had been killed at about the same time but buried at different intervals, although in the same cemetery and under the same condi- tions. Further, if a number of bodies are buried in a grave without coffins, bodies lying in the centre may be compara- tively better preserved than those lying at the periphery.

Endogenous Factors Endogenous factors may include the following:

- Cause of death: Bodies dying of acute violence/accident generally putrefy slower than those dying from infectious diseases. Deaths due to gas gangrene, intestinal obstruction, bacteraemia/septicaemia, certain abortions, may show putrefaction with remarkable rapidity. Poisons that resist putre- faction include potassium cyanide, barbiturates, phosphorus, dhatura, strychnine, etc. In case of death due to strychnine poisoning, if it occurs following prolonged and repeated seizures, rate of putrefaction may be enhanced whereas if it occurs following a few seizures with little muscular exhaustion, putrefactive changes may be delayed. Chronic poisonings by metals may delay putrefaction as they may have preservative effects upon the tissues. Chronic alcohol- ism generally hastens putrefaction.

If the body has been dismembered at the time of death, limbs will show slower putrefaction being devoid of bacte- ria; the trunk, however, will putrefy as usual. In general too, bodies having injuries upon the surface will show early putrefaction owing to the ease with which the organisms gain access to the damaged tissues.

- State of the body: Moisture content of the body prior to death has a profound bearing on the rate of putrefaction. The water content of human body is nearing two-thirds of its body weight. Therefore, body tissues containing less water like hair, teeth and dense bone resist putrefaction for a long period. QueKett (Taylor's Medical Jurisprudence, 12th ed.) examined a portion of dried human skin with hair upon it that had been exposed for many centuries on the door of some church and the hair were proved to be of human under microscopy, thus lending credence to the old tradi- tion that the skin of the persons who were guilty of com- mitting sacrilege was nailed to the doors of the churches which they had robbed.

Similarly, dehydration from any cause prior to death will

retard the process of putrefaction. A thin, emaciated body decomposes late in comparison with a well-nourished bulky body due to less fluid contents in the former.

- Clothing upon the body: Their effect in case of drowning is discussed under 'Drowning'. In bodies exposed to air, cloth- ing act initially by hastening the putrefaction by maintaining the body temperature. Tight clothing may delay putrefaction owing to pressure producing a degree of bloodlessness in that part. At the later stage, clothing delay decomposition by protecting the body against the flies/insects, etc.

- Age and sex: Bodies of newborn or stillborn infants decompose slowly as they are usually sterile. Newly born infants, if sustain some injury during or after birth or have been fed after birth, putrefy early. Bodies of the children putrefy rapidly than those of the old people, which decompose slowly and sluggishly as they have less water contents.

Sex does not have much influence. Female bodies having abundant fat may retain heat for a longer period, which may enhance the putrefactive process to some extent.

Contents of Stomach, Intestines and Bladder in Estimating Time Since Death

The state of digestion of food in the stomach and the approximate quantity of food material emptied from the stomach can, to some extent, help to ascertain the period the person survived after taking his last meal. Further, if the time of his taking last meal (quantity as well as quality) is known, the approximate time of his death can be made-out indirectly. The length of time required to empty the stomach is variable as it depends upon a host of factors like nature and consistency of food, motility of stomach, osmotic pressure of the stomach contents, surroundings in which the food is taken, emotional/psycho- logical factors and residual variations.

A meal containing carbohydrates usually leaves the stomach early and the one containing proteins, later. The fatty food delays the emptying time, whereas liquids leave the stomach immediately after ingestion. Dals usually retain their form up to 2 hours and rice grains up to 3 hours. Usually, the bulk of meal leaves the stomach within 2 hours and stomach gets emp- tied in 4–6 hours. The digested food residue reaches the ascending colon by about 6–8 hours, left flexure of transverse colon by about 9–12 hours, the pelvic colon by about 12–18 hours. (It needs be remembered that the process of digestion may not cease at death. Enzymes released due to autolysis may digest even the stomach wall. Such an event vitiates the find- ings, making them unreliable.)

Sometimes, the emptying of a stomach remains in abeyance for a long time in states of profound shock and coma. Head injury may completely inhibit the secretion of gastric juice, the motility of stomach and the opening of pylorus. Literature speaks of a case where the stomach was found completely full of food that was so fresh-looking that it might just have been swallowed and yet the same had been present in the stomach for 5 days, the victim remaining unconscious during the inter- vening period. However, if a person has been suddenly killed without any warning or previous state of apprehension or fright, it may be assumed that the normal processes of diges- tion were continuing up to the point of death and therefore, the amount and nature of the contents will be in their usual physiological state. It may be added that even this normal state can be subject to personal variation and only broad inferences can be drawn.

Apart from questions of quantity and state of digestion, the actual recognition of stomach contents may be useful in some circumstances because it may indicate what the last meal con- sisted of and therefore, narrow-down the time of death to the interval between two meals, assuming that the type of meal is known and that digestive processes have not proceeded so far as to make the contents unrecognisable. In a case, one of the pros- ecution witnesses deposed that roti was served to the deceased persons, while autopsy revealed rice and dal in the stomachs of the deceased. It was argued on behalf of the accused that there was, thus conflict between the medical evidence and the oral evidence. The Supreme Court repelled this argument observ- ing that "roti " is generally used to connote "meals". On the other hand, the presence of undigested rice and dal in the stom- achs of the deceased persons lended assurance to the prosecu- tion evidence that shortly before the occurrence of death the deceased were served with "meals".

The average urine volume in a healthy adult is about 1.5 litre per day. About 50% of the urinary volume occurs during sleep. Thus, in case of an individual having been done to death in the bed at night, one can state that the individual had lived for sometime after going to bed, if the bladder was found full of urine, since it is customary with most people to evacuate the bladder at night while going to bed. Similarly, the contents of pelvic colon and rectum may be helpful in the same context. If at autopsy, the large intestines is found empty of faecal matter, one can form an opinion that death occurred sometime after the victim had got-up in the morning and had attended the nature's call and if the usual time of his attending the call is known to the family members or the neighbours or the friends, further deductions can be made out. However, the mere pres- ence of faecal matter in the large intestines does not necessar- ily mean that the occurrence had taken place in the early hours of the morning. It is common experience that some people even after easing themselves in the early morning, often go for easing for a second time.

ADIPOCERE

This was first described as 'adipocire' by Fourcroy in 1789, dur- ing the removal of vast number of bodies from the Cimetiere des Innocents in Paris. He gave it the name owing to its proper- ties being intermediate between those of fat (adipo) and wax (cire). Under certain conditions, the process of putrefaction is checked and is replaced by formation of adipocere.

Formation

This change used to be called as saponification, on the belief that the change occurred due to formation of soap in the fatty tissues. But now that term is not accepted and the original name, as described above, is in use. It is formed by the hydro- lysis and hydrogenation of body fats after death by the action of bacterial enzymes. The main constituent of adipocere is pal- mitic acid. Some calcium soap may be formed in the process but only as a byproduct. The older view that its formation was restricted to only subcutaneous fat is not sustainable. It is now established that the change can also occur in the internal organs. The essential process consists of postmortem hydroly- sis and hydrogenation of pre-existing unsaturated body fats comprising lower fatty acids into saturated firmer fats, com- posed of higher fatty acids. As adipocere is the product of hydrolysis and hydrogenation of fat, water is essential for its formation. Intrinsic water content of the body may be suffi- cient for its development as bodies kept in lead-sealed coffins have shown its development as reported by Mant AK (1957) in J For Med. In such cases, water is drawn from the internal organs and skeletal muscles, which get dehydrated and mummified. The optimal conditions for its formation are:

- Abundance of moisture (running water, however, can retard the process by washing out electrolytes.) (Mant and Furbank, 1957).
- Presence of bacteria, especially Clostridium welchii.
- Optimum temperature.
- Relative diminution of air.
- Abundance of adipose tissue.

Properties When relatively recent, adipocere is a soft, greasy material, look- ing pale-white or cheese-like but becomes hard, dry, brittle and yellowish when old or exposed to air. It has a peculiar rancid or sweetish odour. It cuts soft and is friable. Floats in water and read- ily dissolves in ether and alcohol. It is inflammable and burns with a feebly luminant yellowish flame. It melts at about 200° F.

Distribution

Adipocere is usually first seen over the subcutaneous fats of cheeks, breasts, buttocks and abdomen, because these areas are better padded with fat. However, it can occur at any place where fat is available. This is especially so, if owing to some disease, the internal organs contain excess of fat at the time of death. The liver, heart and kidney were affected in a woman aged 93, buried for 100 years, as has been reported in the literature. At times, whole body may get affected, in which case soft tissues are markedly dry. Small muscles get dehydrated and become very thin, having a uniform greyish colour. The intestines and lungs are usually parch- ment like in consistency. The liver is prominent and usually retains shape. Histologically, gross features of the organ can sometimes be appreciated, even though cells are lacking recognition.

Time Required for Adipocere Formation

It depends upon multiple factors as enumerated. In Europe, it ranges from 3 months to 1 year. Stiffening, hardening and swelling of fat occurs over a period of months to get converted into adipocere. Usual time may be 3–6 months. In India, Dr. Coull Mackenzie found it occurring within 3–15 days after death, in the bodies drowned in the Hooghly or buried in the damp soil of Lower Bengal.

Medicolegal Importance

- Primarily lies in its ability to preserve features to an extent, which can allow identification long after death.
- Some tentative conclusions can also be drawn as to the cause of death, as the injuries, if present, can be appreci- ated after long period.
- Some idea about the place of disposal of the body can be gathered.
- Positive sign of death indicating that the time interval since death was at least weeks or probably several months. (Body fat at the time of death contains only about 0.5% of free fatty acids but within 4 weeks after death it can rise to 20% and after 12 weeks to 70% or more. By this time adipocere is obvious to the naked eye as a greyish-white material, replacing or infiltrating the soft tissues of the body. In early stages of its formation, before it becomes visible, it is best detected by analysis for palmitic acid.)
- Adipocere may be found mixed with other forms of decom- position depending upon the presence of various parts of the body in varied environments. Therefore, one end of the body may be putrefied or skeletonised whereas other parts may be showing adipocere formation or mummification.

MUMMIFICATION

It is another modified form of putrefaction, where drying and desiccation of the tissues occurs instead of liquefaction, depending upon the conditions prevalent at the terminal stages. Like other modes of decomposition, this can also be partial and can co-exist with other changes, especially adipocere. In fact, some degree of adipocere may also be formed along with the mummification, as the two seem to be related in the sense, adipocere essentially involves utilisation of body water for hydrolysing fat, which in turn helps to dehydrate the tissues, a state which forms some basis for mummification.

Formation

The conditions necessary for its formation are:

- Deprivation of moisture, which inhibits proliferation of putrefying microorganisms.
- Free circulation of air around the body.
- Warm dry atmosphere.

It is, therefore, seen in case of burials in shallow graves, in dry sandy soils, especially in deserts of Rajputana, Sindh and Baluchistan, where high temperature, hot dry wind, loose hot sand, etc. will help in its formation by rapid dehydration of the body tissues through evaporation of body fluids. Marked loss of body fluids before death and keeping the body open in warm dry atmosphere will favour its development.

Properties and Distribution

The soft tissues of the body get desiccated and shrivelled up. The skin becomes dry, leathery and looks blackish-brown, clinging firmly to the body frame. The hair on the scalp and the skeletonised body features are well-preserved. The internal organs also get dried and shrivelled up. They may disappear altogether or get blended into thick, brownish-black homoge- nous mass. The entire body becomes stiff and brittle. As the skin contracts, some of the fat cells in the subcutaneous tissues are broken and the liquid fat smears the dermis, which becomes translucent. If a mummified body is not protected, it will slowly break into fragments, become powdery and disintegrate, but if protected, it may be preserved for years. A mummified body is practically odourless.

Medicolegal Importance

- Mummified tissues may be sufficiently preserved for pos- sible identification and some appreciation of the injuries.
- Rough idea about the time since death can be obtained.

Depending upon the extent of availability of favourable conditions, mummification may be achieved in 3 weeks to 3 months. But no categorical timings can be adhered to.

- Some indication about the place of disposal of the body may also be obtained. (Cases have been reported where a number of mummified bodies may be hidden-homicides, as concealment favours its production by providing dry, warm atmosphere. One of the best instances being of 'Rhyl Mummy' where a strangled woman remained concealed in a cupboard for many years.)

A Case of Mummification Reported as Spiritual Coma

A lady died due to gastroenteritis and was declared dead. When they were taking the body back to the home they wanted to confirm death and took the body to the private doctor who was not even a registered medical practitioner. He told that lady is not dead but in a spiritual coma. He advised them to take this dead body to a tantrik and this lady will recover. The family took the dead body to the tantrik and he gave them a bottle of water and told them to go on giving this sacred water and she will recover from this spiritual coma. Family members took the body to home and started giving water by spoon. By the time when rigor mortis was disappearing some water went inside the mouth and they thought that she is recovering. Body was lying in a well-ventilated room and they lighted two heaters near the body so that she may not catch the cold. As the temperature got high, the body gradually mummified. Now the people from nearby area started coming to visit that place and started pray- ing, offering money and other things considering that she had become 'Devi '. This went on till there was a dispute over the offerings. The case was reported to the police after about 2 years of death. The case was brought for postmortem exam- ination. Before starting the postmortem examination, family members had to be convinced about the death of the lady by showing them a flat ECG of the dead body. It was a mummified body and adipocere formation was also present at the cheeks. The features were well-preserved. The skin was dry, leathery in appearance and the internal organs were in the form of small black masses and the cells of the body showed ghost appear- ances on microscopic examination. Sometimes myths have to be cleared in a scientific manner (.. 4.7). (A Communication from Dr. RK Gorea)

POSTMORTEM DESTRUCTION BY PREDATORS

Animal predation is a part of the natural food chain. In India, one often encounters jackals, dogs, crows, ants, flies and mag- gots, etc. badly damaging the dead body or carrying their parts. The type of predation varies greatly with geography, season and whether the dead body is indoor or outdoor. If lying on the countryside, large predators will cause severe damage and if the corpse is in water (river or sea water) then damage by normal inhabitants of water is caused with a remarkable rapidity.

The damage affected by canine and rodents is usually obvi- ous as the impressions of typical teeth marks are usually observed at the sites of localised removal of flesh. Their edges appear nibbled or crenated, the postmortem origin of which can easily be appreciated by the absence of haemorrhage or the inflammatory reaction.

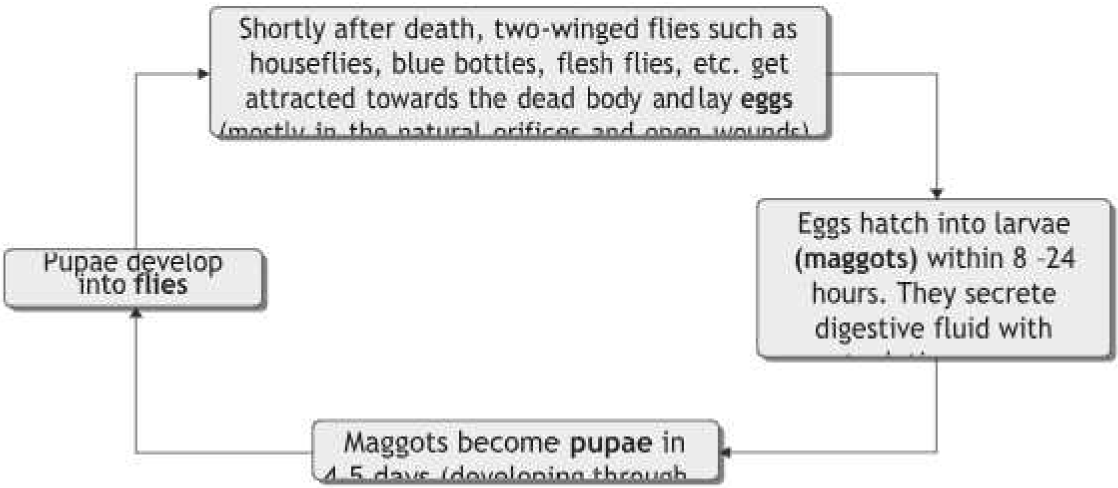
The most efficient tissue removers are maggots, the larval stage of common house and blowflies. These lay eggs over the natural orifices and ulcerated areas. This is because these areas are usually moist and shaded, lowering the risk of desiccation to the eggs. If some ulcer is present on the body surface, it may be perceived yet another orifice and thereby attract them to lay eggs. These eggs then hatch into larvae or maggots. First attacking the natural orifices, they subsequently burrow into the tissues and invade the cavities too. They secrete digestive fluids with proteolytic enzymes that help in softening the tis- sues and making their way to creep into the interior of the body. They, therefore, also help in providing easy access to the external microorganisms.

Ants and insects mostly attack the exposed parts and the moist areas of the body, such as around the eyelids, lips, axilla, groin and on the knuckles. The lesions are characterised by superficial ulcers with scalloped, serpiginous margins. Cockroaches are common in the residential setting. They are omnivorous scav- engers having predilection for devouring keratin. Postmortem insect bites may become desiccated giving appearance of brush-burns. Confusion may also exist because of the site, i.e. superficial abrasions at the neck region may simulate nail abrasions produced in the course of manual strangulation. Lack of haemorrhage, inflammatory reaction and features of margins as described make them easily distinguishable.

Mutilation of the body may be the work of (i) a person with anatomical knowledge of the body as was seen in the well-known Ruxton case [wherein Dr. Ruxton dismembered body parts of Mrs. Ruxton (aged about 35 years) and Ms. Mary Rogerson, the nurse-maid of the Dr. Ruxton (aged about 20 years) so calculatively with a view to effacing all evidence of sex and identity. However, identity could be established through photographs taken from the skulls and superimposing on those of the heads of Mrs. Ruxton and Ms. Rogerson. They were found matching in every respect], (ii) a person without knowledge of anatomy (wherein the body is mutilated haphaz- ardly leaving much evidence for tracing out the case), (iii) mutilation by animals (wherein gnawing of the tissue will be appreciable and moreover, animals generally eat away the medulla of the long bones and spicules of cortical bone may be found depressed into the medullary cavity), and (iv) mutila- tion resulting from decomposition changes (wherein the usual sequence is: disappearance of soft tissue first, then articular cartilage and finally ligaments. Bones are foul-smelling and humid in recent cases. Old bones tend to be dry, light, fragile, and the marrow cavity is also dry and devoid of fat).

Entomology of the Cadaver and the Postmortem Interval

Occasions may arise during the course of forensic work, when the study of insects or their larvae infesting a dead body may be a means of ascertaining possible time since death. The applica- tion of entomology was first reported by Bergeret (1855). Megnin, an entomologist, placed Forensic Entomology on a sound footing with his publication of La Faune des Cadavers in 1894. Lothe emphasised the need for exercising caution while making any estimate of the interval since death, i.e. it must be assumed that the eggs were deposited on the body at or nearing the time of death. Further, it is also important to identify the species, as the life cycle of each species varies. When the larvae are identified, it is possible to determine the minimum postmortem interval based on the larval age, i.e. if it is esti- mated that the maggots on the corpse are 4 days old, the deceased could not have died with a postmortem interval of less than 4 days, although the body might have been dead for a longer period than that. Since blowflies usually arrive at the corpse and lay eggs on it within an hour or two after death (unless the body is buried or placed in a sealed bag or concealed in any other manner so as to prevent access to the flies), the minimum time of death estimate may effectively be the actual time of death .Flowchart Below).



Usual stages in ordinary summer season in the life cycle of house fly assisting in estimation of approximate postmortem interval. It may be recalled that 'environmental conditions' is the most important factor governing the rate of development of these stages.

Forensic Entomology may be considered as a science (the so-called, 'junk science/voodoo science') relating to the appli- cation of knowledge of insects during investigation of crimes or other legal matters. The use of entomology in death inves- tigation may be traced to thirteenth century wherein some particular suspect was traced (among others) from the attrac- tion of adult blowflies to the one hand sickle amongst more than a dozen hand sickles placed upon the ground by other suspects. The hand sickle, as alleged, had been used to kill a Chinese peasant farmer and it was carrying some bits of human tissues, blood and hair and thus, attracting numerous flies humming around the murder weapon. The owner of the implement confessed to the commission of the murder. During 1930s, in a famous case from England, entomological evidence helped in proving that Dr. Ruxton had ample opportunity and time to kill his wife and housekeeper and return to his home within an allotted time frame.

Factors/parameters helping to answer questions at a death scene have been studied by numerous naturalists, biologists and entomologists. Megnin (France) identified eight specific seral waves of insects approaching the body, colonising for a period of time and then leaving. He observed that with such a sequence of insects moving onto the body, feeding for their specific peri- ods of time during the progression of decomposition and then leaving the body when the tissues had no longer remained attractive/useful, it was possible to use them as indicators of 'time since death'. Nearly all studies reported in the literature— though carried under differing temperatures, varying habitats, diverse geographic locations, and different seasons of the year— have been consistent in showing some particular time frame relating to the sequence of insect groups and species moving, colonising and then leaving the carrion (decomposing tissues). In most cases, flies usually colonise immediately upon death (within seconds to minutes) and therefore, one can conclude safely that the time calculated/analysed is an established/calculated minimum of time for remains to have been dead. (Timings within ± 12 hours in cases of 8–15 days duration and ± 48 hours with cases in the 20–25 days range have been reported.)

This science can also be used to identify areas of trauma on a badly decomposed body where the decomposed remains pre- vent due recognition of injuries. It has been documented that for the first several days of decomposition, the skin is the major barrier to the early feeding maggots. In the absence of any trauma to the body, natural orifices (nine natural body openings) provide the weak points for maggots to approach the body. Hence, preferred site for initial blowfly egg laying is the face including eyes, nose and mouth, etc. This is due to the fact that the gases that are being formed in the dead body, purge from these orifices and the compounds carried within these gases constitute an attraction for the blowflies. Pelvic area, due to its architecture and relatively safe location, is another area preferred for egg laying. Hence, if colonies of blowfly maggots are found in areas other than the face and pelvic area, it needs careful obser- vation for presence of some type of wound(s) that opened the skin and facilitated blowflies to invade the tissues. However, dif- fering circumstances attending each case need to be taken care of. Further, in bodies that are badly decomposed to allow any successful toxicological analysis of the tissues, maggots may be used to determine the presence or absence of drugs/chemi- cals. It has been reported that maggots feeding on such body tissues containing drugs, ingest these chemicals and store the same in their fat bodies or in the outer chitin covering. (Chitin is a protein-like substance that is arranged in a molecular matrix and is considered to be ideal for trapping and locking chemical substances.) Hence, actively feeding maggots can be tested for such substances using usual drug-testing techniques. In one case, as reported in the literature, empty puparial cases found with skeletal remains were tested and revealed cocaine in large quantities. The victim had been missing since 4 years, and it was suspected that he had died of cocaine poisoning.

Collection, Preservation and Dispatch of the Specimens

As stressed above, the main concern of the doctor conducting the medicolegal postmortems is the careful collection, preser- vation and dispatch of specimens to the forensic entomologist. This may be carried out as follows:

- Maggots (including different stages, i.e. mature, immature, pupae, empty pupa cases and eggs, etc.) should be placed in separate tubes and placed directly in acetic alcohol (three parts 70% alcohol and one part glacial acetic acid). If no preservative is available, killing of the specimens may be done by putting them in hot water.

- Some 'live' larvae should also be collected and placed in a tube with a fragment of meat or a portion of muscle from the body, acting as a food for the maggots. [Erzinclioglu (1983) reviewed the literature and recommends larvae should be taken from different parts of the body and proper labelling done on the tubes regarding the place and other things. This large sampling makes it possible to interpret the population of maggots more confidently.]

- If outdoors, a sample of the soil beneath the body along with the various stages of maggots should be sent.
- Available facts about the environment in which the body was found should be recorded and sent to the entomolo- gist. Recording of temperature of the body (with the help of an electric thermometer with thermocouple) and ambi- ent temperature at the scene must be accomplished and proper information dispatched, because temperature is the single most important factor governing the rate of develop- ment of maggots. If recording of the temperature has been omitted, local records from the nearest metrological centre may be called for.

CHAPTER-7

SUDDEN AND UNEXPECTED DEATH

Natural death means death occurring due to some natural disease or pathological condition, old age, debility or devitalisa- tion; here the death is not intended or attempted and also does not occur accidentally. Sudden deaths are mostly natural deaths that occur immediately or within 24 hours of the onset of the terminal symptoms, which may be completely different from the symptoms that the patient was having so long. The explanation does not essentially exclude or rule out deaths due to means other than natural diseases, but no unnatural factor/ cause need be apparent.

The word 'unexpected' seems to import more information and appears more suited. Agreed that many unexpected deaths may be sudden, but there may be delay of hours or even days without a satisfactory diagnosis being clinically evident. In sud- den and unexpected death, the immediate cause is almost always to be encountered in cardiovascular system. Hence, an attempt has been made in this chapter to present an analysis of the problem and an approach towards finding out the cause of death in cases of concurrent trauma and cardiac pathology. Other conditions of some medicolegal significance will also receive some comments as they amount to only small percent- age of causes. The proper study of sudden and unexpected age is exempt, sudden and unexpected deaths are relatively uncommon in the younger population.

MORBID ANATOMY OF THE HEART AND ITS BLOOD VESSELS

The heart of an adult Indian male usually weighs between 275 and 300 gm and that of female between 225 and 250 gm. Thickness of atrial walls is 1–2 mm, of right ventricle 3–5 mm and left ventricle 10–15 mm. The wall of the heart is composed of three layers—an outer epicardium, a middle myocardium and an inner endocardium. The heart is surrounded and enclosed by the visceral and parietal pericardium, separated by pericardial cavity.

BLOOD SUPPLY

The left and right coronary arteries originate from the respective aortic sinuses. Their course and distribution of blood supply to the heart is as under:

The Left Coronary Artery after originating from the left aortic sinus, after a short course, bifurcates into: death will obviously include full laboratory investigations like toxicology, serology, histology, bacteriology and chemistry, to avoid danger of acceptance of the obvious. (It is easy to accept the obvious but it needs to be emphasised that the people do not always die of the expected; it is easy to apply a pillow or some other soft material to the face of a dying person, particularly when he/she is about to alter a 'will'.)

- Left anterior descending that runs in the anterior interventricular groove
- Left circumflex branch, which runs in the left atrioventricular groove

Provides blood to the anterior

left ventricle, the adjacent anterior right ventricle and anterior two-thirds of the interventricular septum

Supplies the lateral wall of the left ventricle

Sudden Death and Heart Disease

Sudden deaths in adults from presumably natural causes may occur more frequently than usually thought of. Although no The Right Coronary Artery runs in the right atrioven- tricular groove. It usually nourishes the remainder of the right ventricle and the posteroseptal region of the left ventricle, including the posterior third of the interventricular septum. (At the right border of the heart, this vessel gives off a small marginal vessel and the main part continues to the back of the heart where it becomes posterior descending and runs in the posterior interventricular groove.)

Developmental anomalies of the proximal part of both the coronary arteries are rare; however, there may occur con- siderable variations in the arrangement of the vessels on the posterior surface of the heart. The territories of left circum- flex and right coronary arteries vary greatly and one vessel may take over almost whole of the function of the other. This is of importance in determining the site and extent of the infarction when one of the vessels is stenosed, and because of this one can encounter paradoxical infarction.

The localisation of atheroma or thrombus varies greatly in different areas. In various published analyses, the ranges for frequency of the sites of occlusion, with or without throm- bosis, are (.. 5.1):

- Left anterior descending (left anterior interventricular)—45–64%.
- Right main coronary—24–46%.
- Left circumflex coronary—3–10%.
- Left main coronary—0–10%.

TYPES OF OCCLUSION

Simple Atheroma

It may be concentric, when a central pin-hole may eventually be formed or crescentic, with a lumen usually at the side of the vessel.

Ulcerative Atheroma

It is a complicated atheroma where endothelium over the ath- eromatous plaque may break down and expose an ulcerated surface, which is an attractive seat for thrombus formation.

Subintimal Haemorrhage

The vessels in the wall of the coronary artery may rupture, the haematoma thus formed may force the plaque inwards to further narrow the lumen of the vessel.

Coronary Thrombosis This may occur upon the damaged endothelium due to aggre- gation of platelets and thus further narrowing the lumen. Rarely, thrombosis may occur in the absence of typical stenos- ing atheroma.

Periarteritis Nodosa

Most commonly affects the males around the fourth decade of life, possibly related to the collagen disorder. Muscular arteries of many organs get involved, notably of heart and kidneys.

SEQUELAE OF CORONARY OCCLUSION

Sudden Death

The occlusion may lead to sudden death either at the time of appearance of occlusion or subsequent to that.

Myocardial Infarction

Infarction will occur in the myocardium distal to the complete occlusion of any coronary artery, in the absence of adequate collateral circulation. The infarct may be subendocardial, intra- mural, transmural or full thickness infarct, papillary muscle infarction, etc. Infarcts involve much more commonly and extensively the left ventricle than do the right ventricle, partly due to greater work-load imposed and greater thickness. In a few cases of acute myocardial infarction, the patient succumbs to pump failure (cardiogenic shock). However, in majority of cases, clinical course may be dominated by a variety of complications of the infarct, viz.:

- Arrhythmias: Virtually all patients who suffer infarction usually suffer from some abnormality of the cardiac rhythm at sometime during the course of their illness. Arrhythmias usually account for half of the deaths from ischaemic heart disease. The causes of arrhythmias are obscure but may be due to increased sympathetic activity mediated by increased levels of local or circulating catecholamines.

- Left ventricular failure and cardiogenic shock: The most feared complication of acute myocardial infarction is cardiogenic shock. The incidence, however, is only about 7% owing to the development of methods that assist the damaged myocardium. Cardiogenic shock is likely to occur if the infarct involves more than 40% of the left ventricle, and the mortality in these cases is as high as 90%.

- Rupture of the myocardium: Myocardial rupture may occur at almost any time within first 3 weeks of acute infarction but is most common between first and fourth day, when the infarct wall is the weakest. After this time, the scar becomes increasingly stronger so that rupture becomes less likely. It usually occurs at the junction of the infarct and the normal muscle. Rupture of the infarcted myocardium usually results in haemopericardium and death from peri- cardial tamponade.

- Aneurysms: Left ventricular aneurysms complicate 10–15% of healed transmural myocardial infarcts. The mechanism of production is that following the develop- ment of acute transmural myocardial infarct, the affected ventricular wall tends to bulge outwards during systole. Localised thinning and stretching of the ventricular wall in the region of the healing myocardial infarct forms an early aneurysm. As the aneurysm becomes more fibrotic, its ten- sile strength increases. However, the aneurysm continues to dilate with each heart beat, thereby snatching some of the ventricular output and contributing to the work load of the heart.

- Myocardial fibrosis: Localised patches of fibrosis are almost invariably the results of healed myocardial infarcts. They are seen in the areas of predilection of infarcts, namely, the distal interventricular septum, the apex and the posterior wall. Diffuse fibrosis may arise from many causes but is also seen in cases where there has been long-standing coronary stenosis of a degree insufficient to produce a focal infarct. It may be seen in hypertensive heart disease where the hypertrophied muscle is relatively ischaemic, though the coronaries may show little atheroma.

- Mural thrombosis and embolism: Involvement of the endocardium over the infarct predisposes to the adhesion of platelets and to the deposition of fibrin. Moreover, poor contractility at this area further adds to the growth of the thrombus. Pieces of thrombus can get detached and be swept along with the arterial blood.

- Pericarditis: A transmural myocardial infarct involves the epicardium and leads to the inflammation of the pericar- dium in 10–20% of patients.

- Postmyocardial infarction syndrome (Dressler syndrome): It refers to delayed pericarditis developing 2–10 weeks after the infarction or cardiac surgery. Amelioration by corticosteroid therapy suggests its immu- nologic basis.

MEDICOLEGAL CONSIDERATIONS

It is generally agreed that large amounts of almost instantaneous and rapid deaths in adults are caused by this disease, the process of coronary atherosclerosis, or its sequelae. The disease might have been present in the individual for months or probably years before the traumatic episode, and therefore, relationship of trauma towards the genesis of the disease may not be satisfactorily clinching. Further, history of blow or application of some other blunt force against the region of the heart needs be there in order to blame that such trauma was instrumental in insulting the heart surface and causing a direct traumatic lesion of the coronary system, or was instrumental in dislodging an atheromatous plaque; or in causing subintimal haemorrhage and triggering coronary thrombosis, etc. Under such a scenario, it would be better to argue that the physical and emotional stress associated with the traumatic event, in a way, led to increased demands upon the weakened heart pre- cipitating its failure. Research on large cohorts has shown an authentic relationship between exertion and sudden cardiac death. In USA, Mittleman et al. (1993) investigated 1228 patients with acute myocardial infarcts and showed that there was six-fold increase in the incidence of infarction during or within 1 hour of heavy physical exertion, such as jogging, lift- ing heavy weights, applying excessive force at some workplace, or even sexual activity. In Germany, Willich et al. (1993) researched 1194 patients with the same condition and showed a two-fold increase in the risk. Both surveys showed that the risk was greater in those who were otherwise of sedentary hab- its and that long-term moderate exercise assuredly reduced this risk of infarction (Curfman, 1993). Increased risk during sud- den severe exercise was proposed to be due to involvement of multiple factors including the splitting and dislodgment of an atheromatous plaque. It was also claimed that occurrence of increased platelet activation in sedentary people undergoing sudden exertion could add to the eventuality.

Bernard Knight reported an interesting case wherein an elderly man landed into altercation with another concerning parking of the car. Scuffle ensued, in which only trivial blows were exchanged. However, one participant immediately com- plained of chest pain and breathlessness, and soon died. The other man was arrested, but the prosecution decided to drop the charge after going through the autopsy findings showing marked cardiac enlargement, extensive myocardial fibrosis and gross occlusive coronary atherosclerosis. In civil issues, considerable sums of money may hang upon the judgement of the court by way of damages and insurance payments. Here, the standard of proof is much lower, i.e. the plaintiff showing that there was better chance of the association being present.

Certain incompatibilities between morbid presentations (anatomical and clinical) warrant specific comments so as to interpret the findings documented at autopsy and the clinical course of the victim. There is no denying the fact that recent thrombotic occlusion of some major coronary artery may be unhesitantly labelled as the cause of sudden death. In this con- text, the severity of stenosis incompatible with the continuity of life is deba.. Davies and Popple (1979) consider that 85% stenosis is the minimum reasonably associated with sudden death. Absence of demonstrable myocardial infarction in such cases may be attributed to the brief interval between the vascu- lar occlusion and death or the alternative blood supply provided by the effective collateral circulation. Conversely, no recent vas- cular occlusive lesion may be found in a person dying suddenly from stenosing coronary atherosclerosis. In this concern, Spain and Bradess noted a positive relationship between survival time and appearance of recent coronary thrombi. Only 17.5% of 80 subjects who survived less than 1 hour following the attack showed recent thrombi. On the other hand, 36.4% of 22 indi- viduals who survived for 1–8 hours and 57% of 100 subjects who survived longer than 8 hours had recent thrombi.

APPROACHING THE CAUSE OF DEATH

Determination of cause of death may better be a multiapproach phenomenon and collective interpretation of all the findings/information including the laboratory studies, as enumerated below.

Historical Data

Presence of relatively chronic cardiovascular disease alone can- not confirm that the cardiac disease, in fact, gave rise to patho-physiological phenomenon leading to death. The common causes, i.e. pain, fear, apprehension, emotional stress, anger or the like situations leading to dysfunction or inability of the heart to respond to a demanding situation may occur without a conclu- sive anatomical evidence in the heart. Designation of cardiovas- cular disease as a primary cause of death with reasonable certainty, therefore, needs evidence confirming association between symp- toms and signs of acute cardiac dysfunction and death.

In cases of concurrent heart disease and trauma, witnesses may have a key role on the basis of observation of symptoms and signs observed by them. Evaluations depending upon the statements of witnesses showing symptoms and signs of car- diac dysfunction preceding/during/immediately succeeding the episode and eventual death may finally be interpreted properly in the light of the circumstances. The final outcome, of course, rests with the court. However, many cases of sud- den deaths may skip unwitnessed or the witnesses may die in the ensuing accident/trauma, etc. In such cases, the cause of death may be gathered from the presence of significant cardio- vascular disease at autopsy, absence of potentially lethal trauma and other information available from the scene.

Autopsy Documentation

Autopsy documentation of findings is essential for determin- ing the role of heart disease in fatal trauma or role of trauma in relatively expected or predic. deaths resulting from chronic disease that appears to offer no immediate threat to the life of the victim.

Needless to emphasise that a detailed and meticulous autopsy is mandatory inclusive of laboratory studies. Problem may be experienced in quantifying the amount of stenosis at autopsy because the walls of the vessels are lax and col- lapsed after death, which are patent during life, the patency being maintained by the intraluminal blood pressure. However, relative degree of stenosis may be observed and evaluated.

Interpretations

The goal in all these cases is to arrive at the heart disease—trauma situation as objectively as possible. After compiling and carefully examining the entire data as detailed above, the interpretations may be grouped as under:

- Observations supporting 'cardiovascular disease' as the primary cause of death:
  - Historical data including observations of the witnesses as presented in the 'Inquest Papers' consistent with acute cardiac dysfunction preceding death.
  - Autopsy documentation of specific potentially lethal cardiovascular disease.
  - Autopsy documentation may reveal nonfatal traumatic lesions.
  - Toxicological analysis is nil or may reveal nonfatal quantities.
- Observations supporting 'trauma' as the primary cause of death:
  - Historical data including observations of the witnesses not revealing any evidence of acute cardiac dysfunction.
  - Autopsy documentation reveals potentially lethal traumatic lesion.
  - Autopsy may reveal any chronic cardiovascular dis- ease that does not seem to offer any immediate threat to life.
  - Toxicological analysis is nil or may reveal nonfatal quantities.
- Observations supporting 'toxic data' as the primary cause of death:
  - Historical data including statements of the witnesses not concrete.
  - Autopsy documentation of chronic heart disease that does not seem to offer any immediate threat to life.

- Autopsy may reveal some nonfatal traumatic lesions.
- Toxicological analysis reveals fatal amounts of the agent used.

POSTMORTEM DEMONSTRATION OF MYOCARDIAL INFARCTION

The demonstration of early myocardial infarction is of considerable forensic importance, especially in the exclusion of some unnatural cause of death.

A great number of deaths due to occlusion or stenosis may not show any evidence of myocardial infarction as detailed earlier. These deaths may result from ventricular fibrillation or damage to the conducting system.

Macroscopic Appearances

Authorities differ in their opinions as to time of occurrence and progression of changes in the infarct with the passage of time. However, general broad criteria may be as follows.

- For the first 12–24 hours: It is generally impossible to detect myocardial infarction with the naked eye within first 12 hours after the coronary occlusion. By 24 hours, the characteristic pallor area of infarction with the swelling of the area may become apparent because the swollen fibres squeeze the blood from the vessels lying among them. The bundles of the muscles seem separated and on cutting the ventricle at the autopsy ., the affected muscle shows more coarsely fibrillar arrangement than the normal area.
- From about the end of first day and progressing through second and third day: The colour usually changes to brownish-purple that progresses through a red- dish blush until the muscle becomes necrotic and assumes yellowish appearance at about 24–48 hours after the occlu- sion. An alternative stage may sometimes appear after 24 hours, called the 'tigroid appearance' depicting alternate indistinct bands of red and pale areas. The fully developed infarct is yellowish as the blood vessels in the area of infarc- tion also undergo necrosis and haemoglobin, which is thus liberated, diffuses into the surrounding necrotic muscle, giving it a reddish or greenish hue. This is a patchy process and therefore the area may show appearance of small punc- tate haemorrhages. Associated with these changes in the

infarcted muscle, acute inflammatory reaction occurs in the neighbouring surviving muscle so that the infarct is sur- rounded by a zone of hyperaemia.

- 3–10 days: Progressive lysis and removal of the dead

muscle leads to softening and thinning of the area of infarction, this process being at its peak about the 10th day. Rupture usually occurs at this stage.

- Beyond 10 days: During this time, the process of fibrous repair dominates, and the infarct is slowly converted into a fibrous scar. Fibrosis of the tissue is apparent to the naked eye after about 2 weeks, progressing ultimately into a fully established dense white fibrous scar. However, it is not uncommon to see an area of muscle showing a mixture of changes, e.g. small white fibrous scars set in a zone of yellow infarcted muscle.

Microscopic Appearances

Conventional formalin-fixed paraffin-embedded sections offer considerable assistance in the detection of the infarction, though postmortem autolysis may make the picture compli- cated. The following features are usually observed in sections stained by haematoxylin and eosin.

One of the earliest changes is the eosinophilia of the muscle cytoplasm, which begins to occur some 6 hours after the onset of infarction and is best seen in the lightly stained specimens. Eosinophilia or hyperchromasia can be accentu- ated by placing a green filter in the light path of microscope. When looked at with ultraviolet light, such fibres usually 'auto- fluoresce' as yellow against greenish background. Side by side appears the swelling of the muscle fibres and the granularity of the cytoplasm. The former causes the reduction in the normal inter-cellular spaces due to oedema of the cells. Later on, the cell outline becomes indistinct, the stage therefore may be called as blurring of the cell membranes. (Loss of integrity of the sarcolemma leads to release of intracellular proteins such as myoglobin, lactic dehydrogenase and creatine kinase from the myocytes into the extracellular space. Ion gradients are also dissipated, tissue potassium decreases as the contents of sodium chloride increase.)

By 24 hours, the myocytes are deeply eosinophilic and show the characteristic change of coagulation necrosis. However, it takes several days for the nucleus to disappear totally. Time of appearance of polymorphonuclear leukocytes is variable. They generally get attracted to the necrotic myo- cytes and reach their maximum concentration in the infarcts after 2 days.

By 2–4 days, the muscle cells become more clearly necrotic and nuclei disappear.

By 5–7 days, the acute inflammatory response has abated so that the periphery of the infarcted region shows phagocy- tosis of the dead muscle by macrophages. Fibroblasts begin to proliferate and collagen formation is evident.

During 1–3 weeks, collagen deposition proceeds further and the newly sprouted capillaries are progressively obliter- ated. Fibrosis of the tissue is apparent to the naked eye after about 2 weeks, progressing ultimately into a fully established dense white fibrous scar. (The changes described are those as observed experimentally in the dogs by inducing myocardial ischaemia and reported in the literature.)

Frozen Section Histochemistry

It may be of value; the most commonly used techniques are lactate dehydrogenase (LDH), succinic dehydrogenase (SDH) (Wachstein and Meisel, 1955; Aronsen and Pharmakis, 1962), malate dehydrogenase (MDH) and nicotinamide adenine dinu- cleotide diaphorase (NADD) (this was formerly called diphos- phopyridine nucleotide diaphorase—DPND). Details of the standard methods for demonstrating these enzymes are given by Pearse (1972). Sahai and Knight (1976) described a very simple fluorescent technique for demonstrating early myocardial damage. It has the advantage that frozen sections are not necessary; ordinary formalin-fixed, paraffin-processed material is satisfactory. Lie et al. (1971) reported that a basic fuchsin technique using formalin-fixed, paraffin-processed sections could be used to detect early hypoxic damage to myocardial fibres and may be expected to provide evidence of infarction as early as half to one hour after the event. Olsen (1974) has found the method reliable. Mcvie (1970) believed that measurement of the ionic ratio (K/Na) by a simple technique could be useful in the diagnosis of early myocardial infarction.

Gross examination with macroenzyme techniques has shown only the triphenyl tetrazolium chloride (TTC) method to be of some value. It is possible to highlight the necrotic area by immersion of the tissue slices in a solution of TTC. It imparts brick red colour to the intact area, i.e. noninfarcted myocardium where the dehydrogenase enzymes are preserved. Because dehydrogenase enzymes are depleted in the area of ischaemic necrosis (they leak out through the damaged cell membranes) and infarcted area is revealed as an unstained pale zone. Infarction can thus be identified at about 4 hours but the results appear to be variable.

HYPERTENSIVE HEART DISEASE

Hypertension may kill a person in a number of ways such as cerebral stroke, renal failure, ruptured aneurysm and, of course, primary heart failure. The primary heart failure due to hyper- tension is usually responsible for the so-called 'cardiac asthma' or 'paroxysmal nocturnal dyspnoea' produced by the massive pulmonary oedema due to hypertension.

Cardiac hypertrophy beyond accep. weights, especially over 400 gm, is a common finding. Such hypertrophy is usually associated with severe coronary artery disease, and death appears to be due to ischaemia of the muscle. Hypertrophy of the left ventricle occurs as it has to work against the higher pressure in the systemic arteries. The muscle fibres increase in length and thickness (concentric hypertrophy). Sometimes the overall weight of the heart may be normal, yet there is a relative left ventricular thickening.

CARDIOMYOPATHIES

They represent an uncommon group of causes of sudden death. Though they are quite rare but fall in the forensic field due to the fact that the sufferer suddenly drops dead without any warning. The outstanding feature is the enlarged heart in the absence of hypertension or valvular lesion. The victims are usually young adults.

Three main types differentiated on the morphological basis are congestive cardiomyopathy, hypertrophic obstructive cardiomyopathy and obliterative cardiomyopathy. Out of these, hypertrophic obstructive cardiomyopathy is most often

associated with sudden death. The blocks of tissues for histo-pathological examination should include from each of the lateral walls of right and left ventricles and from the interventricular septum. Isolated myocarditis as a cause of sudden death was recorded by Corby (1960).

NONATHEROSCLEROTIC CORONARY ARTERY DISEASE

There are a variety of nonatherosclerotic diseases and congenital abnormalities of the coronary arteries that can be potential causes of sudden death. Because they tend to manifest within the childhood and adolescent groups, their possibility should be entertained in case of sudden apparent natural death in sub- adults. Anomalies may include erratic origin of coronary arter- ies, abnormal location of the ostia, ostial stenosis and/or ostial ridges and acute angle take-off of the proximal position of a coronary artery, etc. Coronary artery spasm (Prinzmetal angina/variant angina) is typically seen as angina at rest accom- panied by demonstration of ST-segment elevation on ECG with a reversible decrease in the luminal diameter of a coronary artery on angiogram. Individuals with atherosclerotic artery disease are greatly victims of this entity. Difficulty for the autopsy surgeon is that a diagnosis of coronary artery spasm cannot be approached through autopsy findings. It requires previous medical history plus clinical documentation of the spasm. Spontaneous coronary artery dissection is a rare cause of death. It has no known association with hypertension but tends to affect women more than men. The dissection usu- ally affects outer third of the media or between the media and adventitia. Traumatic dissection of a coronary artery is excep- tionally rare. However, when encountered, will reveal history and/or autopsy evidence of blunt impact injury involving the anterior chest wall. Cardiac conduction system disorders can also be cause of sudden death. Where there is gross or histologic evidence of a disease process that is also capable of affecting conduction system of the heart, the examination of the system can be of merit. Furthermore, past medical history should also encourage one to go in for such an examination. A detailed examination of the conduction system can involve processing and examining hundreds of slides from a single case. Wolf–Parkinson–White (WPW) syndrome is another known entity caused by an accessory pathway, or multiple path- ways of conducting tissue extending between the atria and ven- tricles. Occasionally, accessory pathways also permit retrograde transmission of an electrical impulse from the ventricles to the atria, creating a re-entrant circuit and potentially lethal tachyar- rhythmias. Autopsy diagnosis through serial sectioning and examining both atrioventricular rings is beyond practicality. All such lethal arrhythmias arising out of conduction system disor- ders often occur during exercise, and in particular, during swimming. Therefore, one must entertain the possibility of such disorders when a good swimmer 'drowns' for no apparent reason.

SOME OTHER CAUSES OF SUDDEN DEATH HAVING MEDICOLEGAL SIGNIFICANCE

DISEASES OF THE CENTRAL NERVOUS SYSTEM

The heart and brain share the notoriety of organs giving rise to sudden natural death, with heart being responsible for the big- ger share. Furthermore, a number of diseases traditionally considered as primary central nervous system pathologies are, practically speaking, diseases of the cardiovascular system (e.g., ruptured berry aneurysm, hypertensive intracerebral haemorrhage, etc.). Sudden death may occur under following CNS circumstances.

Meningitis

Acute meningitis is a well-known but relatively uncommon cause of sudden death. Hyperacute bacterial meningitis in the very young and the elderly can lead to death within 24 hours of onset of symptoms. Mechanisms (occurring singly or in vary- ing combinations) leading to production of sudden death may include (i) cerebral oedema, (ii) obstruction to the flow of CSF and (iii) systemic collapse. Inflammatory bacterial media- tors can produce a direct toxic or cytopathic effect leading to cytotoxic oedema. Additionally, bacterial toxins affecting neu- rons can increase metabolic demand leading to hypoxia and injury to the blood–brain barrier that may further result in vasogenic oedema. At autopsy, purulent exudates may not be apparent on gross inspection of the brain. Microscopic exami- nation in untreated cases will usually demonstrate subarach- noid spaces infiltrated by leukocytes and bacteria. Postmortem blood cultures and/or cerebrospinal fluid cultures need be taken in such cases. A swab of the purulent meninges can be submitted for culture if cerebrospinal fluid is not obtained.

Cerebral Tumours

Although majority of tumours involving central nervous sys- tem are diagnosed clinically within time, yet occasions may be there where primary or secondary involvement of the system may become evident after an apparently sudden death. Further, detection of a tumour may at times be an incidental finding in an individual dying of some other cause. A case has been reported wherein a police officer who was shot while on duty and subsequently died had a subependymoma in the fourth ventricle. He had no known previous symptomatology. Mechanisms, acting singly or in varying combinations, through which sudden death may be caused may include (i) simple mass effect with increasing size, (ii) acute haemorrhage into the tumour causing a sudden increase in the mass effect with her- niation etc., (iii) blockage of the ventricular system leading to acute noncommunicating hydrocephalus with rapid rise in intracranial pressure, (iv) compression of anatomic regions critical to cardiac or respiratory functions and (v) precipitation of an epileptic seizure with resultant apnoea and/or cardiac arrhythmia, etc.

A causal relationship between trauma and tumour is extremely difficult to establish. However, one may come across such cases and occasional claims be litigated. The prerequisites to the assumption that any given case of tumour was caused by trauma rests in the fulfillment of Ewing's postulates (James Ewing, a US pathologist, 1866–1943): (i) evidence of previous integrity of the injured part, (ii) the injury must have been of sufficient severity to produce tissue disruption, (iii) the tumour must have originated in the part of the body that sustained the injury, (iv) it must be of the histologic type that could originate from the cells that have been disrupted by the trauma and

(i) there must be proof of reasonable time interval between injury and appearance of the tumour.

Epilepsy

Epilepsy can cause sudden death during seizure or even otherwise. Seizures limited to autonomic nervous system without motor involvement (paroxysmal autonomic dysfunction) have been held responsible for the possible mechanism of death in some epileptics found dead in bed without 'any evidence of major convulsions having occurred'. Therefore, absence of tongue-biting or faecal or urinary incontinence does not exclude the occurrence of epileptic fits.

In many deaths, mode of death may be apparent, such as asphyxia during a fit in the bed when the face may be pressed into the pillow and saliva and mucus may be observed at the mouth and nostrils. Epileptics may also suffer in other obvious ways: loss of consciousness and/or muscular control during the seizure may lead to occurrence of traumatic incidents like drowning, vehicular accident or due to results of obstruction of respiratory tract due either to aspiration of gastric contents or to the peculiar position of the individual following the attack.

Hirsch and Martin (1971) suggested that death may some- times be related to acute disruption of brain-stem, cardiac or respiratory functional control or both as a result of an epilep- tic discharge and cited a number of cases where witnessed sudden deaths in epileptics had occurred without manifesta- tions of a major seizure except for a brief tonic phase.

Autopsy should always include a search for evidence of any 'bite marks' on the tongue, examination of clothing for evidence of incontinence of urine or faeces or presence of any vomitus. Blood should always be sent for chemical analysis because with- drawal of barbiturates can also lead to convulsions and, there- fore, negative results may show that a known patient had failed to follow the treatment. Examination of the brain usually fails to reveal any lesion in idiopathic epilepsy, which may enable the doctor to form an objective diagnosis of epilepsy.

Characteristic history of convulsions, ideally supported by abnormal electroencephalographic changes, is needed to base the diagnosis. However, in the absence of witnesses to the termi- nal episode, the autopsy diagnosis may be based upon the reliable history and conducting complete autopsy so as to exclude any other anatomic or chemical cause of death. Any cause of post- traumatic epilepsy may also be searched in the brain.

For deaths due to rupture of berry aneurysm and intracere- bral haemorrhage see discussion Head Injury in the Chapter "Regional Injuries".

DISEASES OF THE GASTROINTESTINAL SYSTEM

Diseases of the gastrointestinal system ordinarily do not tend to present as sudden death. However, their signs and symp- toms do warrant medical attention. Avoiding or ignoring such signs and symptoms, at occasions, can create a situation wherein the death may appear to be sudden. Bleeding gastric or duodenal ulcers are one of the most common gastrointestinal diseases that may present in this manner. Another presentation leading to sudden death may be peritonitis arising from ulcer perforation. In such cases, it is wise to check the gastric antrum and the duodenum as these are the most likely sites of gastro- intestinal perforation. In pre-autopsy X-ray, free air will be demonstrable in the peritoneal cavity, although it may not nec- essarily be located in the subdiaphragmatic region as seen in an upright antemortem abdominal X-ray.

DISEASES OF THE ENDOCRINE SYSTEM

Diseases of the endocrine system again do not tend to present as sudden natural death ordinarily. However, it is surprising that at occasions, how some individuals can simply adjust to or put up with the symptoms of acute-on-chronic endocrine imbalance and subsequently may die. Those with known endo- crine disorders can die rapidly of an acute exacerbation of their disease, usually by some superadded infection or by poor com- pliance with treatment. In known diabetics, it is always wise to check the postmortem vitreous glucose level, even when there seems to be some other plausible cause of death. A high vitre- ous glucose level (झ 200 mg/dl or so) is likely reflective of hyperglycaemia. As reported in an analysis of ⊠6000 vitreous fluid specimens, no nondiabetic had vitreous glucose level

झ 200 mg/dl (because vitreous glucose levels decrease after death, a low vitreous glucose level is not considered significant in most circumstances).

VAGAL INHIBITION

Also known as vasovagal attack, reflex cardiac arrest, nervous apoplexy, instantaneous physiological death or syncope with instantaneous exitus or primary neurogenic shock. This state is characterised by sudden stoppage of heart following reflex stimulation of vagus nerve endings. There is a wide network of sensory nerve supply to the skin, pharynx, larynx, pleura, peritoneum covering the abdominal organs or extending to the spermatic cord, uterine cervix, urethra, etc. These receptor nerve endings form the afferent pathways for the reflex action and pass through the lateral tracts of spinal cord, effect the local reflex connections over the spinal segments and then travel to the vagus nucleus in the brain. The vagus nucleus has connections with sensory cerebral cortex and thalamus, besides the spinal cord, as stated. The efferent then originate from there and affect the heart through the related branches.

Such deaths occur with dramatic suddenness within seconds or at the most in a few minutes. The loss of con- sciousness is usually instantaneous on these occasions and death follows soon afterwards. Consequently, the mobility is negligible and the victim is likely to be found in the posture/ position in which he/she was at the time of death. The condi- tion, therefore, is characterised by fulminating circulatory fail- ure that may be attributed either to reflex slowing/stoppage of heart, reflex vasodilatation leading to profound fall in blood pressure or a varying combination of both the mechanisms.

The victims are usually young adolescents of nervous temperament but anyone may be susceptible. The factor responsible for initiating or triggering the vasovagal phenomenon may be a minor trauma or relatively simple and harmless peripheral stimu- lation at the vulnerable sites upon the body as described earlier. Obviously therefore, a variety of circumstances have been incriminated as precipitating factors, as outlined below:

- Sudden pressure over the neck, especially over the region of carotid sinuses as may be operating in occasional cases of strangulation and hanging (carotid sinus is a dilated part of the wall of the carotid artery and contains numerous nerve endings from the glossopharyngeal nerve and com- municates with the medullary cardiovascular centre and dorsal motor nucleus of vagus in the brain, related with the control of blood pressure and regulation of heart activity). Such deaths are of considerable medicolegal significance as death may ensue under the circumstances in which there had been no intention to kill. In some instances, it may be reasonable to regard such deaths as borderline between a natural and an accidental death.

- Sudden blow on the abdomen or scrotum, larynx or genital organs.

- During intubation of, or from impaction of food/some other material into the larynx.

- During minor surgical procedures involving penetration of pleura or peritoneum for tapping purposes, stretching of peritoneal sacs, dilatation of urethra or of a muscle sphincter and dilatation of the cervix in instrumental abortion.

- Sudden cerebral concussion or blow on the back of the neck.

- Sudden immersion of body in cold water. Here, vagal inhibition may act in several ways, i.e. a sudden in-rush of cold water into the nasopharynx or larynx, sudden blow of water upon the abdomen as in horizontal entry into the water with a consequent blow upon the abdomen, etc. Keatinge (1969) found sudden rises in arterial pressure and vagal output in men exposed to ice-water showers. Bradycardia and ven- tricular ectopic beats have also been reported by the ECG studies in the volunteers during the first few minutes of their immersion in cold water.

- Sudden death may also be seen as occurring with intense fear, fright, emotions, from extreme unpleasant/horrible sight or smell.
- The reflex gets accentuated by a high state of emotional tension and also in many conditions that lower the volun- tary cerebral control of reflex responses, like mild alcoholic intoxication, some degree of hypoxia or partial narcosis due to incomplete anaesthesia.

Autopsy

The examination of body does not disclose any typical post-mortem findings by which to diagnose death due to vagal inhi- bition. Consequently, the diagnosis is made only on the basis of circumstantial evidence and careful exclusion of other causes of death. The availability of accurate observations by the reliable witnesses surrounding the circumstances of death is of paramount value in ascertaining the cause of death, pro- vided that the elimination of natural disease, poisoning/chem- ical analysis or some other obvious cause has successfully been carried out. Occasionally, a frank admission of inability to arrive at the cause of death may be declared.

Stress and/or emotion related death: Severe emotions/ physical stress can elicit powerful physiological responses and may predispose a person to a sudden and unexpected death. Explanation may reside in the concept that severe physical exertion, emotional stress, or some life-threatening situation exerts stress on the heart through the release of catechol- amines. This stress may get compounded if the individual is under the influence of some sympathomimetic drug. Since heart and central nervous system are neurally linked (both parasympathetic and sympathetic nerves innervate the heart contributing to the formation of cardiac plexus), the cardiac– neural interactions can help to explain such deaths as well as those with sudden seizure disorders or subarachnoid haemor- rhage. Arrhythmias may arise secondary to an overactivity of the sympathetic nervous system, or subsequent to rapid shifts between sympathetic and parasympathetic effects. It has been documented that myofibrillar degenerative changes in the car- diac myocytes occur in individuals dying of assault, but there is no clear fatal physical injury. The term 'human stress cardio- myopathy' has been applied to these histological changes. 'Somewhat delayed death', at occasions, may be explainable on the concept that the levels of catecholamines continue to increase during the first few minutes after cessation of physical activity (attainable up to 10 times higher than normal). This coupled with electrolyte imbalance (plasma potassium levels have been shown to rise during exercise and then falling rapidly minutes after the exercise) play pivotal role in inducing cardiac dysfunction. This has been termed as post-exercise peril. Further, medical intervention may be another factor interfering with the 'vulnerable period'.

It is possible for a person to be scared to death through heart attack. If the death occurs as a result of a crime, the death may be considered a homicide, even though no physical injury was inflicted. Death is usually sudden and most likely due to lethal dysrhythmia. Usually, some cardiac abnormality has been reported in such cases. However, in cases where there is no demonstrable cardiac pathology, one may also consider acute vasospasm of a coronary artery, precipitating dysrhythmia.

Sudden Death in Infancy

This has been given various names but presently most commonly accepted is 'Sudden Infant Death Syndrome' or 'SIDS'. It is known as Cot Death in Britain and Crib Death in North America. The definition put forward by Beckwith is generally followed, "The sudden death of any infant or young child that is unexpected by history and in whom a thorough necropsy fails to demonstrate an adequate cause of death".

INCIDENCE

It is estimated that incidence of death from sudden infant death syndrome is about 1.8 per 1000 live births in the United Kingdom; 90% of all infants who die being less than 8 months. The syndrome is also recognised in other countries. Rates in the range of 1.5–3 per 1000 live births are quoted in countries like New Zealand, USA, Ireland and India.

SIDS is now most common cause of infant mortality in the first 12 months of life in the Western countries.

Identified risk factors include the following:

- Winter season: Higher rate of incidence in the winter season.
- Respiratory disease: Deaths occurring particularly in the regional occurrence of respiratory disease.
- Male child: SIDS has a male predominance.
- Higher incidence in cities than in rural areas.
- A characteristic age distribution with three-quarters of the cases between 4 and 6 months.
- An increased incidence in twins, in babies of low birth-weight, among off-springs of young mothers.
- Poor living conditions.
- Bottle-fed babies.
- Most fatalities seem to occur during the night, the babies being found dead in the morning, the child being previously healthy or only mildly unwell.

PATHOPHYSIOLOGY

There are multiple theories, but each provides the possible cause in a proportion of infants. The older concepts of 'overlaying' or 'suffocation' or ' inhalation of vomitus' usually account for small number of unexpected deaths and have been discredited.

- Prolonged sleep apnoea associated with age, low birth weight and infections may be the cause in some cases.
- It has been observed that human infants who are given cow's milk at the first feed choke more frequently than those given human milk, but this observation is absent in older babies.
- Airway obstruction from the blocked nose may operate in some cases.
- Respiratory viruses found in about 25% of cot deaths may cause a rapidly fatal infection or trigger sudden apnoea.

- The findings of most studies in England support the view that sudden infant death is essentially a mode of death in children suffering from some occult illness.

AUTOPSY Detailed history and examination of the scene may be essential to exclude child abuse or an 'accidental death'. Birth weight and full measurements must be taken. Gross examination should be meticulous including all the orifices. Swabs need to be collected from air passages, and blood from heart may be preserved for microbiological culture. Complete histology studies should be carried out. Middle ears should be opened and swab obtained. A separate piece of lung may be sent for virological culture. Petechial haemorrhages on the visceral pleura, epicardium and thymus may be seen in a few cases but may also be agonal in nature from terminal respiratory efforts against the obstructive airways. The findings of gastric contents in the air passages may not be used as a cause of death in itself, which may again be agonal or actually postmortem in origin. It should be evaluated in conjunction with the other attending circumstances.

Asphyxial Deaths

The term asphyxia commonly means 'lack of oxygen'. However, etymologically, the term has been translated from the original Greek, implying 'pulselessness/absence of pulsation'. How the lack/absence of oxygen is related to pulsation may be explainable on the fact that the air (pneuma) necessary for maintaining life is carried through the blood (i.e., through the oxy-Hb) and therefore, this movement of air obviously will come to a standstill when movement of blood ceases, i.e. pulselessness occurs. Hence, failure or interruption of one function is inevitably linked to the other.

Hypoxia is a general term referring to inadequate supply of oxygen to the tissues or an impairment of the cellular utili- sation of oxygen for any reason, whereas hypoxaemia refers only to decreased carriage of oxygen in the arterial blood.

The term anoxia implies 'absence of oxygen' and is often incorrectly used to indicate any condition characterised by defective or insufficient oxidation of the body tissues. Barcroft (1920) using this term, divided the situation into three groups:

Anoxic anoxia, i.e. prevention of oxygen from reaching the lungs.

Anaemic anoxia, i.e. inability of blood to carry sufficient oxygen due to low haemoglobin contents.

Stagnant anoxia, i.e. where the circulation of blood is impaired so that there is lack of oxygenated blood transport to the tissues.

Later on, a fourth group called the histotoxic was added (Peters and Van Slyke, 1931). In the histotoxic anoxia, oxygen— although freely available in the bloodstream—cannot be utilised by the tissues. It can further be subdivided into:

Extracellular, i.e. tissue oxygen enzyme system is poisoned. Classic example is cyanide poisoning, in which then cytochrome-oxidase system is interfered with. The effects of most of hypnotic and anaesthetic drugs may also be included in this because they depress cellular enzyme activity.

Pericellular, i.e. oxygen cannot gain access to the cell because of the decrease in the cell membrane permeability that may be seen in lipid soluble anaesthetic agents like halogenated hydrocarbons, e.g. chloroform, halothane, etc.

Substrate, i.e. there is inadequate food for efficient metab- olism by the cell.

Metabolite histotoxic hypoxia, i.e. the end products of cellular respiration cannot be removed thereby preventing further metabolism as in uraemia or carbon dioxide poisoning. Adelson defined asphyxia as, "the physiologic and chem- ical state in a living organism in which acute lack of oxygen available for cell metabolism is associated with inability to eliminate excess of carbon dioxide". Even in some textbooks on physiology, the definition of asphyxia is extended to these

two elements, i.e.:

Hypoxia implying inadequate supply of oxygen to the tis- sues, and hypercapnoea implying an increase in the carbon dioxide tension in the blood and tissues. (The normal levels of oxygen in the arterial blood (PO2) with a 95% saturation of haemoglobin range from 90 to 100 mmHg at the age of 30 years to 65–80 mmHg at 60 years or more.) Reduction to 60 mmHg results in hypoxia even though the haemoglobin is 90% saturated; 40 mmHg represents severe hypoxia and death might be expected when the level falls to 20 mmHg [Eastham, RD (1971), Biochemical Values in Clinical Medicine, 4th ed., Bristol: John Wright and Sons].

However, from the medicolegal point of view, it may be useful to categorise the asphyxia into two broad groups— mechanical and non-mechanical. Mechanical asphyxia may be taken to mean that the flow of air into the body is interfered through some physical impediments. It may be considered depending upon the location of respiratory blockage

- Pressure upon the exterior of the neck as in cases of hanging, strangulation, etc. Although such deaths are not pre- dominantly asphyxial, as will be revealed later while discussing these individually, yet they may be considered under this entity of mechanical asphyxia.

- Obstruction of the airways from the exterior, i.e. when the mouth and/or nose, is/are obstructed through some means as in cases of suffocation, smothering, etc.

- Submersion deaths may be viewed as a complex form of mechanical asphyxia, as the mechanism of death involves an asphyxial element due to occlusion of air passages by fluid as well as some biochemical changes in the blood.

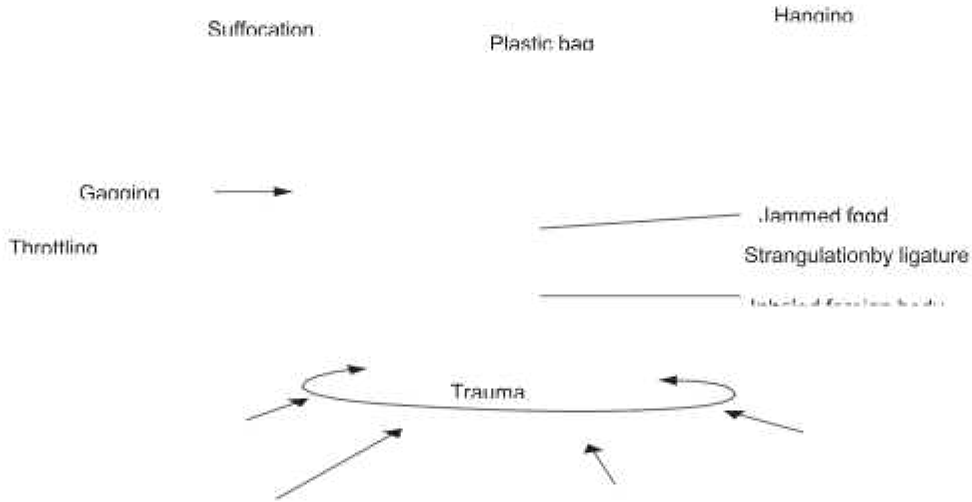
Non-mechanical asphyxia may be taken to mean physiological impediments/ disturbances where there occurs exclusion of oxygen by its depletion and replacement by another gas or by chemical interference with its uptake and utilisation by the body itself or where there is insufficient oxygen in the atmosphere itself. Examples may be carbon monoxide poisoning, cyanide poisoning, etc.

- Obstruction of the airways from the interior, i.e. when the obstruction happens to occur in the internal respiratory passage as in cases of gagging, choking, etc.

- Pressure upon the chest leading to a sort of mechanical fixation of chest sufficient to prevent adequate respiratory movements as in cases of traumatic asphyxia.

Asphyxial Stigmata

The traditionally preached signs of asphyxia are due to pathological changes resulting from lack of oxygenation of tissues, i.e. hypoxia. The effect of hypoxia on tissues is mainly two-fold,



Diagrammatic representation of the mechanism of some asphyxial deaths of common occurrence in the medicolegal field.

SUFFOCATION

Suffocation literally means 'to die as a result of not being able to breathe or to have difficulty in breathing, etc.'. Therefore, it may be regarded as a general term, indicating that form of asphyxial death which is caused by deprivation of oxygen by any of the following means (.. 6.1):

- By lack of oxygen in the atmosphere, the so-called environmental suffocation.

OR

- From obstruction of the air passages by means other than compression of the neck and drowning.

Lack of oxygen in the atmosphere may occur in a variety of ways:

- Commonly by physical replacement of oxygen by other gases or by chemical changes such as combustion. Examples may be the presence of toxic gases in the environment such as carbon monoxide, cyanide, carbon dioxide, etc.

- Decompression such as cabin-failure of aircraft at high altitudes leading to sudden fall in the partial pressure of oxy- gen and hence reduced penetration through the alveolar walls.

- In domestic circumstances, death may ensue due to accu- mulation of carbon monoxide in the room where heating apparatus with burning of coals has been left burning inad- vertently or otherwise throughout the night, especially when the room is lacking adequate ventilation or when a gas cylin- der is left open/incompletely closed.

- Children may get suffocated when they become locked in old disused refrigerators or when they hide themselves into some box/trunk during play.

- It may also be seen in tanks of the ship or other industrial metal chambers where oxygen is replaced by nitrogen.

- Lastly, there may occur circumstances associated with high altitudes. Undoubtedly, the most important environmental fac- tor at high altitudes, from the point of view of its biological effects, is the decreased oxygen tension of atmospheric air. Other variables may include barometric pressure, wind veloc- ity, changes in temperature during the day (which are much greater at high altitudes), lower relative humidity and greater ultraviolet and cosmic radiations, etc. An oxygen concentration of 16% or less is considered to be dangerous. It is more or less at an altitude of 3000 m (9840 ft) above the sea level where statistically significant physiologic and anatomic differences are usually observed. Studies carried out during climbs of Mount Everest have proved that after some training, man can function without resorting to supplementary oxygen up to 8600 m (28,200 ft). Anatomophysiologic studies suggest that at more than 4750 m above sea level the possibilities of achieving a s. homeostatic balance are increasingly reduced.

Carbon Monoxide

Carbon monoxide is a major and ubiquitous component of fire atmospheres. It is colourless, tasteless, nonirritative, inodorous gas, which is lighter than air. Various sources include inefficient combustion of coal, exhaust gas of the automo- biles, fuel gas and explosion gas. Being completely miscible with air, it is likely to readily spread all over by ordinary air movements. It is a highly poisonous gas, which is absorbed through lungs and avidly combines with haemoglobin to form a s. compound, known as carboxyhaemoglobin (COHb) and thus producing 'anaemic hypoxia'. Its high affinity for Hb (about 250 times than that of oxygen) is primarily instrumental for its toxic effects. An additive factor influencing the toxicity of CO is the fact that the presence of COHb causes a shift to the left of the oxygen–haemoglobin dissociation curve. As a consequence, there is increased bondage of Hb with oxygen and thus at any given PO2, the release of oxygen will be reduced as compared with conditions where COHb is not present. When death is solely from CO poisoning, the COHb concen- trations, stated to be compatible with death from acute carbon monoxide poisoning, are usually in the range of 50–60%. In interpreting lower concentrations of COHb in fatal cases, it should be remembered that hypoxia may enhance the toxicity of CO and that the CO may be an interactive factor in the pres- ence of other toxic substances and physical and thermal trauma. Patterns of COHb found in differing fires may reflect the circumstances of an individual specific fire. Exposure time and exposure concentration, however, remain the major fac- tors affecting degree of COHb concentration in an individual. Alcohol, barbiturates and many other drugs are other factors that potentiate the toxic effects of CO. For example, a CO saturation of around 40%, from which a healthy victim would probably recover after temporary incapacity, may prove fatal in the presence of a blood alcohol concentration of about 0.2%. Where absorption is slow and life persists longer, autopsy samples may show more than 50–60% saturation. The varia- tion in the fatal concentrations is wide and irregular. This may be exemplified from the fact that when two or more victims die in the same environment, the COHb concentrations of the bodies may be totally different, even in the persons of the same age group carrying similar physical health.

MEDICOLEGAL CONSIDERATIONS

Poisoning by CO is mostly accidental. The decrepit, the diseased, the drugged and the drunk are more often involved in accidental poisoning. Accidents may occur in connection with inefficient combustion of coal/wood in ill-ventilated room(s), leaky gas pipes and taps in the dwellings and motor car exhausts in small garages. Many deaths in house conflagrations are caused by inhalation of smoke rather than by burns. These fatalities are largely occasioned by CO poisoning, though other lethal gases like cyanide, phosgene, etc. may be partly respon- sible. Some victims of house fires may die remote from the flames and may be overcome in different rooms or even on different floors. This may be explained on the basis of ability of CO to percolate considerable distances. Further, as the gas is lighter than air, it is likely to be present in significant quantities in the upper reaches in the vicinity of a fire. That is why it is always advisable to crawl on the floors to get out of the scene than to walk or run.

Suicidal poisoning by CO frequently occurs in Western countries. The deliberate introduction of fumes into the interior of a car by means of a pipe attached to the exhaust or by running the engine in a closed garage is a common method of suicide in those countries. Accidental death can also occur in the latter circumstances if the victim is unaware of the toxic nature of the exhaust gases or fails to make adequate provi- sions for ventilation when working on a vehicle. In India, suicide by CO is rare.

The use of this gas for homicidal purposes is also rare. However, a murderer may turn on a gas tap when his victim is asleep in the bedroom and thus suffocate him to death.

The human foetus is particularly sensitive to CO because of several differences from the adult. Firstly, greater contents of haemoglobin leading to greater COHb in the foetus than the corresponding maternal blood COHb under steady conditions. Secondly, the partial pressure of oxygen in the foetal blood is lower as compared to the adult. Thirdly, the foetal oxygen–haemoglobin dissociation curve lies to the left of the adult curve, resulting in greater tissue hypoxia at equivalent COHb concentrations.

AUTOPSY

The most striking appearance is imparted by the colour of the skin, especially in areas of hypostasis. The typical 'cherry- pink' colour of the COHb is usually evident if the saturation of blood exceeds 30%. When the victim is anaemic, the colour may be faint or even absent because insufficient Hb is present to demonstrate the colour. In racially pigmented victims, the colour may obviously be masked, though it may still be appre- ciable on the lips, nail-beds, tongue and palms and soles. Cyanide poisoning and exposure of dead body to cold (refrig-eration, etc.) may cause redness/pinkness similar to CO poisoning. This cherry-pink discolouration changes to greenish and to brownish/blackish with the progression of putrefac- tion. However, putrefaction exercises little effect on COHb, which is extremely s.. There is no evidence that CO is evolved during putrefactive process and may be detected in the blood several days after death from poisoning by CO by using sophisticated laboratory techniques. Autenrieth detected CO in the blood of an adult 2 months after he died from poisoning by coal gas. Laguma describes a case in which CO was detected chemically and spectroscopically in the fluid content of the pleura and abdomen of the woman whose body was exhumed 7 months after death, which occurred suddenly from poisoning by CO from a defective oven. When no blood is available at autopsy, an aqueous extract from bone marrow, lung, brain, spleen or other organs or tissues containing blood may still allow determination of COHb content by gas chromatography.

In delayed deaths, i.e. in cases who survive an acute episode of CO poisoning but die later from complications/other causes, bilateral necrosis of basal ganglia and globus pallidus has been reported. These structures are particularly vulnerable to anox- aemia due to their unique blood supply. Identical lesions have also been reported in barbiturate poisoning and in cases of marked arteriosclerosis of the vessels of the corpus striatum.

Foetal half-life of elimination of CO is longer than in themother. Hence, acute exposure to CO concentrations that are nonlethal to the mother have been reported to be associated with foetal loss or permanent neurological sequelae in the foetus.

Forensic expert should be cautious about a couple of con- fusing features of CO poisoning, i.e. occasional blistering of the skin of dependent areas such as calves and buttocks that may be mistaken for burns because their rupture leaves a red, raw surface that later dries to a brown parchment-like area. They are not specific to CO toxicity and are the result of cutaneous oedema in a state of profound coma leading to immobility and impaired venous return. Second circumstance includes the tendency of the dying victim to wild, flailing movements inside the room disturbing clothing and furniture to give an impression of violent quarrel, thus creating an erroneous suspicion of murder in a death due to accidental or suicidal CO-poisoning.

Carbon Dioxide

It is a heavy, colourless, inodorous gas and is a constituent of the atmospheric air in which it exists to an extent of 0.04%. It is given off in the process of respiration, combustion, fermen- tation and decomposition of animal matter. It is also evolved in the neighbourhood of lime kilns owing to decomposition of carbonates. Cases used to occur in the olden days where vagrants sleeping near the lime kilns for having warmth were sometimes asphyxiated by this gas. This gas, being heavier than air, tends to accumulate at the bottom of old wells, damp cellars, mine shafts, brewer's vats, grain pits, ship holds, etc. Therefore, if a victim is seen lying unconscious at the bottom of a well or a pit used for storing grains, an attempt should be made to discharge oxygen from an oxygen holder into the bottom of the well or pit by means of a hose that may not only revive the victim but also displace the carbon dioxide so that others can descend to render help. Manning et al. (1981) describe the deaths of three men who descended into an open drainage pit to recover a fallen grate lid. Each victim died within minutes of his descent. Analysis of the air samples taken at various levels of the pit revealed that as one descended, there occurred decrease in oxygen level, from 20% at the top to 3% at the bottom. Carbon dioxide, however, increased from the top of the pit and showed a level of 22% at the 6 feet depth of the pit. The accepted lethal level usually ranges from 10 to 20%. Blood CO2 content determination has no diagnostic sig- nificance, since CO2 readily accumulates postmortem. Of crit- ical importance, however, is the analysis of air sample collected from the scene for its CO_2 content.

Suffocation from obstruction to air passages by means

other than compression of the neck and drowning may include the following:

- Obstruction of the airways from the exterior, i.e. when the mouth and nose are obstructed by some means, may be by some material or by the application of hands, e.g. smothering.
- Obstruction of the airways from the interior, i.e. when the obstruction happens to occur in the internal airways by some foreign material, may be food or any other material, as in gagging, choking, etc.
- Traumatic asphyxia may also be included here where pressure upon the chest leads to a sort of mechanical fixation of chest thereby preventing adequate respiratory movements.

Smothering

It may be brought about by any circumstance that prevents breathing by obstruction of the nose and mouth, as writ- ten earlier. Smothering agent is usually fabric, pillow or hand(s). Sometimes, sand, grain, mud, flour, thick grass or vegetation may be responsible for blocking the air passages. Death in such cases may occur either by occluding substance pressing over the nose and mouth or by the passive weight of the head press- ing the nose and mouth into the occlusion.

SUICIDE, ACCIDENT OR HOMICIDE

Suicide by Smothering

It is possible by burying the face in the mattress or by lying against the bed clothing so as to obstruct the nose and mouth, particularly when under the influence of alcohol or some drug. The victims are usually mental patients or prisoners. Suicidal smothering can be effected by tying a polythene or similar bag over the head and face. In such cases, the hypoxic features may be slight. There may be few petechial haemorrhages in the eye- lids. Internally, there may be found subepicardial petechiae. The circumstances in which the body is found are usually of auto-erotic activity. The process is sometimes combined with the inhalation of 'sniffing substances' such as ether, amyl nitrate, etc. The induction of partial hypoxia as by hanging or any other form of mechanical asphyxia accentuates the sexual sensations during an auto-erotic exercise. Therefore, some cases may be accidental too.

Accidental Smothering

Circumstances can vary according to the age of the subjects, as discussed below.

- Infants: An infant, particularly when premature, may be suffocated merely by the weight of the bed clothes covering the nose and mouth or an infant 'born in a caul' may get accidentally suffocated by an intact amniotic sac. A child may get suffocated on turning his face in the cot, face get- ting buried inside the bed clothing or pillow or mattress, etc.

- Children and young adults: Children may get accidentally suffocated while playing with plastic bags and putting them over their heads when the material gets electrically charged and stuck over the face during inhalation. An epileptic child may occasionally get suffocated because of burying the face in the pillow or bed-clothing.

- Adults: Accidental smothering may occur in the workers during the course of their occupation. A worker can fall and get buried into semi-solid or finely divided materials like sand, ash, cotton, mud, wool, flour, coal dust, grains, wheat or cinders, etc., when the mouth and nose will get obstructed. Adult deaths may often occur when the indi- vidual is already weak or unconscious due to drug or dis- ease. During masochistic exercises or in auto-erotic practices, as described earlier, accidental smothering can lead to death amongst young adults.

Homicidal Smothering

To accomplish homicidal smothering in an adult, there needs to be a great physical disparity between the assailant and the victim or alternatively, the victim must be incapacitated by vir- tue of disease, age, drink or drug. But it is also practicable if the victim is stunned by a blow prior to the act. Usually, the mouth and nose are closed by hand(s) or clothes or the face may be pressed by a pillow or be thrust into the pillow, mud, sand, sawdust or thick grass, vegetation, etc. Homicidal smothering, however, can be effected in a normal adult in his full senses if the number of assailants is more.

AUTOPSY FINDINGS IN SMOTHERING

When hands have been used as the smothering agent, the evidence of violence is likely to include nail scratch abrasions, bruises (especially the fingertip bruises) and even lacerations of the soft parts of the face. Lips, gums and tongue may show bruising and/or lacerations. Bruising and abrasions may even spread over forehead, cheeks, lower jaw, nape of the neck, etc., especially when there has been struggle. Bruising on the inner aspect of lips from pressure against the teeth, with or without bruising of the gums and tongue, is an important suggestive finding. The areas must be examined acutely with magnifying glass and confirmed by dissection. Tissues may also be taken for microscopic examination. Occasionally, the injuries may amount to mere ruffling of the skin, which will invite micros- copy for its confirmation.

When some soft material, clothing or pillow has been applied gently, there may not be any external signs of vio- lence. Under such circumstances, medical evidence may not be able to go further than the conclusion that the death was attributed to asphyxia. Occasionally, an area of pallor in an otherwise suffused face may be demarcated that may indicate the agent responsible for causing obstruction.

Presence of sand, dust, mud, cotton wool, flour, barley grains, etc. in the mouth and nostrils is highly significant find- ing. Presence of such particles/matter in the deeper respira- tory passage intermixed with fluid and mucus is another crucial finding. Lungs may show congestion, oedema and areas of haemorrhage and collapse with intervening emphysema. Where a struggle develops during smothering, laboured efforts to breathe against the obstructed airways may lead to conges- tion, cyanosis and facial and conjunctival petechiae. Blood should be examined for drugs and alcohol. Presence of any natural disease should also be taken care of.

CASE: SIGNIFICANCE OF CIRCUMSTANTIAL EVIDENCE IN DEATH DUE TO SMOTHERING

On 19.12.2007, a newly married lady aged about 29 years was found dead in bathroom. A complaint was lodged by the par- ents of the deceased alleging that their daughter had been killed by her husband and in-laws. The Police conducted investiga- tions instituting Section 498A (husband or a relative of hus- band of a woman subjecting her to cruelty) and Section 302 (punishment for murder) of the IPC. At the scene of crime, the investigating team did not find any significant evidence suggesting homicide (the body had already been removed to the mortuary). Polygraph test of in-laws was found to be inconclusive. No poison was detected in the viscera or blood of the deceased. Histopathology report revealed congestion of viscera in general with "oedema, congestion and haemorrhage in the lungs". The postmortem report showed presence of two abrasions, viz., (i) abrasion with reddish brown scab of

○ 0.1 cm over the bridge of nose and (ii) abrasion 1.0 ⊠ 0.1 cm over the inner aspect of left half of lower lip with reddish brown scab. Board of doctors who had conducted the post- mortem expressed inability to furnish any definite cause of death. The case was thereby referred to another board of doc- tors at PGIMS, Rohtak. The opinion was, "FIR and inquest papers alleged the cause of death to be strangulation. Although features of strangulation have not been observed in the neck on postmortem examination, possibility of asphyxial death due to smothering cannot be ruled out in view of reddish brown scab covered abrasion on nose and lower lip and marked con- gestion without associated inflammation in internal organs reported on histopathology. These findings must be inter- preted keeping in view circumstantial evidence." (Contributed by Dr. SK Dhattarwal, Professor of Forensic Medicine, PGIMS, Rohtak).

GAGGING

It is caused when some pad or any piece of cloth is thrust into the mouth. It is usually resorted to prevent the victim from shouting for help, and death is usually not intended. Hence, sometimes victim's hands and legs may be found tied to prevent him from removing the gag and walking for help. At times, it may be homicidal, particularly when victims are infants or individuals incapacitated by alcohol or drug, old, infirm, etc.

The gag not only blocks the mouth but also prevents the entry of air through the back of throat coming through the nostrils. It soon gets moistened with saliva, mucus and oedema fluid and may also get further sucked with inspiratory gasps, thus pro- gressively leading to complete obstruction. Therefore, death in such cases is more likely to be due to pharyngeal obstruction. The autopsy findings will depend upon the intensity of the struggle to breathe and sometimes may be negligible or absent. If the gag has been removed, mucosal bruising, abrasions or lacerations, individually or in varying combinations, may be evident on the lips, soft palate and in the pharynx. There may be traces of material in the mouth and between the teeth.

To achieve some idea whether the particular material has been employed in the process of smothering or gagging, it may be examined for presence of buccal epithelial cells. The nor- mal saliva contains between 200 and 2000 buccal epithelial cells per mm3 and if the material has been in contact with the mouth, these cells may be demonstrable.

CASE: DEATH OF A 'CHOWKIDAR' BY GAGGING

On 5th February, 1999, at about 8.30 a.m., on receiving infor- mation about the alleged murder of a 'chowkidar ', the police reached the site and found the 'chowkidar ' with hands tied at the back and legs tied about the middle with some cotton cloth (.. 6.2). Mouth was stuffed with a brown coloured 'monkey cap' (partly inside and partly hanging outside the mouth), which was secured by a red coloured muffler going tightly around the mouth, covering the nose too. Investigations by the police revealed that the assailants probably intended to commit burglary and to accomplish the same, they had undergone this exercise of tying the limbs and gagging the victim to prevent him from shouting/crying for help. The 'Inquest Papers' showed the FIR, dated 5th February, 1999, under Section 460 IPC, i.e. all persons jointly concerned in lurking, house- trespass or house-breaking by night punishable with death or grievous hurt caused by one of them. The case showed following features of interest:

- Hands had been crossed and tied at the back.
- Legs tied in the middle.
- Stuffing of the mouth with a 'monkey cap', probably belonging to the victim.
- Securing of mouth and nose by a muffler, again belonging to the victim.
- One whistle was found entangled loosely in the clothing.

CHOKING

This term refers to the blockage of internal upper respira- tory passages by some solid/semi-solid material. The common agents may be piece of food, lump of meat, coins, bunttas, buttons, set of false teeth, marbles, corns, etc. Of these, choking by food material deserves special mention.

Food may be drawn into the larynx, either while travelling down in the mouth in the act of swallowing or may be regur- gitated from the stomach. In the former case, undigested food may be found in the air passages. This is usually seen in old persons and mentally disturbed persons, but can occur in any age group. A popular term 'cafe coronary' was coined by Dr. Roger Haugen, Medical Examiner of Broward County, Florida for such impaction of food in the respiratory passage. The victim may be observed slumping over the dining . or collapsing suddenly while walking across the room after having meals, with no signs of respiratory distress. The original series of deaths involved well-nourished businessmen dying sud- denly and unexpectedly in restaurants and cafes, while sitting or shortly after sitting in their chairs, as if they died of heart attack. Hence, the name 'cafe coronary'. However, autopsy usually reveals a bolus of food in the pharynx or larynx. Many cases have been reported where the victim was merely seen dead while sitting or just after sitting in a chair, the mode of death probably being cardiac arrest due to overactivity of parasym- pathetic nervous system through the stimulation of branches of vagus nerve supplying the laryngeal and/or pharyngeal mucosa. Fairly high level of alcohol has been found in most cases of cafe coronary deaths. The suppression of gag reflex due to alcohol or drugs makes the individual susceptible to this calamity. The latter case, i.e. regurgitation of the stomach con- tents into the respiratory passage, deserves a cautious interpre- tation. Knight (1975) found in a series that 25% of deaths from various causes revealed presence of gastric contents in the air passages. It may be reasonable to suggest that the finding of gastric contents into the respiratory passage can be due to (i) inhaled vomit as a terminal event in asphyxial deaths; (ii) disorganised and uncoordinated muscle movements during terminal moments of life, which often result in regurgitation of stomach contents; (iii) intoxication and unconsciousness as a result of alcohol/drugs; (iv) an after-effect of head injury and (v) agonal or postmortem spillage, etc. Vomit inhalation, there- fore, may be an incidental finding or a final common event in such cases and may not be related to the cause of death. The appropriate way to diagnose inhalation or aspiration of gastric contents is by copious lung histology when products of digestion are found in the bronchi and bronchioles.

ACCIDENTAL CHOKING

Choking is almost always accidental. Victims are mainly very young or elderly people. It may also be witnessed in children while playing and putting the materials in the mouth suddenly in the act of concealing the same. Infants may 'belch out' clotted milk after a feed and this may fall into the larynx and cause choking. Individuals in the state of unconsciousness or under the influence of drugs or alcohol or anaesthesia or during the fit of epilepsy may inhale the vomitus and suffer choking. But the usual circumstances occur during the meals, when the food is accidentally inhaled, especially when the victim is laughing or crying or talking to someone during the meals. It may be seen in the mental hospitals where a patient may snatch food from the other and may get choked while finishing the same in haste. The circumstances of 'cafe coronary' have already been described.

SUICIDAL CHOKING

It is very rare but may be possible in cases of a determined suicide or in mental hospitals or prisoners, etc.

HOMICIDAL CHOKING

Choking is a mode of infanticide but not commonly practised. This can possibly be procured when either there is appreciable physical disparity or the victim is incapacitated by disease, drugs, drink or age.

TOLERANCE OF FOREIGN BODY IN THE AIR PASSAGES

Inhalation of foreign bodies usually causes choking and unless promptly removed may lead to death. But cases have been reported showing that the foreign body may remain lodged in the air passages without giving much trouble. Acute respiratory distress, of course, ensues immediately but once crossed, the victim may suffer little discomfort afterwards. After sometime or after a significant latent period, the foreign body may be discovered while investigating for some trouble. Literature speaks that portions of chicken bones, pins, safety pins and even partial dentures may be lodged in the air passages for rela- tively long periods without causing serious trouble. A remark- able example of tolerance of foreign body in the air passage is given by Ravenel (1891), where a pin had been retained in the air passages of a patient for about 38 years and its presence was felt by him when it was dislodged during the act of violent coughing. Two inflamed, circumscribed areas, at opposite points on the posterior end of each ventricle were seen and, possibly, the pin had long been lying impacted in the larynx.

CAUSE OF DEATH IN CHOKING

Usual mechanism of death in choking is mechanical asphyxia due to obstruction of the respiratory passage interiorly, and the findings of death due to hypoxia may be evident. However, occasionally, the entry of foreign material may produce sudden death due to reflex neurogenic cardiovascular failure as detailed under 'cafe coronary'. In such cases, mechanism of death is not airway obstruction, but rather a vagal mediated event. The proposed mechanism is oesophageal distention-mediated stimulation of tenso-receptors in the wall of oesophagus, caus- ing vagal outflow that terminates in the medulla. Here, impulse pathways overlap with those of the cardiac and respiratory pathways, producing bradycardia, dysrhythmia or broncho- spasm. Additionally, vagal reflexes may also arise from the pharynx and larynx. All this helps to explain why in some cases of choking due to upper airway obstruction death appears to ensue quicker than might be expected from an asphyxial event alone. Another mechanism of death by choking, in occasional cases, may be asphyxia due to laryngeal spasm. The cases are usually those where the material is irritant in nature and only partially obstructs the laryngeal lumen and triggers laryngeal spasm. In a case reported by Gardner (1942), a young man was found dead outside his home. He was deeply cyanosed and appeared to have died of asphyxia. Some acid fluid, resembling gastric contents, was present in the air passages but the air pas- sages were not occluded by the fluid. Death was considered to be due to laryngeal spasm. The man had returned home under the influence of drink and had vomited.

- Burial under the rubble of a collapsed building.
- Similarly, burial under sand, grains, coal or minerals or by falling timber or masonry in industrial accidents.
- May also happen during sexual intercourse, especially when one or both the parties are affected by drug or drink.
- When panic in a crowd leads to stampeding.
- Crushing under an automobile.
- Occasionally, it may result from indirect compression while the victim's thighs and knees are driven against the chest, the so-

called 'jackknife' position.

AUTOPSY FINDINGS

The outstanding feature is the intense cyanosis of deep pur- ple or purple-red colour, confined to the face, neck and shoul- ders up to the thoracic inlet. It may sometimes extend even lower than the clavicles. Areas of pallor may be seen at the level of the collar, folds or creases in the garments, buttons, braces, etc. The mechanism of this gross-discolouration of upper part of chest and face may be ascribed to the fact that heavy load/ pressure upon the chest primarily compresses the thinner and less potent right side of the heart (which receives the blood from the head, neck and face) while the more powerful left side of the heart continues to pump blood. This leads to considerable overfilling in the region of the head, resulting in such a gross discolouration of the face and adjacent regions. Shapiro (1975) suggested that the pressure on the chest forces blood backwards into the major veins, the valveless jugular system allows the blood to be forced upwards to congest the head and face whereas the valves of the subclavian veins prevent the displacement of blood into the arms. The abnormal purplish-red colour of the skin may remain for several days. Poison and Gee ascribed it to the occurrence of haemorrhages into the corium, which is responsible for persistence of colour change in these cases.

In addition to above gross discolouration, other changes usu- ally include congestion and haemorrhages in the conjunctivae and oedema of the conjunctivae. Face, lips and scalp may be swollen and congested. Bleeding from the ears and nostrils may be there. Internally, lungs are usually dark, heavy and may show sub- pleural petechial haemorrhages. Right side of the heart and the great veins above the atria are enormously distended, as explained above. Injuries to the chest wall and even the pleural cavities, with or without fractures of the ribs, may also be encountered.

In some cases where the force moves and rolls over the chest, the veins and capillaries of head and neck may get ruptured due to sudden increase in pressure and produce numerous petechiae. Such cases may be seen in industrial and road traffic accidents.

Traumatic/ Postural Asphyxia

The term 'traumatic asphyxia' or 'crush asphyxia' is applied where there is pressure upon the chest leading to a sort of mechanical fixation of chest and thereby preventing respiratory movements. Examples include:

It is a related condition, where a person incapacitated by drug, disease, alcohol, etc. lies with the upper portion of the body lower than the rest of the body. The common example is of a drunk who slides out of bed so that his head and adjoining region hang down from the edge and the remain- ing body is resting at an upper level. Such an almost inverted position allows the abdominal viscera to push up the dia-phragm and this, combined with the decreased respiratory movements, can cause death with prominent cyanosis, conges- tion and petechiae in the face and neck.

BURKING

This is a particular method of homicidal smothering and trau-matic asphyxiation, named after Burke and Hare who during the 1820s used to kill their victims by this method, to supply dead bodies to the Edinburgh Medical School for anatomical dissection purposes. The practice was carried out as follows.

The victim, usually a lonely one, either alone or away from the family, was to be invited by the assailants to their house for a drink. When the victim became tipsy, he was made to lie on the ground. Then Burke used to kneel or sit on his chest and close his mouth and nostrils by hand or towel and Hare used to pull him round the room by feet. Hare turned approver and in 'King's evidence' described how Burke used to carry out the work. [Burke and Hare, 1948, No. British Trials, TW Roughead, 2nd ed., London.]

Death by Compression of the Neck

As described under the broad categorisation of asphyxia, death by compression of neck structures include hanging and stran-gulation (.. 6.3). Other rare circumstances may include blows upon the neck, arm-locks (mugging) and certain circumstances of accidental origin.

MECHANISM OF DEATH BY COMPRESSION OF THE NECK

A number of anatomical and physiological factors in varying permutations and combinations usually operate in bringing death, that is why it has repeatedly been pointed out that though considered under asphyxial deaths, yet it is not the sole element involved. The closure of the airway is not an essential element of hanging can be gathered from a case reported by Reineboth (1895)—a case of suicide by hanging in a man who had undergone tracheostomy for relief of cancer of the throat. Although he died of hanging, the ligature was above the tracheostomy. The factors are enumerated as under:

- Occlusion of the airway: Airway obstruction may result from the combined effects of direct compression of the larynx or trachea and upward lifting of the back of the tongue blocking the pharynx. The cartilages being soft and yielding in nature may permit a good amount of pressure but still inconclusive to result in complete closure of the airway. Brouardel calculated that a force of the order of 15 kg was required to close the trachea.

- Occlusion of the blood vessels: Jugular venous system lying superficial in the neck is much more susceptible than the deep seated carotid arteries. Moreover, carotid arteries are largely protected by the sternomastoid muscles and the vertebral arteries are protected by the bony canals in the transverse processes of the vertebrae. Most of the findings of asphyxia met in such deaths originate from this venous occlusion. However, under extreme pressure, as seen in hang- ing from long drop, even carotid vessels may get affected in which case unconsciousness ensues almost immediately and face may impart pallor look rather than congested.

- Effects on the nerves of the neck: Pressure on the baroreceptors situated in the carotid sinuses, carotid sheaths and carotid bodies may result in bradycardia or even total cardiac arrest mediated through parasympathetic system. The carotid sinus, it may be recalled as mentioned under 'vagal inhibition', is a dilated part of the wall of the carotid artery at its bifurcation that is situated at the level of the upper border of the thyroid cartilage and is supplied by numerous nerve endings from the glossopharyngeal nerve. It is concerned with the control of blood pressure and heart rate. When the area gets compressed, the impulses pass to the brain through the glossopharyngeal nerves to the vagal nucleus in the brain stem (afferent pathway) and then they return via the branches of the vagus nerve

supplying the heart and other organs (efferent pathway). The effects, therefore, are brought about by the stimulation of vagus nerve supplying the heart leading to its inhibition or standstill, if the stimulation is too strong.

Stimulation of nerve endings in the carotid sinus or adjacent carotid sheath may be effected by direct pressure from hands or ligature in strangulation or in hanging in occasional cases, or from a blow high-up on the side of the neck and death may ensue immediately without permitting enough time for the asphyxial changes to develop. Keith Simpson recorded a case in which a soldier at a dance party playfully 'tweaked' his partner's neck and was shocked to see her falling lifeless to the floor.

- Combined effects: As stated earlier, various anatomical and physiological factors may operate in varying combina- tions leading to death. Typical instance may be searched in manual strangulation (throttling) where the initial pressure for sometime may be sufficient to allow the asphyxial changes to develop but a sudden change in the grip involving the carotid apparatus may lead to death with dramatic sudden- ness. Therefore, the intensity of asphyxial changes may be present to any degree resting upon the circumstances of death.

Having considered these mechanisms at length, it will be easier to appreciate the varied findings while discussing deaths in cases of hanging and various forms of strangulation and the explanations need not be repeated time and again.

HANGING

Death by hanging is due to compression of the neck as a result of suspension of the body by means of a ligature in such a manner that the weight of the body (or a part of the body weight) acts as a constricting force. It is distinguished from strangulation where the neck is constricted irrespective of any effect caused by the weight of the body. This distinction is of practical importance because hanging is usually presump- tive of suicide, whereas strangulation is usually homicidal (Homicidal hanging or suspension of the victim after murder is quite rare.

TYPES OF HANGING

On the Basis of Position of the Knot

The term 'typical hanging' is applied when the point of sus- pension is placed centrally over the occiput, i.e. the knot is at the nape of the neck on the back. If the point of suspension is at any other position, then the term 'atypical hanging' is often applied. In atypical hanging, the commonest location for the knot is near the mastoid process or angle of mandible. Occasionally, it may be under the chin.

On the Basis of Degree of Suspension

The term 'complete hanging' is often used when the feet do not touch the ground or any other material so that the body is completely suspended, the constricting force here is the weight of the entire body. For all other positions, the term 'incom- plete or partial hanging' is used, i.e. hanging in a sitting, kneeling or even lying position. Here, only a part of the body weight acts as a constricting force. It has been reported that a tension of 15 kg (33 lb) on the ligature will occlude the trachea, a tension of 2 kg (4.4 lbs) will compress the jugular veins, a ten- sion of 45 kg will occlude the carotid arteries and a tension of 30 kg will compress the vertebral arteries.

The most common method of self-suspension involves attaching the suspending device (rope, string, sari, chunni, wear- ing apparel, etc.) to a high point such as fan or ceiling beam, etc., and the lower end may be formed into a 'fixed loop or running noose' and is placed around the neck. The victim stands on the chair/stool/. or some other support and either jumps or kicks away the support and gets suspended.

CAUSE OF DEATH IN HANGING

Hanging may lead to death by any one or varying combination of the following:

- Injuries to the spinal cord: These usually occur when the hanging is exercised with a long drop. Fracture dislocation of the neck was the aim of judicial hanging in Great Britain and is unusual in other forms of hanging. It was found in judicial hanging where a drop of 6 feet resulted in fracture dislocations at the level of 2nd and 3rd or 3rd and 4th vertebrae. Fractures of 1st and 2nd vertebrae are less common. The upper cervical cord is stretched or torn and occasionally separated from its junction with the medulla. This causes immediate unconsciousness although heart action and respiration may continue for up to 10 or 15 min- utes. Congestive changes are absent.

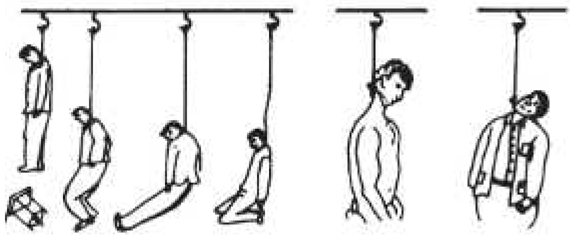
In judicial hanging, some writers speak of 'quick death' in some cases and others speak of 'struggled death'. It would depend upon the nature and mode of application of the ligating material plus other attending factors. A coarsely woven hemp rope may not get tightened well and the noose may bear pressure unevenly, thus allowing some cerebral perfusion to continue. In some cases, element of apprehension owing to the mere thought to execution may induce a high level of circulating catecholamines, encouraging fibril- lation. It has been established that heart continues to beat for up to a few minutes following judicial hanging. Usual absence of asphyxial signs confirms that cerebral circulation is cut off rapidly by the sudden suspension of the body.

- Vagal inhibition: It has amply been discussed under 'Mechanism of Death by Compression of the Neck'. It should be considered as a possible cause when there are no or minimal congestive findings.

- Mechanical constriction of the structures of the neck, as described earlier, may be responsible for death. Practically speaking, combined obstructive asphyxia and interfered cerebral circulation is the most common cause of death.

FATAL PERIOD

Usually depends upon the mechanism of death. In case of judicial hanging or hanging from a long drop resulting in injuries to the spinal cord, death is almost instantaneous, respiration ceasing abruptly though the heart may continue to beat for few minutes. The same is with the vagal inhibition, where death ensues within seconds or occasionally up to a few minutes. In other mechanisms, unconsciousness occurs almost instantaneously, although death may not ensue for few minutes. That is why it is remarked that 'once launched upon suicide by hanging, there is no retreat'. It is not preferable to go into saying, 'within so and so minutes' because the circumstances are so varied (attribut- able to the victim, type and nature of the ligature material and its mode of application, type of hanging—both on the basis of position of the knot and degree of suspension) that they advise to avoid giving a categorical timing.

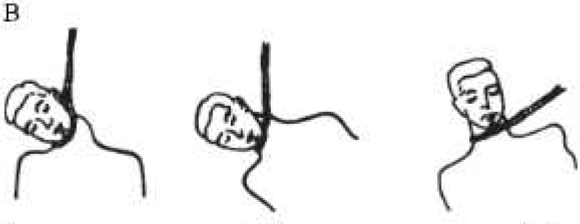


A

Complete and partial hanging

Typical and atypical hanging

B



(i) (ii) (iii)

(A) Types of hanging. (B) The position of the hanging mark on the neck: (i) Usual position with fixed noose and high suspension point. The mark rises high and may show a gap. (ii) If a slip-knot is used, the tightness of the deeply impressed loop tends to find the smallest circumference on the neck and may be lower and more horizontal. (iii) If the suspension point is low and the subject leans away, the mark can be horizontal.

AUTOPSY FINDINGS

These will depend upon the predominance and the combination of the mechanisms of death described above. These may be considered as external and internal and are further subdi- vided into general and local.

General External Findings

FACE

Facial appearance may vary as per the mechanism of death, viz.:

- If death is due to vagal inhibition or injury to the spinal cord, face will appear pale.
- If due to asphyxia, the face will be flaccid and congested.
- If due to apoplexy (venous congestion), the face will be markedly congested, eyes suffused and petechiae may be noticed over forehead, face and temples.
- If the suspension is complete with feet off the ground, the pressure on the neck is such that all blood supply to and from the head is interrupted, i.e. even the deep seated carotid arteries may get occluded and therefore the face looks pale, asphyxial signs may be minimal and petechial haemorrhages are relatively uncommon.
- If suspension is incomplete (hangings may be effected from low suspension points as from door knobs, bed ports and any other easily available low securing point), it may lead to slow asphyxia, the face will be dusky-purple, congested and often swollen because the pressure upon the neck will be insufficient to occlude both the arteries as well as veins and only the veins that are lying superficial as compared to the arteries will be occluded. This obstructs the backflow of the blood from the head and makes the face dusky purple, eyes protuberant and cause petechial haemorrhages over the face, conjunctivae, forehead and temples, etc.

EYES

May be closed or partly open or may be protruding. More often they are protruded and petechial haemorrhages may be noticed over the subconjunctival region and inner aspects of the eyelids. Etienne Martin (1950) described a state called as 'La Facies Sympathique' with right eye remaining open with dilated pupil and the left eye closed with small pupil (Lopes C, 1945, Portugal Medical, 29, 361). This may be due to pressure upon the cervical sympa- thetic, the eye on the same side remaining open and pupil dilated.

TONGUE

It is usually swollen and blue and usually forced in between the teeth when the jaw is closed or the tip may be found projecting between the teeth. The protruding part of the tongue is usually dark brown or even black due to drying. Slight haemorrhages or bloody froth may sometimes be seen at the mouth and nostrils.

SALIVA

It is often found dribbling from the angle of the mouth, oppo- site to the side of the knot. This may be due to stimulation of salivary glands or congestive hypoxia. Salivation may not occur when the death is due to vagal inhibition or injury to the spinal cord. Evidence of dried marks of dribbling of saliva is sugges- tive of antemortem hanging but its absence alone will not sug- gest that the body was suspended after death. Moreover, it is more likely to be noticed at the scene of suspension rather than on the autopsy ..

NECK

It may be found stretched and elongated in prolonged com- plete suspension or in cases of long drop. It may become freely movable from side to side.

HANDS

These are usually found clenched. Sometimes hands may show presence of fibres or of any other material, allegedly involved as a suspending agent.

GENITALS

Engorgement of the penis usually occurs due to hypostasis with emission of semen at its tip. Similarly, the turgescence of vagina accompanied by discharge of blood-stained fluid may be noticed in females. Urine and faeces may escape due to relaxation of sphincters.

Postmortem Staining

If the suspension is in the upright position, the postmortem staining will be limited to lower half of the body including the hands, forearms and the region surrounding the genitalia. If the body has remained suspended for sometime, scattered petechial haemorrhages may be seen in the skin of the legs and in other areas of lividity resulting from excessive engorgement,

i.e. they simply represent accentuation of lividity. Some blood may also be found under the body of the victim due to rupture of the engorged blood vessels and therefore may not be taken for foul play. But if the ligature is cut down and the body is made to lie on the floor within about the period during which the 'so-called' fixation of postmortem staining develops .Hypostasis), secondary areas of hypostasis will develop in the then dependent areas, though original areas may also be appre- ciated on careful observation.

Cyanosis

Deep cyanosis is usually noted when the suspension is from low point and the ligature deeply set or when the ligature has broken between the knot and the point of suspension. The lips, fingertips, nail beds, tip of the nose, and ear lobules will be blue and livid in appearance.

Local External Findings

The mark on the neck is the principal external sign of hanging and therefore requires detailed description. It can almost always be distinguished from ligature strangulation unless under rare circumstances where the ligature breaks at a point between the knot and point of suspension and the victim is found in some open space under a tree or something like that. In most hangings, fixed loop is applied where the mark appears in the form of a groove or furrow, being deepest opposite to the knot. When fresh, the groove may be consider- ably less conspicuous than after drying. The mark is generally yellowish or yellowish-brown shortly after death but often gets dried due to exudation of tissue fluid after sometime and assumes parchment-like consistency. The mark may show an impression of the pattern of the material used as a ligature, which is usually best appreciated by oblique lighting and the use of a magnifying glass. The knot is usually observed either on the side of the neck or in the nape of the neck. Quite rarely, it may be under the chin. The width of the groove may be equal or rather less than the width of the ligature. The mark almost never encircles the neck completely, being deficient at the nape of the neck due to hair intervening between the ligature material and the skin and the firmer nature of neck structure at the back. There may also be some gap near the site of the knot due to pull on the knot from the point of suspension above. When the knot is in contact with the skin, it usually forms an inverted 'V', the apex of the 'V' corresponding with the site of the knot. The location of the groove is nearly always above the larynx and can be traced going obliquely upwards on either side. This may be explained on the basis of the fact that when hanging takes place in vertical position, the ligature will obvi- ously slip up until it is held by the jaw. There may be narrow haemorrhagic border, though interrupted, suggesting its ante-mortem nature. This was the description in a typical case of hanging. However, there may be multiple factors influenc- ing the appearance of the mark as may be enumerated below. (After describing the manner of application of the ligature around the neck and the condition, type and location of the knot, the ligature material should be removed by cutting it away from the knot so as to keep the knot intact to be pre- sented in the court later on. It should then be properly labelled, sealed and handed over to the police.)

Composition of the Ligature Material

Since most of the victims are suicides, they usually hang at the spur of moment with little premeditation, using any type of ligature, which is most readily accessible. Articles used as liga- ture may include rope (which may be made of cotton, jute, coconut fibre, etc.), dhoti, sari, chunni, turban, bed sheet, cord of pyjamas or dressing gowns, belts, brace, neck tie, scarves, boot- lace, towel, torn pieces of wearing apparels, etc.; these may be employed in hangings from a low point of suspension.

If the ligature material is tough and narrow, the mark is expected to be deep and prominent but if the material is soft and broad, the mark is less prominent and less deep. When a folded cloth has been used, there may be great disparity between the appearance of the neck mark and the size of ligature. When the fabric is pulled tight, certain parts of it become raised into ridges, which form the ligating surface and only these may be reproduced on the skin. When nylon, terylene or silk fabrics are used, they may leave a mark of insignificant width. Unusual ligature materials should arouse suspicion. A man, who hanged himself from a pine tree, used its roots passing over a low branch of the tree as a ligature (Gulbis, 1939). A patterned material may leave an imprint or impression upon the skin.

Mode of Application of the Ligature

Any deviation from the running noose or a noose fixed by a granny or reef knot demands a careful interpretation. Occa- sionally, there may be more than one turn around the neck and/or more than one knot, imparting corresponding com- plexity to the mark on the neck. A running noose can tighten at the time of suspension and may then produce a mark that takes a horizontal turn but it is likely to be above the thyroid cartilage.

Position of the Knot

As described earlier, the common sites for the knot are the right or left side of the neck or at the occiput. Suspension by a knot below the chin is very rare.

Course of Ligature Around the Neck

It may also make a difference. As written earlier, the loop is likely to slip up until it is held by the jaw and therefore the loca- tion of the mark is above the larynx in a vast majority of hang- ings. It may be at the level of the thyroid cartilage in about 15% and below the cartilage in about 5% of hangings (cited by Etinne Martin, 1950).

Period and Degree of Suspension

If the period of suspension is more, i.e. the body is discovered late in the hanging posture, the mark is likely to be prominent and parchmentised. Further, in case of total suspension, i.e. complete hanging, the ligature mark is more prominent as compared to partial hanging. It has already been pointed out that successful hangings may be accomplished from low point of suspension as from door knobs, bed posts or other easily available low securing point. Thus, the victim may kneel, sit, slump back or forward or lie prone with only the face and chest off the ground. The point of suspension in Hurphy's case (1881) was only 17 inches from the floor. The victim was a woman aged about 77 years who hanged herself by a ligature of 40 inches long attached to the leg of the kitchen . and she was found lying on her chest on the floor. When the hang- ing is affected from a low point of suspension, the mark on the neck may take a horizontal course, at about the level of upper border of larynx and the congestive changes are well pro- nounced due to lessened constriction force.

Slipping of the Ligature

If the ligature is originally fastened at a lower level and during suspension it slips up to be held under the jaw, this may prevent formation of a deeper ligature mark. On the other hand, a wider impression or chaffing or abraded area may be noticed due to such frictional displacement of the ligature material.

Weight of the Body of the Deceased

Obviously, the mark is likely to be more prominent and deep if the weight of the body is more and vice versa.

Ligature Mark may not be Evident

The ligature mark may not be evident if soft broad ligature material is used or if anything like long beard or clothing intervene between the skin and the ligature material or if the point of suspension is very low. If something, say a collar or a muffler or some ornament upon the neck or any other article, interposes between the ligature material and the skin of the neck, the liga- ture mark may be deficient or less prominent upon that area.

Scratches and abrasions, if present, must excite suspicion. Rare possibility of these lesions having been produced by the victim himself/herself, in an attempt to pluck at the ligature (reflex action to preserve life) could exist but however distinct abrasions, especially the crescentic nail marks, may suggest manual strangulation prior to hanging. The fact, as mentioned earlier, that the skin can be abraded during upward slipping of the ligature should also be kept in mind.

General Internal Findings

These are remarkably less in cases of hanging. Depending upon the mechanism of death, there may not be any finding as in the case of death due to vagal inhibition, or general findings of asphyxia in cases where death is due to asphyxia.

Local Internal Findings

Schrader (1940) drew attention to the artefacts likely to be encountered from seepage of blood from the neck vessels and recommended that neck should be drained of blood by removing the brain and dissecting the heart before reflecting the skin of the neck. Prinsloo and Gordon (1951) confirmed the importance of these artefacts and recommended dissection of the neck structures in situation. The dissection of the neck may be carried out by a V-shaped incision, the apex of the V being at sterno- clavicular joints.

- The subcutaneous tissue under the ligature mark is usually dry, white and glistening—more so if the body has been suspended for a long time and there has been a long drop (complete suspension). There may be petechial haemorrhages in the adjacent tissues above and below the ligature mark, especially in congestive asphyxial mode of death. There may be bruising in the subcutaneous tissue and the muscles deep to the mark, but this is by no means invariable.

- Occasionally, muscle fibres of platysma and sternomastoids may get ruptured, especially in long drops or complete hangings.
- Damage to the intima of the carotid arteries, usually around the region of the sinuses with extravasation of blood in their walls, particularly in case of a long drop, may be found.
- Gordon et al. (1982) suggested that a portion of the skin and deeper tissue in relation to the ligature mark should be examined microscopically for evidence of tissue reaction. Careful and detailed microscopic examination may reveal the presence of effusion of red cells but no evidence of tissue reaction, which takes some hours to develop.

Damage to the Hyoid Bone and Larynx

In order to appreciate the injuries to the hyoid bone and larynx, it would be much better if something is discussed about the forensic aspects of anatomy of the hyoid bone and larynx (.s. 6.5 and 6.6).

The hyoid bone is almost a U-shaped structure and is composed of the central horizontal portion, i.e. the body, to which are attached 'greater horns' through a natural joint with the body. The greater horn lies behind the front part of sterno- mastoid, 3 cm below the angle of mandible and 1.5 cm from the midline. The greater horns, in early life, are connected to the body by cartilage but after middle life, these are usually connected to the bone. There are two 'lesser horns' situated close to the junction of the greater horns with the body that carry no forensic significance. The hardening of the bone usually is related to age but there can be considerable variations and sometimes even elderly people show only slight ossification. Body may get calcified as usual but the horns may calcify irregularly; both in space and time. Evans and Knight (1981), in a series of 110 excised hyoids, found complete fusion of the greater horn with the body in 39 subjects and partial fusion in 14. The youngest subject in whom fusion occurred was 18 years of age. At the other end of the age range, there were subjects in their eighth and ninth decades where no fusion was found.

The larynx occupies the front of the neck, and its position varies with age and sex, being opposite to the 3rd to 6th cervi- cal vertebrae in adult males and somewhat higher in adult females. It is composed of nine cartilages—thyroid, cricoid, epiglottis and smaller pairs of cuneiform, corniculate and ary- tenoids. From forensic point of view, thyroid and cricoid are most important.

The cricoid is shaped like a signet-ring with the signet part at the back. Ossification occurs late and is frequently incomplete. Being less accessible and very often remaining cartilaginous, it is rarely injured and may only be injured where there is an application of considerable force with anteroposte- rior compression against the spine.

The thyroid comprises of a central shield-shaped body, which is angled forward at some 90° in males and around 120° in females. This is a susceptible structure as it lies in the front and covered merely by the skin and fascia. At the back of the body, upper and lower horns (superior and inferior horns) are attached to it. The superior horns are firmly attached to the hyoid bone through thyrohyoid ligament. It consists of a hya- line cartilage and tends to become ossified as the age advances. Ossification is generally considered to commence around 25 years, although it is quite variable and one may find a thyroid still completely cartilaginous in old age. Furthermore, the ossification varies in incidence as well as in degree, increases with age and often occurs earlier in men than in women.

The hyoid bone may get fractured or fracture-dislocated in hanging. The fractures usually involve the greater horns, which are likely to break at about the junction of their outer third and inner two-thirds. There is lack of unanimity of opin- ion regarding the frequency of hyoid bone fracture in hanging. Reuter (1901) reported this fracture to be relatively common, present in 60% of cases in 'typical' hanging and 30% of 'atypical' hangings. Etienne Martin (1933) had made a collection of these fractured bones and described the event as 'assez frequente' in hanging. Smith and Fiddes (1955) remarked that 'the hyoid bone is practically never injured'. The discrepancy may be due to the ages of the victims and the extent of search. The fracture is more frequent in persons over 40 years, i.e. where the hyoid bone is likely to be ankylosed. Weintraub (1961) found the hyoid bone fractured in 9 out of 33 cases. The fracture of the hyoid bone may fall under any of the following groups:

- Anteroposterior compression, where the distal fragment is displaced outwards, and periosteum may be torn on the inner aspect.

- Side-wise compression, where the distal fragment will be bent inwards, and periosteum may be torn on the outer aspect. Here, one or both the horns (cornu) may be frac- tured due to compression on one or both the sides, as was found by Weintraub where one horn was fractured on inner side and the other on the outer side.

- Traction or avulsion or tug fracture. The hyoid bone is drawn upwards and held rigid by powerful muscles attached to its upper and anterior surface (.. 6.6). Violent lateral or downward movements of the thyroid cartilage or the pres- sure between the cartilage and the hyoid bone will exercise traction through the thyrohyoid ligaments, leading to the fracture of the bone.

The fractures are usually associated with at least some haemorrhage but this is not invariable in hanging, and the absence of haemorrhage does not necessarily mean that the body was suspended after death. This absence of haemorrhage may be explained on the suggestion that the circulation may be compromised during hanging and hence the absence of haemor- rhage even when the hanging is during life. Obviously, the other possibilities like postmortem origin of the fracture or fracture occurring during the autopsy procedure need to be taken care of and the findings should be appreciated in con- junction with the other injuries.

Regarding the involvement of thyroid cartilage, opinions again vary. As per Taylor's Principles and Practice of Medical Jurisprudence (13th ed., 1984) fractures of superior horn of the thyroid cartilage are approximately equal to fractures of the greater horn of the hyoid bone and are related to the state of ossification of these structures. In a series of 80 cases, age varying from 18 months to 81 years, Polson and Gee found the fracture of the superior horn/horns of thyroid cartilage in 37 cases (almost 50%).

The article entitled 'Analysis of Neck Injuries in Hanging' (retrospective study of 175 cases of suicidal hangings during a 5-year period) published in 'The American Journal of Forensic Medicine and Pathology Volume 24, Number 2, June 2003 by Nikolic et al. revealed the following:

- The most frequent injuries were the muscle haemorrhages brought by direct pressure as well as indirect stretching of these structures.

- The neck blood vessel injuries were rare. When present, there was higher tendency of their occurrence to the ipsilat- eral side related to the location of the ligature knot suggest- ing their production due to traction rather than direct pressure on the blood vessel.

- Frequency of hyoid bone fracture was more in victims older than 30 years (victims varying from 10 to 87 years formed the sample of their study). Factors like age, point of suspension and width of ligature carried considerations.

- Fractures of the superior horns of the thyroid cartilage were the most frequent injuries of the solid neck structures. Factors like age (significantly more frequent in individuals older than 30 years), location of the knot, location of the ligature, length of ligature and possible swing carried considerations. It may also occur due to indirect force, i.e. caused by stretching of thyroid ligament and thyroid membrane.

WHETHER THE HANGING IS ANTEMORTEM OR POSTMORTEM

As already stressed, the absence of tissue reaction to the ligature and the lack of congestive changes may not be taken as evidence that the body was hanged after death. Circumstances in which the body was found may be of much help. A detailed autopsy supported by necessary laboratory investigations may be quite rewarding. The following points will be of help:

- The presence of any other possible cause of death or presence of injuries that could not have been self-inflicted.

- An unaccep. distribution of hypostasis, i.e. hypostasis is not in keeping with the suspension.

- Evidence from the ligature mark: The mark on the neck is the principal sign though not the conclusive one. If the mark is dried and brown in appearance, it may have been applied before or soon after death. Exercising caution from the exper- iments of Casper (who concluded that a mark of hanging where hanging took place during life can also be produced if the body is suspended within a couple of hours or even longer after death), the evidence/findings, etc. must be scru- tinised in entirety. Gordon et al. (1982) suggested that a por- tion of the skin and deeper tissue in relation to the ligature mark should be examined microscopically for evidence of tissue reaction. Careful and detailed microscopic examination may reveal the presence of effusion of red cells but no evi- dence of tissue reaction that takes some hours to develop.

- Evidence from presence/absence of saliva: As stressed earlier, dried marks of dribbling saliva are suggestive of antemortem hanging as it is occasioned due to pressure upon the salivary glands but its absence alone will not sug- gest that the body was suspended after death. Moreover, it is more likely to be noticed at the scene of suspension rather than at the autopsy .. Slight haemorrhage or bloody froth is sometimes seen at the mouth and/or nostrils.

SUICIDE, ACCIDENT OR HOMICIDE

Suicidal Hanging

Hanging is ordinarily presumed to be suicidal unless the cir- cumstantial and other evidences are strong enough to rebut the

presumption. The age of the victim may be anywhere between extremes of life. Both sexes are almost equally prone. Often a suicide failing in other methods may lastly resort to hanging. In these cases, evidence of some other adopted means may be forthcoming. Fibres of the ligature material like jute fibres, etc. may be found in the clenched hands. The following points may be of help:

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ı Corroboration of suicidal hanging may be gathered from the facts like presence of a suicide note in the handwriting of the deceased, place of occurrence being a secluded place, easily approachable point of suspension and easily accessible ligature material usually some household articles or belongings of the victim.

- Presence of blindness or even some physical infirmity may not prevent suicidal hanging. Cases have been reported where gagging, tying or fixing the limbs, stabbing or cut- throat injuries and even the attempt by firearm injury was resorted but being unsuccessful, hanging was followed as a last resort.

- Presence of poison in the body of the deceased does not contradict suicide by hanging. In a couple of cases in the author's series, alcohol (though in nonfatal doses) was present.

- An insane person may disturb the articles in the room and may splash the blood by inflicting injuries to self and finally may hang himself or herself, the scene simulating a homi- cidal hanging.

- Presence of injuries upon the deceased does not always suggest homicidal hanging. The injuries might have been originated while cutting down the body or bruising over the chest might have been sustained during attempted resusci- tation and occasionally minor injuries in the form of abra- sions might have been self-produced during an attempt in plucking at the ligature.

.ures 6.7 and 6.8 represent two different cases of suicidal hanging, the important features have been described in the .ure captions.

Accidental Hanging

Hanging can occur accidentally, while at work, during playing, exhibiting hanging exercises or showing some performances in the circus, etc. (.. 6.9).

- During auto-erotic masochistic exercises, erotic fantasies may be deliberately induced by partial cerebral ischaemia, achieved by some form of hypoxia or pressure upon the neck. Hypoxia may be produced by masks, pads on the face or enveloping the face; but self-suspension or incomplete strangulation is more often practised by the individual. Victims are usually adolescent males, usually found nude or wearing female clothing. They arrange a situation by placing a noose around the neck and create a state of incomplete asphyxiation in themselves by pulling the other end of the noose across some arrangement. In the course of such practices, the victim can die if he fails to release the pull. At times, mirrors or cameras may be used to see the events by themselves. Nude photographs or pornographic literature may also be found at the place of occurrence. Such exer- cises of sexual asphyxias speak of some sexual perversion and some mental eccentricity and in most of the cases, death is accidental in origin. Mislabelling the same as suicide or occasionally homicide may have implications in insur- ance and inheritance, etc.

- It may occur in the individuals while at work; for example, in the factories when a worker working at a height falls off accidentally and gets hanged on a sling or rope or sometimes a labourer who carries load on this back secured by a strap may slip and cause accidental hanging or strangulation.

- During climbing ladders or railings, if one loses foothold one may fall and the clothing may get caught by a bough or spike that may be drawn across the neck.

- Children can get accidentally hanged due to slippage from the restraining apparatus, while crawling away or by cloth- ing being tightened around the neck, etc.

Accidental hanging can also occur when a person's neck gets compressed below the chin by getting suspended by a steering wheel of a motorcar, tail board of a lorry or cart, edge of a sofa or arm of a chair, etc.

Homicidal Hanging

It is not usual but not unknown also. A few cases have been reported in the literature; for example, six cases by Reuter (1901) and single reports by Klauer (1933), Weidemann (1940) and Mayne (1942).

Unless the victim is an infant or an adult but incapacitated by drug, disease or drink or rendered unconscious by a stunning blow on the head or attacked while asleep or taken unaware, it is difficult to accomplish homicidal hanging single-handedly. However, two or more persons acting in concert can accom- plish homicidal hanging. There may be evidence of pulling or dragging of the victim on the ground as evidence of friction at the point of suspension in the ligature material. The hands of the victim may show presence of some foreign material like hair, button or piece of clothing, etc. Signs of struggle may be present on the body of the victim and at the scene.

Lynching

It is an example of homicidal hanging. In such cases, people enraged by an offence hang the offender publically with a view to teaching others a lesson for committing the offence. It was common in North America where a Black rapist used to be lynched by the angry White mob. Presently, this term is used more liberally for any type of killing of a social offender.

The word 'lynch' means 'to put a person to death by mob action for an alleged offence without a legal trial'. The practice was in use under the 'Lynch Law', named after Capt W Lynch (1742–1820), head of a self-constituted judicial tribunal in Virginia. The usual means employed include hanging, burning, etc. However, the mob may resort to any activity that may be practicable in the particular situation. Recently, as per report published in the newspaper (The Tribune dated 6th July, 2002), a man of 40 years of age accused of blasphemy was stoned to death by hundreds of villagers following a religious edict for his execution. First, the deceased was beaten with iron rods and sticks and when he fell unconscious, he was dragged to village square where the local religious leader ordered the mob of villagers to stone him to death.

CASE: DEATH OF MOTHER AND CHILD FROM HANGING

Here is cited a case carrying an unusual gravity where the lady, aged about 35 years, managed to hang her son, about 3 years of age, and then subsequently herself resorted to commit suicide by hanging. .. 6.10A shows the ligature material (chunni) around the neck secured with a double knot; swollen, puffy face with petechial haemorrhages; right eye semi-open and left fully open; protruding tongue (with protruded portion appearing black) and a distinct ligature mark, high up in the neck under the jaw and quite discernible even at the back (.. 6.10B).

STRANGULATION

Strangulation is another entity representing death by compression of the neck from the exterior. Compression of the neck may be effected by:

- Application of ligature (ligature strangulation).
- Application of human hand(s) (manual strangulation/ throttling).
- Any other means, with stranglehold, foot or by some solid substance, etc.

It must be appreciated that in all such cases the pressure is purely exerted by ligature or hand(s) or sometimes by both and the weight of the victim's body plays no part. It is in this way distinguished from hanging.

LIGATURE STRANGULATION

The pressure upon the neck may be affected by compressing whole or a part of the circumference of the neck by ligature as has substantially been echoed under hanging, especially under hangings from low points of suspension that it is sufficient if the front and the adjoining part of the neck are compressed.

Cause of Death

As already debated under mechanisms of death by compression upon the neck, it may again be stressed that death is not merely due to asphyxiation but a varying combinations of all the mechanisms involved. An element of cardiac inhibition (vagal inhibition) is more frequently observed in strangulation than in hanging, as is obvious from the anatomy of the neck structures and the location of the carotid sinus described ear- lier .under Mechanisms of Death).

Autopsy Findings

In majority of cases, general features associated with the asphyxial type of death are evident with some demonstration of their local accentuation. However, on the pattern of hang- ing, the findings may be described as:

- General appearances—external and internal
- Local appearances—external and internal

General External Findings

The asphyxial findings will be prominent when undue pressure has been exercised. In deaths due to vagal inhibition, the asphyxial findings will be least or none at all.

- Face: It may be swollen and blotchy with scattered petechial haemorrhages over the eyelids, face, forehead and scalp.
- Eyes: Usually suffused and bulging with dilated pupils.
- Tongue: Swollen, protruding (the protruded portion may be dark coloured) and sometimes caught between the teeth. Frothy blood tinged fluid may exude from the mouth and nostrils. There may be evidence of passage of urine/faeces and/or seminal emission.

Local External Findings

The ligature material with which the neck is being compressed usually leaves on the neck a pressure furrow (ligature mark) whose depth varies inversely with the width of the constricting material, i.e. the narrower the material, the deeper it sinks into the tissues of the neck. Examples amongst those that tend to sink deeply into the neck may be cords, wires, narrow ropes, chains, twines from the trees, etc. and those of softer materials may be scarves, ties, towels, stockings, tights, strips of bed linen, mufflers, etc.

If the ligature material is present around the neck, it needs to be removed by dividing it away from the knot, so that the knot may be preserved for future correlation of the findings. The knot should better be secured by tying the component parts with a string so that the parts do not fall apart as the ligature is to be handed over to the police in a sealed packet after proper labelling.

Typically, under ordinary circumstances when single turn has been employed, the mark usually is horizontal, appearing either across or below the thyroid cartilage. The mark may be completely encircling the neck or be deficient or indistinct at the back due to thick musculature or showing localised irregu- lar indentations at the site or sites of knot(s). When fresh, the furrow (groove) may be less conspicuous than after drying. The mark is generally yellowish or yellowish-brown shortly after death but often gets dried due to exudation of tissue fluid and assumes parchment like consistency. Homicides have been accomplished by pulling an almost U-shaped ligature against the front and sides of the neck, the assailant attacking from behind. There may be multiple factors influencing the appearance of the mark on the neck, as may be enumerated below:

- Composition of the ligature material: Depending upon the composition of the material, the ligature mark on the neck will show regular or irregular pattern indicative of surface contour of the ligature material employed in con- stricting the neck. As mentioned under hanging, the pattern may be better appreciated by examining under oblique lighting and using a magnifying glass. Even flexible stick or cane can act as a ligature if the ends are pulled back from behind the victim. The mark may be quite indistinct or may not appear if the material used was soft, broad and yielding and removed soon after death. If the ligature material is not in situation, a transparent adhesive tape may be spread over the front and sides of the neck surface, striped off and be transferred on to the clean microscope slide and examined directly under the microscope.

- Mode of application of the ligature: Usually, the ligature is crossed over itself after encircling the neck and secured with one or more knot(s) at the front or side or may be at the back of the neck. The knot may be fixed after each turn or may be fastened at the end of the turns, imparting cor- responding complexity to the ligature mark on the skin. If there are more than one turns around the neck, skin- folds between the adjacent circumferential loops may be pinched and haemorrhagic particularly when the ligature material is tough and of sinking nature like cords, wires, etc.

- Position of the knot or knots: As written earlier, there

may be one or more knots present either at the front or sides or on the back too, showing localised irregular inden- tations or abrasions or abraded contused area(s).

- Course of ligature around the neck: As already stated, the ligature mark may completely encircle the neck but is more prominent on the front and sides of the neck but may be indistinct on the back due to thick musculature at the back and interposition of some clothing or long hair. The mark may even be oblique resembling hanging, when the victim is dragged after being strangled in recumbent posture or if the ligature was applied from the back with the assailant standing behind the sitting victim and the pull being exerted backwards and upwards.

- Period and degree of constriction: Obviously, the period and degree of constriction will proportionately influence the appearance of the mark upon the neck.

- Shifting of the ligature: If there has been some move- ment of the ligature, as may be expected during struggle, it will impart complexity to the mark upon the skin and the skin may be severely abraded and haemorrhagic.

- If something is interposed between the ligature mate- rial and the skin, it may not allow the mark to appear upon that area; for example, long hair or clothing or some orna- ments at the front may interpose between the ligature and the skin of the neck. At times, ligature mark may be inter- rupted at the front by the interposition of the victim's fin- gers or hand in an attempt to pull the ligature and frustrate the attempts of the assailant.

- The ligature may appear to be deeply embedded into the tissues of the neck due to oedema of the tissues, which initially might not have been applied so tightly. The swelling can continue to increase after death due to decomposition and thus adding to the depth of the groove.

Other external local findings may include evidence of abrasions, scratches or abraded contusions over the face, arms and other parts of the body of the victim, originating during the struggle and the resistance offered by the victim in an attempt to get free and frustrate the attempts of the assailant. If the assailant happens to kneel over the chest or abdomen, bruising of these areas (with or without injuries to the underly- ing structures) may be present.

General Internal Findings

These usually are those of asphyxia—congestion of the respi- ratory tract is often present. Lungs are congested and oedema- tous with subpleural petechial haemorrhages (Tardieu spots), emphysematous bullae at occasional places. Other organs may also show congestion. When the death happens to be due to vagal inhibition, lungs may not show these changes.

Local Internal Findings

- Bruising of the soft tissues of the neck and the muscles, especially underneath the ligature mark, is more common in strangulation by ligature than hanging, more so when some rough ligature has been used and there has been struggle and resistance. Bruising of the subcutaneous tissue may be present even when there are no external marks on the surface of the skin. However, bruising may be absent when the ligature has been tightly secured and not removed until circulation ceases.

- Injuries to the blood vessels are rare in strangulation. However, a deeply sunken narrow ligature applied forcibly may damage the carotids.

- Injuries to the hyoid bone are not commonly observed because the level of ligature is below the bone and the trac- tion on the thyrohyoid ligament is not much. However, if some broad ligature is tightly and forcibly applied, the hyoid bone may get involved.

- Thyroid cartilage, especially one or both the superior horns, may at times be fractured.

In general, damage to the subcutaneous tissues, muscles, hyoid bone and laryngeal cartilages tends to be less common and less severe than from pressure from the hands, i.e. manual strangulation where much bruising and abrasions are seen. Bruising and/or abrasions if scattered and distantly placed from the ligature mark, the possibility of combination of liga- ture and manual strangulation may be entertained.

CASE: Strangulation by Using Insulating Tape and Maxi

A household servant, about 16 years of age, was allegedly strangulated to death by some persons who came to the house for committing robbery. The landlady only came to know of it when she returned home at about 2 p.m. and found the dead body of the servant with face downwards in the bath-tub.

The area around the collar of the shirt and banyan was smeared with blood and the latter was torn at places (possibly while offer- ing resistance). Typical external findings were in the form of swollen face and eyelids with petechial haemorrhages, suffused eyes, presence of blood at the mouth and nostrils, protruding tongue (protruded portion being bluish-black). A reddish bruise adjoining the area just below and lateral half of the right eye.

A check-patterned 'maxi' was present around the neck with a single simple knot on the right side (.. 6.11A). Some por- tion of the maxi was blood-stained. On removing the maxi, an insulating tape was found around the neck (.. 6.11B). A por- tion of the collar of the shirt on the left side was interposed between the tape and the skin. The tape, on being removed, revealed multiple layers. A faint pressure furrow was appre- ciable at places, more so in the central portion of the neck across the thyroid eminence and upon areas lying below and inside the angles of the mandible on either side.

MANUAL STRANGULATION (THROTTLING)

Catching or grasping by the neck of a person is commonly seen in street quarrels, attempted robbery, and in sex-related murders. Manual strangulation is rarely committed by a female except of a child.

At occasions, there may not be any intention to kill but death may ensue all of a sudden because irrespective of the degree of asphyxia that develops, an element of cardiac inhibition (vasovagal shock) is likely to operate in cases of sud- den pressure upon the neck. This occurs because of location of the carotid sinus (which is situated in the wall of carotid artery at its bifurcation at the level of upper border of thyroid cartilage) and this site, therefore, is likely to be involved in manual strangulation, particularly when there has been shifting of grip during the struggle.

Cause of Death

As detailed under 'Mechanisms of Death by Compression of the Neck', there may be varying combinations of different effects involved and as stated above, an element of cardiac inhibition may be operating in occasional cases and death may ensue without permitting enough time for the congestive changes to develop.

Autopsy Findings

Only the 'local findings', i.e. findings at the neck, will be focussed because the general findings are almost the same as described under ligature strangulation. However, local intensi- fication of congestive changes, i.e. presence of well-marked petechiae in the eyes, face, head and neck, must be sought as these are strongly presumptive of some pressure upon the neck, means employed may be any.

Findings upon the Neck

The effects of manual strangulation upon the neck include the following: appearance depends partly on the length and contour of the nails of the assailant and partly on the other circum- stances attending the case. If the nails of the assailant are short and in lining with the pads of the fingers, unpredict- able results may be encountered. If the constricting hands were gloved, nail injuries will be absent. Conversely, where the nails are projecting and well-manicured, distinct and well-marked injuries may be observed. Where the nails are relatively pointed, paradoxical results in the form of reverse crescents may be seen due to anchorage of the skin to the pointed position of the nail. In some instances, nail scratches on the neck of the victim may be produced by the victim himself/herself in an attempt to get free from the throttling grip or dislodge the throttling grip. Examination of the nails of the victim as well as the suspected assailant may provide some assistance in tracing the origin of such marks. Finger- nail scrapings or clippings may be obtained for further examination in the Forensic Science Laboratory. Fragments of skin/epithelium or blood under the nails may provide material for blood typing or DNA-profiling, which can be matched with the alleged assailant. Other trace materials like hair, fibres might be found entangled in the nail beds.

- Cutaneous bruising: The neck of manually strangled vic- tim often shows areas of abrasions and bruising, associated with the nail marks. The abrasions may be due to the epi- dermis being rubbed off by the tips of the grasping fingers of the assailant and bruising is produced where the subcu- taneous vessels are torn by stretching or squeezing. If the con.uration, location and number of the surface injuries are well-pronounced, for instance, one prominent bruise on one side of the neck (compatible with the production by the thumb) and three or four contused abrasions/scratches on the other side (compatible with the production by other fingers or fingernails) one may be able to draw inference about the involvement of the hand responsible for the compression, although it is seldom possible to give a dog- matic opinion as to which finger or thumb caused which bruise. This becomes particularly difficult when there is extensive subcutaneous bruising (which is often expected in such cases) that may render the skin surface to be mottled

- Cutaneous abrasions
- Cutaneous bruising
- Haemorrhage/bruising into the deep structures of the neck Injuries to the hyoid bone and larynx and blotchy, giving the false appearance of a number of separate bruises, whereas all of these may be the part of the same injury. Furthermore, as a result of shifting grip, bruis- ing can be anywhere, and even the posterolateral sides of the neck and upper part of the chest may be involved. Several

reapplications of the fingers due to shifting grip and the 'handedness' (whether right or left handed) of the assailant add further problem to the interpretations. Hence, exercising caution as revealed from this debate, it would be futile to go to describe, viz. 'when one hand is used' or 'when both the hands are used', and so on.

- Cutaneous abrasions: Irregular abrasions and linear or crescentic scratches, either singly or in varying combina- tions, are usually present upon the victim's neck.

- Haemorrhage/bruising into the deep structures of the neck: Bruising in the deep muscles is the result of direct injury, except in the attachments of sternomastoidmuscles, where it may be due to violent contraction of these muscles during the struggle. Subcapsular and intersti- tial thyroid haemorrhages are common and mucosal sur- faces of pharynx, epiglottis and larynx frequently show focal and/or confluent haemorrhages.

Bruising and even lacerations of the deeper structures can be present without injuries to the overlying skin, par- ticularly when any soft material is interposed between the surface of the neck and the fingers/hands of the assailant and so also when the assailant maintains pressure on the neck until the death of the victim ensues.

- Injuries to the hyoid bone and larynx: It is agreed that the injuries to the superior horns or cornuae of the thyroid cartilage and greater horns of the hyoid bone are consider- ably more frequent in manual strangulation than hanging and are normally related to the state of ossification of these structures. Thyroid horns are more vulnerable than the horns of the hyoid. Although fractures of the horns are more common with the advancing age, yet they can rarely occur in the teenagers too. Lateral pressure by the fingers can displace any of the horns of the thyroid or hyoid bone, inwards, either by direct pressure or pressure through the thyrohyoid ligament. Details of mechanisms of fractures and the forensic aspects of anatomy of the hyoid bone and larynx have been discussed under 'Hanging'.

Fracture of the body of the thyroid cartilage is rare. Vertical fracture near the midline between the laminae or on one of the wings may occur from direct blow or forceful anteroposterior compression. Cricoid is not usually frac- tured but if the fracture occurs, it is due to its anteroposte- rior compression against the spine.

SUICIDE, ACCIDENT OR HOMICIDE

Suicidal or Self-Strangulation

Though rare, yet it is possible to strangle oneself by ligature. Apart from the absence of signs of struggle and resistance, the injuries to the deeper structures of the neck will be insignificant. Self-strangulation by ligature may be effected in several ways:

- A ligature may be applied tightly around the neck, once, twice or more times and the final tying of the free ends may be effected even by a partial knot.
- Sometimes, the ligature may be applied by tourniquet mechanism. Only a single turn of ligature is given around the neck being tied by complete granny or reef knot, when a small piece of rod or stick may be passed through the ligature and twisted as lever. When consciousness is lost, the stick unwinds but can do so to a limited extent, because of its getting struck under the angle of the jaw; thus the compression is maintained and death ensues. It is also called Spanish Windlass Technique.
- The victim may apply a running noose to the neck and pass the free end of the ligature several times around the right hand. The victim pulling the ligature by the hand will thus strangle himself. Presumably, the weight of the hand and forearm will maintain sufficient constricting force on the ligature after loss of consciousness till death follows.
-

ı After applying a running noose around the neck, the victim may attach some weight to the free end of the rope, throwing it over the end of the bed or couch on which he is lying.

Accidental Strangulation

Accidental strangulation is unusual. Freak entanglement of a scarf in moving machinery is recorded—the death of Isadora Duncan is well-known. Isadora Duncan was an American dancer who met a tragic death at Nice on the Riviera. On the unfortunate night, she was wearing a silk scarf wrapped about her neck and streaming in long folds, part of which was swathed about her body with part trailing behind. As she took seat in the open rented car, neither she nor the driver noticed that one of the loose ends fell outside over the side of the car and was caught in the rear wheel of the machine. The scarf suddenly began winding around the wheel and with terrific force dragged Miss Duncan bodily over the side of the car, precipitating her with violence against the cobblestone street. She was dragged for several yards before the chauffeur halted. She died there and then. Circumstances of accidental strangu- lation may include the following:

- Before or during the process of birth, some infants can get strangled by their own cord.
- Children may get accidentally strangled while at play.
- Old and infirms, drunkards, epileptics, etc. sometimes fall into a situation from which they cannot escape and com- pression of the neck results.
- While working near a machine, a worker may get acciden-tally strangled due to clothing (shawl, scarves and neck tie, etc.).
- Accidental throttling leading to death may occur on sudden application of pressure by hand or hands over other person's throat, though in joke or as a token of one's affec- tion. Sudden deaths have been reported due to vagal inhibition.

Homicidal Strangulation

It is a common form of murder. Strangulation is always pre-sumed to be homicidal unless proved otherwise. Generally, the assailant exerts far more force than is necessary to kill and therefore the injuries to the structures of the neck are more severe and extensive. Evidence of signs of struggle, both at the scene and on the victim's body, is usually present unless the victim is taken unawares or rendered unconscious by a stun- ning blow upon the head or by drink or drug. Old, infirms, females, etc. are the other victims, and therefore in such cases there may not be signs of struggle or resistance.

Quite often, evidence of sexual assault or attempted rape may be forthcoming and strangulation is perpetrated to qui- eten the cries or to prevent the victim from shouting. Infanticide by strangulation can be procured by applying the umbilical cord around the neck of the infant, where displace- ment of Wharton's jelly will be the conspicuous finding in addition to other signs of violence.

STRANGULATION BY MEANS OTHER THAN LIGATURE OR MANUAL STRANGULATION

MUGGING (ARM-LOCKS)

The term 'mugging' means pressure upon the neck by the arm held around the throat. The attack is usually made from behind, the neck being trapped in the crook of the elbow and pressure exerted when the front and sides of the larynx get squeezed. Death may ensue either due to asphyxia or reflex cardiac arrest.

GARROTTING

In garrotting, a loop of thin string is thrown around the neck of the victim, who is attacked from his back. This liga- ture is then rapidly tightened with the help of two sticks tied at the free ends of the string so as to constrict the neck strongly. Asphyxiation of the unaware victim ensues rapidly and ulti- mately death. This method is usually used in lonely places to kill travellers and rob them (as was adopted by the thugs in India in the past). This used to be the official method of judicial exe- cution in Spain, from which also comes the description of the twisting device—the Spanish Windlass.

BANSDOLA

It may be considered a form of strangulation where the neck is compressed in between two bamboos or other sticks, one in front and the other behind the neck. The ends of the sticks are tied with a rope through which the victim is squeezed to death. Sometimes only one stick is used which is placed across the front of the neck and the assailant stands with a foot on either end and exerts pressure to bring the desired results. Occasionally, the neck may be compressed by the foot alone when the victim happens to be thrown upon the ground.

PALMAR STRANGULATION

Here, the palm of one hand is placed horizontally across the mouth and nostrils, its pressure being reinforced by plac- ing the other palm on top of it at right angles, the heel of the palm above, pressing upon the front of the neck.

DROWNING

Drowning literally means, 'suffer death by submersion in water or any other liquid because of being unable to breathe'. While 'submersion' or 'immersion' means 'putting or plunging the person under water', differentiation is obvious, i.e. 'drowning' denotes a confined concept where death is suffered due to submersion in water or any other liquid and the word immersion/submersion conveys a broader concept where death might have been due to drowning or some other cause, though the body had been recovered from water. Therefore, during autopsy, one must focus attention to distinguish between changes that are due to drowning and those that are otherwise,

i.e. those that occur in bodies immersed/submerged/disposed in water after death from causes other than drowning.

As pointed out already, while considering the circumstances of production of mechanical asphyxia, deaths due to drown- ing are attended by a series of physiologic and biochemical disturbances and to regard it as a straightforward 'asphyxial death' will appear to be oversimplification of the events. However, 'asphyxial' phenomena do constitute a significant portion of the fatal course of events; hence, deaths from drowning are usually considered under 'asphyxial deaths'. (Here, the respira- tory passage is occupied by the fluid, i.e. water or any other fluid, due to submersion and inhalation of the fluid. This cre- ates physical impediment to the process of respiration.) Three major factors influencing the human reactions to the drowning process include: pre-existing state of the body of the victim, chemical components of water and the amount of solution inhaled. Complete submersion of the body is not necessary. Death due to drowning can take place when nostrils and the mouth are occluded by water or any other fluid. To put it otherwise, one can drown in a sea/river or in a bath tub a few inches deep.

TYPES OF DROWNING

Depending upon the various circumstances, the following types have been recognised.

WET DROWNING (TYPICAL DROWNING)

This is a typical type of drowning, whether in fresh water or in salt water, where water is swallowed and inhaled and the respiratory passages get waterlogged. The lungs present the appearance of typical 'drowning lungs' associated with other classical findings of death due to drowning. Course of events in fresh water and sea water drowning will be discussed later on separately.

DRY DROWNING (ATYPICAL DROWNING)

This term may include deaths from submersion which are due to:

- Vagal inhibition (immersion syndrome).
- Laryngeal spasm.
- Submersion of the unconscious, also known as 'shallow water drowning'.

Vagal Inhibition due to Submersion (Immersion Syndrome) (Also Known as Hydrocution in Europe)

This condition is usually found in temperate and cold zones. Death here is attributed to cardiac arrest due to vagal inhibi- tion, which results from stimulation of vagal nerve endings and in case of drowning, this may be brought about by several ways:

- A sudden entry of water into the nasopharynx or larynx.

- Falling or diving into water in a manner so that it suddenly strikes the abdomen, especially the epigastric region.
- Sudden in-rush of cold water into the ears.

The victims are usually the young swimmers and alcohol, high state of emotions or excitement or overeating prior to swimming may be the predisposing factors. Loss of conscious- ness is almost instantaneous and death follows soon after- wards. At occasions, death may ensue within a few minutes. Diagnosis may be achieved by excluding all the possibilities and critical evaluation of the circumstances. (Also see Death due to Vagal Inhibition under Sudden and Unexpected Death.)

LARYNGEAL SPASM DUE TO SUBMERSION

Sudden entry of water into the larynx may provoke laryngeal spasm that prevents entry of water into the respiratory passage and death occurs due to asphyxia and only a minute quantity of water may be found in the air passages. Practically speaking, laryngeal spasm is usually provoked at some stage during drown- ing due to a transient or intermittent factor. The amount of water inhaled and the degree of 'emphysema aquosum' may vary appreciably in the bodies of the victims of the same accident/ incidence. However, at occasions, laryngeal spasm may be the prime factor towards causing death wherein prominent asphyx- ial signs will usually be evident but the lungs, however, are not waterlogged or ballooned.

SUBMERSION OF THE UNCONSCIOUS (SHALLOW WATER DROWNING)

Alcoholics, infants, epileptics, drugged, persons suffering from heart disease or rendered unconscious due to head injury, etc. may get drowned in shallow water such as drain, pit, ditch or anywhere when the depth of water is only a few inches. A healthy victim may sustain head injury during the fall into water and become unconscious when submerged. In case of presence of head injury, it is imperative to keep in mind the possibility of homicide and therefore should clearly be excluded. In such cases, complete picture of death by drown- ing is not found. Ballooning of the lungs may be absent and the formation of froth may be minimal. In case of presence of heart disease, the death might have been due to drowning with a contribution by heart disease or heart disease with an agonal contribution by drowning.

POST-IMMERSION SYNDROME OR SECONDARY DROWNING OR NEAR-DROWNING Survival beyond 24 hours after the victim is removed from the aqueous environment has been considered as 'near drowning'. The victim may survive or die later. Injury to the central nervous system (CNS) has been reported to be the major determinant of subsequent survival and long-term morbidity. Hypothermia and decrease in oxygen delivery to vital tissues, especially the brain, are the most important contributing factors towards morbidity and mortality resulting from 'near drowning'. In such cases, the pulmonary and CNS findings at autopsy will depend mainly upon the amount of initial insult to the lungs and brain by the aspirated water/vomitus and hypoxaemia coupled with oxygen and other therapy. Kvittingen and Naess (1963) recorded recovery of a child after submersion for 20 minutes. Artificial respiration, therefore, need not be aban- doned readily.

MEDIUM OF DROWNING

Though the medium is usually water, yet occasionally the victim may fall into any other fluid (dye, paint, or some other chemical solution). James (1966) reported a case of drowning in a vat of beer. Therefore, the composition of the medium in which the drowning has allegedly occurred should be deter- mined. If the medium contains some peculiar substances, similar substances may be demonstrated in fluid from the respiratory passages or stomach of the victim. The nature of chemicals or any suspended matter in the medium may or may not contribute to the cause of death but their detection in the fluid and in the body of the victim confirms the fact of drown- ing in that medium, i.e. pond, lake, river, ditch, tank, etc. An excellent example of a case has been cited in Taylor's Principles and Practice of Medical Jurisprudence (12th ed.) where the body of a child was found in a tank at a distance from his house. The examination revealed death due to drowning. The air passages showed some peculiar green vege. matter but no weed of this kind was growing in the tank in which the body was found and the enquiry led to the discovery that the body had been found by a woman in a tank near her home, in which a weed like that recovered from the air passages grew abundantly. She had conveyed the dead body to a more distant tank, which belonged to a person against whom she carried some grudge.

MECHANISM OF DROWNING

Specific gravity of a human body as a whole is 1.08. Specific gravity of various parts of body.

When a non-swimmer in possession of his/her senses falls into water, he/she immediately tends to sink to the depth proportionate to the momentum accrued during the fall, weight and specific gravity of the body and to some extent the nature of clothing. The victim at this stage may die at once, either from concussion following head injuries by fall from a height or from heart failure due to old coronary artery disease or from sudden cardiac arrest because of vagal inhibition, specifically if the fluid happens to be cold, and the victim happens to be under influence of alcohol or drug, etc.

Usually, however, the victim rises up to water surface, owing to natural buoyancy of the body and air locked in the clothing, accompanied by struggling movements of his/her limbs. On reaching water surface, the victim cries for help and in an effort to breathe is likely to inhale water. While some air is inhaled into the lungs, some water also passes into the mouth and some of it may be aspirated into the air passages, inducing coughing. Out of fatigue or difficulty, the victim tends to make clutching movements with arms and legs and lay hold of anything within his/her reach and alternately sinks and rises. Each time when his head dips beneath water, some fluid is drawn into the respiratory passage. This ingoing water irritates the mucous membrane of the air passages and provokes the secretion of mucus. This mucus when mixed with water and possibly some surfactant from the lungs is whipped into tena- cious foam by the violent respiratory efforts made by the vic- tim. Its amount and consistence soon becomes sufficient to act like a 'check valve'. The more powerful inspiratory efforts carry air past the obstruction but expiratory efforts are insuf- ficient to expel air, water and foam. The struggle for life may continue for sometime according to the prior status of the individual but eventually exhaustion ensues and the victim sinks beneath the surface, opens the mouth, tries to draw in air but only water enters. There usually occur some convulsive move- ments prior to coma or suspended animation and death. The body eventually sinks until it floats because of development of sufficient gases of decomposition.

PATHOPHYSIOLOGY OF DROWNING

As already stated, the pathophysiology of drowning has been attributed to something more than the simple mechanical obstruction of the air passages by the fluid. The ultimate cause of death in drowning had been studied on experimental ani- mals (dogs) by Swann and his colleagues, notably Spafford during 1947–1951. They showed that the course of events was different depending upon whether the drowning fluid was fresh water or sea water. When fresh water enters the alveolar spaces, it is rapidly absorbed into the pulmonary circulation resulting in gross local haemodilution. They observed that within 3 minutes, the circulating blood could be diluted by as much as 72%, and this massive increase in blood volume leads to bursting of the red blood cells with coincident liberation of potassium (a potent myocardial toxin). This causes increase in the plasma potassium with corresponding reduction in the sodium. In consequence of this electrolyte imbalance, heart suffers a 'serious biochemical insult' as remarked by Donald. Due to this insult to the heart, ventricular fibrillation sets in. Although the heart may continue to beat feebly for several minutes, the severe cerebral anoxia thus produced forms the immediate cause of death .Flowchart 6.3A).

In sea water drowning, a reverse osmotic flow occurs due to higher saline contents of sea water. Fluid leaves the circula- tion and enters the alveolar spaces resulting in local haemocon- centration in the pulmonary circulation and massive pulmonary oedema. Exchange of electrolytes from the sea water to the blood also has its effects, resulting in haemoconcentration and rise in plasma sodium levels. Due to haemoconcentration, RBCs get crenated. This was less deleterious to the function of the heart and therefore helped to explain the longer survival time in the sea water drowning. Here, ventricular fibrillation is not a feature and heart failure is slower and its cause being the myocardial anoxia, which along with the increased viscosity of the blood causes weakening and failure of heart .Flowchart 6.3B).

FATAL PERIOD

Death in fresh water takes 4–5 minutes, whereas in sea water, it takes 8–12 minutes.

Criticism

While these findings are in keeping with the usual clinical concept that the drowning in fresh water is produced more rapidly, how far these results from animal experiments can be applicable to human beings is doubtful. Moreover, as pointed out by Crosfill, these experiments were conducted on animals who were kept totally immersed. Furthermore, in the dog's erythrocyte, the main intracellular cation is not the potas- sium but sodium and hence the release of potassium from the bursting red cells cannot be a satisfactory and thorough explanation.

Modell (1968) reviewed the mechanism of drowning and suggested that about 10% of victims of drowning do not aspi- rate water but die of asphyxia due to laryngospasm. In human near-drowned victims, he found no significant alterations in the electrolyte values, but severe hypoxaemia and acidosis. This is believed to be due to the disturbance in the anti-surface tension agent (surfactant), phospholipid in nature, which lines the alveoli of the human lungs. Fresh water destroys this surfactant with resultant alveolar shunting. The hypertonic sea water has less effect on surfactant, but hypertonicity of sea water causes osmotic transfer of water from the blood into the alveoli and results in relatively more profuse pulmonary oedema. Because the amount of water actually inhaled is variable in each case, the degree of reaction, regardless of salinity, is also variable. The major threat is from persistent arterial hypoxaemia, a process that required minimal aspiration.

Aspiration of only 1–3 ml/kg of fluid can result in signifi- cantly impaired gas exchange. Alterations in the blood volume have been reported to occur with 11 ml/kg and more than 22 ml/kg of aspiration is required before significant electrolyte changes develop (Model JH, Davis JH. Electrolyte changes in human drowning victims. Anesthesiology 1969;30:414–20). It has been commented that drowning is often the final com- mon pathway of different initiating causes of the individual's incapacitation in water. Circumstances like inability to swim, hazardous environment, heart disease, seizure disorder, alcohol/drug use, hypothermia, exhaustion, and other causes need be sought to answer the query that why the individual was unable to get out of water.

DIAGNOSIS OF DEATH BY DROWNING

Diagnosis of death by drowning may be established from the following observations: (i) external signs of drowning, (ii) inter- nal signs of drowning, (iii) biochemical and biophysical tests for drowning and (iv) analysis of diatomaceous material (. 6.3).

External Signs

These signs will depend upon the period of submersion and the period before the postmortem is carried out. It may be recalled that some factors influencing the process of decom- position are peculiar to immersion. The endogenous factors include age, sex, clothing and the prior state of the body, whereas the exogenous factors include whether water was still or running, polluted or clean, fresh or salted and the season of the year. The over-riding factor seems to be the tempera- ture of water that exercises considerable influence upon the process of decomposition (for details see the chapter 'Death and its Medicolegal Aspects'). As remarked in that chapter, the head and the face of a drowned person may show more pro- nounced colour changes of decomposition, while the lower part of the body may be in a reasonably fresh condition. This is because the usual posture of a floating body is head and face at a lower level than the rest of the body as the head is relatively heavy and consequently the body tends to assume a characteristic posture—the trunk is the uppermost due to lungs and gastrointestinal tract being full of gases, and the head and limbs hanging passively. This favours early gravitation of blood into the head and face and hence more marked decom- position. Another fact that needs to be kept in mind is the remarkably hastened process of putrefaction once the body has been removed from water due to presence of abundance of moisture in the body and the more favourable temperature than was prevalent under water.

The appearances in fresh cases of drowning, i.e. when the body is recovered from water within a few hours after its immersion and the autopsy is conducted within a short period after the removal from water, may be as under:

- Body and clothes may be found wet. Sand/mud stains may be present upon the body and clothing. However, these are not specific findings.

- The body surface is usually pallid and cold but may be green or bronze in colour. The face may become bloated and discoloured with the progression of putrefaction, when it may preclude identification. There may be irregularly dis- tributed areas of discolouration upon the skin due to move- ments of the body in water. The tongue may be protruding and occasionally may have teeth marks. The eyes are often congested but rarely show petechial haemorrhages, as has amply been voiced under the mechanism of development of the petechial haemorrhages. The male genitalia may be contracted, erect or semi-erect. The importance of obtaining finger prints or dermal prints has already been highlighted under section 'The Identity of the Dead Body'.

- Postmortem hypostasis may be confined to head, neck and front of upper part of chest and may be pink in appearance. The colour is due to exposure and oxygen- ation of dependent blood, and its distribution is dictated by the posture of the body as it floats in water, as explained above. Such pinkish colour of the hypostasis is somewhat similar to that of carbon monoxide poisoning or may be seen in bodies that have been refrigerated or exposed to cold.

- Development of cutis anserina (goose skin or goose flesh) is another sign that is of little diagnostic value. It is a state of puckered and granular appearance of the skin that develops due to contraction of the erector pilae muscles of the skin occurring due to contact of the body with cold water. This appearance of skin can also occur while immersing the dead body in water soon after death, while the muscles are still irri., i.e. molecular death has not yet supervened. It can also be a postmortem change due to rigor mortis of the erector pilorum muscle.

- Maceration of the skin (washer woman's hands): This is the finding that helps in estimation of approximate dura- tion of immersion. As the period of submersion or immer- sion lengthens, its estimation will present difficulty. The concomitant use of two passive words, i.e. 'approximate' and 'duration', amply dictates not to be too dogmatic in extending opinion in this context, since the changes are open to many exceptions, owing to different rates at which decomposition takes place in bodies exposed to apparently similar circumstances. This is more so in bodies recovered from water that may be due to: Firstly, uncertainty of site(s) where the body had lain during various times of its period of submersion and, moreover, the water tempera- ture may vary even at the opposite shores of the river/canal where the effluent are being discharged by some factory on one shore. Secondly, mechanical pinning-down or locking of the body for a variable period, keeping it down and therefore cooler, delaying decomposition. Thirdly, uncertainty as to the precise state of body on recovery. As stated already, the process of decomposition is remarkably hastened on exposure to air due to abundance of moisture in the body and the more favourable temperature than was prevalent under water. However, factors like still or running water, clean or polluted water, season of the year and the fac- tors attached to the body itself should also be taken care of.

Submersion causes progressive maceration of the skin, par- ticularly the hands and feet and the areas exposed to friction. Hence, the areas usually involved are finger tips, palms, back of the hands and the soles. After prolonged submersion, wide areas of the skin present the similar appearance, such as extensor surfaces of the knees and elbows. The skin at these areas becomes whitened, swollen, sodden, wrinkled and corrugated (.. 6.12). Later on, the epidermis gets loosened followed by the nails and from the hands and feet, it can be detached in 'glove and stocking' fashion. Hands showing these changes have often been termed as 'washer woman's hands' because the changes are similar to those as produced in women after prolonged washing of clothes. The change has nothing to do with the antemortem or postmortem nature of drowning and simply speaks of the duration of submersion of the body in water. The change is attributed to the imbibition of water into the outer layers of the skin. It is first seen in finger tips usually by 3–4 hours and the entire hand may get involved by 24 hours. Duration of submersion may be determined from the following changes:

- Wrinkling of the skin starts by about a couple of hours.
- Bleaching of the cuticle becomes evident by about 12 hours.
- Bleaching, corrugation and soddening of the cuticle becomes pronounced within about 24 hours of submersion.
- Cuticle begins to separate from palm of hand, sole of foot by 48 hours of death; it may get easily peeled off by 3–4 days or even earlier.
- Floatation of the body, in our country, usually occurs by about 24 hours of submersion in summer and 2–3 days in winter.

These findings serve as an approximate rough and broad guide to the timings and need to be evaluated in conjunction with the other usual changes after death that in turn are influ- enced by a host of factors as stressed under 'Death and its Medicolegal Aspects'.

- Grass, gravel, mud, sand, silt, weeds or aquatic vegetation may be found held in firmly clenched hands or feet and also under the nail beds due to cadaveric spasm. The phe- nomenon is rare but when present is a significant sign of presence of life when the immersion took place. Therefore, damaged or broken nails, abrasions or lacerations of the fingers and/or toes with presence of such materials as writ- ten earlier in the nail beds suggest that the victim struggled for existence. Hence, nail scrapings merit investigations. That is why it has been remarked, 'a drowning man clutching

at a straw'. Substances floating or suspending in water may sometimes be found in nose, mouth, ears, etc. The finding showing presence of such elements carries more impor- tance than their absence because there may be circum- stances where there may be nothing for the drowning victim to grasp. Further, if the victim was insensible, drugged/drunk/stunned or in a state of syncope, he/she would not be able to undergo such an effort.

- External examination may also reveal the presence of injuries that might have been received prior to and/or dur- ing fall and/or after the fall while under water. Postmortem injuries by animal predators or by striking of the dead body against some object may be present.

- Presence of fine, leathery and tenacious foam or froth at the nostrils or mouth or both is a significant finding but must be considered in association with other findings (.. 6.13). The foam may not be apparent when the body is first recovered from water but appears on applying pressure upon the chest. Occasionally, it may be blood-tinged because of some admixture with the blood due to tears of the lung tissue by the increased pressure within the lungs, which is a part of the drowning process. It may also be mixed with debris and stomach contents. It is copious, tenacious and persistent and may appear again on wiping away. The mass of foam com- prises of fine bubbles that do not readily collapse on touch- ing with point of knife. The production of such foam in drowning is a vital process. The entry of fluid into the respiratory passage provokes the production of mucus, which when mixed with water and air is churned into the tena- cious foam by the violent respiratory movements made by the victim during the course of drowning. Foam of almost similar nature may also occur in cases of opium poisoning, organophosphorous poisoning, strangulation, epileptic attacks, acute pulmonary oedema and occasionally after an electric shock. However, the nature, character and distribution of foam in drowning, along with the other findings, make it possible to differentiate it from other causes.

Internal Signs

Assuming that the putrefactive changes are minimal, the respiratory system affords the best evidence of drowning. Foam may be apparent in the air passages in variable amounts, together with watery fluid and debris, etc. The lumen of larynx, trachea, bronchi and bronchioles may show the presence of froth mixed with debris. Silt, sand and pieces of water weeds may also be seen. Sometimes, regurgitated stomach contents can be found in the air passages because a vomit reflex is often triggered by the effect of hypoxia on the medullary centre, and the gastric contents may be drawn into the air passages by attempts to breathe during the act of vomiting.

The lungs are voluminous, bulky, water-logged and over-inflated, filling the chest cavity and overlapping the heart. They may present ballooning, surface may show indentations of ribs. On sectioning, blood stained froth escapes. The lungs are generally of pale grey appearance because of squeezing out of blood owing to compression of the vessels in the interalveolar septa by the trapped air and water in the alveoli. Though the surface of the lungs shows generalised pal- lor, there may be mottled areas of red and grey, i.e. alveoli that contain blood and those that are anaemic. Large patches of haemorrhages, known as Paltauf 's haemorrhages, may be seen subpleurally. They are found when the alveolar walls rup- ture as a result of increased pressure during forced expirations. These haemorrhages are mostly found on anterior surface and margins of the lungs in cases of drowning associated with great struggle and exertion. Minute punctiform haemorrhages (Tardieu spots), which are frequently found in those cases where there has been some mechanical pressure upon the neck, are rare to be seen in drowning. This overall picture of the lungs and respiratory passage has been described as emphysema aquosum. However, if the victim is unconscious at the time of drowning, mere flooding of the lungs with water but with- out any formation of columns of froth will occur, which is known as oedema aquosum. It may also be kept in mind that when a dead body is thrown into water, water may simply trickle down into the lungs, the condition termed as 'hydro- static lungs', but the picture of 'drowning lungs', as described above, is unlikely to be produced.

Histological Contributions to Diagnosis of Death by Drowning

Histological contribution may be provided by the changes brought about by the process of drowning and the medium in which it takes place. Here, the depth of water in which the corpse was lying, water temperature, fresh or salt water, impuri- ties in water, general state of preservation of the corpse, previ- ous physical status of the victim and the injuries (if any) that could have caused death or contribution to its occurrence should be taken into account. At least one central and one peripheral section need be investigated from every lobe of the lung and the material must be removed in a way so as to avoid causing contusion(s). In addition to the lungs, liver, cardiac muscle and kidneys may also be examined for signs of acute oxygen deficiency and asphyxiation.

An important histological finding in the lungs usually appears in the form of acute dilatation of the alveoli with extension, elongation and thinning of the septa and compres- sion of the alveolar capillaries. The intensity of the alveolar expansion can be affected by the manner and duration of the drowning process, age-dependent compliance and prior pul- monary disorders, etc.

Where drowning occurs over a relatively long period and the victim happens to come to the surface several times and thus inhales air, the histologically detec. expansion of the alveoli is expected to be most pronounced. Studies into the differentiation of rapid and slow drowning have largely shown only quantitative differences. In case of rapid drowning, emphysematous expansion, partial ruptures in the alveolar septa, empty alveolar spaces and dilatation of the capillaries are the prominent features; whereas in case of slow drowning, the findings basically are similar, though less pronounced quantitatively. Janssen has reviewed the subject and concludes that the histological changes may be helpful in the diagnosis of drowning but should be evaluated in conjunction with the other findings and the circumstances of the case.

Changes in the Heart and Blood Vessels

Obstruction of the pulmonary circulation due to inhalation of water results in distension of the right heart and great veins that are usually found filled with dark blood. Dilution of blood by the inhaled water usually prevents its coagulation. Biochemical and biophysical changes in the blood have been described ahead.

Stomach Contents in Drowning

Stomach may contain water and foreign material like sand, mud, weeds, etc. that might have been swallowed during drowning while struggling for life. The possibility of the victim having ingested that water prior to drowning should also be kept in mind, and therefore chemical analysis of the contents of the stomach showing composition similar to that of the submerging medium will be helpful.

Presence of some dis- agreeable material like muddy water, liquid manure, aquatic vegetation, etc. that could not have been swallowed voluntarily is highly suggestive of antemortem drowning. Absence of water in the stomach may suggest sudden death from vagal inhibition, shock, unconsciousness supervening before falling into water, death due to laryngeal spasm, etc. Rushton (1961) made experiments in order to show that water could or could not enter the stomach after death and concluded that it was possible. Hence, it is extremely important to note the quantity of water found in the stomach and also the nature and extent of foreign matter like algae, water weeds, mud, etc. Microscopic and chemical examination needs to be carried out for this pur- pose. Traces of soap have often been reported to be detected in the bath water drowning.

Haemorrhages in the Middle Ears

Haemorrhages in the middle ears and mastoid air cells are rarely encountered in persons recovered from water. The pathogenesis of these haemorrhages is obscure but may be believed to be due to barotrauma, i.e. the pressure differences between the middle ear and the surrounding water produces a relative vacuum and this negative pressure within the closed cavity leads to inward stretching of the tympanic membrane and haemorrhages in extreme cases. However, Haarkoff and Weiler (1971) found bleeding into the tegmen tympani in 80 of series of 100 cases of deaths from all causes.

Biochemical and Biophysical Tests for Drowning

Numerous laboratory investigations have been reported for diagnosing drowning. In 1921, Alexander Gettler, Toxicologist of Department of Medical Examiners, New York City sug- gested a comparison between chloride contents of blood from the right and left sides of the heart and this test is known as Gettler's test after his name. Normally, the chloride content of the left and right sides of the heart is the same, i.e. about 600 mg per 100 ml. The difference between two chambers may not be more than 5 mg/100 ml under usual circumstances. He suggested that a difference of 25 mg% between the chlo- ride concentrations of the two sides of the heart was an indication of death due to drowning. In fresh water drowning, the chloride content of left heart was lower than that of the right heart and in case of salt water drowning, reverse situation was observed.

Gettler's observations have since been challenged by many

workers and are no longer accepted. It has been shown that changes in chloride content of blood is a usual postmortem phenomenon and occurs irrespective of drowning and that the rate of change may be different on each side of the heart. In 1944, Mortiz suggested magnesium as being more reliable than chloride, especially for determination of sea water drown- ing. In 1955, Freimuth et al. on the basis of specific gravity of plasma of two sides of the heart concluded that negative dif- ferences between left and right sides may be observed in either drowning or non-drowning cases, whereas positive values usu- ally indicate that death was caused by means other than drown- ing. Since then many have worked on the changes in serum electrolyte contents as a result of drowning but the results are not rewarding. The possible factors obscuring the reliability of results of chemical tests may be the rapidity of onset of post- mortem changes in the blood and in the tissues and the much varied conditions to which the body is usually exposed.

Analysis of Diatomaceous Material

Because the chemical tests described earlier could not stand up to the standard of precision needed in the forensic field, the circumstances necessitated the discovery of some other more dependent and reliable method. A major breakthrough in the diagnosis of death by drowning was achieved in 1904 by Revenstorf, who first attempted to use diatoms as a test for drowning, though he stated that Hofmann in 1896 was the first to discover them in the lung fluid. An attractive review of dia- tom controversy was published by Peabody in 1980.

Diatoms or bacillariophyceae are a class of unicellular algae that are found wherever there is water and sufficient light to support photosynthesis. There are about 15,000 species; roughly half of them live in fresh water and remainder live in sea or brackish water. The identification of various types is, of course, the domain of an experienced biologist but their gen- eral classification may be (i) oligohalophilic diatoms that live in fresh water with salinity less than 0.05% and (ii) mesohalo- philic and polyhalophilic diatoms living in brackish water and sea water with salinity higher than 0.05%. The Diatom Test is based on the premise that when a person gets drowned in water containing diatoms (algae with silicaceous exoskeleton), many diatoms are carried to the pulmonary parenchyma inci- dent to the aspiration of water during the process of drown- ing. From the pulmonary parenchyma, the probable portal of entry of diatoms into the blood stream (alveolar capillaries) is through the microscopic tears of the alveolar walls that occur during forceful inspiratory and expiratory efforts (.. 6.15). Once the entry into blood stream is gained, they are dissemi- nated by the blood stream throughout the body. They have been demonstrated into the organs of the experimentally drowned animals, even though the animals were drowned for a short period and were removed from the drowning medium alive and gasping. If a dead body is deposited in water or when the death in water is not due to drowning, then though the diatoms may be able to reach the lungs by passive percolation but not to the distant organs because of absence of circula- tion. Therefore, the organs examined routinely are lung, liver, brain and bone marrow.

The detailed studies of Thomas, Van Hecke and Timperman have shown that the method is reliable provided sufficient precautions are exercised to prevent contamination at each stage in the process of demonstration of diatoms from the organs of the drowning victims. Two main points of criticism, as put forward by some critics, remain:

- Some known cases of death from drowning have shown no diatoms.

- Diatoms have been found in the organs of persons who have died from causes other than drowning (probably depending upon the fact that certain foods, notably the shell fish, con- tains large quantities of diatoms that can therefore be taken along with the food and reach the distant organs after pen- etrating the intestinal lining and gaining entrance into the portal vein tributaries or lymphatic channels).

These objections can satisfactorily be taken care of by:

- Comparing the number and variety of visceral diatoms with their number and variety present in the alleged medium of drowning.

- Taking into consideration the type of drowning, the amount of water inhaled, the season of the year and the other attending circumstances.

Method for Demonstrating Diatoms

Thomas and his associates described a technique for the detection of diatoms in tissues. 2–5 gm of the tissue or about 40 gm of the bone marrow from the shaft of a long bone or from the sternum may be taken by means of gynaecological curette. The marrow is placed in a Kjeldahl flask in which it is chemically digested by adding small quantities of concentrated nitric acid at a time. The contents are heated for about 1–2 hours. This yields a transparent yellow fluid with a supernatant disc of fat. The yellow fluid is next centrifuged. The centrifuged deposit (usually hardly visible to the naked eye) is to be poured on a slide and examined while still wet under a cover-slip.

Water from the drowning medium should always be exam- ined for diatoms (.. 6.16). While collecting the sample of water from the reservoir/lake/river, etc., it is advantageous to take a fairly large volume of water (1–2 litre) and add a few drops of iodine solution to kill the micro-organisms and allow to stand overnight. Decant with care and preserve the concen- trate for examination.

Comparison of number, nature and distribution of diatoms observed in the visceral organs/marrow with the number, nature and distribution of those observed in the alleged medium of submersion will be rewarding to label the death due to drowning. However, as said earlier, the type of drown- ing, the season of the year, the amount of water inhaled and other attending circumstances should also be taken into con- sideration. Some recent research in Japan claims that, using detergent or enzyme digestion instead of destructive acid, even soft-bodied algae and protozoa can be recovered from the tissues in drowning.

R V Verrier, 1964 unequivocally throws light on the significance of diatoms: A yacht disappeared in the English channel. It was the month of January. Six weeks later, body of a man was seen on the Belgian coast. It was transferred to England and was identified by means of a surgical scar and finger prints as one of the men who had sailed with the miss- ing yacht. Postmortem examination posed problem due to advanced decomposition. However, there was no antemortem injury upon the body and only natural disease was renal calculi. Study for the diatoms showed number of diatoms in the lungs, liver and bone marrow of both the femora. These diatoms and silt from the organs and marrow were found to be similar to those present off the Kent coast where the missing yacht was thought to have abandoned. Hence, it is suggested that when carried after observing due precautions at each step, the diag- nosis of drowning could be made even in putrefied bodies where the anatomical recognition of drowning is least possi- ble. Further, some evidence about the site of drowning might be gathered from the ecological typing of the diatoms.

FLOATATION OF BODY IN WATER

At occasions, the issue of time interval after which a body makes its appearance on the surface of water assumes impor- tance. The prosecution may allege some specific period that may not be sustainable by scientific data. The specific gravity of a human body is determined by the combined specific gravities of different parts. The only element of body that is lighter than water is fat. The specific gravity of fat is 0.92, and it is considered that in an averagely built adult, it constitutes about 5% of the weight of the body. The buoyancy of the lungs and the lightness of the fat are counterbalanced by the weight of the skeleton so that the naked human body has a tendency to sink in water. This obviously follows that women are generally of lower specific gravity than men because of smaller/lighter skeleton and greater proportion of fat and hence can float more readily. Infants and young children also float more readily. When the living body is immersed in water, expansion of chest further lowers the specific gravity and it differs so little from that of water that a little motion/move- ments of the hands and/or feet will be sufficient to keep the individual on the surface. The condition of the lungs plays an important role in influencing buoyancy of the body, that is why a person with large and capacious chest tends to float more easily than one with a smaller contracted chest. Obviously therefore, a scream/shriek leading to an almost emptied chest at the time of fall is unfavourable to floating. Nature of cloth- ing on the person may also make a difference. Loose light clothing may serve to buoy up the body, whereas heavy cloth- ing may cause it to sink. Again here, women are better placed as their loose clothing usually traps air that helps them float readily. Generally therefore, as discussed above, a recently dead unclothed body is heavier than water and sinks when immersed. After a variable period, the body will rise again and float upon the surface. This period of floatation is influenced by both endogenous and exogenous factors. Endogenous factors may include specific gravity of the body, age, sex and prior physical status, etc. Exogenous factors may include nature of water (whether salt or fresh, polluted or clean, stagnant or running, etc.), temperature of water, season of the year and other conditions facilitating putrefaction. Therefore, with the development of sufficient gases of decomposition, the body rises to the surface and usually floats with belly upwards owing to abundance of gases in the gastrointestinal tract. The head and face have a tendency to remain at a lower level than the rest of the body as the head is relatively heavy. This favours early gravitation of blood into the head and face and hence more marked decomposition. The body tends to assume a characteristic posture—the trunk being uppermost, head and limbs hanging passively. If the developed gases happen to escape, the body may again sink, but may again rise as a result of formation of more gases. However, some dead bodies may not float because of being entangled in vegetation/weeds or any other impediments. Conversely, a body may sink like a stone if weighted by some apparatus or stones or heavy boots etc. Rarely, a body may become disintegrated (if attacked by some fish or crabs or the like) before the conditions tending to promote floating are established. In India, floatation of the body usually occurs by about 24 hours in summer and 2–3 days in winter.

SUICIDE, ACCIDENT OR HOMICIDE

Majority of deaths due to submersion are either by accident or by suicide. The victim of accidental drowning is usually a child or an adult male, whereas the suicide may be committed either by a male or female adult. Admittedly, the medical data are of secondary importance against the other collateral evidence. However, the medical evidence as to the actual fact of death from drowning is of critical significance in this direction. The deceased might have been stunned prior to or during fall into water or might have been so intoxicated as to have been unable to help himself or might have succumbed to vagal inhibition due to fright or shock from sudden immersion or death might have ensued from some totally independent natural event such as coronary catastrophe, epilepsy or otherwise, when the posi- tion of the victim at about the time of death was such as to cause a fall into water. All such situations have already been discussed at length.

Injuries upon the body must be attended carefully. Injuries may be sustained before and/or during and/or after entry into water or may have been inflicted through physical violence. They may be grave enough to account for death or may be slight but of much medicolegal significance depending upon their nature and distribution. However, pressure marks by the collar or tie or by woman's neckwear or by some other clothing that may become more pronounced as the body becomes dis- tended owing to decomposition may not be misinterpreted. The principal problem hangs about the issue, whether the injury or injuries is/are result of accident or design, and in framing an opinion, compatibility or incompatibility of such injuries with the circumstantial evidence available at the scene must be taken care of. Significant surface injuries may some- times be caused under water when the body has been carried by the current of water against mechanical forces. Therefore, presence of injuries should not lead to a hasty suspicion of foul play. Conversely, the victim may be pushed or chased into water and bear no evidence of assault. Recognition of injuries being antemortem or postmortem is of paramount importance. Ordinarily, they may not present any difficulty in differ- entiation as the injuries sustained/inflicted after death are attended by absence or negligible haemorrhage. At occasions, perimortem production of injuries may pose a problem and further, the presence of body under water (which is likely to wash away the blood) may multiply the problem.

Drowning in shallow water always merits explanation. This may occur accidentally under the circumstances described above. However, under rare situations, the assailant may hold the victim's head in such a position until life is extinct. But its accomplishment requires an appreciable physical disparity between the assailant and the victim except when the victim is a child or is incapacitated by drug/disease or is taken by sur- prise or is overpowered by more than one stalwart. Marks of violence may or may not be present in such cases. In the case of RV Smith, known as 'the brides in the bath case', no less than three women were done to death by drowning in a bath. The assailant had managed to immerse the victim by suddenly lifting the legs up and pushing the head under water. Only in one case, some signs of violence were available, which were in the form of three bruises on the arm.

Ligatures on the body or weights attached to the body may be a good pointer towards homicide but cases have been reported where determined suicides have tied themselves before rolling into water to ensure success. The nature and manner of application of weights to the body and the presence/absence of attending injuries deserve consideration. Constrictions or marks, especially around neck, give strong evidence for homicide provided signs of drowning are want- ing. Another situation raising suspicion for homicide may be that there are evidences of struggle on the banks of river/ canal from where the body has been recovered and especially when the articles belonging to someone other than the deceased are found on the banks and associated with those known to have belonged to the deceased, or where some frag- ments of clothing/hair, etc., (not corresponding to his own) are found grasped in the hand(s) of the victim.

Analysis, especially for alcohol, may throw some light on the circumstances because drunkenness is a common cause for accidental immersion. Even good swimmers drown if they are intoxicated. The explanation may be found in the vasodilatation of the skin produced by alcohol, which leads to an increased skin temperature, enhancing the sudden cooling effect. A similar mechanism may be operating when an already exhausted person jumps into the water to cool off, without first letting the skin to cool.

Homicidal drowning is extremely rare. Copeland (1986) reported 10 cases out of a total of 2617 homicides. Homicide by drowning is easier to conduct if the victim is rendered help- less by intoxication or drugs or by violence. In the notorious insulin case, the husband (a male nurse) gave an injection of insulin to his pregnant wife, the wife taking it to be of ergono- vine intended to induce abortion. Thereafter, when she lapsed into hypoglycaemic coma, the husband placed her in a bathtub to present the case as of death due to drowning (Bir Kinshaw et al., 1958).

Infanticide and Foeticide

Finding dead bodies of newborn infants in the sewers, alleys, trash dumps, streams, lakes, public lavatories, bushes, dry wells, etc. is somewhat common in large cities. The killing of the newborn infants has been practised from time immemorial for a variety of reasons. One of the basic reasons, probably, was the survival of the fittest or the safety of the tribe, i.e. those with some malformations or having less potential value for the family (such as females) were used to be killed. Tribal supersti- tions—the issue of unlucky child as per astrology and even the leg presentations—used to be the other causes. Today, the social stigma attached to the out-of-wedlock pregnancy is usu- ally the most common motivating factor to resort to the com- mission of such a crime. Superstitions, poverty and ignorance may be the other factors, especially amongst the village folk.

CHAPTER-8

INFANTICIDE AND FOETICIDE

INFANTICIDE

From the point of view of law, the offences against children may be dealt with on the same lines as if the victim were an adult. In India, there is no distinction in law between infanti- cide and murder, such as exists in many Western countries like England, Germany, France, etc. In English law, there are spe- cial provisions dealing with certain offences against children. The English Infanticide Act, 1938, Section 1, provides: Where a woman by any willful act or omission causes the death of her child, the child being under the age of 12 months, but at the time of act or omission the balance of her mind was dis- turbed by reason of her not having fully recovered from the effect of giving birth to the child or by reason of effect of lactation consequent upon the birth of the child, then, not- withstanding that the circumstances were such that but for this act, the offence would have amounted to murder, she shall be guilty of felony of infanticide and may for such offence be dealt with and punished as if she had been guilty of the offence of manslaughter of the child.

The analysis of the above provision reveals:

- The word 'woman' speaks that this benefit of diluting the offence to the manslaughter only extends to the mother— not the father or any other person. If anyone else is involved in the charge in assisting the woman for this crime, he will be charged with murder.

- The words 'causes the death of her child' lay stress that it has to be a 'child', i.e. a person with a separate existence outside the mother's body.

- The child must be under the age of 12 months; though most of the infanticides are committed within hours or a short period after birth, yet this limit has been provided for legal purposes.

- The circumstances leading to the death of the child must be willful (deliberate) act(s) of omission or commission.

- There must be evidence to show that the mother (accused) was suffering from disturbance of functions of mind due to reasons mentioned in the provision. For this purpose, the opinion of an experienced forensic psychiatrist, who had been attending to the accused, should be invited.

Whether the crime is to be treated on the lines of man- slaughter (as in England) or on the lines of murder (as in India), certain facts have to be established by a doctor, as amply revealed from the above provisions, before the criminal charge can be brought, namely:

Primary issues:

- The child was capable of survival after birth.

- The child was born alive and had a separate existence out- side mother's body.

- The death was caused by willful act or omission. Here the violence inflicted upon the child has to be differentiated from the injuries incidental to the birth, i.e. accidental inju- ries connected to the birth trauma, whether during or suc- ceeding the birth.

Secondary issues:

- Probable duration of life of the child, i.e. degree of maturity of the child.

- It may also be necessary to prove that the mother has recently delivered, and the period of delivery coincides with the probable duration of the life of the infant and she had been suffering from the disease of the mind due to effects of having given birth to the child or due to the effects of lactation at the time of act of commission or omission.

- Connection between the identities of the child and the mother requires to be traced, i.e. the suspect, in fact, is the mother of the child.

Primary Issues

The first primary issue is to show that the child was capable of survival after birth. It comprises two components, i.e. 'capa- bility to survive' and 'after birth'. In the legal sense 'birth' con- stitutes complete expulsion of the child from the maternal genital passage irrespective of severance of the cord or delivery of the placenta. Therefore, the destruction of a par- tially born child (a child whose head is out of the genital pas- sage but legs still within the genital passage and the child has cried after the delivery of the head) is not regarded as infanti- cide, though it does seem paradoxical from the medical point of view. But this is the law and one has to bear with it. Cases have been reported to have occurred where the killing of the child, one of whose legs were undelivered, was not held to be infanticide and consequently the woman was acquitted. Such cases, however, may be covered under the Infant Life (Preservation) Act, 1929, which covers the eventuality of delib- erate destruction of the child before birth. In this respect, the Indian law is better placed and more appropriate that considers it to be a 'live birth', even if any part of the living child has been brought forth from the body of the mother. The other component is the capability to survive, which imports the con- cept of viability.

Establishing the particular duration of pregnancy is an important part of the complete medical burden. Unless the child has attained such degree of development as to be consis- tent with physical ability to survive, a charge of infanticide will not stand on any sound footing because the children whose age is less than this gestational period (period of viability) are usually presumed to be incapable of leading an independent existence owing to their immaturity. This age of viability may vary according to the condition of the particular foetus and the availability of medical facilities but under the English law, a period of 28 weeks of gestation was fixed for the onset of viability for the purposes of Infant Life (Preservation) Act, 1929. However, a foetus is usually considered to be viable at the age of 210 days (seven calendar months) as per Indian standards. Proof of viability is relatively simple because most of the victims of infanticide and child destruction are mature, usually having attained a period of 36th week of gestation. A combi- nation of criteria as given below should be adopted to have a reliable opinion:

- General condition of the body of the infant should be observed for any disease or malformation, etc. Weight, head circumference and crown heel length of the child need to be determined. It has been shown that there is reasonably close relationship between the age and weight of the foetus. However, when there are multiple births, the weight of each infant may be considerably less than that of single birth at the same stage of gestation. Due allowance may also be given to the sex since the female foetus is usually about 100 gm lighter than the male at the same stage of gestation.

- The crown heel length carries importance. According to the Haase Rule (1895), the length of a foetus up to 5th month (20th week) of gestation represents the square of its age in months. Thus, a foetus of about 4 months will have a length of 16 cm. Beyond 5th month, the length of the foetus measured in centimetres divided by 5 gives the age in months. Thus, a foetus of 35 cm length will be about 7th month of age. This is known as Morison Rule (1964).

- Radiological examination of the entire body may be carried out rather than conducting extensive dissection for the demonstration of the epiphyses. Though the time of appearance of the ossification centres is variable, yet their values cannot be overlooked (.. 7.1):

At the 28th week: There are usually centres of ossifica-

tion in the calcaneum, and talus.

At the 30th week: (Usually accepted as age of viability)

Ossification centres for all sacral verte- brae are usually present.

At the 36th week: The centre of ossification in the lower

end of the femur. This centre in the lower end of femur is most important because it is exceptional for this centre to be absent at maturity of the infant.

The second primary issue is that the child was 'born alive' and had a separate existence.

The concept of 'separate existence' must be understood unambiguously because the critical legal requirement resides in proving that the child was born alive and that it did have an independent existence. The law, therefore, lays stress on the differentiation of 'foetal life' and 'independent life' and the latter inevitably calls for presence of independent respiration or any other sign like independent circulation. This is some- thing where the law runs parallel with the views of Barcroft, who said, 'Breathing is living: the onset of respiration is the beginning of (extra-uterine/independent) life'. It may be made more clear by citing an example, i.e. if an injury inflicted upon the mother who is quick with the child, results in death of the mother as well as the child, it will obviously be homicide, but if it causes the death of the unborn quick child only, it may be treated under Section 316 of IPC dealing with 'causing death of unborn quick child by an act amounting to culpable homicide'. However, an injury inflicted upon the unborn child that necessitates the process of delivery and causes death of the child when the child is fully born amounts to felony of homicide.

Before proceeding to a detailed discussion about 'live birth', it is better to have some idea about the conditions like stillborn or deadborn, etc. so that one is able to differentiate them easily. As already described, a stillborn child is one who has issued forth from its mother after 28th weeks of pregnancy and which did not, at any time after being completely expelled from its mother, breathe or show any other sign of life. A deadborn child is one who died in utero before the birth process began and may show one of the following signs after it is completely born:

- Signs of maceration: Maceration is a process of aseptic autolysis that occurs when the dead child remains in the uterus for some period surrounded with liquor amnii, but with the exclusion of air. Hence, if the child died in utero about 12 hours before it was born, the signs of maceration may not be seen and in such cases it would be difficult to say whether the child died in utero or during the birth.

The earliest sign of maceration is skin slippage, which may be seen in 12 hours after the death of the child in utero (.. 7.2). The body of the macerated foetus is soft, flaccid and flattened and emits a sweetish disagreeable smell, which is quite different from that of putrefaction. The skin shows red or purple colouration but never greenish as in putrefaction. Large blebs containing serous or serosanguin- eous fluid are raised upon the surface of the skin, and epi- dermis is easily peeled off leaving moist greasy areas. The tissues are generally oedematous and turbid reddish fluid collects in the serous cavities. The bones become flexible and readily detached from the soft parts. All the viscera are oedematous and lose their morphology but lungs and uterus may remain unaffected for a longer period. The umbilical cord is red, smooth, softened and thickened. Loss of alignment and over-riding of the bones of cranial vault occurs due to shrinkage of the brain after death. This is known as Spalding's sign. It may be detected within a few days of death of the foetus in utero.

- Signs of mummification: May be seen when the foetus dries up from the deficient supply of blood and scanty liquor amnii, but with the exclusion of air. If the air gains entrance due to rupture of the membranes, the foetus undergoes putrefaction instead of maceration.

Proof of live birth/separate existence: This particularly implies the achievement of breathing, as already remarked, "Breathing is living: the onset of respiration is the begin- ning of (extra-uterine/independent) life" (Barcroft).

In the civil cases, the cry of the child, feeling, seeing or hearing of the heart beat or slight muscular movements such as twitching of the eyelids or a pulsating cord may be taken as sufficient to establish respiration. However, it may be kept in mind that it is possible for the child to cry while the head is still in the uterus (vagitus uterinus) or in the vagina (vagitus vaginalis) and to die before it is completely born. This can occur only if the membranes have ruptured and air has gained entrance into the uterus. It may also be possible that the child may not utter a cry, particularly when immature, and even then may be born alive. The law presumes that every newborn child found dead was born dead until the contrary is proved. Therefore, in criminal cases, signs of live birth have to be demonstrated by postmortem examination, and obviously the air passages and digestive tract will afford the strong evidence—whether the respiration has taken place or not.

Examination of the respiratory system includes the following:

- Shape of the chest: Before respiration, the chest is flat but it becomes arched or drum shaped after respiration.

- Position of the diaphragm: The abdomen should be opened before the thorax, and highest point of the dia- phragm should be noted that is found at the level of fourth or fifth rib if respiration has not taken place. The arch becomes flattened and depressed and descends to the level of sixth or seventh rib after the establishment of the respi- ration. The position of the diaphragm may be affected by the pressure of the gases of the decomposition.

- Changes in the lungs: These may be considered with reference to the following:

  - Volume: Before respiration, the lungs are small with sharp margins, covered by wrinkled loose pleural mem- branes lying in the back part of the chest on either side of vertebral column. After complete respiration, the lungs increase considerably in volume, covered by thin, tense pleura, have rounded margins and occupy the thoracic cavity, the left lung covering more or less the thymus and the heart. Glistening bullae may appear along the margins when there has been a struggle to breathe due to any natural or unnatural obstruction to the breathing.

  - Consistency: Before respiration, lungs are dense, firm, noncrepitant and liver like. After respiration, they are spongy, elastic and crepitant.

  - Colour: Before respiration, the colour of the lungs is uniformly reddish-brown like that of liver. The surface of the lobules is marked with shallow furrow. On sec- tion, little frothless blood exudes on pressing the cut surface. After respiration, the collapsed air cells first become distended with air, usually on the edges and concave surface of the upper lobe of the right lung and then on the remaining portions of the lungs. They are more or less mottled or marbled in appearance as the blood becomes aerated in the expanded area. On sec- tion, frothy blood exudes from the surface on applica- tion of pressure. The foetal lungs may assume more or less rosy colour on exposure to air after death but the air cells can never be distended by simple passive entrance of air into the lungs. This condition may be simulated by artificially inflating the lungs, giving similar appearance in volume and colour but mottling is mostly absent.

- Weight: The weight of the lungs is almost doubled after the aeration. Before respiration, the lungs usually weigh about 30–40 gm and after respiration about 60–70 gm. The increase in weight is due to filling up of pulmonary blood vessels with the blood. The weight may increase from 1/70th to 1/35th of body weight after respiration. This is called the Ploucquet's test. But these factors like increase in the weight of the lungs in relation to the total weight of the body vary greatly and have little medicolegal bearing.

- Presence of extraneous material in the lungs: Presence of extraneous material in the respiratory passage is an important finding suggesting live birth, particularly in the distal respiratory passage because extraneous material can enter the air passage even after death but up to a limited distance and not into the intrapulmonary bronchi where its entry may be resisted by the air in the lungs. Hence, demon- stration of extraneous material in the secondary bronchi and beyond is strongly indicative of its inhalation.

- Hydrostatic test: The test was first noted by Scheyer in 1683. With due recognition of its limitations, the test is helpful and may be performed. It is based on the principle that the specific gravity of the unrespired lungs varies from 1.04 to 1.05 and that of respired lungs is 0.94, because of increase in volume due to inhalation of air. The fetal lungs therefore sink in water and those that have respired float.

Remove the lungs as far as the trachea along with the larynx by tying at the laryngeal end and place them in a jar of water and note for their floatation. The lungs are then separated and each is tested separately for the presence or absence of floatation. Finally, each lung is then cut into fragments that are again tested for floatation. If in all such events, floatation is present the test is positive (provided putrefaction is absent). If there is some decomposition, then the fragments should be compressed to remove the tidal air. The fragments are again placed in water. If they continue to float even after this compression due to pres- ence of residual air, the test is positive and respiration has taken place. If some of the pieces sink and some float, it shows feeble respiration owing to the partial penetration of the air.

- False-positive findings may be evoked under the fol- lowing circumstances:

— Expanded lungs may sink from:

– Diseases like acute oedema of the lungs causing death of a newborn infant within a short time may be demonstrated histologically, if due pre- cautions are taken to prevent draining of the amniotic fluid and the oedema fluid during prepa- ration of the sections for histopathology.

Bronchopneumonia should also be excluded. Further, it may not affect the entire lung uni- formly and the unaffected portion may float in water.

– Atelectasis (nonexpansion) may be due to obstruction by alveolar duct membrane or due to extreme feeble respiration or sometimes more air may be expelled from the lungs during expiration than it is inhaled during inspiration or air may not reach the alveoli but the aeration of blood is being maintained through the lining membrane of the trachea and bronchi.

— Unexpanded lungs may float from:

– Presence of putrefactive gases for which obvi- ously other signs of putrefaction will also be evident.

– Artificial respiration: The foetal lungs may be artificially inflated by blowing air through a tube or catheter or by mouth-to-mouth method or by Schultze's method. But lungs may be inflated partially and complete expansion is unlikely. In such cases, the stomach also usually contains air while it is airless in stillborn infants. The possibility of inflating the lungs artificially should be kept remote because it is difficult to conceive why a person who desires the death of the child should endeavour to resuscitate the child. However, an ultra-criminal mind may go in for such tactics (..7.3).

- Hydrostatic test is not necessary when:

— The foetus is born before 180 days of gestation.

— The foetus is a monster and thereby incapable of leading a separate existence.

— The foetus shows signs of intrauterine maceration.

— The umbilical cord has separated and the umbilicus has cicatrised.

— The stomach contains milk showing active digestive function.

Other tests for separate existence include the following:

- Air in the gastrointestinal tract: Hajkis (1934) suggested that radiological demonstration of air in the stomach and intestines is a strong evidence of respiration. This is due to the fact that during the process of respiration, some air is likely to be swallowed, going into the stomach and further into the intestines due to peristalsis. According to Hirvonen et al., the air swallowed during crying can be seen in the stomach of the infant 5–15 minutes after the birth, in the small intestine after 1–2 hours and in the large intestine after 5–6 hours. Putrefaction and artificial respiration should, however, be excluded (.. 7.3). Test may be carried out by removing stomach and intestines after applying double ligatures at each end of the stomach, at the end of the duodenum and also some lower parts of the intestines. On placing them in water, they will float. Then they are tested separately for floatation. This is known as Breslow's Second Life Test. It is a corroborative test. On careful dissec- tion under water, the stomach may show presence of mucus with air bubbles and saliva if respiration has taken place, and presence of only glairy mucus if respiration has not taken place.

- Presence of milk in the stomach: Presence of milk or farinaceous food in the stomach is a strong indication that the child was not only born but also lived for sometime after birth.

Concludingly, it has been forwarded that there are three schools of thought in general in considering 'proof of live birth', viz., (i) hydrostatic test, (ii) microscopy of the lungs and

(iii) circumstances (whole case investigation plus examination). Hydrostatic test is presently considered to be of limited value. It has been suggested that if the whole 'respiratory apparatus' floats, indication of breathing is invited and this may serve as a corroborative role of this test towards deter- mining 'live birth'. However, difficulty in interpretation of findings arising out of even minimal degree of decomposition restricts its practicality. Difficulty is further confounded by considerations that so many potential infanticides are found hidden, buried, or submerged, thus evading performance of test in a large proportion of cases. Further in the present sce- nario, the advent of resuscitation attempts (like mouth-to- mouth breathing, external cardiac massage, and administration of oxygen, etc.) has made the evaluation of breathing more difficult. Hence, doubts better be resolved in the direction of 'no breathing' so as to avoid false sense of scientific validity.

Microscopy of the lungs involves looking for the evi- dence of alveolar aeration or pulmonary interstitial emphysema. For this purpose, thoracic contents should be removed intact up to the larynx by 'no touch' technique of Osborn, thus eliminating the artefacts likely to be produced by careless manipulation. Sections need be prepared from the whole lung after due fixation (it is worth mentioning here that even ordi- nary handling of the dead body has been incriminated for the entry of air into foetal lungs and apparently respired alveoli have been found in lung sections from a dead infant taken from the uterus of a dead mother). An added problem may arise in cases where there has been minimum respiration or in those infants who have succumbed to 'struggle to breathe' wherein blood may be drawn into the lungs but the process may finally not be successful, thought it may slightly expand the lungs or give a few subpleural spots and cause oedema in the lung tissue (such changes may also be found in an intentional attempt to prevent an infant from breathing but here, other external corroborative evidence of injury/pressure on the face or neck will be self-explanatory). Therefore, microscopy of the lungs too has been considered to be of dubious value. Circumstances (whole case investigation plus examina- tion): Investigators must try to obtain as much information as possible and to consider the findings in entirety. Such a view is amply supplemented in the advice of Lester Adelson, "Unless the pathologist has incontrovertible criteria of post- natal survival, e.g. well-expanded lungs, food in the stomach or vital reaction in the stump of the umbilical cord, he is legally bound not to diagnose live birth. Convictions for infanticide have been set aside where there was any doubt whatsoever that the child was born alive. Many courts have pushed this propo- sition to the extent that the state has been given the burden of proving that the baby was born alive beyond any possible doubt rather than beyond any reasonable doubt, the latter being the general level of proof required in a criminal prosecution."

Secondary Issues

Probable duration of life of the child, i.e. if born alive, how long did the child survive after the birth?

This issue is connected with the second secondary issue that requires to be proved that the mother has recently delivered and that the period of delivery coincides with the probable dura- tion of the life of the infant or the degree of maturity of the infant. To determine the probable length of time the child has survived after its birth, the following changes may be helpful.

- Changes in the skin: The skin of the newborn infant is bright red and covered with vernix caseosa (a white cheesy substance made of sebaceous secretions and epithelial cells. Being sticky, it cannot be removed easily). The vernix caseosa is chiefly present in the flexures of the joints and neck folds. It is not easily removed and persists for a day or two. After birth, the skin becomes darker on the second or third day and finally assumes its normal colour within a week. Physiological jaundice is evident between the third and sixth day. Exfoliation of the skin occurs during the first 3 days after birth.

- Subgaleal haematoma, cephalohaematoma and caput succedaneum: A subgaleal haematoma is a space occupy- ing blood clot located between the periosteum of the skull and the galea aponeurotica. In most cases, it is located at the top of the head. It has been theorised that the negative forces imparted by traction applied on the top of the head can pull the aponeurosis from the cranium and injure the emissary veins connecting dural sinuses with the scalp veins. Cephalohaematoma is also a space occupying blood clot but situated beneath the periosteum of the skull and is caused by tearing of diploic veins due to mechanical trauma. They have been associated with higher parity, higher birth weight and instrumental delivery. Caput suc- cedaneum is another entity needing differentiation. It is an area of transient congestion and oedema in the scalp tissues located over the presenting region of the head in cephalic presentation. Caput succedaneum disappears from 24 hours to 2–4 days after birth; cephalohaematoma, if pres- ent, will show the usual colour changes common with the bruises and disappears in about a fortnight.

- Changes in the umbilical cord: Changes in the umbilical

cord begin to appear in the cut end to its base at the umbi- licus soon after birth. Even when the putrefaction has ren- dered the evaluation of breathing extremely difficult, vital signs in the cord may be helpful in indicating live birth if there has been sufficient survival period. The portion of the cord attached to the child shrinks and dries within 12–24 hours and an inflammatory ring or a reddening ring appears at its base and the adjacent skin from 36 to 48 hours. By the second or third day, it shrivels up, mummifies and falls off on fifth or sixth day, leaving a raw area that heals and cicatrises within 10–12 days.

- Circulatory changes: Nucleated red blood cells begin to be formed in the yolk sac and mesothelial layers of placenta at about the third week of foetal development. At about 6 weeks, the liver begins to form blood cells, and in the third month, the spleen and other lymphoid tissues begin form- ing blood cells. From third month onwards, the bone mar- row gradually becomes the chief source of the red blood cells as well as most white blood cells. Foetus contains foe- tal haemoglobin (haemoglobin F). Its structure is similar to that of adult haemoglobin except that the ʒ chains are replaced by □ chains. The □ chains contain similar number of amino acid residues but some differ from those in the ʒ chain of the adult haemoglobin. Foetal haemoglobin is normally replaced by adult haemoglobin shortly after birth. Oxygen content of foetal haemoglobin at a given PO2 is greater than that of adult haemoglobin because the former binds 2,3-DPG (diphosphoglycerate) less avidly.

This facilitates movement of oxygen from the maternal to the foetal circulation. Nucleated red blood cells usually dis- appear from the peripheral circulation within 24 hours or so.

At birth, following essential changes in circulation take place:

- The tremendous blood flow through the placenta is lost, which increases the aortic pressure as well as pressure in the left ventricle and left atrium.

- Pulmonary vascular resistance gets decreased considerably as a result of expansion of lungs. Due to expansion, the blood vessels are no longer compressed and the resistance to blood flow decreases. (In the unexpanded foetal lungs, blood vessels were compressed due to small volume of lungs.)

Depending upon the above changes, closure of the fora- men ovale (the aperture in the septum secundum of the foetal heart that provides a communication between the atria, also called ovale foramen of foetal heart or ovale foramen of foetus) may be explained thus: high left atrial pressure that occurs secondarily to the above described changes at birth results in attempting to cause the flow of blood backwards through the foramen ovale. Therefore, blood tends to flow from the left atrium to right atrium, rather than in the other direction prevalent during foetal life. Consequently, the valve that lies over the foramen ovale on the left side of atrial sep- tum closes over this opening. Further, closure of the ductus arteriosus (a foetal blood vessel connecting the left pulmo- nary artery directly to the descending aorta, also called arterial canal, duct of Botallo or pulmoaortic canal) occurs due to changes like (i) elevation of aortic pressure due to increased systemic resistance and (ii) reduction of pulmonary arterial pressure due to decreased pulmonary resistance. Consequently, after birth, blood begins to flow backwards from aorta into the pulmonary artery through the ductus arteriosus, rather than in the other direction as in foetal life. However, the muscular tissue of the ductus arteriosus starts constricting and within 1–8 days, the constriction becomes sufficient to stop the blood flow. During the next few months, the lumen of ductus arte- riosus ordinarily becomes occluded by the growth of fibrous tissue. Closure of ductus venosus (major blood channel that develops through the embryonic liver from the umbilical vein to the inferior vena cava, also called canal or duct of Arantius, canal of Cuvier or ductus Arantic) occurs because of the fact that immediately after birth, blood flow through the umbilical vein ceases, but most of the portal blood still flows through the ductus venosus. However, within a few hours, the muscular tissue of the wall of ductus venosus starts constricting and ultimately closes. Consequently, portal venus pressure rises enough to force portal venous blood flow through the liver sinuses

- Respiratory changes: The most obvious effect of birth on the baby is the loss of placental connection with the mother and the most important immediate adjustment is the Superior vena cava (It brings deoxygenated blood from the head region of the foetus into the right atrium from where it is directed downwards through the establishment of breathing. The child begins to breathe within seconds after birth. The process of breathing probably results from sensory impulses originating in the suddenly cooled skin and some asphyxiated state incidental to the birth process. This explains the delayed onset of respiration for several minutes if the mother had been instituted gen- eral anaesthesia during delivery. This can also occur in pro- longed delivery of head trauma during delivery.

At birth, the walls of the alveoli are collapsed because of the surface tension of the viscid fluid contained in them. To over- come the effects of this surface tension and to open the alveoli, powerful inspiratory efforts are required. As reported, the initial inspirations of the normal neonate are powerful enough for creating as much as 50–60 mmHg negative pressure in the intrapleural space. Once the alveoli get opened, further respiration can be effected with relatively weak respiratory movements. The surfactant secreting cells (type II alveolar epithelial cells) do not begin to secrete surfactant until the last 1–3 months of gestation. Hence, many premature babies may be born without the capability to secrete sufficient surfactant leading to collapsed tendency of alveoli. (Surfactant is a substance normally secreted into the alveoli that decreases the surface tension of the alveolar fluid, thus allowing the alveoli to open easily during respiration).

Another secondary issue involves the establishment of connection between the identities of the child and the mother.

Newborn infants found dead may not necessarily be the victims of infanticide. The stillborn or dying naturally may be hidden or abandoned, for which the crime is 'concealment of birth'. A verdict of concealment of birth is an alternative to that of infanticide and in view of the problems for proving the main charge of infanticide, the person may be convicted of concealment of birth. Although the mother is the person usu- ally convicted of concealment of birth, yet all who are con- cerned with the process of concealment stand as principals.

Identity of the child may be traced from blood grouping, which may help in eliminating or helping to confirm the con- sanguinity of any putative mother. DNA profiling is the latest achievement that helps in the establishment of identification.

AUTOPSY TO ESTABLISH CAUSE OF DEATH

As already emphasised, the circumstances leading to the death of an infant must be some act(s) of commission or omission and, consequently, the violence inflicted upon the child has to be differentiated from the injuries incidental to the birth, i.e. the accidental injuries connected to the birth trauma. The pro- cedure for autopsy is almost same as in adults except certain deviation and need for specific attention to certain matters as detailed below:

- Clothing and wrappings: The coverings or wrappings and other articles associated with the infant need to be examined and retained. It may be torn clothing of the mother or newspaper or plastic bag or rags, etc. Any foreign material available should also be collected. All this would help in identification.

- Measurements: Estimation of weight, crown heel and crown rump lengths, head circumference, etc. is essential to know about the degree of maturity. For details, see the description at the end of this chapter.

- Changes of decomposition: It is vital to assess the changes of decomposition as these will help to ascertain the time since death and also make the doctor aware of the pre- cautions to be observed while performing hydrostatic and other tests. Bodies of the newborn infants are normally ster- ile. When they breathe and swallow, micro-organisms gain entrance. Therefore, there may be differences in onset and degree of putrefaction in the stillborn and liveborn infants.

Decomposition must be differentiated from intrauterine mac- eration, because the latter is a sure sign of deadborn foetus.

- Presence/absence of vernix caseosa, any injuries upon

the body, particularly around the mouth, nose and upon the neck should be carefully examined. Presence of vernix caseosa is not as useful a sign as its absence, as the latter indicates that the child had been washed suggesting that it survived for sometime after birth. Foreign material/objects may be found in the mouth, nose or respiratory tract. Other orifices should also be examined at this stage. Presence or absence of caput succedaneum requires to be noted.

- Umbilical cord and placenta: If the cord and placenta are present, they constitute very important evidence and help in solving many issues. Placenta should be weighed to evaluate maturity, and any abnormality should also be observed. The changes in the cord are an important indicator of separate existence. The severed end of the cord deserves special attention as it may help in concluding whether the cord has been actually cut or broken because in the latter case, the defence of the mother that the death of the child occurred due to falling upon the ground in the course of precipitate labour may succeed. In such cases, length of the cord (if placental segment is available) should be measured so that the compatibility with the defence offered by the accused mother could be assessed. Morris and Hunt conducted experiments on the cords and determined that they could easily be broken with the traction of the hands. They described the appearance of ends of the cord by different modes of severance. The cut ends with a sharp instrument like scissors or knife will appear clean-cut but occasionally may appear ragged if the instrument is relatively blunt.

- Any evidence for malformations or birth injuries should be meticulously searched for, which may reveal obvious incom- patibility with the continuation of life.

Internal Examination

The examination must follow a certain routine and should be complete.

Head

The scalp is opened by the usual incision from ear to ear and the flaps reflected. The skull is opened by cutting with scissors anteroposteriorly and across, and reflected as four flaps. Observation is made regarding injuries to fontanelles (espe- cially punctured wounds through anterior fontanelle), tears of meninges, tentorial tears (common in forceps delivery), haem- orrhages, contusions and lacerations of brain.

Neck

This is examined for internal injuries, and trachea for foreign body, froth, mucus, amniotic fluid, etc. The region of the nape of neck deserves special attention.

Thorax

The shape of the chest is observed. Before opening the thorax, the abdomen is opened and the position of the diaphragm noted by passing a finger up to its concave arch.

The lungs are examined for their volume, colour, consis- tency, weight and the presence of petechial haemorrhages. Hydrostatic test may be performed after taking due precau- tions as stressed at various points.

The chambers of the heart are opened to see the difference in colour of blood and whether it is normal. Observation is also made regarding the patency of foramen ovale and ductus arteriosus.

Abdomen

Stomach is removed by ligating both ends and tested for floata- tion. The contents are examined for presence of milk, poison, blood, amniotic fluid, mucus, etc.

The intestines are examined for presence of air and for presence of meconium and its location, which will help to fix the intra-uterine age of the foetus.

Other Viscera

These are examined for their development, any malformations, asphyxial signs and injuries.

Genitals

These are examined for any malformations. The position of the testes—whether descended or where located is noted.

Limbs and Sternum

These should be examined for presence of ossific centres to fix the age of the foetus. Centre of ossification for the calcaneum appears by the fifth month, first division of sternum by the sixth month, talus by the seventh month and lower end of femur by the ninth month. At birth, a centre of ossification is usually present in the cuboid and upper end of tibia.

Centres of ossification may be demonstrated as follows: For the ossific centres in the various divisions of the sternum, the bone is placed on a wooden board and sectioned in its long axis with a cartilage knife, which exposes centres of ossification in the various divisions of sternum. For the ossific centre in the lower end of the femur and the upper end of tibia, the leg is flexed against the thigh and a horizontal incision made across and into the knee joint. A number of cross-sections are made through the epiphysis starting from the articular sur- face and continuing until the largest cross-section of the ossi- fication centre is reached. In the lower end of the femur, this is seen as brownish-red nucleus that is surrounded by a bluish- white cartilage. The centre appears about the 36th week. A centre of ossification in the upper end of tibia is found in some cases, but in others, it appears after birth. To expose the ossific centres in the bones of the foot, the heel of the foot is placed on a sponge and firmly held by one hand, and with the other hand an incision is made through the inter space between the third and fourth toes and carried downwards through the sole of the foot and heel. Centres in calcaneum and talus, which usually appear towards the end of the fifth and seventh month respectively of intrauterine life, are exposed.

Cause of Death

Once again, to repeat, the concern here is to determine whether the death was due to violence; if due to violence, the injuries incidental to birth trauma or other accidental injuries occurring during or after birth must be excluded.

ACTS OF COMMISSION

Dejected mothers may resort to a variety of ways but some modes of infanticide are more common; depending upon the frequency, the modes may include the following:

Smothering

It is a simple and convenient mode and extremely difficult to prove as it may not leave any evidence, particularly when exer- cised by pressing the face into a pillow or by closing the nose and mouth by a soft cloth. But the application of more force than usually necessary is likely to leave some pressure marks on

the lips and face, especially the bruising of the inner surface of the lips. Sometimes, an area of pallor in an otherwise suffused face may be delineated. Petechial haemorrhages are rarely seen. At occasions, even mucus and squamous respiratory epithe- lium from the victim may be found in the smothering material.

Strangulation

If strangulation has been effected by a ligature, the ligature material may be found upon the neck but its antemortem nature, i.e. it was applied before death, must be ascertained. Sometimes an explanation that the infant was strangled acci- dentally by the umbilical cord may be forthcoming from the mother. Examination of the cord may reveal evidence of rough handling in the form of displacement of Wharton's jelly; moreover, there may be some evidence of injuries upon the neck of the infant.

Manual strangulation will present only relatively insignifi- cant bruising or scratches upon the skin surface, though on dissection they may be more prominent. Traditional features like cyanosis, oedema and petechial haemorrhages may be present.

Head Injuries

Head injuries are relatively common. The mother may throw the child to the ground or dash its head against a wall or press under the leg of a charpai or sometimes may swing the child by holding legs. Depressed or comminuted fractures of the skull bones with cerebral contusions and/or lacerations, with or without lacerations of the scalp, may be noticed in such cases. The usual defence may be that the child fell on the ground or the fracture occurred as a result of precipitate labour while the mother was standing erect. Here comes the usefulness of measuring the length of the umbilical cord. The usual length being 50 cm is likely to check a violent fall and further, the labour does not usually result in a forcible and rapid expulsion of the foetus. Cords can get broken during the precipitate birth and that is why it has repeatedly been stressed to examine the severed ends of the cord carefully. Even if the infant happened to fall on the ground, the force is usually insufficient to result in a fracture; none appeared in 183 pre-

cipitate labours in the Klein's series.

Precipitate labour is likely to occur in multiparous women with an old laceration of perineum or the woman may show recent rupture of perineum but it may be ruptured in the pri- mipara even if the delivery was normal. Moreover, in a case of precipitate labour, the foetal head will not show caput succeda- neum or moulding and the fracture, if it occurs, will usually be fissured and limited to the parietal bones and may radiate to the frontal and squamous portions of the temporal bone.

Fractures of the skull that occur during and as a result of the process of labour usually exhibit certain characteristics, namely, they are not associated with the lacerations of the scalp, usually involve the parietal bones and run downwards at right angles to the sagittal suture and are fissured fractures.

Fractures produced by the forceps may be associated with the lacerations of the scalp but lie at points normally gripped by the instrument and are usually 'gutter' or 'pond' fractures.

Multiple Injuries

Stabbings and cuttings are not common. Stab wounds may be inflicted by using an easily accessible weapon like a pair of scis- sors, domestic knife, etc. Rarely, weapons like needles and pins may be employed, and careful search for the puncture wound must be carried out before proceeding for the dissection, as the wounds may be concealed puncture wounds inflicted through the fontanelles, inner canthus of the eyes, through nostrils and nape of the neck and therefore might escape notice. The posi- tion and nature of wound will obviously be inconsistent with an accidental injury. Incised wounds are again rare, but cases have occurred when instruments such as razor blades have been used. A distinctive feature of such wounds may be that these are well-arranged and parallel because the child can easily be immobilised. These suggest the intention to kill. In such cases, the kind of instrument and nature and extent of injury are important. An extensive incised wound of the throat is highly unlikely to be of accidental origin. Infanticide by decap- itation was described by Amoroso (1935). Cutting of the umbilical cord so as to cause exsanguination of the infant could be another mode of infanticide.

Drowning

Infanticide by drowning is unusual. Submersion, however, may be the mode of disposal of the stillborn infants. Most often, it is the household receptacle such as a bowl, bucket or bath but the infant may be taken out and disposed of in any open source of water where the likelihood of delay in the recovery of the infant will add putrefactive changes leading to the difficulties as described at each step. The mother may put the infant into a closet and allege that she gave birth while using it. In such cases, the possibility of precipitate labour (usually seen in mul- tipara with roomy pelvis) and the demonstration of fluid in the respiratory passages and in the digestive tract, resembling the contents of the closet, may be evoked. The usual practice is to kill the infant by suffocation or strangulation and then to throw the body into a cesspool, well, tank or river with a view of con- cealing the crime. A living body may be similarly thrown, in which case the signs of drowning will be evident.

Poisoning

Presently, it is not a common mode of infanticide. In the olden times, tincture of opium, arsenic, antimony, acids and yellow phosphorus obtained from the matches have been used. Occasionally, coal gas may be used by the mother to include her child in the suicidal pact, as reported in Western countries. Poisoning is a premeditated crime to which the defence of accident or mental imbalance may not stand boldly.

Live Burial

It is extremely rare, though instances have been reported. The case of Berardinelli (1935) is an example. The author cited instances of live burial of infants. In her opinion, the common modes of infanticide in order of frequency were smothering, violence (especially to the head), strangulation, drowning and exposure. Live burial was common in the continent than elsewhere.

ACTS OF OMISSION

The law presumes that a woman who is about to be confined should take ordinary precautions to save her child after it is born. She is guilty of criminal negligence if she fails to do so. Deaths from omission are often rare and almost outside the purview of the doctor. Proof of lack of care immediately after birth will be a matter of witnesses and clinical observations. The circumstances may include the following:

- Omission to make the necessary preparation for the birth of the child (e.g., arrangement for medical aid).
- Omission to tie the cord after dividing it.
- Omission to remove the child from the mother's discharge.
- Omission to protect the child from exposure to cold or heat.

- Omission to supply proper food (deliberate starvation).

A woman must make necessary arrangement for the birth of her child. As soon as she gets labour pains, she must arrange for medical aid. Evidence to the effect that no provi- sion of any kind had been made suggests that she had the intention of doing away with the child.

ABANDONING OF CHILD

Section 317 prohibits the exposure and abandonment of a child less than 12 years of age by the parents or person entrusted with the care of the child. The 'exposure' contem- plated under the Section must be one by which some danger to the life of the child may ensue, and the child must have been exposed or left in any place with the intention of wholly aban- doning it. The explanation attached to the Section makes it clear that the child must be alive when he/she is exposed or left at any place. If the child dies in consequence, the offender may be tried for culpable homicide or murder as the circumstances may warrant.

Section 318 deals with the concealment of corpus delicti. One way of preventing the detection of the crime of infanticide, and probably the most effective, is the conceal- ment of corpus delicti (i.e. here, concealing the body of the child). This Section punishes secret disposal of the dead body of a child with the intention of concealing the birth of such child. Question may arise that what constitutes a child? Ordinarily, the term has been applied to an infant who has attained certain degree of maturity/development, so that it ceases to be a foetus and becomes capable of independent existence in the event of its birth. The question is of the facts and may be left for the jury in each case. However, expert opinion is of significance. Here, the words spoken as early as 1869 need mention, "No specific limit can be assigned to the period when the chance of life begins, but it may perhaps be safely assumed that before 7 months the great probability is that the child would not be born alive".

Development of Foetus

The term developing ovum is used for the first 7–10 days after the conception until the implantation occurs. From 1 week to the end of the second month, it is called embryo and later foetus. Infant is the term applied to the foetus when it is completely born. Neonate is the term applied to the infant in the first 28 days of extra-uterine life. Intra-uterine developmental mile- stones are as follows ..

- At the end of the first month: The length is about 1 cm. It weighs about 2.5 gm. The eyes are seen as two dark spots and the mouth as a cleft.

- At the end of the second month: The foetus is about 4 cm in length and 10 gm in weight. Eyes and nose are recognisable. The hands and feet are webbed. The anus is seen as a dark spot.

- At the end of the third month: The length is about 9 cm, and the weight about 30 gm. Nails begin to appear in the form of thin membranes on the fingers and toes. The sex is not yet distinguishable. Placenta is formed and differenti- ated. The eyes are closed and pupillary membranes appear.

- At the end of the fourth month: The length is about 16 cm, and the weight is about 120 gm. Sex is easily recog- nised. Lanugo is visible on the body. The pupillary mem- brane is visible. Meconium is seen in the upper part of small intestines (mixture of bile, mucus, and shedded off mucosa).

- At the end of the fifth month: The length is about 25 cm, and the weight is about 400 gm. Vernix caseosa appears on the body. It is supposed to protect the foetal skin from amniotic fluid. Fine hair on the scalp are visible. Lanugo is quite distinct. Meconium is seen at the beginning of the large intestine. Centre for the calcaneum usually present.

- At the end of the seventh month: The length is about 35 cm, and the weight is about 1 kg. Subcutaneous fat begins to be deposited. The nails are thick but do not extend to the tips of fingers and toes. The eyelids are open. The pupillary membrane has almost disappeared. The tes- ticles may be found in the external inguinal ring. Meconium is seen in the whole of large intestine. Centre of ossifica- tion for talus has appeared.

- At the end of the eighth month: The length is about 40 cm, and the weight is about 1.5 kg. Scalp hair is thicker. The skin is red, but not wrinkled, and covered with soft hair. Lanugo has disappeared from the face. The nails reach near to the end of the fingers and toes. The left testicle has descended to the scrotum.

- At the end of the ninth month (or just before birth): The length is about 45 cm, and the weight is about 2–2.5 kg. Scalp is covered with dark hair. Lanugo is seen only on the shoulders. Vernix caseosa is present over the flexures of joints and neck folds. Nails have grown over the tips of the fingers and toes. Both the testicles have descended to the scrotum. Meconium is seen at the end of the large intestine. Ossific centre appears at the lower end of femur.

- At the end of the tenth month (appearance of a full- term mature infant): The length is about 45–50 cm. The weight is about 3–3.5 kg. The head is about 28 cm in cir- cumference and well-covered with hair. The lanugo is seen only on the shoulders. The skin is covered with vernix caseosa, which is readily seen in the flexures of the joints and neck folds. Vernix caseosa is a white cheesy substance, made up of sebaceous secretion and epithelial cells. Being sticky, it cannot be easily removed. It protects the foetal skin against maceration while in liquor amnii. The pupillary membrane is absent. The nails project beyond the finger tips and to the end of the toes. The umbilicus is situated midway between the pubis and the ensiform cartilage. The umbilical cord is fleshy, with a normal spiral twist and a glistening surface about 45–50 cm in length. Both the tes- ticles have descended into the scrotum. Meconium is pres- ent in the large intestine. It is generally expelled in a day or two after delivery. The lower end of the femur shows a centre of ossification. A centre of ossification may be pres- ent in the cuboid and the upper end of tibia. Placenta is about 22 cm in diameter and about 700 gm in weight.

FOETICIDE

In view of the declining sex ratio because of female foeticide, it was considered necessary to bring out a legislation to regulate the use of and to provide deterrent punishment to stop the misuse of diagnostic techniques. Ultimately, the Prenatal Diagnostic Techniques (Regulation and Prevention of Misuse) Act was passed by both Houses of the Parliament and received the assent of the President on 20th September, 1994. Later, by amendment during 2002, the nomenclature of the Act was amended and now it stands as The Preconception and Prenatal Diagnostic Techniques (Prohibition of Sex Selection) Act, 1994. (This necessity emerged out of the fact that in the present set-up, sperms can be processed in the labo- ratory to effect separation of X and Y chromosomes, thus ensuring the birth of a male child, i.e. sex selection takes place even before conception. Hence, the amendment in the nomen- clature of the Act was carried out.)

menstrual extraction, implantation of embryos, artificial insem- ination and even artificial wombs has made the issues much more complicated. There has been a tendency in the past that in cases where the abortion was caused by the action of another person, to compensate the mother or the family in limited way,

i.e. they were used to be compensated for their mental and physical anguish and any impairment of health of the mother occasioned by the miscarriage but not for the productivity of the aborted foetus as if it were a potential wage earner. However, on 5th March 2007 Maharashtra State Commission in the case of Kanta Mohan Lal Kotecha vs. United India Insurance Company ruled that the claim in respect of the unborn child was maintainable provided certain requirements

Law's Difficulty in Dealing with Foetus

The law has difficulty in dealing with the foetus. This is because of the controversy of focussing the evidence upon 'concep- tion' or upon 'live birth' or upon the interim point at which the foetus becomes 'viable'. Furthermore, literature purports to indicate that conception is a 'process' overtime, rather than an event, and introduction of new medical techniques like were satisfied. The forum laid stress upon the concept of 'via- bility', i.e. whether the foetus had reached the stage of 'viabil- ity' at the time of the accident and thereby attained the status of a 'potential person' who could be able to live outside the mother's womb albeit with artificial aid. Penalties as provided under the Act are .

so as to apprise the readers of gravity of situation in the event of violation of the Act.

CHAPTER-9

THERMAL DEATHS

Thermal deaths are those that result from the systemic and/ or localised exposure to excessive heat or cold. The main fac- tors determining the deleterious effects of heat are the tem- perature (i.e., the intensity of heat applied) and the duration for which it is applied. This is amply clear from the observations of Moritz and Henriques, who found that the lowest tempera- ture that would produce damage was 44° C, though the time required to produce burn was of the order of about 5 hours, whereas if the object was at 60° C, it required only 3 seconds to cause burn.

SYSTEMIC HYPERTHERMIA

Human body is far more susceptible to elevation than to dimi- nution of temperature. Neurons in both the pre-optic anterior hypothalamus and posterior hypothalamus receive two types of signals—one from peripheral nerves that reflect warmth/cold receptors and the other from the temperature of the blood bathing the region. These two types of signals are integrated by the thermoregulatory centre of the hypothalamus to maintain normal temperature. The normal body temperature is main- tained despite environmental variations because the thermo- regulatory centre balances the excess heat production derived from metabolic activities in the muscle and liver with the heat dissipation from the skin and lungs, etc. [Endogenous/febrile hyperthermia implies an elevation of body temperature that exceeds normal daily variation and occurs in conjunction with an increase in the hypothalamic 'set point'. (This set point has been considered as 37.1° C. When the temperature goes above or below this point, drastic changes occur in the rates of heat loss or production so that the body temperature re-approaches 37.1°

C.) Exogenous/Nonfebrile hyperthermia, on the other hand, implies an unchanged setting of the thermoregulatory centre in conjunction with an uncontrolled increase in the body temperature that exceeds the body's ability to lose heat. For example, work or exercise in hot humid atmosphere can produce heat faster than peripheral mechanisms can lose it. Hyperthermia is often diagnosed on the basis of the events immediately preceding the elevation of body temperature.]

Depending upon the progressive order of severity, effects of excessive heat may be divided into heat cramps, heat exhaustion and heat stroke. Ultimately all result from the loss of equilibrium between heat load (metabolic and climatic) and the capacity of the body to eliminate/dissipate heat.

BURNS

The term 'burn' denotes a variety of conditions of which the local effects of dry heat are the classical examples. There are differences in the circumstances and the resulting destruction of tissues and therefore some separate account for several kinds of burns is being furnished before we march on to the 'classical burns' because the conclusion as to the agent producing the burns may be of importance as derived from Sections 324 and 326 of the Indian Penal Code wherein it is laid that causing of 'hurt' or 'grievous hurt' by some specified means is punishable more severely than when such means have not been employed. Among the means are also included means like 'fire or any heated substance' or any 'corrosive substance' or 'explosive substance', etc. under these Sections.

BURNS BY X-RAYS AND ULTRAVIOLET RAYS

Burns resulting from X-rays are usually from fault exposure and vary from mere redness of the skin to dermatitis with shedding of the hair and epidermis and pigmentation of the surrounding skin. Severe exposure may produce vesicles and/ or pustules, which often form sloughing ulcers on bursting and usually take a long time to heal. Ulcers on healing form radiate scars, and the surrounding skin shows pigmentation. However, these are rare these days because of improvements in the equipment, use of protective screens and the precautions taken by the operator. Occasionally, late reaction may be after months or even years can occur that presents like a bruise, followed by extensive deep sloughing of the tissues and delayed healing. Burns by radium are similar to those produced by X-rays. Improper use of ultraviolet lamps can cause ill effects. A short exposure of parts normally covered by clothing may be suffi- cient to produce hyperaemia and irritation, which may subside within a few hours. Overdosage with ultraviolet light can some- times lead to severe and persistent dermatitis. Same thing holds good with the exposure to infrared rays. Similarly, the sunrays can also cause dermatitis, particularly in sensitive and fair com- plexioned individuals.

BURNS BY ELECTRICITY AND LIGHTNING

Electric burns may be caused either due to contact with an electric circuit (i.e., the electric mark) or burns produced by a flash, which usually accompanies a short circuit (i.e., thermal burns or flash burns). The latter are essentially the same as burns produced by a flame, and their gravity is evaluated in terms of first, second or third degree. In case of the former,

i.e. the 'electric mark', the lesion appears as a round or oval shallow crater, bordered by ridge of skin having raised margins. The skin looks distinctly pale as it is produced by conversion of electricity into heat within the tissues. That is why they are sometimes termed as 'endogenous burns' to distinguish them from the flash burns or 'exogenous burns'. Burns from light- ning may appear in the form of 'arborescent markings' on the surface of the skin, looking like branches of a tree.

BURNS BY CORROSIVES

Burns produced by corrosive acids and alkalies are usually simi- lar in character. 'Corrosion' means to destroy something by chemical action. The lesions often show distinctive stains and result in eschars, which are soft, moist and readily slough away. In these burns, the red line of demarcation is absent, hair are not scorched nor are any vesicles formed. In these chemical burns, the characteristic appearance along with stains, stains on clothing and chemical analysis of the tissue and clothing will establish the diagnosis. These burns usually may not cause death yet they may cause permanent dis.uration of head and/or face leading to grievous hurt. Involvement of eyes may further add to the problem.

BURNS BY DRY HEAT

They are usually the result of contact with a naked flame or the heated elements of an electric wire or contact with hot metals or glass. These substances outwardly may appear to be harm- less but may be at dangerous temperatures, which the victim realises only after the mishap. The worst burns in the domestic circumstances are those that usually occur following the igni- tion of clothing that have come in contact with the coal, gas or an oil stove. The lower part of the clothing may catch fire and within a few seconds the entire garment is usually affected. The burns will usually commence on the side of the leg immedi- ately opposite to the part of the garment that first caught fire. Wilson's classification is widely acclaimed and therefore some details are given below

EPIDERMAL

Erythema (reddening) and blistering without involvement of dermis are the characteristics of the epidermal burns. There is capillary dilatation and transudation of fluid into the tissues resulting in swelling. The blister thus formed contains albumin- ous fluid and is covered by avascular whitened epidermis and surrounded by a zone of hyperaemia. If small, the blister may resorb due to absorption of the fluid and the raised dead epidermis is later on shedded to be replaced by the new growth from the periphery of the burn area. Such blisters are painful and heal without scar formation.

DERMO-EPIDERMAL

Here, the burns involve full thickness of skin, including hair fol- licles and sweat and sebaceous glands. Hence, they are extremely painful as they expose and affect the sensory nerve endings. They heal with scar formation as they damage the full thickness of skin.

DEEP

These involve destruction of the deeper tissues below the skin. Therefore, these can be of any severity, varying from damage to the subcutaneous tissues to the involvement of muscle, bone, etc. The burnt parts may even be completely charred. These burns are relatively painless as the nerve endings are completely destroyed.

RULE OF NINES

The body surface involved is traditionally determined by the surgical 'Rule of Nines', though for the purposes of autopsy reports a detailed description of the burnt areas is essential (. 8.3). According to this rule, the percentage of area attributed to the different parts of the body surface is as described in . 8.3.

'Rule of Nines' was advocated by Wallace (1951). However, explanation furnished by Lund and Browder (1944) needs to be used for more accurate estimate, particularly in children, whose proportions are quite different from those of adults (.. 8.1 and . 8.4).

The prognosis of the burn injuries depends more upon the extent of body surface involved than upon the degree/depth of burns. A third degree burn of a limb, though may result in a great disability but may not prove fatal, whereas a first degree burn involving 40–50% of body surface is nearly always incom- patible with survival. However, infants, very young children and old people appear to be more vulnerable to lethal complications. Older children and adults can withstand burn injury better. Women are more susceptible than men. A useful rule of thumb for estimating total surface area involved by a scattered burn injury is the 'palm of the hand rule', viz., 'the surface area of the patient's palm is roughly 1% of the total body surface area.'

CAUSES OF DEATH IN BURNS

IMMEDIATE CAUSES OF DEATH

SHOCK

Death may occur within a few hours due to primary or neurogenic shock or it may occur within 24–48 hours due to secondary or hypovolemic shock, which is principally due to loss of fluid from the burned surfaces due to increased capillary permeability. Shock can also occur merely from fright or extreme fear before the indi- vidual is affected by burns if the heart is debilitated or weak.

SUFFOCATION

Victims removed from houses destroyed by fire or from any other building destroyed by fire are often found dead from suf- focation due to inhalation of smoke, carbon monoxide or any other irrespirable gases. Toxic inhalation of combustion products of synthetic materials may accentuate the toxic effects of the car- bon monoxide. Burning of plastic materials may produce toxic and potentially lethal gases like hydrogen cyanide and oxides of nitrogen. Burning of wool or silk may yield ammonia, hydrogen cyanide, hydrogen sulphide and oxides of sulphur. Death may also occur due to mechanical asphyxiation, i.e. traumatic asphyxia in case of a collapse of a house or building resulting from out- break of fire.

ACCIDENT/ INJURIES

Death may result from an accident occurring in an attempt to escape from a burning building or by injuries sustained from the falling of walls or other structures upon the body.

DELAYED CAUSES OF DEATH

TOXAEMIA

It occurs from absorption of toxic products from the burned areas. Death usually occurs in such cases after 4 or 5 days or sometimes even later. Death occurring on 3rd or 4th day is usually due to irreversible hypotension and renal failure due to acute tubular necrosis.

INFLAMMATORY COMPLICATIONS

Inflammatory complications of serous membranes and internal

Lastly, they may also fall under the category of last clause of grievous hurt, i.e. if the individual has suffered 'shock' so as to endanger life or if he/she has been in severe bodily pain or bedridden and thereby incapacitated to follow ordinary pur- suits of life for a period of 20 days. The kind of weapon in such cases will obviously be 'dry heat'.organs such as meningitis, bronchopneumonia, pleurisy, perito-nitis, pericarditis and so on can be responsible for delayed deaths. A less common complication is the duodenal ulcer, also known as Curling ulcer. They may occur in association with head injuries too. Gastric ulcers occurring due to burns have been named as Dupuytren ulcers. Gastric ulcers may occur within a day or two of burning, but duodenal ulcers appear late. Various factors attributed to their production may be local ischaemia, infection and effects of stress on adrenocortical function.

FATAL PERIOD

Most of the deaths from burn injuries occur from shock within about 24–48 hours. Death due to toxaemia occurs usually within 4–5 days. The first week happens to be the most critical period. In suppurative cases, death may ensue after a few weeks.

NATURE OF BURN INJURIES IN THE ABSENCE OF DEATH

AGE OF THE BURN INJURY

Sometimes the question may arise as to the time of infliction of burn injuries and further, in case of several burns on the same individual, the issue may be that whether they were inflicted simultaneously or at different times. Different stages of the repairative process may provide the answer.

Erythema (redness) appears immediately after the burn. Vesication usually develops within about 2–3 hours. The exudate begins to dry in 12–24 hours, and within 48–72 hours, it forms a dry brown crust. The red inflammatory zone disap- pears in 36–72 hours. If infection happens to occur, pus is formed in 2–3 days but not before 36 hours. Superficial sloughs usually separate out from the 4th to 6th day and deeper sloughs within about 2 weeks. After this period, granulation tissue begins to cover the area and a scar is formed after several weeks or even months depending upon the amount of suppuration, sloughing and depth and extent of the burn.

In a case where death has not occurred, burns may constitute simple or grievous hurt as the case may be. Burns of the first degree, if not extensive, constitute simple injury. Burns consti- tute grievous hurt if they result in permanent dis.uration of head or face or permanentprivation of sight of either eye or permanent impairment of powers of any member or joint, etc.

AUTOPSY FINDINGS

The remnants of clothing, particularly the portions that were in rigid contact with the body and those that got pressed against the body surface during the process of burning should be looked for and removed carefully. They should be examined for presence of any characteristic smell like that of kerosene, petrol or some other combustible substance. It is possible to recover and identify hydrocarbons from clothing, even when they are severely burned. Clothing should, therefore, be pre- served and transmitted to a Forensic Science Laboratory/ chemical examiner through the police, after sealing them in glass containers and not in plastic bags.

EXTERNAL FINDINGS

Before opening the body, a careful record, supplemented by photographs (if possible), should be made of the distribution of burns. If the body is severely burnt, then all the surface of the skin might have been damaged, making it impossible to determine the antemortem or postmortem nature of the burns from the external examination as no skin surface is available to observe for the presence or absence of vital reaction. However, if some undamaged skin is present at places adjacent to the damaged areas, the appearance of vital reaction in the form of reddened borders adjoining the burnt areas is an important finding towards antemortem nature of burns. Burns inflicted after death present a distinctive appearance, usually showing no red margins and dried scorching of the skin surface. The scalp hair and other body hair may be singed. There may be blacken- ing of the extensive body surface. In lesser degree burns, ends of the hair may be 'clubbed'. Here the keratin melts at the distal end nearing the heat and resolidifies on cooling forming a ter- minal knob on the shaft and thus imparting 'clubbed' appear- ance. The burns caused by kerosene oil are usually very severe and are identified from its characteristic odour and the sooty blackening of the parts. Blood-tinged froth may be seen at the mouth and nostrils owing to pulmonary oedema provoked by heat irritation of the respiratory passages and the lungs. The tongue usually protrudes and may be scorched.

When the body has been exposed to substantial heat, it will almost always assume the appearance known as 'pugilistic or boxer's attitude'. This occurs due to coagulation of the mus- cle proteins resulting in contraction of the muscle fibres. As the flexors are bulkier than the extensors, they contract more and force the body to assume such an attitude. However, this atti- tude does not speak anything about the fact that whether the victim was alive when the fire started or not

Another finding of importance and needing careful evaluation is the appearance of heat ruptures, usually seen over the area of severe burning and over fleshy areas like calves and thighs, etc. These are the splits occurring in the skin due to contraction of the heated and coagulated tissue and the resultant breaches may simulate incised or lacerated wounds. They can be differentiated from the antemortem lacerations by their appearance, distribution as written above and by associ- ated findings like bleeding into the deeper tissues. In such heat ruptures, absence of blood clot or absence of infiltration of blood into the cellular spaces and the presence of intact blood vessels and nerves stretching across the floor of the ruptures will be sufficient to indicate their spurious nature. Sometimes, the charred and brittle skin due to effect of heat may undergo cracks while the body is being removed from the house or building destroyed by fire or during transportation of the body to the mortuary or within the mortuary, if handled carelessly.

INTERNAL FINDINGS

On opening the body, the depth of heat coagulation of the tissues should be observed. It is generally considered that a badly charred body with no heat changes beyond the subcutaneous tissues indicates a short exposure to intense heat, whereas heat coagulation of deeper muscle proteins without severe external charring suggests that the body was exposed to moderate heat over a long period. However, there is no reliable method to evaluate the duration of burning as it depends upon multi- tude of factors and the opinion must be given with due reservations.

Internal organs are usually congested but may be coagu- lated, firm and pallid and occasionally the body cavities might have given way by partial destruction of their walls. The blood is usually bright pink in colour if death has occurred due to inhalation of carbon monoxide .discussion under Antemortem and Postmortem Nature of Burns). The mucosa of stomach and duodenum is frequently reddened and may show ulcers as described earlier.

Internally, the finding of 'heat haematoma', if revealed, deserves special evaluation. This condition has an appearance of extradural haemorrhage but actually is an artefact, occur- ring only in the circumstances where the head has been exposed to intense heat and, obviously, will be maximum in amount opposite to the site of greatest external damage to the skull. Therefore, the usual sites of this haematoma will be frontal or occipital regions. Other characters of such a haema- toma may include chocolate brown colour of the blood, the clot is soft, friable and presents a honeycomb appearance due to presence of bubbles of steam produced due to boiling of blood by external heat. The mechanism of its production is obscure. Possible sources may be that either it arises from venous sinuses or the blood may be squeezed out of the diploic space through emissary venous channels. It is a post- mortem phenomenon or may be produced agonally when the victim is already unconscious either due to inhalation of car- bon monoxide or shock due to severe burns .discussion under Antemortem and Postmortem Nature of Burns).

Most important findings are to be observed in the respiratory passage and blood, which will be extremely clinching towards the fact that whether the victim was alive when the fire commenced. The tongue, fauces, larynx, trachea and bronchi are usually inflamed and contain soot often inti- mately mixed with mucus. If the deceased had inhaled very hot gases or fumes or rarely the flame itself, then the mucosa over the tongue and larynx may be oedematous and exhibit blister- ing or shredding. Sometimes, some vomitus (presumably due to bouts of coughing) may also be present in the respiratory passages. Carbon impregnated mucus may be swallowed and found in the oesophagus and/or in the stomach.

Together with the soot, the inhaled smoke usually contains some carbon monoxide, which is therefore absorbed by the blood. The presence of carbon monoxide in the blood is often obvious from the bright pink appearance of the blood, the muscles and even the cut surfaces of the organs .dis- cussion under Antemortem and Postmortem Nature of Burns.)

MEDICOLEGAL CONSIDERATIONS

The death investigation of a person exposed to excessive heat may warrant the following medicolegal considerations.

IDENTITY OF THE DECEASED

Identification of the deceased is done on the usual lines and may not be a problem in routine cases when the burn injury has left the body in its usual con.uration. However, when differ- ent parts of the body are charred including the face, it poses a problem. The internal examination may contribute signifi- cantly, especially in cases where the deceased has been shown to have had diseases like myocardial infarction, pulmonary tuberculosis or some surgery such as appendectomy, hysterec- tomy, nephrectomy, etc. The detection of pacemaker, valve implant, etc. may be especially helpful towards identification. The subject of identification is lengthy and only certain points, peculiar to the burns, will be discussed.

One must look for any remnant clothing or any other article near or on the body. Even on mostly charred body, fragments of clothing may be found in the folds of the skin or in the flexures of armpits or inguinal regions or some traces of jewellery may be found.

X-raying the entire body carries unique importance. It will help to demonstrate any old bony deformity or presence of any foreign body like bullet or any calcified object. Comparison of the X-rays of the corpse with previous X-rays, taken sometimes back in the hospital, may prove helpful in establishing identity. If the face is badly charred by fire, the front teeth may also be damaged but the premolars and molars lying farther back under the cheeks may be saved and can be examined. In a badly charred victim, dental identification is the best hope as the teeth are relatively resistant to fire. X-rays of the teeth may reveal the evidence of some root canal fillings or some other treatment. When heat contractures have locked the jaw rigidly and visual examination is precluded then proper dissection may be carried out and the upper jaw may be excised. (Webster was not able to destroy the evidence of the identity of his victim when he attempted to dispose of the body of Dr. Parkman in a laboratory furnace. The dentures of the victim were sufficiently preserved to establish the identity.) A fire in the open, as in a field, may not usually permit complete combustion of the human body as was observed in case of attempted disposal of Hitler's body at the end of World War II. Though the gasoline was used as an accelerant, yet in spite of widespread charring, positive dental identification could be made. (Bezymenski L. The Death of Adolf Hitler, New York, Harbrace World, 1968.) In occasional cases (in case of an edentulous body with extremely burnt extremities), the identification may remain pre- sumptive and may pose medicolegal problems. However, one must keep in mind that regardless of the surface destruction by fire making the sight recognition of the body unreliable, internal organs (particularly uterus and prostate due to their thick mus- culature and relatively well-protected pelvic location) may be available and if not, then bones, especially teeth, dentures/parts of dentures may hold the key for solving the issue.

CASE: Burns vis-á-vis Identification—Gravity towards Criminality thereof (Vide Communication from Dr. Manpreet Kaul et al.)

On 14.02.2002, a lady R lodged a complaint to the police alleg- ing that her daughter (aged about 17 years) who as usual had gone to do work in the house of some H Singh on 13.02.2002 had not returned back. When R visited H Singh's house to ask about the whereabouts of her daughter, he told R that the girl had left his place. R getting panicky, curiously raised queries about one dead body lying in the verandah. To this, H Singh satisfied her by telling that the dead body was of his wife who had died of burns while working in the kitchen. However, R asserted that she was able to recognise the body from the spared hand (carrying specific colour of the nail polish) and from the teeth, etc. (Such structures being relatively resistant to fire due to their hard composition provide best hope for iden- tification. This has been duly stressed in the text of the chapter too.) These developments made her to inform the police. The police recorded the FIR under Section 302/201/34 IPC and took the body in custody from the cremation ground. The postmortem was conducted. In the columns of 'name' and 'age' of the deceased, the Inquest Papers showed:

- Name of the deceased as Jagdish Kaur/Kiran', i.e. the wife of H Singh/daughter of R.

- Age of the deceased as 'about 27 years/17 years', i.e. the age of the wife of H Singh/daughter of R.

Various issues were resolved by exercising due precautions as follows:

- Dead body was subjected to 'radiography' before proceed- ing for autopsy (considering radiological and dental findings, the age of the deceased was estimated to be about 17 years).

- Videography of the entire procedure was got conducted so as to escape any element of bias, which may creep up sooner or later.

- Further evidence of age was afforded by findings of the genital organs, viz. intact hymen, vaginal rugosities and uterine size being 32○22⊠12 with convex walls and triangu- lar cavity.

- Vaginal swabs sent to the Chemical Examiner showed negative results.

- and acute laryngeal oedema. If oedema develops rapidly as may occasionally be encountered when the victim happens to inhale the flame or superheated air, the laryngeal region may be damaged and sudden asphyxiation may ensue. Most of the burns in such rapid deaths will usually be of postmortem nature and severe postmortem burning will obliterate the few surface burns, which might have been sustained by the victim up to the moment of death. Under such circumstances where no antemortem surface burns are appreciable, it may be a logi- cal conclusion to attribute death to asphyxia due to suffocation originating from the thermal damage to the respiratory passage.

ELEVATED BLOOD CARBOXYHAEMOGLOBIN LEVELS

Smokes differ in the composition depending upon the type of material undergoing combustion, the amount of available oxy- gen to supplement fire and the temperature attained by the fire. However, in most of the fires, particularly the house fires, most of the carbon of the organic material such as timber, furniture, etc. leads to production of carbon monoxide along with other gases. Slow smouldering fires are likely to produce more carbon monoxide as may be seen in the confined places than the open fires.

Saturation of haemoglobin with carbon monoxide varIndications that the victim was alive at the time of fire are discussed below

PRESENCE OF SMOKE IN THE AIR PASSAGES

Presence of greyish-black or black amorphous material embedded/adherent to the mucosae of larynx, trachea and bron- chi indicates that the victim inhaled smoke and hence was breath- ing during the fire. Finding of soot/smoke in the superficial areas like mouth and/or nose etc. does not serve any meaningful pur- pose towards the diagnosis. The quantity of soot/smoke in the air passages is influenced by the type of fuel and fire, amount of smoke produced depending upon the degree of combustion, the nature of articles burnt and the period of survival of the victim. Adherence of soot to the oesophageal and gastric mucosae indi- cates that it was swallowed and accordingly shows that the life existed at the time of fire. Absence of this finding of smoke may suggest two possibilities, viz.:

- Either the victim died before the fire commenced or
- Death was so rapid that it prevented any inhalation of smoke by the victim. Such a situation may occur in extremely hot fires or rapid flash fires or explosions.

EVIDENCE OF THERMAL INJURY OF THE RESPIRATORY TRACT BY FUMES/ HOT GASES

Death may sometimes be occasioned by inhalation of fumes or hot gases, causing thermal damage to the respiratory mucosa vaies from case to case, as it is dependant upon a number of factors like concentration of the carbon monoxide in the inhaled air as outlined above, the duration of exposure, rate and depth of respiration of the victim, haemoglobin content of the blood of the victim and the local variations in the draughts. Activity of the individual within an atmosphere con- taining carbon monoxide also increases the rate of absorption. Therefore, the interpretations of results of carbon monoxide blood analysis in the fire victims must be evaluated in concur- rence with the circumstances of combustion, the anatomical findings and the factors attribu. to the prior state of body of the victim.

More than 10% blood haemoglobin saturation with carbon monoxide in bodies recovered from fires usually indicates that the victim inhaled smoke and hence was alive at the time of fire. This level of more than 10% blood haemoglobin saturation with carbon monoxide indicating that the victim had inhaled smoke and therefore was alive should be particularly adhered to in case of chain-smokers because they could build up a level of 8–10% merely due to cigarette smoking. Therefore, in a nonsmoker even such a blood level of carbon monoxide may be considered as an evidence of smoke inhalation and conse- quent existence of life when the fire started. When death results solely from carbon monoxide, carboxyhaemoglobin levels may range as high as 50–60% haemoglobin saturation except in old and debilitated individuals where deaths have been reported at much lower saturations. When death occurs extremely rapidly from a violent explosion or flash fire or an intensely hot quickly engulfing blaze, little or no carboxyhaemoglobin may be present in the blood of the victim because respiration ceased too rapidly to allow inhalation of any appreciable quantity of the gas.

A high percentage of carboxyhaemoglobin in the blood may explain why the victim was not able to escape. As written already, the activity of the individual within the atmosphere containing carbon monoxide increases the rate of absorption and may cause immediate loss of consciousness even when the levels are well below the lethal level. Hence, one may encoun- ter persons lying dead in the immediate vicinity of fires, who may have none or only a few surface burns but the blood revealing a lethal saturation of carboxyhaemoglobin.

Another remarkable advantage of estimation of car- bon monoxide in the blood may be seen in the circumstances where the autopsy reveals injuries or haemorrhage. Here, esti- mating the quantity of carbon monoxide in the blood compos- ing the haemorrhage or surrounding the injury and comparing it to that of its concentrations in the circulating blood may lead to disclosure of the circumstances of death. Thus, if finding of 'extradural haematoma' is encountered at autopsy, its origin (i.e., whether it is a true traumatic lesion that occurred before the fire began or a fake heat haematoma formed from the blood that has been squeezed out of the venous sinuses or emerged out of the diploic space due to exposure of the head to intense heat) may be determined by demonstrating presence of carbon monoxide in the blood. In the former case, the blood from the haematoma will be free from carbon monoxide, whereas in the latter case, the haematoma will show the pres- ence of carboxyhaemoglobin if the victim had absorbed this gas during the process of death in the fire. Hence, blood car- bon monoxide levels must be evaluated in all victims known, alleged or suspected of having succumbed to death in a fire. Fluid blood may be obtained from chambers of the heart or major blood vessels and put in chemically cleaned, tightly stop- pered containers and sent to a Forensic Science Laboratory through the police. The container must be filled with the blood or a layer of liquid paraffin be spread over it to prevent disso- ciation of the carboxyhaemoglobin—a process that readily takes place at low concentrations. If the blood is solidified, the coagulum should be sent.

PRESENCE OF OTHER TOXIC GASES IN THE BLOOD

Many fires produce noxious gases and fumes that can kill by many different mechanisms. Several toxic gases may be pro- duced in the same fire depending upon the nature of sub- stances undergoing combustion, as already mentioned. The gases may include hydrogen cyanide, ammonia, sulphur diox- ide, hydrogen sulphide, nitrogen oxide and carbon dioxide, particularly when some plastic substances have been burnt in the fire. All of these are potentially toxic, but cyanide deserves special mention. Small concentrations of cyanide have been found in blood of victims dying in ordinary house fires. The role of hydrogen cyanide in fire deaths is difficult to assess. However, a caution needs to be exercised while interpreting the presence of cyanide in the blood of the deceased, because cya- nide is produced in significant quantities by the postmortem decomposition. It has been found to be generated in stored samples of blood, even when refrigerated for some days. [Curry AS, Price DE, Rutter ER. Acta Pharmacol Toxical 1967;25:339.] When such toxic gases are also present along with presence of carbon monoxide, it becomes difficult to assign the relative contribution of each and further, where there are antemortem burns too, the problem gets more com- plicated. However, where there are lethal levels of carbon monoxide in the blood, death may be assigned to that. Whetherell found both carbon monoxide and cyanide in 75% of fire victims that he analysed. The level of cyanide detected was less than the minimum lethal level of 300 ᵹg per 100 ml.

CUTANEOUS REACTION TO HEAT AND FLAME

A dead body recovered from fire may exhibit skin burns sus- tained prior to or after death or at both the times. The distinc- tion whether the burns were sustained before or after from the surface appearance of the body does not usually present much difficulty provided that the entire body surface has not been damaged. The points for differentiation include the following:

Presence of Vital Reaction (Red Flare / Red Line)

The intact skin adjacent to the burnt area will normally show a line of redness when the burns are sustained during life. This line even persists after death. It may take sometime to develop but may be absent in weak, debilitated subjects dying immedi- ately from shock due to burns.

VESICATION (BLISTERS)

Vesication caused by burns during life contains a serous fluid containing albumen and chlorides. The vesicles have red inflamed base and erythematous border. In contrast to it, the postmortem blisters (vesicles) are not bordered by red hyperaemic zone, may contain traces of albumen and chloride and more air. The base of such blister will be dry, hard, yellow and horny instead of being red and inflamed as seen in antemortem blisters.

Microscopic examination of the tissue from the burnt area and the sample should include skin from the intact area also beyond the margins of the burnt area. It will show conges- tion of the vessels and infiltration of polymorphonuclear leu- cocytes into the tissues and into the blister fluid depending upon the period of survival of the victim.

Histological methods of distinguishing antemortem and postmortem burns have been described by Mallik (1970) using burns inflicted experimentally on guinea pigs, burns of human skin obtained from autopsy examinations and burns inflicted experimentally on amputated human tissues [Mallik MOA. J For Sci 1970;5:489]. In case of human burns, the earliest histological change in antemortem burns was leucocytic infiltra- tion at 6 hours after burning. Staining reactions for DNA and RNA at the margins of the burnt area increased at the same time, as for the enzymes alkaline phosphatase. An increase in the reaction for acid phosphatase was detected at 3 hours, for leucine amino peptidase at 2 hours and for nonspecific esterase at 3/4 hour. The histochemical reactions were not affected by surgical dressings or a lapse of time between death and post- mortem examination up to 3 days. Raekallio has reviewed the application of histochemical methods to burns but states that no reports have been published on some extensive work on human material. [Raekallio J. Z Rechtsmed

1973;73:83.]

SUICIDE, ACCIDENTS OR HOMICIDE

SUICIDAL BURNS

Suicides are not uncommon. In India, suicide by burning in domestic environment is much more common in females. Usually, some inflammable material like kerosene or petrol is used. A suicide note may sometimes be left.

Cases of self-immolation may be encountered as a means of indicating political dissent. In such circumstances, usually the clothes are soaked with some inflammable liquid like kerosene or petrol. At times, superficial burns may be inflicted over the acces- sible parts of the body for the purpose of false accusation against the enemy. Similarly, burns sustained accidentally may be falsely ascribed to have been inflicted by some particular person.

ACCIDENTAL BURNS

A vast majority of cases occur accidentally when the victims are trapped in the burning buildings or vehicles. Some accidents occur in the kitchen. In India, the victims are often women because their synthetic sarees or chunnies etc. easily catch fire while cooking, sitting or working near a stove or gas, or open lighted kerosene lamps. Children, epileptics, old, infirm, drunk- ards or otherwise incapacitated individuals may fall accidentally into the fire or vats of boiling water. Children or people engaged in show business or circus may get accidentally burnt in a variety of ways. Leakage of cooking gas, at times, may saturate the kitchen and accidental conflagration may occur when under such circumstances an attempt is made to light the gas. During Diwali days, accidental burn injuries are common.

HOMICIDAL BURNS

Homicidal burns, though not common, are known. Cases are on the record when lighted fire sticks, hot metals, boiling liquid or corrosives have been used with a criminal intent. Burns are occasionally caused by a mother-in-law on the body of her young daughter-in-law for trifling faults. At times, grown-up females may be punished by inflicting burn injuries over the pudenda for adultery. A husband in a drunken state or in a fit of temper may push his wife or child into the fire. A suspicion of homicide may be entertained under two situations. Firstly, when it is evident that several distinct and separate parts/ portions of the body have been involved and are not readily explainable by the accident under issue. Secondly, when there appear marks of homicidal violence. (However, the possibility of such marks being effaced by the burns may also be kept in mind and at the same time marks of physical injuries may be received prior to or at the time of accidental ignition.)

304B: DOWRY DEATH

(1) Where the death of a woman is caused by any burn or bodily injury or occurs otherwise than under normal cir- cumstances within 7 years of her marriage, and it is shown that soon before her death she was subjected to cruelty or harassment by her husband or any relative of her husband for, or in connection with, any demand for dowry, such death shall be called 'dowry death' and such husband or relative shall be deemed to have caused her death.

(2) Whoever commits dowry death shall be punished with imprisonment for a term that shall not be less than 7 years but that may extend to imprisonment for life.

498A: A HUSBAND OR RELATIVE OF HUSBAND OF A WOMAN SUBJECTING HER TO CRUELTY

Whoever being the husband or the relative of the husband of a woman subjects her to cruelty shall be punished with imprisonment for a term that may extend to 3 years and shall be liable to fine.

Explanation: For the purposes of this Section 'cruelty' means:

(1) Any willful conduct that is of such a nature as is likely to drive a woman to commit suicide or to cause grave injury or danger to her life, limb or health (whether mental or physical) or

(2) Harassment of a woman where such harassment is with a

view to coercing her or any person related to her, to meet any unlawful demand for any property or valuable security or on account of failure by her or any person related to her to meet such demand.

113A: PRESUMPTION AS TO ABETMENT OF SUICIDE BY A MARRIED WOMAN

When the question is whether the commission of suicide by a woman had been abetted by her husband or any relative of her husband and it is shown that she had committed suicide within a period of 7 years from the date of her marriage and that her husband or such relative of her husband had subjected her to cruelty, the court may presume, having regard to all the other circumstances of the case, that such suicide had been abetted by her husband or by any relative of her husband. Explanation: For the purposes of this Section, 'cruelty' shall have the same meaning as in Section 498A of the Indian Penal Code.

113B: PRESUMPTION AS TO DOWRY DEATH

When the question is whether a person has committed the dowry death of a woman and it is shown that soon before her death, such woman had been subjected by such person to cruelty or harassment for, or in connection with, any demand for dowry, the court shall presume that such person had caused the dowry death. Explanation: For the purpose of this Section, 'dowry death' shall have the same meaning as in Section 304B of Indian Penal Code.

BURNS BY MOIST HEAT (SCALDS)

A scald is an injury resulting from the application of liquid above 60° C or from steam. Because of cooling of the liquid due to evaporation, the lesion due to scald is not very deep. (The protection afforded by the skin and the short duration of contact of the liquid prevent inward conduction of heat. Thus, generally superficial skin layers are affected.) However, the latent heat (heat retention capacity) of the sticky viscid liquids is high and hence, the penetration capacity of heat of such liquids is also more. Thus, an injury caused by hot tar, syrup, oil, etc. is comparatively deeper than that caused by hot water.

FEATURES OF SCALDING

- The liquid responsible for scalding may be seen on the clothes and body. Sometimes, its smell may be obvious. Scalding can occur through intact clothing.

- The injury is usually limited to the area of contact and is more severe at the point of initial contact.

- As the hot liquid gets cooled while being dispersed, scalds are severe at places where the hot liquid has come into ini- tial contact with the skin. As the liquid runs down the body, the degree of scalding also progressively diminishes.

- Redness appears at once, and blistering (vesication) takes place within a few minutes. Vesicles are abundant along the course of the running liquid. There is usually a well-demarcated edge, corresponding to the limits of contact of the liquid. The blis- ters have a hyperaemic zone surrounding them. There is red- dening and swelling of the papillae in the floor of the blister. If the blister skin is removed, the floor appears reddish with serosanguinous discharge. Postmortem blisters (as already stressed under burns) contain mostly gas or may contain little fluid, which is scanty in proteins and chlorides. They do not show any antemortem reaction in and around them.

- Superheated steam soddens the skin, making the skin dirty white in colour. Occasionally, steam may be inhaled causing thermal injury to the respiratory tract, producing death by asphyxia due to obstruction of airway by the oedematous mucous membrane.

- Burning of clothes, singeing of hair, deposition of carbo- naceous material and charring of tissues (common in burns) are not seen in scalding.

CIRCUMSTANCES OF SCALDING

- Scalds are usually accidental due to splashing of fluid from the cooking utensils or pouring hot water during bath or from bursting of boilers, etc.

- Children may upset the vessel containing hot water/milk/ tea etc. or suck the spouts of kettles containing such hot liquids resulting in severe scalds of mouth and throat.

- Boiling water may be thrown with the intent to injure or annoy. Deliberate scalding by hot fluid is common in child abuse.
- Suicide by scalding is rare because it is very painful and moreover, there is no guarantee of death.

Differences between Burns from Dry Heat, Moist Heat and Chemicals

Trait	Dry heat	Moist heat	Chemicals
Cause	Flame, heated solid substance or radiant heat	Steam or any liquid at or near boiling point	Corrosive acids and alkalies
Clothing	Burnt and may be adherent to the body	Usually wet but not burnt	Characteristic stains
Discolouration	Skin roasted, charred etc.	Skin bleached	Distinctive depending upon the action of chemical on the skin
Site	At and above the site of flame	At and below the site of contact	At and below the site of contact
Skin	Dry, shrivelled, charred	Sodden and bleached	Stained, corroded
Vesication	At the circumference of burnt area	Most marked over burnt area	Rarely found
Red line	Present	Present	Absent
Singeing	Present	Absent	Absent
Charring	Present	Absent	May be present in case of mineral acids
Trickled marks (splashing)	Absent	Present	Present
Ulceration	Absent (unless infected)	Absent (unless infected)	Present due to penetrating and devitalising effects of the agent
Scarring	Thick and causes dis.urement	Thin and causes less dis.urement	Keloid scar and much dis.urement

HYPOTHERMIA (EXPOSURE TO COLD)

As in the case of heat, cold may affect the body in two ways:

- Through the generalised effects caused by lowering of body temperature as a whole.
- Through the local effects of cold producing lesions on the

extremities, such as frostbite or immersion foot.

PATHOPHYSIOLOGY OF HYPOTHERMIA

The temperature of peripheral parts of body may vary depending upon the environmental and other factors, but the central (core) part of the interior of the body is usually kept out at a constant temperature. There may be slight diurnal variations of about 1.5° F. The internal temperature of the body is regulated by heat produc- tion or heat loss by the body, the former through metabolism controlled by thyroid hormone and muscular activity and the latter by increasing blood flow through the skin or by sweating. Clothing, obviously, plays a part. Central receptors, usually con- sidered to be situated in the hypothalamic region of the brain and also near the carotid sinus, regulate the body temperature. Peripheral temperature receptors are also known to exist.

Skin and lungs are the two most affected systems of the body. The colder temperature of the atmosphere results in the loss of body heat from the skin surface. To conserve body heat, blood vessels of the skin contract thereby lowering the surface temperature and causing a feeling of chill. Continued exposure to cold, therefore, results in injury to the superficial surface as well as loss of the body heat.

However, the major source of heat exchange is the lung surface. The air we breathe gets equilibrated with the body temperature almost immediately after it passes through the respiratory tract. Therefore, continuous breathing of cold air results in a massive loss of body heat, lowering the tempera- ture of inner core of the body. Furthermore, since the mois- ture content of the cold air is rather scanty, the problem gets compounded due to inhalation of dry air.

The local effects of cold upon the tissues may result from the following factors:

- Vasoconstriction, which is usually a protective mechanism for the maintenance of body temperature.
- Injury to the small blood vessels with the formation of agglu- tinative thrombi in them, caused by stagnation of blood.
- An additional factor may be subsequent overheating, which elevates the metabolism beyond the level that the damaged blood

supply can support.

Three phases of hypothermia as recognised by Duguid et al. (1961) are as under:

- First phase, which has no clinical significance, is that where rectal temperature is between 98.4° and 90° F. There is a feeling of being cold and shivering. It promptly responds to simple measures.
- Second phase, where rectal temperature is between 90° and 75° F, the subject is depressed and there is progressive fall in pulse, respiration and blood pressure. Shivering ceases at about 90°–85° F.
- Third phase, where rectal temperature falls below 75° F. Here, the temperature regulating centre usually ceases to function and there occurs progressive cooling of the body until it attains the level of atmospheric temperature. Survival from this phase is rare.

CIRCUMSTANCES OF HYPOTHERMIA

Hypothermia may be due to exogenous or endogenous causes or due to both. Exogenous causes are almost always environ- mental. Air temperature below 10° C is probably low enough to lead to hypothermia in vulnerable individuals but air move- ments like draughts will also affect by increasing the rate of body cooling. Damp conditions will also aid cooling from latent heat of evaporation. The elderly with waning defences and the children with poorly developed thermoregulatory mechanisms are likely to suffer the onslaught of cold weather. Similar ill effects are likely to ensue in individuals whose thermoregulatory mechanisms are already impaired, such as hypothyroid patients and those who are drunk. Sips of brandy or other forms of alcohol are usually consumed in an attempt to ward off ill effects of cold. However, they are counterproductive and tend to aggravate the lowering of body temperature rather than raising the same (the heat generated by alcohol is due to internal combustion, which therefore lowers the temperature of inner core of the body). Further, the tendency to consume more and more alco- hol to keep oneself warm impairs judgement and sense of the risk.

Endogenous causes may involve the following:

- Some disease process or drugs etc. that modify the normal physiological temperature regulating mechanism. Diseases of endocrine glands like hypopituitarism and hypothyroidism .ure in many reported series. Drugs like barbiturates, phenothiazines, tranquillisers, diazepam and alcohol have all been recognised to cause increased suscep- tibility to cold.

- Age and physique: There are usually three groups of persons who are liable to suffer from accidental hypothermia, namely, newly born babies, elderly persons and persons engaged in hazardous outdoor activities such as mountain- eering, pot-holing and sailing, etc. In general, individuals whose vitality has been lowered by fatigue, alcohol or some other factor are less able to withstand the effects of cold. Owing to greater deposit of subcutaneous fat—a nonconducting material—women can endure cold longer and better than men.

- Lack of food, adequate clothing, etc.: These are the social or financial factors often related to the depressed, apathetic state of many old people, particularly those having atherosclerosis.

MECHANISM OF DEATH

The temperature regulating mechanism gets disturbed as described earlier. As the body temperature falls, progressive decrease in the dissociation of oxyhaemoglobin occurs and, therefore, there is less supply of oxygen to the tissues. Most affected is the nervous tissue. Also, the utilising capacity of the tissues is reduced at lower temperatures. All these depress the oxidative process in the tissues and there results stagnation of blood, leading to tissue hypoxia. Therefore, the immediate cause of death is the circulatory failure.

AUTOPSY FINDINGS

Hypothermia, like some situations of drowning, epilepsy, electrocution, etc., may present difficulty as there may not be any specific finding diagnostic of death due to cold exposure. This is particularly so when the victim of hypothermia has been admitted to the hospital and death may ensue while he is being 'warmed up'. Hence, in cases of deaths due to hypothermia, circumstances of death may be all important to establish the diagnosis with a degree of certainty.

Obviously, the extent of findings will depend upon the intensity of cold and duration of exposure. A typical case of death due to hypothermia may reveal the following findings.

External Findings

The body surface is usually pale in appearance with irregular dusky-red patches of frost erythemas, particularly on the exposed parts, large joints and extensor surfaces. Hypostasis appears pink. The colour is obviously due to the persistence of oxyhaemoglobin in the skin capillaries as discussed under mechanism of death. Rigor mortis is slow to appear and lasts longer. Extremities may be cyanosed or white. The exposed parts such as ears, nose, fingers and toes may show localised effects, known as frostbite, which occurs primarily by impaired local circulation. The lesions here may be superficial involving skin and subcutaneous tissues showing blisters or may also involve muscles, bones, etc. Prolonged exposure of extremities to cold sea water or cold tranches (nonfreezing temperature) for many hours produces a condition known as 'Trench Foot or Immersion Foot' as may be seen in shipwreck survivors or soldiers. The condition of frostbite is indicative of excessive exposure to intense cold (freezing temperature of the range of –8° to –10° C) and suggests the pres- ence of vital reaction and hence the existence of life at the time of exposure to cold.

Internal Findings

The internal appearances are not characteristic. Signs of some preexisting disease may be seen. The subcutaneous tissues are relatively avascular. The blood is often of bright red colour due to retention of oxygen by the haemoglobin at low tempera- tures. More specific changes are to be found in the diges- tive tract, pancreas, parotid glands and brain. Acute small submucosal gastric and duodenal haemorrhages, appearing dark brown due to the presence of altered blood, may be pres- ent. If a period of survival follows the hypothermic state, the mucosa over these haemorrhages may slough leaving shallow ulcers. Perivascular haemorrhages in the region of the third ventricle with chromatolysis of the ganglion cells may occur. A variable degree of fat necrosis in the pancreas, related to the high serum amylase levels, is probably the most striking find- ing. It varies from occasional patches of fat necrosis to a frank nonhaemorrhagic pancreatitis with fat necrosis in the adjacent mesentery. Multiple visceral infarcts caused by stagnation of blood by packed red cells may be the other feature. Venous thrombosis may also be found.

From a series of six fatalities and a review of the literature, Mant (1964) suggested that the criteria for the diagnosis of death due to hypothermia may appear to depend upon the presence of all or most of the following changes:

- The body may not be cyanosed owing to the lack of dis- sociation of the oxyhaemoglobin.
- Large, irregular, erythematous patches on the trunk and limbs due to packing or sludging of the corpuscles in the superficial capillaries.
- A relatively avascular state of the subcutaneous tissues with congestion of the internal organs associated with packing of the blood cells in the small capillaries.
- A variable degree of fat necrosis along the pancreas. This is the most constant finding and varies from occasional patches of fat necrosis to a frank nonhaemorrhagic pancre- atitis with fat necrosis in the adjacent mesentery.
- Small submucosal gastric and duodenal haemorrhages, brownish-black due to the presence of altered blood. If a period of survival follows the hypothermic state, the mucosa over these haemorrhages sloughs, leaving shallow ulcers; these ulcers only rarely become deep and perforate into the peritoneal cavity.
- Excellent histological preservation of tissue.

CHAPTER-10

STARVATION AND NEGLECT

Starvation and neglect are not synonymous but are usually considered together owing to their close association. Extremes of life are the usual victims because they are dependent upon other family members for the necessities of life. That is why certain countries have passed some legal provisions in this direction to check this menace. In Britain, the Children and Young Persons Act places the responsibility upon the parents/ guardians/community to care for the children. In India, Sections 317 and 318 dealing with 'abandoning of infants' and 'concealment of birth', respectively are the steps to curb this evil. Presently, 'child abuse' (physical, sexual and mental) is inviting more attention than starvation and neglect.

Starvation may result from complete or partial deprivation of regular and constant supply of food. It is regarded as acute when the necessary food and water are suddenly and completely withheld as, for example, in mines or landslides, in entombment in pits, willful withholding of food and also willful refusal to take food. Chronic starvation occurs when there is gradual deficient supply of food, as in famines and camp conditions. The minimum food requirement for an adult depends upon his ideal weight (not current weight) and his normal work and daily activities. For an ideal weight of 60 kg, the usual requirement would be 1800 calories per day. Life is threatened when more than 40% of the original body weight has been lost, though the speed of loss also matters.

FATAL PERIOD

Death usually occurs in 10–12 days if both water and food are totally withdrawn. If food alone is withdrawn, death may occur in 6–8 weeks or even more. The period, however, is influenced by a number of factors like age, sex, condition and environ- ment of the body. A 50-year-old Jain woman successfully com- pleted a 108-day religious fast. She used to have only boiled water during the fast, as reported.

In both children and adults, the major problem remains the connection between the cause and effect, especially when some disease is also present. It is always advisable to perform radiog- raphy prior to autopsy so as to exclude the physical abuse, which is often associated with neglect. Photography should also be performed.

EXTERNAL APPEARANCES

Size and weight should be recorded. In case of children, crown heel and crown rump lengths and diameter of head are essen- tial to be noted down. Fontanelles may be depressed owing to loss of pressure of cerebrospinal fluid (CSF). Hair may be dry and brittle, sometimes becoming depigmented. Then the com- parison may be made with the standard paediatric growth charts. Diameter of the limbs at recognised landmarks should be measured. The body usually appears greatly emaciated showing dry shrivelled skin. The skin of the face is stretched tightly across the cheek bones, the cheeks are sunken and the eyes are also deeply sunken due to loss of orbital fat and an element of dehydration. The skin surface, in general, may pres- ent differing appearances varying with the length of time of the nutritional loss and qualitative deficiencies in the diet, par- ticularly of some vitamins. Skin may be pale, lustrous and semi- translucent or coarse and rough. Pigmentation, either diffuse or localised, may sometimes be seen. Dehydration is a usual feature, and there is almost complete loss of subcutaneous fat. Pressure sores may occur on buttocks, heels and spinal region, or other frictional areas like elbows, knees, shoulders or occiput. Prominence of ribs is conspicuously observed on the trunk, with concavities in the intercostal spaces and sunken supracla- vicular fossae. The abdomen is of typical 'scaphoid shape', and the limbs are almost skeletonised from loss of fat and muscular tissue. In chronic starvation, hypoproteinaemia can lead to oedema.

INTERNAL APPEARANCES

The loss of adipose tissue will also be evident internally in the internal fat depots like omentum, mesentery and perirenal fat. Organs will be small and contracted. More specific internal signs include small, contracted empty stomach with bile- stained mucosa. It may contain undigested food if it had been given shortly before death to avert suspicion of willful starva- tion. Intestines show atrophy of all the coats showing extensive thinning out and translucency of the walls, thereby indicating that no food had passed the stomach down to the intestines for a considerable period. The lower portion of the large intestines may sometimes contain hard, scybalous faecal matter. The gall- bladder is usually distended and contains dark inspissated bile.

It is preferable to exercise caution in expressing opinion regard- of a patient/prisoner to refuse treatment/nourishment. This may be resolved depending upon the circumstances of each case. Loss of weight and acidosis are the two criteria to advise forced feeding.

Homicidal starvation may be encountered in old, infirm, helpless or feeble-minded persons and illegitimate children and infants, who may be done to death by deliberate withholding of food and also exposure to cold. In big cities, small children may be kidnapped, starved, maimed and forced to beg and the earnings taken by the kidnapper.

In accidental starvation, the circumstances are self-explanatory such as famine, cyclone or earthquake, shipwreck, persons entombed in collapsed mines or the wreckage of bomb explosion. Diseases like anorexia nervosa, ankylosis of jaw, stricture or carcinoma of oesophagus and stomach, etc. may also lead to inanition. Signs of neglect and emaciation may also be seen in drug addicts where the desire for the drug surpasses the desire for food.

Increasing death by acute or chronic starvation, and diseases like malignancy, progressive muscular atrophy, Addison disease, tuberculosis, pernicious anaemia, etc. must be excluded. It is often difficult to assess precisely the roles of starvation, neglect and cruelty. Occasionally, it may be impossible to determine cause of death, especially when the victim is newborn. In some cases, natural disease, wholly or partially, may be responsible for death.

Suicide as a result of starvation is rare because the person cannot usually resist the intolerable thirst or quest for food. However, it may be seen in lunatics or prisoners, who may go on hunger strike. Voluntary starvation for political and religious reasons is also well-known. In this context, it may be remembered that forcible feeding of prisoners, when they refuse to take food, is not an assault but is lawful because the prisoners are under the care of the State, which has duty to protect them. The declaration of Tokyo (1975), which lays down guidelines for the doctors concerning torture and cruel treatment or other inhuman and degrading punishment, may be referred to when a prisoner refuses food. However, the doctor may be confronted with two conflicting ethical issues— his duty to preserve life and his obligation to respect the rights.

CHAPTER-11

DEATH BY ELECTOCUTION

The passage of electric current through human body is capable of producing a wide range of effects, varying from insignifi- cant localised muscular spasm and little or no contact burns to instantaneous death with little or no burns or extremely severe burning.

Fatal electrocution may be divided into three groups, according to the voltage involved:

- Domestic: The voltage of domestic supply varies from coun- try to country and within the country itself. Standard domestic voltages in the United States are 110 volts at 60 cycles and in Great Britain, usually 240 volts at 50 cycles whereas in India, it is usually 220–240 volts alternating current with 50 cycles per second.

- Industrial: Very high voltages are involved in driving heavy electrical machinery, and the voltages employed by different industries may vary. Voltages up to 400,000 volts may be employed in electric grid networks for the bulk transfer of power.

- Lightning: Benjamin Franklin (1706–1790) demonstrated in about 1750 that the lightning flashes were electrical dis- charges and not, as thought earlier, gaseous explosions. He succeeded in collecting electricity from the clouds by flying a kite during a storm and connecting the lower end of its string to the Leyden jar. This experiment led to the inven- tion of lightning rods or conductors, which are presently employed in protecting buildings and other prominent structures .details ahead under 'Lightning').

As all electric supplies are potentially dangerous, some consideration of factors that are likely to lessen the hazards of electrocution is important. Some of these are related to the nature of electric supply, while others reside in the circum- stances of the victim. An appraisal of these factors may not con- tribute in reaching the diagnosis at the time of autopsy but has a considered value in interpreting the findings and reconstructing the events surrounding the death.

FACTORS RELATED TO THE NATURE OF ELECTRIC SUPPLY

Voltage (Tension)

Volt is the unit of electromotive force. It is the force required to produce 1 ampere of intensity when passed through a con- ductor having the resistance of 1 ohm. Low tensions (below 50 volts), as used therapeutically, are usually not fatal. However, fatalities due to alternating current of low tension have been reported. Most fatalities follow shocks from currents at ten- sions of 220–250 volts, which is the usual range of household supply. At such voltages, the usual visible damage to the body occurs in the form of small 'electric marks' and death is owing to internal derangement of functions. Medium voltages,

i.e. under 500 volts, predispose to prolonged contact due to induction of spasm of the muscles and therefore the victim grips and 'holds on' to the conductor. Under these conditions, a current whose momentary passage would merely cause a shock may become lethal. At high voltages, a person may be thrown clear of the source by the violent muscular contrac- tions caused by the current or the body may be extensively damaged with severe and deep burns.

AMPERAGE (INTENSITY)

This is probably the most important factor as far as the elec- tricity itself is concerned. It is the unit of intensity of electric current and may be calculated in any given circuit by dividing the voltage by the resistance in ohms. On receiving a current of 1 mA, a person usually experiences tingling sensations and as the intensity of the current is increased, contraction of the muscles is greater and the current of about 8–20 mA is suffi- cient to prevent the victim letting go off the source of the current. At much higher currents, this factor of 'hold on' is not seen, and the victim may be thrown clear of the source of the current by violent muscular contractions and this may be responsible for secondary injuries to be sustained by the victim depending upon the circumstances. The intensity of 70–80 mA created by alternating current and 200–250 mA by direct current are considered to be dangerous. The danger increases as the amperage rises above 100 mA up to about 4 A and thereafter it decreases. Amperage above 4 A arrests ven- tricular fibrillation; this is the principle of treatment with a defibrillator. A current of high voltage with low amperage can be less dangerous than one with moderate voltage but high amperage. This again emphasises that the amperage is more important than the voltage.

FORM OF CURRENT (WHETHER AC/ DC)

Alternating current is one that reverses its direction at regular intervals. Standard commercial cycles are 25–60 per second. The direct current is one where the current flows constantly in the same direction. Alternating current is more dangerous than the direct current. In one series of 212 fatalities, only 8 were due to direct current (Boruttau, 1918, cited Jaffe, 1928). The body is much less susceptible to very rapidly alternating or slowly alternating currents, for instance, below 10 and above 1000 cycles per second. The danger to the body exists when the rate lies between 30 and 150 cycles per second. An increase in rate above this range decreases the danger. Prevost and Battelli (1899) found that heart was about 20 times more tolerant when the current was raised to 1720 cycles per second than to one at 150 cycles per second. The high frequency cur- rent used in the diathermy, which oscillates at one million cycles per second and carries 20,000–40,000 volts at 1–2 mA, is harmless as the effect of each impulse is to annul the effect of the preceding impulse.

FACTORS RELATED TO THE VICTIM

RESISTANCE OF THE BODY TISSUES

It is well-known that the current flowing through the conduc- tor is determined by the voltage divided by the resistance, i.e. I त्र V/R, where I is the current in amperes, V is the potential difference in volts and R is the resistance in ohms. Therefore, the resistance of the body tissues plays its role. The major barrier to the electric current is the skin, which exercises far greater resistance than the internal body tissues. Once the skin has been overpowered by the electric current, the vascular system filled with electrolyte rich fluid serves as a favourable medium for the passage of current. The resistance offered by the skin is further modified by the thickness (on soles and finger pads and palmar surfaces, the resistance is greater thanthe thin skin elsewhere) and the dryness or dampness of the skin. The dry skin of the palms offers the greatest resistance. In a labourer, it was estimated by Jellinek as from a million to two million ohms. Sweating appreciably reduces resistance. Jaffey stated that sweating could reduce the resistance of the skin from 30,000 to 2500 ohms. The resistance of the skin, as written earlier, varies from one region to the other, it being greatest in the palm and least on the inner side of the thighs. The average skin resistance is of the order of 500–10,000 ohms. Bone has a resistance of about 900,000 ohms. Vascular areas like cheeks, mucosae, etc. offer less resistance.

AREA OF CONTACT OF THE BODY

This carries importance in two respects. Firstly, the smaller area of contact between the skin and the electric supply will exert more resistance than the larger area, e.g., the tip of the finger compared to the palm of the hand. Broad good contact usually reduces the resistance considerably (from 100,000 ohms to 1000 ohms as reported by Simonin, 1955). This may occur when one grasps a hot wire with a wet/sweated hand. Here, the entire skin surface being bathed in salt water (sweat- ing) becomes a conductor and not enough current passes through any localised portion of hand to generate sufficient heat to burn the skin, which is the most efficient barrier against the passage of the current and hence electrocution can occur with no visible skin burning. Similarly, electrocution in a bath may occur without any external mark. Secondly, the part/site of the body and the route of current through the body have a considerable bearing. The passage through the region of the heart is most dangerous. Heart is usually involved when the path is from hand to hand or from left arm to the right leg. When the head of the worker may come in contact with the conductor, brain stem may be directly involved leading to paralysis of car- diac or respiratory centre.

DURATION OF CONTACT

It will obviously determine the amount of damage. The longer the contact, the greater will be the damage. Low tension cur- rents may prove lethal if the contact is maintained for suffi- ciently long periods.

EARTHING/ INSULATION

The pathway of the current will depend mainly upon the relative resistance of the various potential exit points. It tends to follow the shortest route, irrespective of the varying conductivity of the various internal tissues. The current enters at one point (most often at the hand as the hand is mostly used to hold, touch or to manipulate some electric appliances) and then leaves the body at some exit point, usually to the earth. The better the con- tact between the person and the earth at the time of sustaining the electric shock, the more dangerous will be its effects. A per- son, therefore, standing with dry shoes on a dry surface may scarcely notice a shock, which could prove fatal to someone standing bare footed on a wet surface. Hence, stout rubber gloves and rubber boots provide considerable protection.

OTHER FACTORS

Personal idiosyncrasies of the human beings may also play a role. Jellinek considered that the personality and physical con- dition of the individual and the existence of bodily or mental distress at the time of sustaining shock influence the effects of the shock. Further, awareness of the victim towards the pos- sibility of shock being sustained may make the victim with- stand one which might otherwise be dangerous. Reported cases show that an individual taken by surprise may succumb to shocks that ordinarily produce no ill effects. An engine driver used to exhibit his skills by exposing himself to shocks from an electric lamp carrying a tension of 50 volts by catching hold of the lamp with both hands and letting it go as a bet for a glass of beer. He succeeded in doing so with impunity until one day he happened to have accidental contact with the lamp and died of an unexpected shock (Taylor, 1948). Presence of any disease in the victim, especially the cardiac disease, may predispose to death from currents of low tensions. circumstances will be nonspecific except the presence of exter- nal electric marks.

SPASM OF THE RESPIRATORY MUSCLES (TETANIC ASPHYXIA)

Electric current passing through the thorax may lead to tetanic contraction of the muscles of respiration and ultimately pro- ducing respiratory arrest. Here the mode of death obviously will be congestive hypoxia. These victims are likely to be cya- nosed whereas in case of death due to ventricular fibrillation, they usually appear pale. The range of current that can induce tetanic contractions of the extrinsic muscles of respiration may be 20–30 mA.

PARALYSIS OF THE RESPIRATORY CENTRE

Paralysis of the respiratory centre occurs when the current passes through the head, which is a rare event. The passage of several hundred milliamperes through the brain during the electroconvulsive therapy rarely results in suppression of respiratory centre, though a current of much less intensity would be sufficient if it passed through the centre. The heart may continue to beat and hence the importance of resuscitation, as already stressed.

SECONDARY CAUSES

Death, in some cases, may occur actually due to sustaining. In spite of almost universal use of electricity for domestic lighting and heating purposes and its extensive use in industry in the developed and developing countries, the fatal accident rate is meagre. Immediate and adequate resuscitation can decrease the mortality rate because quite often the victim may be in a state of suspended animation. Therefore, resuscitation needs to be continued for a sufficient period until unequivocal Mortality and Mechanism of Death by Electric Shock of mechanical injuries, secondary to the circumstances of

HIGH TENSION OVERHEAD CABLE

Paralysis of signs of death appear. There were 323 recoveries in the series of 479 cases studied by Mac Lachlan (1930), and he observed that artificial respiration was likely to succeed if initiated within 3 minutes of the sustaining of the electric shock. He reported a remarkable recovery of a victim who had received a shock from the current of 22,000 volts, when he was instituted resus- citation at once.

The following mechanisms may operate in causing death.

VENTRICULAR FIBRILLATION

Most deaths from the electric shock are from cardiac arrhythmias, usually ventricular fibrillation terminating in arrest. This occurs when the current passes through the thorax, from hand to hand or from hand to leg routes. The critical level of current seems to be of the order of 100 mA. The most dangerous is from the left arm to the opposite leg; from arm to arm is about 60% as lethal. Lee observed that loss of consciousness needs not be immediate, and some may even be able to walk some electrocution, as may happen when a worker working on a high voltage supply system gets electrocuted and falls from a height and receives head injury or some other injuries. Late deaths can occur in those who do not die immediately and sustain severe burns due to infection or haemorrhage because of damage to the blood vessels.

FINDINGS IN DEATHS DUE TO LOW- OR MEDIUM-TENSION CURRENTS

The point where the current enters the body is usually characterised by the presence of an electric mark or electric burn (Joule burn or endogenous burn). Another mark or marks may appear where the body is earthed or grounded. However, it must be stressed here again that fatal electrocution can occur with no visible skin mark, and the doctor may have to reach the diagnosis by exclusion of all the other possible causes and by attending to the circumstances of death. The examples, as already described, may be deaths occurring in the bath, when the entire body surface acts as a source of entry, and this coupled with the lowered resistance of the wet skin prevents the formation of any localised mark.

The electric mark, though specific of contact with the electricity, is not in itself a proof of electrocution because marks resembling those found on the victims of electrocution can be produced after death (excluding a zone of hyperaemia) as reported by Polson and Gee. It is also possible to produce changes in the skin resembling an electric mark by applying a glowing or intense hot wire to the skin. Distinction between electric mark and thermal burn may be made by acro-reaction and by scanning electron microscopy (SEM), as explained below. However, they do raise strong presumption of death by electrocution and together with the study of circumstances, diagnosis can conveniently be achieved. Some important features of the mark may include the following:

- If the contact of the skin with the conductor is good and firm, the passage of current heats up the tissue fluid and the skin offering resistance gets split and blister may be raised. The blister so formed may get ruptured if the contact continues or the area involved is relatively large. The shape and size of the mark may correspond to the shape and size of the source of the current in such cases (..10.2A).

- If the contact is not good or is less firm, the current jumps the gap between the source and the skin in the form of a spark and causes the outer skin keratin to melt over a small area. On cooling, the keratin gets condensed into a hard brownish nodule and this is termed as the so-called spark lesion (..10.2B).

- Combined lesions are encountered in many electric burns due to the movement of the hand or the body against the conductor.

Characteristically, a well-developed electric mark is a round or oval, shallow crater, bordered by raised areola of blanched skin around a part or whole of its circumference (.. 10.2). This pallor (blanched) border is possibly due to arteriolar spasm caused by direct effects of the current on the vessel walls. The pallor survives after death and is a useful indicator of electric damage. There may be mild hyperaemia of the intact skin imme- diately beyond the blanching. The floor of the crater is lined by a pale flattened skin, and the ridge pattern may or may not be preserved. These electric marks are produced by conversion of electricity into heat within the tissues and, therefore, they might be termed as 'endogenous burns' to distinguish them from 'flash or exogenous burns'. If the contact is with the long axis of the wire, a linear mark or groove may be caused but contact with the end of the wire may produce a hole that may go deep into the tissues involving even muscles and bone. It may be kept in mind that these lesions usually have greater depth than the insignificant surface appearance. Therefore, it is essential to examine the flexor surfaces of the fingers by forcible breaking of the rigor and if need be, flexor tendons may be cut to release the rigor. Occasionally, the mark may be present in the mouth, especially in case of children; therefore, mouth must be inspected and if need be, proper dissection of the mouth may be carried out.

The exit mark(s) are variable in appearance but usually have some of the features of entrance marks. There may be more disruption of tissues, and they are often seen as splits in the skin or sometimes even lacerations. Burns and perforations of the clothing or shoes may be seen over the site of exit. If the current enters and leaves the body over a wide area of low resistance as provided by water (wet hands or wet body sur- face) and good grounding (wet soil), neither current marks nor burns may be found. Hence, absence of electric marks does not exclude death from electrocution. In such cases, exclusion of other possible causes and a study of the circumstances will help to resolve the issue.

HISTOLOGICAL APPEARANCES

The epidermis may appear flattened due to distortion of the cells, caused by the passage of current. Epidermis may get sep- arated from the corium to form blisters. The cells of the epi- dermis are often elongated and the nuclei of the lower layers get stretched. An important feature is the occurrence of spaces of varying sizes and shapes in the corium and epidermis to impart a honeycomb appearance.

Hassin (1933, 1937) found histological changes in the brain even when death was instantaneous. He stressed upon the changes like tearing of the nervous tissue and its shrinkage around the smaller blood vessels. Changes in the brain have been described even when the cause of death was cardiac in origin.

Scanning electron microscopy may be promising in distinguishing electrical damage from that of thermal damage. It pos- sibly provides the chemical analysis by electron microprobes and helps in identifying the metallic deposits.

FINDINGS IN DEATHS DUE TO HIGH-TENSION CURRENTS (EXOGENOUS BURNS)

Injury by high-tension electric currents occurs either by direct contact or by indirect results of arcing or flashover. The high- tension injuries are usually seen in linemen working on the grid systems and occasionally in thieves stealing wires from high- voltage overhead lines. With extremely high voltages, there may be actual arcing of the current over several centimetres, with- out occurring actual contact. The man may be hurled (knocked down) from the vicinity due to sudden and appreciable increase in the local atmospheric pressure and sustain secondary non- electrical trauma. An interesting case has been cited by Polson and Gee of a man who climbed a pylon with the intention of committing suicide, suffered a short circuit and flashover and consequently was knocked down with cloths catching fire. He fell to the ground and died of multiple injuries (secondary trauma) as well as burns due to clothing catching fire. Electricity played only indirect role (Leeds City Coroner, No. 432/37).

Actual charring of the tissues with carbonisation is common but depending upon the degree, there may be:

- Brownish discolouration of the large areas of the skin apart from actual burning.
- Arborescent pattern resembling lightning burns.
- Crocodile skin effect comprising of confluent multiple spark burns over large areas of the skin.

INTERNAL FINDINGS

Gross findings in the internal organs may be absent because the tissues are mainly aqueous and contain electrolytes thus providing a diffuse pathway for the passage of the current and preventing any thermal damage. Mostly the death is due to car- diac arrhythmias leading to ventricular fibrillation and arrest. In such cases, findings in the internal tissues are negligible except for external skin marks.

- In the event of death due to tetanic asphyxia, cyanosis of the face, petechial haemorrhages in the skin of face and beneath the pleura and epicardium may be seen. There may be congestion of viscera and oedema of lungs, etc.

- In the event of the brain in the route of the current, some macroscopic and microscopic changes may be noticed as described earlier.

CIRCUMSTANCES OF ELECTROCUTION

Deaths due to electrocution need to be thoroughly investigated and documented for reasons of compensation and for institut- ing future measures in relation to safety and prevention. A worker who drops dead while working on some electric line should be suspected to have died of electrocution. Close attention must be paid to the hands and the mouth as these are the usual involved sites. Blood and viscera should be analysed to assess whether the victim was impaired at the time of accident. Secondary injuries due to fall or 'knock down' need to be described in detail. The allegedly defective appliance should also be got examined by the investigating officer from some competent expert. The investi- gating officer must prepare a detailed report of the scene along with sketches and photographs. Clothing of the victim should also be described and preserved properly.

ACCIDENTAL ELECTROCUTION

Majority of the fatalities usually result from the accidental contact with the low voltage currents (normally 220–240 volts). Accident may occur from a faulty line, while working on an electric cooking heater, room heater or inside the bathroom from a heating electric coil that, if defective, may charge the water in the bath tub or bucket with electricity. Accidents may occur while repairing high-tensions overhead wire connections. It may occur due to short circuit in temporary wiring in a tent.

Accidental ventricular fibrillation has been recorded in cases of intracardiac catheterisation and from the site of pacemaker. Accidents may also be seen with the use of electric blankets, and the hazards created by these blankets may include electric shock, burns as well as fire. When out of use, the blankets should be stored flat to prevent damage to the wiring by folding. Accidents due to contact with high-voltage supplies are usually seen in industries. Outside the industry, it may be encountered when an individual disregards warning signs or ignores the presence of high-voltage cables while moving some ladder or otherwise engaged in some activity in the vicinity of such cables or systems.

The danger of flying kites in the vicinity of overhead electric supply lines has been reported. While flying a kite with the ordi- nary string, a boy happened to touch a live electric wire with his kite, and was burnt badly and rendered unconscious. He suc- cumbed eventually to his injuries. On the day of the occurrence, the ground was wet with rain and the string moistened by con- tact with it. Indirect contact with high voltage was also reported when a boy urinated on an electrified rail, the current travelled upwards through the urinary stream. .ure 10.3 represent a case of accidental electrocution of two children.

SUICIDAL ELECTROCUTION

Electrocution is an infrequent mode of suicide. The victim usually winds wire round the wrists or other parts of the body, makes their connection with the wall socket and switches it on. Normally, the apparatus is found in situation when the body is examined at the scene. A case was reported in the Times of India (14th April, 1962), narrating suicide by a college lecturer by wrapping his wrists with naked wires and connecting them to the electric plug.

HOMICIDAL ELECTROCUTION

Homicide by electrocution, though extremely rare, is not unknown. In R vs. Whybrow, Chelmsford Assizes case (1951), the husband connected the soap dish in the bathroom used by his wife to a source of electric current in such a manner that while operating the switch in his bedroom, he could cause his wife to receive shock whenever she happened to touch the soap dish. The wife received shocks during baths and eventu- ally called for the electrician, who was able to locate the design. The husband was convicted for attempted murder by electro- cution and sentenced to 10 years imprisonment.

Erection of electrified wires to protect property or to attach a live wire to door knobs, gates, railings, etc. to prevent theft and burglary may cause death of the intruder. At times, the victim may be murdered by other means and a case of electrocution by producing electric burns on the fingers may be presented.

IATROGENIC ELECTROCUTION

Accidents have occurred in the course of investigations or treatment of patients with electrical equipment. Such iatro- genic electrocutions have occurred in the course of electrocon- vulsive therapy. Electrical hazards are increasing in the intensive care units, operating theatre, X-ray room or during direct elec- trical connection to the heart, e.g. when cardiac catheters are used for pressure monitoring, injection of radiographic con- trast media or passage of pacemaker electrodes. Since there is always a risk, the electrical instruments should be of safe design and regularly serviced to keep them in good working order. It is worth mentioning that micro-ampere electrocution and nat- ural death cannot be distinguished at autopsy. In cardiac defi- brillation, though the current flow is enormous, it is for such a brief period that it stops the fibrillating heart. The discharge must be delivered at an appropriate time during the cardiac cycle to prevent induction of fibrillation or standstill.

JUDICIAL ELECTROCUTION

In some of the states in USA, the death sentence is carried out in an electric chair. The condemned person is strapped to a wooden chair and a metal electrode is placed over his shaved scalp and the other metal electrode around one leg. An alterna- tive current of 1700 volts and 7.5 amperes is passed through the body for a minute or two. The current is passed through the body a second time and repeated till life is extinct. In such deaths by electrocution, it is recorded that the brain is heated up to 60° C and that vacuolation around the vessels occurs.

Lightning

Although deaths from lightning are quite rare, yet their effects are so capricious and unpredic. that they demand recogni- tion by a medicolegal expert.

MECHANISM OF INJURY BY LIGHTNING

As already described under Electrocution, it was Benjamin Franklin (1706–1790) who discovered that lightning flashes were electrical discharges and not gaseous explosions. In light- ning, the discharge may be from cloud to cloud or from cloud to the earth through some object, usually the tallest object in contact with the earth. Lightning chooses the easiest path (not the shortest), i.e. the path of least electrical resistance. It liber- ates terrific amount of energy. The electric current is direct, of about 20,000 amperes and about a million volts operating over an average period of 30 microseconds. The effects of lightning are due to:

- Passage of very high potential electricity that liberates tre- mendous energy in the form of heat, responsible for pro- ducing various burns that are usually superficial owing to the very short duration of the flash.
- Blast effects of the rapidly expanding air that may tear the clothing and impart suspicion of foul play.

The burns produced by lightning may be studied under the following groups:

- Surface burns, which are tissue burns and usually travel through metallic objects worn or carried by the victim. Even metals with very high melting points, such as gold (melting point over 1000° C), may volatilise and the metal object becomes molten or heated up producing surface burns of varying depth and intensity. Metallic articles like wrist watches, bracelets, metal hooks or zip and so on may be the source of attraction for the lightning discharge. Some melted metal may be implanted into the skin, produc- ing distinctive colouring.
- Linear burns may be found where the area of the skin offers lesser resistance, i.e. moist creases and folds of the skin.
- Arborescent or filigree burns or feathering, which usually appears like that of the branches of a tree or the fronds of a fern, is due

to rupture of smaller blood vessels mark may also be present at the point of discharge from the body to the earth. This may be more intense than the skin markings between it and the point of entry or it may appear as a deep burn.

BLAST EFFECTS

They may be observed in the form of tearing of clothing or shoes or the effects may also be observed on the trees showing areas of scorched leaves and vegetation in the vicinity of the scene of death. Metallic objects in the area may get fused or become magnetised. Nylon underclothing may melt. Objects at a distance of 100 feet or more may be struck. A dramatic exam- ple was reported by Skan from Africa. He was struck by light- ning inside his hut and the injuries included tearing away of left shoulder, a large hole in the left side of the neck and fractures of the skull and left humerus (Skan DA. Br Med J 1949;i:666). Mant described an interesting case of a girl riding a horse, who was killed by lightning that struck her through a metal stud on the top of her hat and travelled through her body, melting her nylon panties and tearing her jodhpuris. (Mant AK. 1968. In: Gradwohl's Legal Medicine, 2nd ed., Bristol: John Wright.)

DIAGNOSIS OF DEATH BY LIGHTNING STROKE

As doubts may be raised of foul play because of bizarre extent and distribution of injuries and torn clothing, the diagnosis of death may be achieved by carefully considering the following:

- History of thunderstorm in the locality.
- Evidence of the effects of lightning in the vicinity of the scene of death, i.e. damage to the houses or trees or the animals, fusion or magnetisation of metallic substances in the nearby place, etc.
- Bursting open of the clothing is characteristic and the tears may be scorched and impart smell of singeing. Boots and belt can also burst open.
- Characteristic nature and distribution of burns, which are usually superficial due to very brief duration of flash.

- Sudden death may be attributed to the direct involvement of the central nervous system causing death from paralysis of cardiac and/or respiratory centre. High-voltage electric current may cause spasmodic contraction of the cerebral vessels leading to cerebral anaemia, which in turn may be responsible for stoppage of respiration and circulation. However, contraction of the heart muscle may also be due to direct effect of current on the heart. In such cases, no specific findings are to be expected and the diagnosis may rest upon the factors enumerated above.

CIRCUMSTANCES OF LIGHTNING STROKE

Ordinarily, lightning deaths do not pose any problem except in occasional cases when the dead body may be recovered from the open with no marks upon it, but usually the history and evaluation of the scene of death resolves the issue. Lightning tends to pass along the surface of the conductor rather than through it, so that the persons in the building are rarely affected, if the building is struck. Occasionally, persons in the building may be affected when the lightning strikes a chimney or televi- sion aerial and passes down through a living room.

Most fatalities occur in open. Persons sheltering under trees in the thunderstorm make up quite a percentage of the victims. Others may be struck in the open fields, particularly if they are carrying or wearing something that may attract lightning.

Spencer explained the apparent immunity of motor vehicles from the lightning stroke. He opined that it might be due to the insulation provided by the tyres. A car, however, may be indirectly struck by a 'splash' from some other object nearby. According to Dr. AS Curry, this immunity of motor vehicles may be due to the fact that it behaves like an empty metal box having no circuit within it. Immunity may be lost as and when some portion (a fist or hand, etc.) is put outside the vehicle.

Once again, it may be projected that the effects of lightning are extremely bizarre and unpredic.. Imagine two persons standing side by side during a stroke. One may be struck and killed, whereas the other remains unharmed. An example, as cited in Gradwohl's Legal Medicine, is quite instructive:

Two persons with unfurled umbrellas were walking together across a field during a thunderstorm. One was struck through the umbrella he was holding. The charge passed down the umbrella and entered his body through the right side of his head and the right lower chest and abdomen, and was earthed through both legs. His umbrella disintegrated, his clothes were torn into small pieces, and the shoes also disintegrated along the soles. He died in hospital the next day from coronary thrombosis and rupture of a gangrenous caecum due to local thrombosis. His companion was uninjured.

Converse may also be true, i.e. when two or more persons are close together during a thunderstorm, all or several of them may be killed or severely injured although only one of them suffers a direct stroke. For example, 23 climbers in the age group of 20–25 years were caught in a thunderstorm while climbing up a step mountain in Japan. Only one of them was struck but all were killed (Goldie and Lee, 1976).

CHAPTER-12

CUSTODY RELATED TORTURE AND/OR DEATH

TORTURE

Since time immemorial man has been attempting to subjugate his fellow humanTorture. The word 'custody' has been derived from Latin 'custos odis' meaning guardian. Black's Law Dictionary describes it as 'the care and control of ownership'/'responsibility for protection and preservation of the thing/person in custody', etc. 'Police custody' does not necessarily mean formal arrest. It also includes some form of police surveillance and restriction on the movements of the person(s). 'Police detention', however, requires that person has been formally arrested and detained. The word 'arrest' when used in the ordinary and natural sense implies the apprehension or restraint or the deprivation of one's personal liberty. When used in the legal sense in the procedure connected with the criminal offences, an arrest consists in taking into custody of another person under authority empowered by law, for the purpose of holding or detaining him to answer a criminal charge or of preventing the commission of a criminal offence. 'Detention' does not mean 'imprisonment'. The word 'imprisonment' is always used in the sense of punishing a person, whereas 'detention' does not denote any punishment.

Medical profession and human rights are intricately woven in the sense that the doctors can alleviate violations of human rights being among the first to become aware of these violations, particularly in the field of 'Torture'. The definition of 'torture' as we use today is the definition from the UN Convention against Torture and other Cruel, Inhuman or Degrading Treatment or Punishment of December 10, 1984, which entered into force in June, 1987. As per this Convention, torture is defined as "Any act by which severe pain or suffering, whether physical or mental, is intentionally inflicted on a person for such purposes as obtaining from him or third person information or a confession, punishing him for an act he or a third person has committed or is suspected of having committed, or intimidating or coercing him or a third person, or for any reason based on discrimination of any kind, when such pain or suffering is inflicted by or at the instigation of or with the consent or acquiescence of a public official or other person acting in an official capacity. It does not include pain or suffering arising from, inherent in or incidental to lawful sanctions".

METHODS OF TORTURE

From didactic point of view, torture methods have been divided into physical, psychological and sexual. Physical methods of torture challenge any possible classification because of increasing number and variety of methods. Most of the time, torture is selectively tailored to the characteristics of the victims. Despite the fact that there seems to be ongoing research into refining torture methods so as to leave little or no trace of injury, many of the methods used are simple (Thomson et al., 1984).

PHYSICAL TORTURE

The methods for physical torture are those that inflict pain, discomfort and dysfunction in different parts of the body. The torturer also takes care that the torture inflicted upon the vic- tim remains undetected by an ordinary examination. However, despite all precautions, physical torture almost always leaves a trail that eventually leads to its discovery. Methods may include the following.

BEATING AND SEVERE BEATING

Beating with a variety of objects is very common and will result in usual signs, i.e. bruising, abrasions and/or lacerations. Particular weapons/objects may leave particular pattern, for example, a blow/strike from a rod or thong will commonly result in parallel tramline bruises. Where the skin gets lacerated, the scar left will provide evidence of the site of injury. Susceptible persons may develop keloid scarring. The sites of beating are again variable. Blows to the head, back, buttocks, perineum and soles of feet (falanga) are favourite sites for beat- ing. Weapons/objects employed may include sticks, whips, cables, chains, belts, or other instruments. Similarly, punching with fists and kicking, etc. are also employed for beating. Simple beating means slapping on less sensitive and less delicate parts of the body that does not cause significant external and inter- nal damage. (Baton is a short thin stick used by the conductor of a band to direct an orchestra. In athletes, it implies a short stick carried and handed on in a relay race. In relation to police, it implies a short stick that indicates a certain rank and being used to drive a crowd back.) Poking the victim with a baton, rod or any other similar object is common. Any part of the body may be poked. The police personnel using baton must be aware of the relationship between the choice of target and the extent of injury that may be produced from the amount of force going to be applied.

FALANGA

Severe beating on the soles of the feet is known as falanga. It is one of the most common types of systematic torture used in many countries around the world. Presence of thick skin and dense fascia at this site prevents appearance of any appreciable surface injuries even though deep tenderness may be long lasting after the initial pain and swelling have subsided. Other kinds of systematic beating can be beating on both ears, beating on previous fracture sites or punches in the stomach,

e.g. on pregnant women to provoke miscarriage.

EAR TORTURE

The victim's ear may be twisted or pulled to such an extent that the external ear gets torn. One victim may be asked to torture another in this way. Producing impairment in hearing by beat- ing both ears simultaneously may also be used, which is known as telephono. This may lead to rupture of tympanic mem- brane causing extreme pain, bleeding or hearing loss.

FINGER TORTURE

Pencil or a similar object is put in between two fingers, which are then pressed hard together against the objects. Similarly, fingers may be twisted to cause severe pain.

HAIR TORTURE

The victim is dragged by the hair. The hair may be cut short or the head shaven altogether. Hair may also be pulled out forcibly.

SUSPENSION

The victim is suspended by legs or arms or by hair. Suspension is usually combined with other forms of torture like severe beating, electric shock, falanga, heat or cold torture, etc. (hang- ing from the feet or ankles while using a rod as the suspending platform is more universal than the 'Parrots perch', a type of hanging that is more frequent in Brazil and Ethiopia).

FORCED POSITION

The victim may be forced to remain in an abnormal or strained position for hours together and may also be exposed to kicks, blows, etc. In some cases, the victim may be tied down in many ways and then kept in this position for several hours. He may be suspended in this position and also beaten.

ELECTRIC TORTURE

This is excruciatingly painful and is commonly used because it leaves little permanent signs. The points of contact of elec- trodes may leave small lesions in varying stage of healing or scar marks but in general, the residual effects of electricity are almost undetec. in the living. If death occurs during or shortly after electric current, careful histological examination of the sites of electrocution can be helpful in determining the recent electrical injuries.

The electrodes are placed on the most sensitive areas of the body like ears, tongue, gums, fingertips, toes, genitals and nip- ples. It may be applied inside the mouth, which is quite painful and difficult to detect later. Sometimes the victim is soaked with water before applying the electricity so that the magnitude of the shock is greatly enhanced and production of burn being prevented.

SUFFOCATION

It is known especially in the form of wet submarine. The head of the victim is forced under water polluted with excrement, urine, vomit or blood. The head is forced below the surface until the stage of suffocation, or until the physical reflexes cause aspiration of the contaminated fluid (autopsies of the victims who have died following this type of torture have reportedly shown faeces in the lungs). In dry submarine, the victim's head and face are tightly covered with plastic bag or similar article. The victim may also be suffocated by the closing of his mouth and nose with some object or even with bare hands once the victim is tied down in such a way that he cannot exercise resist ance.

BURNING OR HEAT TORTURE

Burns may be inflicted from anything that will either burn or can be heated, for example, cigarette stubs, cigarette lighters, hot irons, branding irons or molten rubber. The residual lesions will depend upon the site and severity of the burns. Cigarette burn is the most common type of heat torture reported. Sometimes, the victims may be forced to stand for hours in the sun in an atmospheric temperature of more than 30° C. He/ she may also be forced to work hard under the scorching heat. Burns can also be caused by acid and caustic materials, the favourite being sulphuric acid in the form of 'battery fluid'. The fluid nature of the agent can often be understandable by the presence of the typical trickle marks. Scarring will depend upon the depth of the lesion.

COLD TORTURE

The victim is subjected to varying degree of cold in different ways. He may be forced to sleep on a damp floor, may be forced to stay naked in extremely cold weather.

PSYCHOLOGICAL TORTURE

This type of torture may include several categories, which are as follows.

Deprivation Techniques

Victims are deprived of various necessities so that they are mentally tortured. These techniques may include sensory deprivation, where the victim is deprived of various sensory stimuli such as light, sound, etc. The victim may be blindfolded, are deprived of seeing visitors or confined to an isolated cell. Deprivation of basic needs, where victims are deprived of basic needs like food, water, medical facilities, clothes, com- forts, communication, etc.

WITNESS TORTURE

The victims are forced to witness the torture of another pris- oner or of family members. In the words of Salvadorian torture survivor, "what happened to me is nothing compared to being forced to witness the torturing to death of other comrades".

THREATS AND HUMILIATION

The torturer may perform humiliating acts such as urinating upon victim. Conversely, victim may be forced to perform humiliating acts. It is obvious that humiliation is an important part of sexual torture. Sometimes, the victims are threatened with death. These threats are extended to their family and occa- sionally they experience sham executions. (In this procedure, the perpetrators blindfold the victim and place him before a wall. The victim is told that a vehicle is going to run over him/ her and that he/she is going to die. The victim then hears an engine starting and coming towards him/her at full speed. However, as it gets really close to the victim it screeches to a halt.)

PHARMACOLOGICAL TECHNIQUES

Various drugs may be used to torture the victim, to facilitate tor- ture, to mask the effects of torture and also as a means of tor- ture, for example, use of drugs to induce self-disclosure, use of muscle relaxants, pain-inducing drugs or psycho-pharmacological drugs, etc.

Thomson et al. (1984) cite direct fatal poisoning in a Middle Eastern Country where political prisoners were given a drink of orange juice before their release. It was later found to have contained thallium.

SEXUAL TORTURE

Most investigators, lately, have defined sexual torture as follows:

- Violence against sexual organs such as electric torture in genital areas, the introduction of foreign bodies into the genitalia or rectum.
- Physical sexual assault, such as rape by torturer or other victims, forced masturbation, fellatio and oral coitus.
- Mental sexual assault, such as forced nakedness, sexual humiliation, sexual threats and forced witness of sexual torture.
- Any mixture of these hooded, kept in a dark room, etc. Perceptual deprivation, where victims are deprived of perceptions so that they become disoriented and confused, for example, frequent transfer of victim from one place to another while blindfolded, frequent disturbance of sleep, etc. Social deprivation, where victims

Deaths in custody may take place due to varied reasons, which may include inadequate medical facilities, inadequate safety measures of inmates and negligent behaviour of the prison authorities. However, cases of custodial violence/torture are also being reported and thereby focussing public concern.

A retrospective study of 277 deaths over the 6-year period (January 1990–December 1996) was conducted by Police Research Group (PRG) in England and Wales. This paper cat- egorised deaths into three groups:

(i) 63% were due to deceased's own causal actions, i.e. deliber- ate self-harm and substance misuse comprising of 17 delib- erate overdoses before arrest and 73 self-hangings;

(ii) 29% due to medical conditions (the most common five causes of death were—heart problems, head injury, lung problems, epilepsy and liver problems); and

(iii) 8% deaths were such in which another person's actions might have been associated (including police restraint).

Authors concluded that detention perhaps had little bearing on the death, and drew attention to the need for careful con- sideration of the term 'custody death'.

DEATHS RESULTING DURING CONFRONTATION WITH POLICE

According to Bittner, the central thread that runs through the police work is that it frequently consists of coping with prob- lems in which force may have to be used. However, police need to be aware of the difference between reasonable force and lethal force. Situations like deaths in police confrontation may be considered pari passu with custody deaths, though techni- cally such deaths may not have occurred in police custody. The use of 'batons' is frequent and has occasionally been impli- cated in causing fatal head injury as occurred in case of death of a school teacher in London in 1979 (R vs. HM Coroner at Hammersmith, ex parte Peach [1980] QB 211). Suicides have also been reported to occur in association with confrontations with police. Haruff et al. (1994) found 14 such cases from 1984 to 1992 in Marion County, Indiana. All were male, with a peak age between 30 and 34 years.

DEATHS FROM PHYSICAL RESTRAINT

Deaths occurring from physical restraints constitute an important controversial sphere in the investigation of custodial deaths. Restraining someone may become necessary in certain circumstances, especially when dealing with a noncompliant or violent person. Methods of restraint may be varied and at one occa- sion, more than one method may be employed. Methods may include hand cuffing, arm restraint, neck holds, carotid sleeper, etc. [Neck hold is designed to occlude the airways by forearm compression of the front of the neck. Resistance by the victim may worsen the situation in the sense that he/she may contrib- ute to increasing the force on the neck. Carotid sleeper is designed to occlude common carotid arteries by compression and producing transient cerebral ischaemia leading to loss of consciousness. The hold is released when the person has been incapacitated and usually complete recovery ensues. Reay and Holloway (1982) assessed the carotid blood flow during com- pression of neck using ultrasonic and laser Doppler blood flow monitoring devices. They observed that blood flow to head decreased by 85% under the neck hold and reached its lowest point in 6 seconds. Because of their relatively protected posi- tions, vertebral arteries continue supplying blood to the brain. However, the vertebral arterial supply cannot completely com- pensate for the occluded carotid blood flow and therefore, cerebral ischaemia is the usual result. Another pathway for the ill effects may be through the bradycardia produced due to stimulation of carotid sinus. Such holds, now-a-days, are severely restricted rather banned.]

DEATHS FROM CHEMICAL RESTRAINT

This may include substances used for immobilisation or drug administration. Irritant spray devices like chloroacetophe- none (CN), orthochlorobenzalmalononitrile (CS), oleoresin capsicum (OC), etc. have been used for such purposes. The increasing use of OC in the United States has been associated with a rise in the number of deaths in custody—from 1 death in 1990 to 26 in 1993—following its use (Granfield et al., 1994). OC is a crude extract of hot peppers. On application to ocular membranes, it causes stinging, lacrimation and blepharospasm, which may vary from involuntary blinking to sustained eye closure. Capsaicin in aerosol causes tingling, coughing and shortness of breath to a varying degree. Immediate decontamination with soap and water (intact skin) or saline (vesiculated skin and eyes) followed by symptomatic measures are usually successful in bringing back visual acuity and nasal breathing in a few minutes.

'Chemical mace agents' like CN and CS have also been in use. [These chemicals, the so-called 'lacrimators', used to be employed for temporarily incapacitating/immobilising the enemy or the public. They were popularly known as 'riot con- trol agents'. The eye damage is complicated by the method of delivery of these agents. The two most common modes/forms of delivery were the pencil-like tear gas gun and the aerosol can, used by law enforcement agencies in the United States under the trade name Mace.]

A couple of cases are being cited below to make the readers apprise of intricacies of the issues related to such deaths.

CASE: DEATH OF A SUSPECT RESULTING FROM INJURIES RECEIVED WHILE BEING CHASED BY THE POLICE

On receiving a tip, police party assumed postures nearby a place where some hardcore miscreants were to visit. Seeing the suspects coming on the motorcycle, police tried to chase them and in the process had to open fire. However, it missed the target and the suspects managed to make their way through narrow lanes. Instinctively, the suspect driving the motorcycle momentarily turned his head back to gauze distance of the police and in the process, motorcycle struck against an electric pole. The suspect received head injury and the handle of the motorcycle significant dents. Both suspects were caught by the police and put under custody. During night, the one who had received head injury complained of severe headache and requested the police to take him to the hospital. However, the police ignored his request thinking it to be malingering as there was minimal external evidence of injury. Consequently, the suspect died in the custody and the happiness of being successful for an 'important catch' turned into feelings of apprehension. Postmortem examination showed a large longitudinally run- ning basal fracture with accumulation of blood. Insignificant injuries were present on the external surface. This coupled with circumstantial evidence and the account offered by the accom- panying suspect led to resolution of various controversies.

Though the mode of injury and its effects may be obvious, various scenarios/situations may be put before the doctor for consideration at a later inquiry and the queries as to the follow- ing must cross the mind of the doctor in order to have a com- prehensive approach to the problem:

- How the fracture of skull occurred? Is the version compatible with the nature and extent of injury or the injuries?
- Was it prior to detention, which was ignored and no measures taken to provide treatment?

contents of stomach, intestines, liver, spleen, and kidney. Histologically, lungs showed acute pulmonary oedema and pulmonary haemorrhages with emphysema. Kidneys showed ischaemic acute tubular necrosis. Mesentery showed haemorrhagic enteropathy with changes of peritonitis and fat necrosis (injury to the mesentery may damage local arteries without causing severe bleeding, but may occlude or thrombose them; with infarction of the bowel as a consequence). It is understandable that kicking, stamping, and punching, etc. in the abdomen can lead to serious and intrac. bleeding. The victim may not seek immediate help/surgical intervention as the condition may remain unrecognised, especially when the victim is intoxicated. Further, trauma to the upper abdomen can precipitate 'acute pancreatitis' (probably through contu- sion of the acinar tissue and disruption of the duct system with the subsequent interstitial leakage of enzymes).

Bernard Knight reported a case of a man, who was forcibly restrained by the police (allegedly after an assault during which he, probably, had been struck in the abdomen). Owing to drunkenness, little did he realise his condition and remained for a few hours in the police cell. He collapsed while going to the lavatory, never having complained of any abdominal pain. Autopsy revealed several litres of blood in the peritoneal cavity occasioned through the several tears in the mesentery.

- Any consideration of accidental head injury within the cell itself ?
- Is it possible that the detainee has been injured by the police, prison wardens, etc.?
- Any consideration that the detainee has been injured by another prisoner/inmate?
- Queries as to the adequacy of care extended to the detainee who had been found dead in the cell?

Role of Autopsy Surgeon

Persons held in custody by police or by prison authorities retain their basic constitutional rights, except for their right to liberty and a qualified right to privacy. The occurrence of such deaths arouses public interest and raises volatile emotions amongst family and friends of the deceased, media and politicians; there- fore, such deaths require effective handling and investigation. There is often an immediate complaint or rumour by the rela- tives or media about the ill-treatment shown by law enforcing agencies. The assessment towards accidental, suicidal, homi- cidal or 'purely natural' nature of death is based on meticulous autopsy coupled with thorough investigation of surrounding circumstances leading to death. This may invite the experience and skill of various investigators whose efforts become com- plementary in providing some satisfactory conclusion needed to dispel or sometimes confirm allegations that an act of com- mission or omission on the part of custodians has led to or contributed to the death. In such cases, it is desirable that at the time of autopsy, interested parties such as relatives or their rep- resentative and the police/prison authorities be properly heard. To carry out another autopsy at a later date may not be free from hazards because the organs would have already been dis- sected and samples obtained, wherever necessary. Further, with the passage of time elapsing death, bruises undergo changes including varied degree of spreading and coalescing with surrounding injuries. There may, however, be occasion(s) when no clear answer can be approached despite exhaustive exercises.

Incisions at autopsy deserve special mention. Physical methods of torture challenge any possible classification and most of the time, torture is selectively tailored to the characteristics of the victims. This calls for meticulous scrutiny of front as well as back of the body. In addition to the usual Y-shaped front incision, backside of the body also needs be scrutinised especially against regions of shoulders, buttocks, back of thighs and calf muscles, etc. shows the necessity for incisions on the front as well as back of the body).

Critically examining the body from front as well as back pays dividends, especially when there is a suspicion of crush injuries (probably produced through moving a roller upon selected areas or through other means). In such a case, there may be consider- able bruising and crushing of the muscles including soft parts with minimal evidence of surface findings (CR vs. Hopeley, under the Chapter "Complications of Trauma"). This was typically observed in a case wherein the victim (about 38-years male) had been apprehended under the Arms Act and died while under custody. At autopsy (conducted by a board of doctors led by Dr. Dalbir Singh, Head of Forensic Medicine at PGIMER, Chandigarh), apart from gross discoloration of skin surface (bluish-black, reddish at places) no trauma was appreciable. However, on exploration, reddish black blood was present in the soft tissues and muscles of the whole of front and inner back of thighs and back of right leg. Chemical examination revealed nega- tive results. Serum myoglobin was estimated to be 108 ɜg/L (normal ⊠85 ⊠g/L). Histopathology revealed massive necrosis of skeletal muscles (from different sites). Skin tissue (from different sites) showed necrosis and inflammation. Lung showed acute pulmonary edema, and kidney showed acute tubular necrosis. Death was attributed to "acute renal failure due to myoglobinuria caused by blunt force trauma to the lower limb muscles".

CHAPTER-13

INJURIES : MEDICO LEGAL CONSIDERATIONS AND TYPES

INJURIES: MEDICOLEGAL CONSIDERATIONS AND TYPES

A wound may be defined as 'Solution of the natural continuity of any of the tissues of the living body'. The injury may be visible externally but not essential, as fatal internal injuries may be inflicted in the absence of any external mark of violence. The definition includes burns from fire/heat, electricity, all lac- erations and bruises of internal organs/tissues and the effects of any corrosive or solid upon the body. It also prevents any possible criticism about the skin being or not being severed. The definition also does not make any reference as to how or by what means it is produced and therefore is simple and gen- eralised one. The word 'trauma', as generally understood, means an insult to the living tissue. It applies as well to emo- tional or mental stress. The term 'injury', under Section 44 of IPC, denotes any harm whatever illegally caused to any person, injury but also in missile injuries and stab wounds, etc. Furthermore, the area over which the force acts, forms another important factor, i.e. the damage to the tissues will be far greater if the narrow edge of the brick is applied than if the impact is from the flat surface. (Weapon: The variety of articles that may be put to use as weapons is, of course, without limit. It may be described as any article made or adapted for use for causing injury to the person or intended by the person having it with him, for such use by him. Sections 324 and 326 of IPC describe a dangerous weapon as any instrument used for shooting, stabbing or cutting or for offence and likely to cause death.)

The characters of an injury caused by some mechanical force are dependent upon:

- The nature and shape of the weapon.
- The amount of energy in the weapon or instrument when it strikes the body.
- Whether inflicted on a moving or a fixed body.
- The nature of the tissues involved.
- The area over which the force acts.

The well-known formula—Force ⊠ ½M ⊠ V2—is applicable in producing the wounds, where M is the mass and V is the velocity of the object/weapon. It is clear from the formula that velocity is much more important than the weight of the weapon used. For example, a brick pressed against the skull may cause minor abrasions or contusions but the same brick when thrown against the head at some velocity may smash the skull. This principle holds good not only in relation to blunt. In cases of death by physical violence, there is always one major point to be determined—whether the injuries were inflicted before death (intra vitam) or after death (postmor- tem). Main points to determine antemortem/postmortem nature of the wound are:

- Haemorrhage (externally and into tissues).
- Retraction of the edges of the wound.
- Signs of inflammation or of repair.

HAEMORRHAGE

There is more or less copious haemorrhage in all the wounds inflicted during life except occasionally when the victim dies immediately from a fatal injury and shock. The effused blood is forced into the tissues in the vicinity of the wound and is found infiltrated into the cellular and muscular tissues. Consequently, staining of the edges of the wound and the neighbouring tis- sues occurs. In a wound inflicted after death, even when the body is still warm, these features are far less pronounced. It would be fair to say that the quantity of blood lost may assist in determining the antemortem or postmortem origin of wound.

When the body has been moved and all marks of blood effaced by some means or the other, rules of this kind may invite further scrutiny.

Another marker helping to assess antemortem/postmortem nature of blood may be the examination of the blood clot(s) at the scene. Antemortem bleeding causes coagulation,

Distinguishing Features of Antemortem and Postmortem Wounds

Features	Antemortem wounds	Postmortem wounds
Haemorrhage	Usually copious, showing signs of arterial spurting	Comparatively very small, may even be absent
Wound edges	Swollen, everted and retracted except those on the neck and scrotum	Not swollen or retracted but are apposed to each other unless inflicted within a couple of hours of death (when muscles remain still contractile)
Extravasated blood	Extravasated blood will extensively infiltrate in and around injured areas with staining of tissues, which will resist washing	No extravasation and infiltration of tissues, no staining of injured tissue (if at all present, will be easily washable)
Blood clot	Coagulated blood is noticed in and around injured tissues. The clot is laminated and firmly adherent to the lining endothelium	Blood is usually not clotted. The clot, if found, is nonlaminated and weakly adherent to the lining endothelium
	Clot is rubbery and firm. On being pulled out from the vessel, it will come out like a horse tail because of elasticity	Clot is soft and friable. On being pulled, will invariably break due to absence of elasticity
	The surface shows apparent lines of Zahn (these lines are formed by alternate layers of light staining aggregated platelets admixed with fibrin meshwork and dark staining layer of red cells)	The surface shows yellow (chicken fat) appearance occasioned through separation of plasma and leucocytes covering the underlying dark red cell constituents (currant jelly) because of sedimentation after death
	Microscopically: composed of fibrin, platelets and RBCs	Mainly composed of fibrin and RBCs

Vital reaction	Sings of inflammation and repair are demonstrable depending upon the age of the wound/injury (antemortem bruises show colour changes)	No signs of any form of inflammation or repair (postmortem bruises do not show colour changes)
Microscopy	Leucocytic emigration appreciable in the surrounding tissue as to the age (neutrophils dominating for the first 6–24 hours)	Vessels distended with postmortem clot without showing any cells outside the vessel wall
Enzyme histochemistry	(at about 2 hours) about 4 hours) Alkaline hours)	No enzyme activity
Wound biochemistry	Serotonin peak (within about 10 minutes) Free histamine peak (within about 20–30 minutes)	

Vitality of wounds in decomposing bodies and bodies recovered from water needs careful evaluation. In decomposing bodies, there will be associated colour and other changes in the tissues. Wounds need be explored to disclose evidence of infiltrated blood into the tissues that tends to persist. In the bodies recovered from water, the wounds (though inflicted during life) become pale and lose the expected red vital reaction because blood is gradually leached out of the wounds by the water over time, and the area will appear bloodless, making the differentiation difficult on the basis of surface appearance. Factors that could help differentiation of antemortem from postmortem wounds under such circumstances may include:

(i) haemorrhage around the wound track;

(ii) location, nature and pattern of wounds/injuries and

(iii) congruency/incongruency in light of other autopsy findings, scene findings, and terminal events.

when the blood partly solidifies after separation of serum. The clot can be taken out en masse from the spot and the area usu- ally retains the impression of fibrinous network due to process of clot formation. Postmortem solidification occurs without proper coagulative change; on removal from the spot, it does not leave the impression of fibrinous network. Furthermore, the blood that has effused during life can be separated into scales on drying, whereas the blood that has flowed after death tends to break into powder on drying.

Clotting of blood occurs normally in about 5–10 minutes; therefore, clots of blood will be found in the wounds and in the tissues and in the area adjacent to the body. However, bleeding in the pleural cavity because of rapid defibrination due to movement of the lungs does not usually show clotting. There has been some controversy about the conditions that lead to the fluidity of blood after death in certain cases. The observations obtained from in vitro and in mortuo investiga- tions (Mant, AK, 1953. In: Simpson, K, Ed. Modern Trends in Forensic Medicine, London, Butterworths) provide a summary in this context [see Livor Mortis (Postmortem Hypostasis) in Chapter 4 "Death and its Medicolegal Aspects (Forensic Thanatology)"].

Sign of spouting of blood is another important factor in

favour of antemortem process. The spouting may be present on the body, clothing or in the vicinity. But the spraying of blood by swinging a blood-covered weapon or splashing out of a wound by repeated blows, etc. should also be kept in mind. Christison's experiments lead to the conclusion that severe blows inflicted on a body recently dead produce no greater degree of ecchymosis or cutaneous discolouration than slight blows inflicted on the living.

RETRACTION OF WOUND EDGES

During life, healthy skin is slightly on the 'stretch' and so are the muscles in a condition of 'tone'. This causes the wounds to gape. But this elasticity does not cease at the moment of death and muscles also retain tone for sometime after death; there- fore, the skin wounds inflicted before or shortly after death will retract, though the degree of gaping may vary and be appreci- ated by an experienced doctor.

SIGNS OF INFLAMMATION OR OF REPAIR

There are signs of vital reaction and will depend upon the period of survivability of an individual after infliction of wound. If the vicinity of the wound shows swelling, extravasa- tion of lymph, blood or adhesion of edges, etc., it not only indicates that the wound was inflicted during life but also may give some indication as to the time of its infliction. If wound has become infected, pus may be seen after a period of about 36 hours. Once infection has supervened, healing may be delayed and it is often impossible to determine the age of the wound with any degree of accuracy.

WOUND HEALING

Questions regarding the age of the wound(s) may be raised under various circumstances so as to match the consistency or inconsistency in their sustaining/infliction as per account given by the victim/assailant. This can be assessed from the process of repair of the wound. In this context, it may be kept in mind that healing is not a distinct series of events but a concert of simultaneously occurring processes, some of which may continue for weeks or months after the physical integrity of the wounded tissue has been re-established. Some idea about the various changes and their timings can be obtained from the following description (here, I would like to describe briefly the healing of skin wounds, a process involving both epithelial regeneration and the formation of connective tissue scar).

HEALING BY FIRST INTENTION (PRIMARY UNION)

One of the simplest examples of wound repair is the healing of a clean surgical incision approximated by surgical sutures with a minimal loss of tissue and the repair occurring without significant bacterial contamination. As mentioned earlier, heal- ing starts very early when the process of inflammation sets in. This process has three major components: (i) alternations in the vascular calibre that leads to a focal increase in blood flow (vasodilatation), (ii) structural changes in the microvasculature that permit plasma proteins to leave the circulation and (iii) emigration of the leucocytes from the microcirculation and their accumulation in the focus of injury. These components account for the earliest 'Triple Response' following the injury, i.e. heat (calor), redness (rubor) and swelling (tumour). Various events may be summarised as under:

Fresh Bleeding may still be present or there may be fresh soft clot present at the site. Margins are swollen, red and tender.

By 12–24 hours Margins appear swollen and red. Blood clot and lymph dry up. Histologically, leucocytic infiltration is appreciable. The identity of the emigrating leuco- cytes varies depending on the nature of the inciting stimulus and also changes as the inflammatory site ages. In most forms of acute inflammation, neutrophils predominate for the first 6–24 hours and are followed by mono- cytes in the subsequent 24–48 hours. In addition, neutrophils are rather short-lived, undergoing apoptosis within 24–48 hours after exiting the blood stream, while monocytes survive substantially longer and may persist for long periods as tissue mac- rophages. (Fateh A, 1966, noted poly- morphonuclear infiltration after only 8 hours of injury in his studies on the human skin wounds.)

By 24–48 hours Epithelial cells from both edges migrate and proliferate along the dermis, meet- ing in the midline beneath the surface scab, yielding a continuous but thin epithelial layer. Dominance of mono- cytes during this period is also exhibited as mentioned above.

By 2–3 days Neutrophils have largely been replaced by macrophages and granu- lation tissue invades the incisional space. (The granulation tissue is an immature highly vascular connective tissue that on gross examination appears granular, hence the name.) Collagen fibres are now evident in the margins of the incision but at first, these are vertically oriented and do not bridge the incision. Epithelial cell proliferation continues, yielding a thickened epidermal covering layer.

By 4–5 days Neovascularisation reaches its peak as the granulation tissue fills the inci- sional space. Collagen fibres become more abundant and begin to bridge the incisional gap.

By about a week Epidermis recovers its normal thick- ness and differentiation of surface cells yields a mature epidermal archi- tecture. A soft, reddish scar is left.

HEALING BY SECOND INTENTION (SECONDARY UNION)

When cell or tissue loss is more extensive, as in inflammatory ulceration, abscess formation, or even large wounds, the repar- ative process is more complex. In these situations, regeneration of parenchymal cells alone cannot restore the original architec- ture. As a result, there is extensive ingrowth of granulation tis- sue from the wound margin, followed in time by accumulation of extra collagen material (ECM) and scarring. This form of healing is referred to as secondary union or healing by second intention.

Secondary healing differs from primary healing in several respects:

- Large tissue defects intrinsically have a greater volume of necrotic debris, exudate, and fibrin that must be removed. Consequently, the inflammatory reaction is more intense with greater potential for secondary inflammation- mediated injury.

- Much larger amounts of granulation tissue are formed. Larger defects accrue a greater volume of granulation tissue to fill in the gaps in the stromal architecture and provide the underlying framework for regrowth of tissue epithelium. A greater volume of granulation tissue generally results in a greater mass of scar tissue.

HEALING OF A FRACTURE

Fracture is a complete or incomplete break in the continuity of a bone. Although there is a distinct history of trauma in most of the fractures, cases of fatigue fracture and of pathological fracture may not show such history. In case of malicious inju- ries, an accurate account of any incident may be deliberately withheld. A fracture is no more than a wound of bone and as such is subject to the same principles of healing that are appli- cable to all tissues. It is, therefore, evident that an orthopaedi- cian dealing with fractures needs first be a physiologist and a clinician, and then only carpenter and an engineer.

Diagnosis of Fracture

The presence of fracture can nearly always be inferred from the history and clinical examination. However, clinical evidence must always be confirmed or refuted by radiological examina- tion. Some fairly constant signs of fracture that should arouse suspicion include the following:

- Local swelling
- Local tenderness
- Visible or palpable deformity
- Impairment of function

A couple of more cardinal signs are following:

- Abnormal mobility between the fragments
- Crepitus or grating when the injured part is moved.

Depending upon the communication of a fracture with the environment, it may be a closed fracture wherein the skin remains intact, protecting the fracture from the external environment or an open fracture wherein the skin over the fracture site is disrupted, and the fracture fragments are open to the external environment with every chance for contamination.

STAGES OF HEALING

Healing of a fracture proceeds through a number of overlapping stages until the bone is consolidated. It may be kept in mind that the pattern of healing is not constant for all bones and in all circumstances. The repair of a tubular bone shows striking differences from the repair of a cancellous bone. For the purpose of simplicity, process of healing in a tubular Muscle

This mass of callus or woven bone is visible in radiography and imparts the earliest radiological indication of a uniting fracture.

STAGE OF CONSOLIDATION

The woven bone that forms the primary callus (soft callus) is gradually transformed by the activity of osteoblasts into more mature bone (hard callus).

STAGE OF REMODELLING

Newly formed bone often forms a bulbous collar surrounding the bone and obliterates the medullary canal. The size of this bulbous mass varies depending upon factors like extent of hae- matoma and displacement of fragments. The bone is gradually strengthened along the lines of stress at the expense of surplus bone outside the lines of stress. This is called 'remodelling'. In children, remodelling after fracture is usually so perfect that the site of fracture may become indistinguishable in the radio- graphs. However, in adults, remodelling usually falls short of this perfection, and the site of fracture is usually permanently marked by an area of thickness.

HAS A BONE EVER BEEN FRA CTURED?

Fractures have many important bearings in relation to medical jurisprudence. They may result from falls, blunt or sharp impact, or at times, a weakened bone may disintegrate or frac- ture spontaneously (as in old age when the bones are more porous, fragile and brittle). In criminal cases, reports have been available wherein the defence raised the contention of abnor- mal condition of the bones but the courts have been of view bone fracture may be considered occurring in the following stages.

STAGE OF HAEMATOMA FORMATION

Haematoma gets formed between and around the fracture sur- faces, and a ring of bone immediately adjacent to the fractured ends becomes ischaemic over a variable length.

STAGE OF SUBPERIOSTEAL AND ENDOSTEAL PROLIFERATION

Proliferation of cells occurs from deep surface of periosteum. These cells are the precursors of osteoblasts and surround each fragment of the fracture. Similarly, cells from endosteum and the bone marrow also proliferate and try to bridge the gap.

STAGE OF CALLUS (WOVEN BONE) FORMATION

Osteoblasts lay down intercellular matrix of collagen and polysaccharide, which becomes impregnated with calcium salts to form immature bone. This is termed as 'woven bone'. that an assailant, intending hurt, has to take his victim as he finds him.

The question, 'has a bone ever been fractured?' may some- times be put to the expert in reference to the living body. It is well-known that a bone seldom unites so evenly that the point of the bony union is not indicated by a node or some irregularity/ thickening, etc. Some bones like radius, collar bone, tibia, etc. can well be palpated for such an examination. In others, detec- tion is difficult by palpation. X-ray examination is always war- ranted to localise an old lesion. However, in case of skull, things may not be as straightforward as are usually expected. This is well-substantiated by an instant case: The victim, about 45-year-old male, reported to the emergency with his- tory of assault on the head with sharp edged weapon. On examination, an incised wound measuring 3.5 cm × 0.75 cm was found on the right parietal region. On X-ray, underneath frac- ture was present. Therefore, injury was declared as 'grievous' by the examining doctor. However after about 3 months, the opposite party approached the court asserting that they had been falsely implicated in the case and requested for re- examination of the victim by a board of doctors. The board of doctors got conducted another X-ray wherein no fracture was demonstrable. Though surprising, yet one should not get alarmed at such finding of nondemonstration of fracture in the X-ray after about 3 months since repair of fractures of the skull is usually attended with a very slight amount of callus, probably owing to the absolute rest of the fragments. The edges of fissured fracture are usually glued together within a week or are gradually smoothened within 3–4 weeks and are united by the formation of bone within 2–3 months or more. Raekallio in his studies of injured human skin noted the differences in the activity of various enzymes at varying intervals. Diminished activity may be demonstrable at the cen- tral zone (injured area) and increased activity at the peripheral zone. It was noted that the activity of esterases and adenosine triphosphatase increased as early as 1 hour after the injury, aminopeptidase in about 2 hours, acid phosphatase in about 4 hours and alkaline phosphatase in about 8 hours. Such deter- mination of enzyme activity by means of histochemistry helps in determining the age of the wound in the early phase of healing (before cellular infiltration has taken place) and in differentiating between postmortem and antemortem wounds.

Postmortem wounds do not show a central zone of dimin- ished enzyme activity and a peripheral zone of increased enzyme activity. These changes can be demonstrated for a few days after death, if autolysis is prevented by refrigeratio

Biochemical methods have also been employed to ascer- tain antemortem or postmortem status of the wounds. Histamine and serotonin are vasoactive amines known to par- ticipate in the acute inflammatory process, especially in the earliest phase after the injury. The maximum increase in the free histamine content occurs within 20–30 minutes after wounding, and the increase in serotonin content is demon- strable still earlier, the maximum increase occurring within 10 minutes after the injury, as reported by Raekallio J and Makinen PL.

FABRICATED WOUNDS

Also known as 'fictitious/forged' wounds; there are usually superficial injuries mostly produced by a person on his own body (self-inflicted) or occasionally caused by another person act- ing in agreement with him (self-suffered). The fabricator usually produces or causes to be produced only that much injury as he thinks necessary to confirm his story. The injuries are, there- fore, usually multiple, superficial and not situated over vital parts of the body. Such wounds are commonly on the front of the body, but may be on those parts of the back that can easily be approached by hands or on the top of the head. The direc- tion varies according to the site; for example, from above down- wards and inwards on upper arm or multiple oblique or vertical interlacing superficial incisions on the abdomen. Though inci- sions are the usual wounds, yet punctures or other wounds can be there. Contused or lacerated wounds are rarely fabricated on account of the pain occasioned by them and the force required to produce them. Still rare are the firearm injuries and burns.

The object may be to support a false charge of assault or attempted murder against an opponent, to augment the seri- ousness of the injuries that one has already received during a quarrel/scuffle, to prove self-defence in an accusation of assault or murder, or to substantiate a charge of violence and robbery in a case where one had appropriated money or valu- ables placed under one's charge. Sometimes the injuries are inflicted to obtain release from army service. Soldiers and policemen may inflict such injuries to bring a false charge of of wounds, examination of clothing is valuable. The individual will almost always bare the part before wounding it, in order to see what he is about. He may then forget to make cuts/defects in the clothing or even when the clothing are damaged, they may show cuts defects incompatible with the site, number, direction and nature of the wounds upon the body. (A study conducted by Dr. J Gargi et al. furnishes rich information about intriguing aspects of such injuries.) Not to talk of sharp or blunt force injuries, fake cases of firearm injuries may also be seen. In a case reported in The Times of India dated 5th October, 2002, two persons were admitted to the hospital claiming that they had received pellet injuries through the attack of their opponents. However, on investigations, the police had to cancel FIR when the case was found to be spurious. Doctors could not retrieve any pellet from the wounds present in the legs of the victims. The police asserted that such cases were mostly linked up with the land holding disputes. Interestingly, as reported, the four holes on the leg of one victim appearing to be of pellets covered a big- ger circumference than ones etched out in the cloth over it. Supposing the cloth could have been in a folded position at the time when the shots were fired, the cloth should have unfolded to cover bigger area (circumference) than one on the leg. At occasions, victims can even collude with doctors who can etch out a small hole and implant a pellet inside the leg or arm of the victim. f collu-

HOMICIDE

It means killing of a human being by a human being. Broadly speaking, it may be considered as destruction of human life by the act, agency, procurement or culpable omission of some other person(s). Homicide by starvation and medically curable disease whose obvious presence is purposefully or willfully ignored by the person shouldering the responsibility of the child may also be included under this.

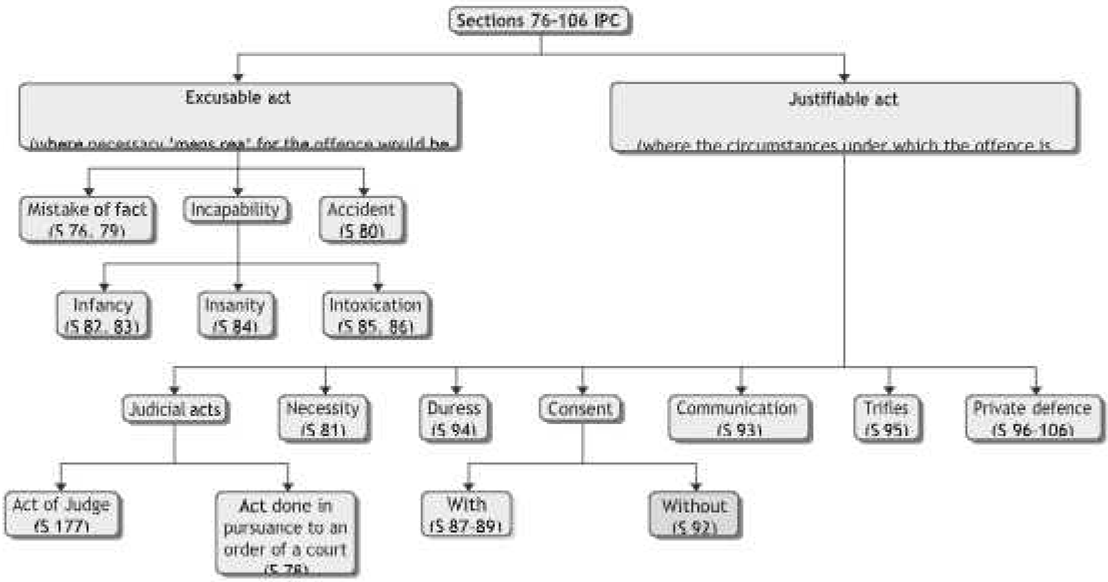
Lawful Homicide

EXCUSABLE HOMICIDE

This includes homicides that are committed with no criminal intention and knowledge. For example:

- Where death is caused by an accident or misfortune, and with no criminal intention and knowledge in the doing of a lawful act in a lawful manner, and with proper care and cau- tion (IPC S 80); or

- Where death is caused by a child or a person of unsound mind or an intoxicated person (IPC S 82, 83, 84, 85); or



Scheme of general exceptions as per Indian Penal Code.

- Where death is caused unintentionally by an act done in good faith, for the benefit of the person killed, when

  - The person killed is minor or lunatic, his guardian has expressly or impliedly consented to such an act (IPC S 87, 88, 89) or

  - It is impossible for the person killed or his guardian to signify consent in time for the thing to be done for the benefit of the person concerned (IPC S 92).

Justifiable Homicide

A homicide is considered in law to be justified if death is caused:

- By a person who is bound or by a mistake of fact, in good faith believes himself to be bound, by law (IPC S 76) or
- By a person who acts pursuant to lawful authority or by reason of a mistake of fact, in good faith believes himself so authorised (IPC S 79) or
- By judge when acting judicially in the exercise of any power that he possesses or in good faith believes that he possesses under the law (IPC S 77) or
- By a person acting in pursuance of the judgement or order of a court of justice (IPC S 78) or
- By a person acting with no criminal intention to harm and in good faith to avert other harm to person or property (IPC S 81) or
- By a person exercising his right of private defence (IPC S 96–106).

UNLAWFUL HOMICIDE

CULPABLE HOMICIDE—SECTION 299

Whoever causes death by doing an act with the intention of causing death or with the intention of causing such bodily injury as is likely to cause death or with the knowledge that he is likely by such an act to cause death, commits the offence of culpable homicide.

Explanation 1: A person who causes bodily injury to another who is labouring under a disorder, disease or bodily infirmity and thereby accelerates the death of that other shall be deemed to have caused his death.

Explanation 2: Where death is caused by bodily injury, the person who causes such bodily injury shall be deemed to have caused the death, although by resorting to proper remedies and skilful treatment, the death might have been prevented.

Explanation 3: The causing of the death of a child in the mother's womb is not homicide. But it may amount to culpable homicide, if any part of that child has been brought forth, though the child may not have breathed or been completely born.

Murder—Section 300

Except in the cases hereinafter excepted, culpable homicide is murder:

- Firstly, if the act by which the death is caused is done with the intention of causing death.

- Secondly, if it is done with the intention of causing such bodily injury as the offender knows to be likely to cause the death of the person to whom the harm is caused.

- Thirdly, if it is done with the intention of causing bodily injury to any person and the bodily injury intended to be inflicted is sufficient in the ordinary course of nature to cause death.

- Fourthly, if the person committing the act knows that it is so imminently dangerous that it must in all probability cause death; or such bodily injury as is likely to cause death, and commits such act without any excuse for incurring the risk of causing death or such injury as aforesaid.

Exception 1: Culpable homicide is not murder if the offender, while deprived of the power of self-control by grave and sudden provocation, causes the death of the person who gave the provocation or causes the death of any other person by mistake or accident.

The above exception is subject to the following provisos:

- That the provocation is not sought or voluntarily provoked by the offender as an excuse for killing or doing harm to any person.

- That the provocation is not given by anything done in obedience to the law, or by a public servant in the lawful exer- cise of the powers of such public servant.

- That the provocation is not given by anything done in the lawful exercise of the right of private defence.

Exception 2: Culpable homicide is not murder if the offender, in the exercise, in good faith of the right of private defence of person or property, exceeds the power given to him by law and causes the death of the person against whom he is exercising such right of defence without premeditation, and without any intention of doing more harm than is necessary for the purpose of such defence.

Exception 3: Culpable homicide is not murder if the offender, being a public servant or aiding a public servant, act- ing for the advancement of public justice, exceeds the powers given to him by law, and causes death by doing an act that he, in good faith, believes to be lawful and necessary for the due discharge of his duty as such public servant and without ill-will towards the person whose death is caused.

Exception 4: Culpable homicide is not murder if it is com- mitted without premeditation in a sudden .ht, in the heat of passion, upon a sudden quarrel and without the offender's hav- ing taken undue advantage or acted in a cruel or unusual manner. Exception 5: Culpable homicide is not murder when the person whose death is caused, being above the age of eighteen years, suffers death or takes the risk of death with his own consent.

Culpable Homicide and Murder Distinguished

The distinction between these two offences is very ably set forth by Melvill J in Govinda's case. For convenience of comparison, the provisions of Sections 299 and 300 may be stated thus Under (c) and (4) there is no intention to cause death or bodily injury. Furious driving, firing near a public road would be cases of this description. Whether the offence is culpable homicide or murder depends upon the degree of risk to the human life. If death is the likely result, it is culpable homicide; if it is the most probable result, it is murder. Under (2), the offence is murder, if the offender knows that the particular person injured is likely, either from peculiarity of constitution, or immature age, or other special circumstances, to be killed by an injury that would not ordinarily cause death. There remain to be considered (b) and (3) and it is on the comparison of these two clauses that the decision of doubtful cases must generally depend. The offence is culpable homicide if the body injury intended to be inflicted is likely to cause death; it is murder, if the injury is sufficient to cause death in the ordinary course of nature. The distinction is fine but appreciable. It is the question of degree of probability, for example, a blow with a fist or a stick on the vital part may be likely to cause death, whereas a wound from the sword on a vital part is sufficient in the ordinary course of nature to cause death. The difference between culpable homicide and murder is only a question of different degrees of probability that death would ensue. It is culpable homicide where death must have been known to be a probable result. It is murder where it must have been known to be the most probable result.

It cannot be said that an injury sufficient in the ordinary course of nature to cause death is an injury that inevitably and under all circumstances must cause death. Even if none of the injuries by itself is sufficient to cause death in the ordinary course of nature, cumulatively such injuries may be sufficient in the ordinary course of nature to cause death.

Culpable Homicide by Causing Death of a Person Other than the Person Whose Death was Intended—Section 301

This Section lays down that culpable homicide may be committed by causing death of a person whom the offender neither intended nor knew himself to be likely to kill. This Section embodies what the English authors describe as the doctrine of transfer of malice or the transmigration of motive. If A intends to kill B but kills C, whose death he neither intends nor knows himself to be likely to cause, the intention to kill C is by law attributed to him.

Punishment for Murder—Section 302

Whoever commits murder shall be punished with death or imprisonment for life and shall also be liable to fine. Death sentence is given only in 'rarest of rare cases'.

Punishment for Culpable Homicide not Amounting to Murder—Section 304

Under this Section, there are two kinds of punishments apply- ing to two different circumstances:

- If the act by which the death is caused is done with the intention of causing death or such bodily injury as is likely to cause death, the punishment is imprisonment for life or imprisonment of either description for a term that may extend to 10 years and fine.

- If the act is done with the knowledge that it is likely to cause death but without any intention to cause death or such bodily injury as is likely to cause death, the punishment is imprisonment of either description for a term that may extend to 10 years or with fine or with both.

Causing Death by Rash or Negligent Act—Section 304A

The provisions of this Section apply to cases where there is no intention to cause death and no knowledge that the act done in all probability would cause death. Criminal negligence is the gross and culpable neglect or failure to exercise the reasonable skill and proper care and caution to guard against injury either to the public generally or to the individual in particular, which the accused had the duty to adopt, under the circumstances of the case.

Culpable rashness is acting with the consciousness that the mischievous and illegal consequences may follow, but with the hope that they will not and often with the belief that the actor has taken sufficient precaution to prevent the happening. The imputability arises from acting despite the consciousness, whereas culpable negligence is acting without the effect that may follow. Of the two, rashness is a graver offence.

Dowry Death—Section 304B

(1) Where the death of a woman is caused by any burns or bodily injury or occurs otherwise than under normal cir- cumstances within 7 years of marriage and it is shown that soon before her death, she was subjected to cruelty or harassment by her husband or any relative of her husband for, or in connection with, any demand for dowry, such death shall be called 'dowry death' and such husband or relative shall be deemed to have caused her death.

(2) Whoever commits dowry death shall be punished with imprisonment for a term that shall not be less than 7 years but may extend to imprisonment for life.

According to a circular from the Home Ministry, a panel of two doctors is required to carry out the postmortem on the body of a married woman, dying of burns or other suspicious reasons within 7 years of her marriage or if her age was less than 30 years at the time of her death.

Abetment of Suicide—Section 306

Abetment of suicide is punishable under this Section and attempt to commit suicide under Section 309. The term 'abet- ment' has been defined under Section 107 IPC wherein it has been stressed that there must be instigation, cooperation or intentional assistance given to the would-be suicide. However, if he consents to be killed by another and in consequence is killed by that other, the offence is culpable homicide (homicide by consent). For example, supposing A and B conspire to pro- duce B's miscarriage. For that purpose, A procures arsenic and gives it to B, which she takes and dies. Here, A is an abettor. However, if A had himself administered the poison to B and thus caused her death, he would have been guilty of culpable homicide (homicide by consent).

Two persons may agree to commit suicide (suicide pact/ mutual suicide). If one dies, and the other survives by accident, the latter would be guilty of an abetment punishable under this Section as well as of an attempt under Section 309, though he could not be sentenced to cumulative sentences.

Attempt to Murder—Section 307

Whoever does any act with such intention or knowledge, and under such circumstances that if he by that act caused death, he would be guilty of murder, shall be punished with imprisonment of either description for a term that may extend to 10 years, and shall also be liable to fine; and if hurt is caused to any person by such act, the offender shall be liable either to impri- sonment for life, or to such punishment as is herein before mentioned.

Attempt to Commit Culpable Homicide— Section 308

Whoever does any act with such intention or knowledge and under such circumstances that if he by that act caused death, he would be guilty of culpable homicide not amounting to murder, shall be punished with imprisonment of either descrip- tion for a term that may extend to 3 years, or with fine, or with both; if hurt is caused to any person by such act, he/she shall be punished with imprisonment of either description for a term that may extend to 7 years, or with fine, or with both.

Attempt to Commit Suicide—Section 309

Whoever attempts to commit suicide and does any act towards the commission of such offence shall be punished with simple imprisonment for a term that may extend to 1 year or with fine or with both. On 21st March, 1996, a five judge bench of the Supreme Court reversed its April 1994 verdict and held that the right to life as guaranteed under Article 21 of the Constitution did not include the right to die and therefore attempt to com- mit suicide and its abetment would continue to be an offence under Sections 306 and 309 of the IPC.

The threat of going on 'hunger strike' to achieve some justified/undesirable ends may well fall within the ambit of attempt to commit suicide. In March, 1999, police registered a case of 'an attempt to commit suicide by hunger strike' against two teachers who had been on fast unto death to protest against the dismissal of the teachers by the Government. One of the teachers was removed by the police and admitted to the hospital on the 9th day of her hunger strike. In the same light, it may be remembered that forcible feeding of prisoners on their refusal to take food on account of passive resistance is also lawful.

Hurt—Section 319

Whoever causes bodily pain, disease or infirmity to any other person is said to cause hurt. The Section comprises three elements:

- Bodily pain: To cause hurt, there need not be any direct physical contact. Where the direct result of an act is the causing of bodily pain it is hurt, whatever may be the means employed. Hurt is constituted by causing bodily pain and not mental pain. Giving alarming news may cause pain but not hurt. Dragging a person by the hair or fisting him, falls under this Section.

- Disease: A person communicating a particular disease to another would be guilty of causing hurt to another. However, there appear to be conflicting judicial decisions with respect to cases of communicating sexual diseases by one to another. In Roka vs. Emperor, the Bombay High Court held that a prostitute who had sexual connections with the complainant and thereby communicated syphilis is liable under Section 269 IPC for spreading of infection and not of causing hurt because the interval between the act and the disease was too remote to attract Sections 319 and 321 of IPC.

- Infirmity: Infirmity denotes an unsound or unhealthy state of body. The same remarks apply to the causing of an infir- mity as to that of disease because it is something akin to, but not identical with disease. The term 'infirmity' is used to convey any inability of an organ to perform usual func- tion. It may be temporary or permanent. A state of tempo- rary mental impairment or hysteria or terror would constitute infirmity. For example, a boy of 16 years of age, being in love with a girl, gave her some sweetmeats. The girl and some of her family members ate them and all of them were seized with violent symptoms of poisoning, though none of them died. It was held that the boy was guilty of causing hurt.

Grievous Hurt—Section 320

The code on the basis of gravity of physical assault has classi- fied hurt as 'simple' and 'grievous', so that the accused might be awarded punishment commensurate to his guilt. This Section designates eight kinds of hurts as grievous and pro- vides enhanced punishment in such cases; these are following:

EMASCULATION

This clause is confined to males only. It means unsexing of a man or depriving him of his virility. The clause was inserted to counteract the practice prevailing in women to squeeze men's testicles on the slightest provocation. Emasculation may be caused in a variety of ways. It may be caused by inflicting an injury to the scrotum as has the effect of rendering the person impotent or to the vertebral column leading to failure of erection of penis. The impotency caused must be permanent. An injury to the scrotum may lead not only to emasculation but to even death. Indeed, as remarked by Dr. Chevers, 'it is a form of assault, which is extremely liable to prove fatal'. In that case, the accused will be guilty of not only grievous hurt, but of culpable homicide.

Injuring Eyesight Such injury must have the effect of permanently depriving the injured of the use of one or both the eyes. The test of gravity is the permanency of the injury, which may be caused by hand as by gouging out one's eye with thumbnail or by poking it with a stick or the like. The injury is grievous, both because it deprives a man of an organ of sight, and also because it Disfigures him for life.

CAUSING DEAFNESS

In this respect, the preceding injury is more serious than the 'permanent privation of hearing of either ear', which deprives a man of the use of his auricular organ but does not Disfigure him. Such injury may be caused by a stunning blow on the head or the ear, injuring tympanum or other auditory nerves, thrusting a stick into the ear or pour- ing some substance into the ear leading to deafness.

In both these clauses, the loss or privation of sight or hear- ing may be partial but has to be permanent. However, 'perma- nent' does not mean that it should be incurable. For instance, loss of sight occurring due to corneal opacity resulting from injury to the cornea may be curable by corneoplasty but being permanent by itself constitutes a grievous hurt and chances of its treating by corneoplasty do not lower its gravity for this purpose.

Privation of Any Member or Joint This clause and the next refer to the old offence of 'mayhem', which Hawkins defined to be violently depriving a man of the use of such of his member as may render him less able in .hting. This offence was, in England at one time, visited with the penalty of death and by the ancient law, the penalty sanctioned for the same crime was, 'membrum pro membro', i.e. an eye for an eye and a tooth for a tooth. The punishment provided by the code depends upon the nature of the member or joint lost because the same penalty cannot be attached to the mutilation of an arm as to the loss of one's little finger. The term 'member' means nothing more than an organ or a limb. Therefore, it includes both the eyes, ears, nostrils, mouth, hands, feet, etc. A 'joint' means a place where two or more bones and muscles join. Their privation must involve such injury as makes them permanently stiff, so that they are unable to perform the nor- mal function assigned to them in human physiology.

Permanent Impairing Powers of Any Member or Joint Deprivation of a limb or joint involves life-long crip- pling with its attendant defencelessness and misery. This clause sanctions the same policy of law in making it a grievous hurt to permanently impair the use of any limb or joint without causing its total destruction. Indeed, the mere retention of a limb, when it cannot be put to use for which it was created, is as great a hardship as if it had been lost by amputation or oth- erwise. Any permanent decrease in utility would constitute a grievous hurt. For example, formation of strictures due to burns, corrosives or any other injury resulting in permanent impairment of power/function of the concerned organ/tissue; damaging of some tendon(s) due to blunt or sharp force injury leading to permanent impairment of power/function of the concerned muscle/joint, etc. A communication (From Dr. Ashok Chanana, Associate Professor of Forensic Medicine at GMC, Amritsar) is quite illuminating: The victim, a male of about 25 years, allegedly received sharp force injuries during an assault. The injuries were (i) an incised wound, 5.0 cm × 1.5 cm, on the left parieto-occipital region of the head; (ii) an incised wound 6 cm × 1 cm, on the back of right forearm and (iii) an incised wound, 3.5 cm × 0.5 cm, on the front of right thumb, bone deep. The doctor on duty who had conducted the medi- colegal examination, after going through X-ray reports, declared the injuries as 'simple' (casually going by the notion that if there was no bone injury, 'it is not grievous'. And, not contemplating that other relevant Clause(s) of 'grievous hurt' too need exclusion in a given scenario). However, the victim constantly complained of pain and restricted movements of the right thumb. He, consequently, requested the head of the institution to look into the matter. An inquiry was ordered and the injury number (iii) was declared as 'grievous' as it had resulted in cutting of the tendon of flexor pollicis longus. And, in the opinion of the orthopaedic surgeon (who had repaired the tendon), "it amounted to permanent impairment of the power/function of the thumb, and the victim would be unable to hold things in the thumb and fingers, and to write".

Permanent Disfiguration of the Head or Face The word 'Disfigure' must be distinguished from the word 'disable'. 'Disfigure' means to inflict on a man some external injury that does not weaken him, but to 'disable' means to incapacitate him permanently. Such Disfigurement may be caused by lopping off a man's ear or nose in which case there would be sufficient Disfigurement without consequential disability, so as to consti- tute a grievous hurt under this Clause . A nasty gash on the face leaving a permanent scar would be another instance of this type of injury. An injury may both Disfigure and disable a person, e.g. gouging out an eye. In that case, the offence will be the same, namely, a grievous hurt, though the injury would then fall both under this Clause and Clause (2).

Fracture or Dislocation of a Bone or Tooth The fracture or dislocation of a bone or tooth is another type of grievous hurt that may or may not be attended with permanent disability, e.g., a bone though fractured or dislocated may rejoin or be set and leave little or no trace behind of its fracture or dislocation. But the injury is esteemed grievous on account of the intense pain and disability it causes to the sufferer. The same disability may be attached to the dislocation or fracture of a tooth.

A fracture is not defined in the Indian Penal Code, but it is beyond the plea of controversy. If there is a break by cutting or splintering of the bone or there is a rupture or fissure in it, it would amount to a fracture within the meaning of Cl (7) of Section 320 of the IPC. Partial cut of the skull vault would amount to a fracture within the meaning of this Clause.

Usual X-raying of the part not revealing fracture— need for repeat X-ray in a given scenario: A middle aged man was allegedly assaulted on 02.03.07 at about 7.00 p.m. He showed graze measuring 12 cm ⊠ 2 cm on the outer aspect of right scapular region with surrounded reddish bruise. On clinical examination, no body deformity, no abnormal mobility, etc. were noted. Usual X-ray revealed absence fracture. All inju- ries, including this, were declared as 'simple'. However, the vic- tim continued of the right shoulder; therefore, the victim was subjected to digital X-ray, which showed fracture of acromian process of right scapula. And then, a supplementary report/ opinion was extended, declaring the injury as 'grievous'. (Contributed by Dr. Parmod

Goyal, Associate Professor of Forensic Medicine, AIMSR, Bathinda).

Hurt Endangering Life or Causing Severe Pain or Refraining from Ordinary Pursuits There is nothing corresponding to this Clause in the English law, and it is admit- ted by the framers that they borrowed this from the French Penal Code. The period of '20 days' fixed by them for making the injury 'grievous' was, of course, arbitrary, but any period fixed would have been the same. The Clause encompasses provisions for cases not only where violence has been used but also for cases where hurt has been caused without any assault as by administration of drugs, setting of traps, digging of pit- falls, etc.

The Clause refers to three classes of injuries, which it designates grievous, namely:

- Those that endanger life
- Those that cause severe bodily pain for 20 days
- Those that disable the sufferer from following his ordinary pursuits for 20 days.

Endangering life: It refers to injuries that endanger life. The question is one of degree, and it must be ascertained in each case to what extent the hurt bears proximate relation to the risk of life. Ordinarily, it is true that injuries inflicted on a vital part of the body, such as head, chest, etc. tend to endan- ger life. The line between culpable homicide not amounting to murder and grievous hurt is a very thin and subtle one. In one case, the injuries must be such as are likely to cause death and in the other, the injuries must be such as endangering life.

A dangerous injury is one that poses imminent danger to life, either by involvement of important organ(s)/structure(s) or extensive area of the body. The word 'imminent' implies a dan- ger that is impending. That 'dangerous injury' is one which may prove fatal in the absence of surgical aid, may not be adhered to literally. Contusion/laceration of brain stem may prove fatal, notwithstanding surgical aid. For declaring the injury 'dangerous to life', the doctor may take into consideration the nature and extent of injury, the kind of weapon used, the part of the body struck and the condition of the patient/victim including nature and extent of medication during the hospital stay (if any).

CAUSING SEVERE BODILY PAIN:

An injury that is dangerous to life would necessarily cause severe bodily pain, unless death supervenes instantaneously. But an injury may cause such pain, and yet be not dangerous to life.

Disabling the sufferer from following ordinary pur- suits: The test for grievousness is the sufferer's inability to attend to his ordinary duties for a period of 20 days. This clause necessarily involves many elements of uncertainty. But here again, to prevent its misapplication in cases of feigned inability, regard must be paid to the nature and severity of the injury, as well as the probability of the disability it was likely to cause. The mere fact that the sufferer did not attend to his duty for the statutory period or that he remained in a hospital for that period is no indication of his inability. As was observed in a Mumbai case: 'An injured man may be quite capable of fol- lowing his ordinary pursuits long before 20 days are over and yet for the sake of permanent recovery or greater ease or com- fort be willing to remain as a convalescent in a hospital, espe- cially if he is fed at the public expense'.

The law requires that the injured person should during the space of 20 days be in severe bodily pain or unable to follow his ordinary pursuits. It is not correct to say that these things can be established only on medical evidence and not by other evidence. The medical evidence may be more reliable but is not legally necessary.

Assault—Section 351

Whoever makes any gesture, or preparation intending or know- ing it to be likely that such gesture or preparation will cause any person present to apprehend that he who makes that gesture or preparation is about to use criminal force to that person is said to commit an assault.

Explanation: Mere words do not amount to an assault. But the words, which a person uses, may give to his gestures or preparations such a meaning as may make those gestures and preparations amount to an assault.

Assault and Battery Distinguished An assault is a threat by one to the unlawful force against another. But a mere threat not in the slightest degree executed, or acts or gestures done under such circumstances or at such a distance that the threat cannot possibly be carried out, does not amount to an assault. A battery includes touching a person and laying hold on his clothes in an angry, revengeful, rude, insolent, or hostile man- ner. Even an act such as striking a horse on which a man is riding so that he is thrown off will amount to battery. A threat to throw boiling water on a man amounts to an assault, and when it touches his body, it amounts to battery.

ASSAULT OR CRIMINAL FORCE TO A WOMAN WITH INTENT TO OUTRAGE HER MODESTY—SECTION 354

Whoever assaults or uses criminal force against any woman intending to outrage or knowing it to be likely that he will thereby outrage her modesty shall be punished with imprison- ment of either description for a term that may extend to 2 years or with fine or with both.

Woman's Modesty What constitutes an outrage to a female's modesty is nowhere defined. This will depend upon the facts and circumstances of each case and according to the moral, social and legal ethos and traditions of the country and the race to which the woman belongs. Thus, assault can be committed on any woman irrespective of her age. Decency means propriety of behaviour, avoidance of obscene language and gestures and of undue exposure.

The word 'outrage' means 'gross infringement of decency/ morality, something that violates the feelings or the proprieties, dangerous display of passion, etc. In State of Punjab vs. Major Singh, the question arose whether a female child of seven and a half months could be said to be possessed of 'modesty' that could be outraged. In answering this question, the Supreme Court observed: 'When any act done to or in the presence of a woman is clearly suggestive of sex according to the "com- mon notions of mankind", that must fall within the mischief of Section 354 IPC'. Needless to say, the 'common notions of mankind' referred to by the learned judge have to be gauged by contemporary societal standards.

ADULTERY—SECTION 497

Whoever has sexual intercourse with a person who is and whom he knows or has reason to believe to be the wife of another man, without the consent or connivance of that man, such sexual intercourse, not amounting to the offence of rape, is the offence of adultery, and the guilty shall be punished with imprisonment of either description for a term that may extend to 5 years, or with fine, or with both. In such a case, the wife shall not be punishable as an abettor.

ENTICING OR TAKING AWAY OR DETAINING WITH CRIMINAL INTENT A MARRIED WOMAN—SECTION 498

Whoever takes or entices away any woman who is and whom he knows or has reason to believe to be the wife of any other man, from that man, or from any person having the care of her on behalf of that man, with intent that she may have illicit intercourse with any person, or conceals or detains with that intent any such woman, shall be punished with imprisonment of either description for a term that may extend to 2 years, or with fine, or with both.

This Section deals with the offence of criminal elopement. The provisions of this Section like those of Section 497 are intended to protect the rights of a husband over his wife. The Section requires following ingredients:

- Taking or enticing away or concealing or detaining the wife of another man from that man or from any other person having care of her on behalf of that man.
- Knowledge or reason to believe that she is the wife of another man.
- Such taking, concealing or detaining must be with the intent that she may have illicit intercourse with any person. Use of physical force is not an ingredient of the offence.

CRIMINAL INTIMIDATION—SECTION 503

Whoever threatens another with any injury to his person, reputation or property, or to the person or reputation of anyone in whom that person is interested, with intent to cause alarm to that person, or to cause that person to do any act that he is not legally bound to do, or to omit to do any act that that person is legally entitled to do, as the means of avoiding the execution of such threat, commits criminal intimidation.

Explanation: A threat to injure the reputation of any deceased person in whom the person threatened is interested is within this Section.

Sections 503–510 of the code deal with criminal intimida- tion, insult and annoyance. This Section has the following essentials:

- Threatening a person with any injury to his person, reputation or property or to the person or reputation of anyone in whom the person is interested.
- Threat must be with intent to cause alarm to that person or to cause that person to do any act that he is not legally bound to do as the means of avoiding the execution of threat or to cause that person to omit to do any act that that person is legally entitled to do as the means of avoiding the execution of such threat.

WORD, GESTURE OR ACT INTENDED TO INSULT THE MODESTY OF A WOMAN—SECTION 509

Whoever intending to insult the modesty of a woman utters any word, makes any sound or gesture, or exhibits any object, intending that such word or sound shall be heard, or that such gesture or object shall be seen by such woman, or intrudes upon the privacy of such woman, shall be punished with sim- ple imprisonment for a term that may extend to 1 year, or with fine or with both.

While Section 375 IPC deals with the forcible ravishment of woman (rape), Section 354 and 509 IPC deal with the lesser acts of indecency such as solicitation for sexual connection or to enjoy pleasurable feelings, etc. Essential component of the offence under Section 354 IPC is the 'intention to outrage modesty of a woman', whereas under Section 509 IPC, it is the 'intention to insult the modesty of woman'. The term 'outrage' is much stronger than the term 'insult', and that is why the resulting punishment in the former case is extendable up to 2 years' imprisonment, whereas in the latter case, up to 1 year only. (The term outrage implies gross infringement of morality or decency, gross violation of other's rights, sentiments, emotions, etc. The term insult implies any act or speech meant to hurt the feelings or self-respect of another or treat a person with offensive disrespect/insolence/contempt, etc.). However, both these Sections have a common feature, i.e. bailable nature of the offence. Reports suggest that such weakness in the law has been exploited frequently. This came to be seen when a few miscreants molested two NRI women near a Mumbai Hotel on the eve of the New Year 2008, but were granted bail soon after their arrest (the term modest implies: to trouble, annoy, disturb or vex, etc. In its ordinary connotation, it applies to any conduct that can be regarded as such a degree of harassment as constituting a criminal offence).

MISCONDUCT IN PUBLIC BY A DRUNKEN PERSON—SECTION 510

Whoever in a state of intoxication appears in any public place or in any other place where it amounts to a trespass and there conducts himself in such a manner as to cause annoyance to any person shall be punished with simple imprisonment for a term that may extend to 24 hours or with fine or with both. Mere intoxication is not an offence. It is only when the person appears in a state of intoxication in a public place or goes to a place where he has no right to go and causes annoy- ance to the people then he becomes liable under this Section.

ATTEMPTS TO COMMIT OFFENCES—SECTION 511

Whoever attempts to commit an offence punishable by this code with imprisonment or to cause such an offence to be committed and in such attempt does any act towards the com- mission of the offence, shall, where no express provision is made by this code for the punishment of such attempt, be pun- ished with imprisonment of any description provided for the offence for a term that may extend to one-half of the impris- onment for life or, as the case may be, one-half of the longest term of imprisonment provided for that offence, or with such fine as is provided for the offence, or with both.

In every crime, there are four successive stages in its commission, viz.,

- Intention to commit it
- Preparation
- Attempt to commit it
- The actual commission of the offence

Intention is the direction/design of conduct towards an object or aim, based upon some motive. The law does not take notice of intention without an external act showing some progress towards maturing and affecting it.

Preparation consists in devising or arranging means or measures necessary for the commission of an offence.

Attempt is made punishable because though it fails, it cre- ates alarm/shock, which itself is an injury and the moral guilt of the offender is the same as if he had succeeded. An attempt is direct movement or action towards the commission of an offence after the preparations are made. The action fails in its object due to the circumstances beyond the control of the offender or independent of his volition.

CLASSIFICATION OF INJURIES

Wounds may be classified in a variety of ways, but it should not be forgotten that the injuries are often mixed. Thus, an abra- sion may be found in association with contusions and lacera- tions and any combination of these three is common.

- Depending upon Causative Factor
- ■ Mechanical or Physical Injuries
- — Those caused by blunt force
- – Abrasions
- – Contusions (bruise)
- – Lacerations
- — Those caused by sharp force
- – Incisions
- – Punctures (punctures may be incised puncture or lacerated puncture)

— Caused by firearms

– By rifled firearms

– By smooth bored firearms

– By country made weapons

▪ Thermal Injuries

— Due to heat

– Generalised effects of heat, i.e. heat hyperpyrexia (heat stroke), heat exhaustion (heat collapse) and heat cramps (miner's cramps)

– Localised effects of heat, i.e. burns (due to appli- cation of dry heat) and scalds (due to application of moist heat)

— Due to cold

– Generalised effects of cold, i.e. hypothermia

– Localised effects of cold, i.e. frostbite (due to dry cold) and trench foot (due to wet cold)

▪ Caused by Chemical Agents

— Corrosions (due to strong acids or alkalies)

— Irritation (due to weak acids, alkalies, vege.s or animal extracts, etc.)

▪ Miscellaneous

— Lightning

— Electricity

— Radiation (X-rays, ultraviolet rays, radioactive sub- stances, etc.)

— Blast injuries

• Depending upon Gravity

▪ Simple

▪ Grievous

▪ Dangerous

• Depending upon Time of Infliction

- Antemortem
- Postmortem
- Perimortem
- Depending upon the Manner of Infliction/Sustaining
- Suicidal
- Accidental
- Homicidal
- Defence wounds
- Self-inflicted/self-suffered
- Fabricated/fictitious injuries

CHAPTER-14

INJURIES BY BLUNT FORCE

As most of the wounds involve the body surface, a peep into the structure of the skin and subcutaneous tissue will be highly appropriate at the very onset. Forensic aspects of the anatomy of skin are described as under:

EPIDERMIS

It is the superficial protective layer of the skin and is composed of stratified squamous epithelium that varies in thickness from

0.007 to 0.12 mm. It is the thickest over the soles and palms, while it is much thinner over the protected areas like scrotum, eyelids, etc. This bears a forensic relevance showing the varying amount of force needed to penetrate the skin at different parts of the body.

The names and characteristics of epidermal layers are as under

- Stratum corneum: It consists of 25–30 layers of flattened scale-like cells, which are continuously shed as flake-like residues of cells. This surface layer is cornified and is the real protective layer of the skin. Cornification is brought about by keratinisation and the hardening flattening process that takes place as the cells die and are pushed to the surface.

- Stratum lucidum: It exists only in the lips and thickened layers of soles and palms.

- Stratum granulosum: It consists of only three or four layers of flattened cells. The cells within the layers appear granular due to the process of keratinisation.

- Stratum spinosum: The spiny appearance of this layer is due to changed shape of the keratinocytes.

- Stratum basale: It is composed of a single layer of cells in contact with the dermis. Four types of cells compose the stratum basale, i.e. keratinocytes, melanocytes, tactile cells and nonpigmented granular dendrocytes (Langerhans cells). With the exception of tactile cells, these cells are constantly dividing mitotically and moving outwards to renew the epidermis. It usually takes between 6 and 8 weeks for the cells to move from the stratum basale to the surface of the skin.

All except the stratum basale and the stratum spinosum are composed of dead cells. That is why these two layers are some- times collectively called as stratum germinativum.

DERMIS

It is deeper and thicker than epidermis. Blood vessels within the dermis nourish the living portion of the epidermis, and numerous collagenous, elastic and reticular fibres give support to the skin. The fibres within the dermis radiate in different definite directions producing lines of tension on the surface of the skin, called the cleavage lines of Langer. Gaping of the stab wounds or incisions will depend upon their location and orientation with respect to these cleavage lines.

The dermis is highly vascular and glandular and contains many nerve endings and hair follicles. Numerous projections (papillae) extend from this layer into the epidermis. Papillae form the base for the friction ridges on the fingers and toes. (ii) The lower layer is called stratum reticularosum. (Tattooing colours the skin permanently, because the pigmented dyes are injected below the mitotic basale layer into the dermis.)

The skin manifestations of blunt trauma differ depending upon the force and nature of the impact. Three basic lesions are recognised:

- Abrasions
- Contusions
- Lacerations

ABRASIONS

Abrasions are the injuries involving superficial layer of the skin (the epidermis or mucous membrane) due to impact against some hard, blunt and rough object/weapon. Thus, the pure abrasions do not ordinarily bleed, because the vascular supply of the skin comes through the vascular network running in the dermis. Practically, because of the corrugated nature of the dermal papillae as detailed in the beginning, quite often dermis is also involved and consequently abrasions often exhibit bleeding. At places, abrasions may penetrate the full thickness of skin. Therefore, large areas of abrasions [such as 'brush abrasions' (vide infra)] may bleed, though the bleeding is rarely serious as only small blood vessels are involved. For an abrasion to appear, some movement along with pressure is essential between the object/instrument/weapon and the skin. This movement and pressure may be exerted either by the body itself or by the abrading instrument.

TYPES OF ABRASIONS

Depending upon the mechanism of the pressure and nature and movement of the weapon/agent involved against the skin surface, abrasions may be classified as follows.

SCRATCHES OR LINEAR ABRASIONS

These are produced by horizontal or tangential friction by the pointed end of some object like thorn, nail, needle or tip of any weapon. Therefore, the contention that abrasions cannot be produced by a sharp weapon does not stand on sound footings as the scratches or linear abrasions can conveniently be produced by pointed terminal portion of even a sharp weapon. All that matters is the manner in which the weapon is being used, the force applied, the area of the body involved and the circumstances governing the positions of the victim and the assailant

GRAZES (SLIDING/ TANGENTIAL/ BRUSH ABRASIONS)

These are caused due to horizontal or tangential friction between the broader area of the skin and the object/weapon or hard rough surface of the ground. The epidermis will get heaped up at the opposite end and the pattern of heaping will indicate the direction of movement of the object/weapon against the skin .

These sliding abrasions are most commonly encountered in traffic accidents where a pedestrian has been knocked down and is dragged over the ground for a varying distance. They may frequently be associated with underlying bruising. These types of abrasions caused by violent lateral (tangential) rub- bing against a rough surface are called brush burns. The sliding of the body against the rough surface scrapes linear furrows across the skin. Strands and tags of epidermis may be peeled along these furrows and get heaped up at the other end where the contact ceased. Similarly, where a victim is imparted a glanc- ing blow with a rough object, similar epidermal strands may indicate the direction of the blow.

PRESSURE ABRASIONS (CRUSHING ABRASIONS/ IMPRINT ABRASIONS)

When the impact is vertical to the skin surface, the epidermis gets crushed and pressure type of abrasions result and the imprint of the impacting object may be produced. These may be seen in manual strangulation (abrasions produced by fingernails) and in hanging, where the weave of the ligature material may be reproduced. If the impact is forcible then the dermis may also be injured and show underneath bruising.

PATTERNED ABRASIONS

Patterned abrasions occur when the force is applied at or around right angle to the surface of the skin, as already mentioned. If a weapon with patterned surface strikes the body or body falls upon a patterned rough hard surface, the abra- sions will usually follow the pattern of the object. The classical example of this is seen in traffic accidents when a tyre of a motor car passes over the skin leaving the pattern where the skin has been squeezed into the grooves of the rubber tread. Abrasions from objects with a recurring pattern such as chain of a cycle or a serrated knife or a necklace, etc. may be the other examples In such cases, skin may also get compressed in the depressions of the pattern, often leading to an associated intra- dermal bruising due to capillary damage. Patterned abrasions are sometimes produced by the recoil of a firearm when discharged at a contact range.

ATYPICAL ABRASIONS

Nail marks and teeth bites may conveniently be included in this category of abrasions though they may produce lacerations too, depending upon the force applied. Nail marks are especially important in cases of child abuse, sexual offences and manual strangulation. They may appear as linear scratches or short straight or curved marks depending upon the circumstances. The pattern may often be fragmentary rather than typical crescentic. Shapiro, Gluckman and Gordon have shown that because the skin is put under tension when it is indented by the nails, it may get distorted so that on releasing tension the elasticity of the skin brings it to its original position, carrying the nail mark also. The curve, which is usually expected to be produced, may then get reversed to produce either a straight line or a convexity. The overall configuration of the nails and the circumstances under which the marks are produced materially influence their pattern; therefore, it is always advisable to use utmost caution in their interpretation.

AGE (FATE) OF AN ABRASION

Abrasions usually heal rapidly without any scar formation, unless they are deep enough to involve the dermis, which prevents regrowth of hair follicles and sebaceous glands. A rough idea about their age may be gathered from the following changes:

Fresh: The area will appear reddish due to oozing out of serum and little blood. The dermis will be congested and painful.

12–24 hours: The exudation dries up to form a reddish scab, comprising dried blood, lymph and injured epi- thelial cells.

2–3 days: The scab is reddish-brown, less tender and adher- ing over the abraded area.

4–5 days: The scab is dark brown in appearance.

5–7 days: Scab is brownish black in appearance and starts falling off from the margins.

7–10 days: The scab shrinks and falls off, leaving some depigmented area underneath. The depigmented area gets gradually pigmented in due course of time.

ANTEMORTEM / POSTMORTEM ABRASIONS

In the living, detection of abrasions does not pose much problem as the victim is aware of their situation since these are painful and moist. In the dead, as the circulation of blood has ceased, there is no exudation of serum and therefore, the surface gets dried up and becomes hard acquiring the consistency of parchment and also appears brownish. The dried abrasion often appears to be a much more extensive injury than it was at the time of death.

Postmortem abrasions may be caused during transportation of the dead body. These abrasions may also leave hard yellow areas that can be differentiated if examined with care. Abrasions sustained at or about the time of death cannot be distinguished with certainty. If, however, any associated bruising or vital reaction can be shown either by naked eye or by microscopy, then differentiation can be established. The presence of fair amount of bleeding, of course, favours antemortem production.

DIFFERENTIAL DIAGNOSIS

Sometimes, abrasions may have to be distinguished from the following:

EROSION OF THE SKIN PRODUCED BY INSECTS, ANTS, ETC.

Ants produce erosions with irregular margins of the superficial layers of the skin and do not show any vital reaction. These are most commonly present at mucocutaneous junctions and at the moist folds of skin.

EXCORIATION OF THE SKIN BY EXCRETA

This is more likely to be seen in infants, and its distribution is self-explanatory. After death, the napkin area may become dry, depressed and parchment-like, especially when the plastic rompers or knickers are worn over a wet napkin.

MEDICOLEGAL CONSIDERATIONS

Abrasions, though trivial injuries involving only the superficial layers of the skin, should not be considered too insignificant to be ignored in the medicolegal investigations. They may be the only external visible signs of a severe or even fatal internal injury.

- Their importance lies in the fact that they are produced at the point of impact of the blunt force, e.g. abraded knuckles or knees may show the involvement of these areas.
- They may exhibit a pattern thereby providing information regarding the nature of force. There seems to be no need to list all the possible patterns that can be distinguished on the body and a few having a particular medicolegal sig- nificance have already been described under 'patterned abrasions'.
- Their sites and distributions over the body may yield some clue towards the nature of crime, for instance, presence of crescentic abrasions or scratches over the neck, face or inguinal regions of a female may well have been produced by the fingernails of assailant during sexual assault.
- Direction of application of force may be inferred from the collected epithelial tags at distal end of the abraded area. This is particularly so in a drag or brush marks ruffling of the skin, indicating the direction of the force applied to the skin.
- Presence of some material like mud, grit, coal dust, cement, sand, lime dust, pebbles or any vegetation, etc. in and around the abraded area will suggest the nature of the surface or agent responsible for its causation.
- Various stages of healing of an abrasion are helpful in determining the approximate period of infliction of the injury.
- It is a well-known postmortem phenomenon that abra- sions and bruises become more prominent after sometime following death. The appearance of body after a lapse of 24 hours or so following death

may be quite different from the appearance immediately succeeding death. In a body recovered from water, abrasions may be appreciated some- times after its recovery when they manifest more promi- nently on drying.

- Lastly, fabricated abrasions may be produced over accessible parts of the body to bring a false charge of assault or for some other extraneous motive. The circumstances are self-explanatory in such cases, and careful examination will solve the problem.

CONTUSIONS (BRUISES)

Contusions are characterised by infiltration of extravasated blood into the subcutaneous and/or subepithelial tissues resulting from rupture of small blood vessels due to appli- cation of blunt force. Therefore, not only the skin but the internal organs like heart, liver, spleen, kidney or muscle could be contused. In all such cases, the integrity of the skin or of the architecture of the organ is not disturbed, though under rare circumstances the overlying epidermis may be abraded, where they may be termed as 'abraded contusion'.

The term 'ecchymosis' too implies extravasation of blood into the cellular tissues but is no longer in use and is more often caused by factors other than direct mechanical trauma and usually involves the serous membranes, though can also be seen on the skin.

The lay term for superficial contusion is 'bruise', which is observed through the overlying intact skin as a bluish-purple discolouration and, in some instances, swelling of the involved area. The two words are often interchanged but the term 'bruise' is more popular and may be preferred in the usual medicolegal examinations. The black-eye following a fist.ht, the scalp haemorrhage from a fall and the bluish-purple appearance after an upper arm is squeezed too tightly are a few examples.

FACTORS INFLUENCING THE PROMINENCE OF A BRUISE

Many factors influence the extent, size, time of appearance and the prominence of a bruise; therefore, opinions regarding their time of appearance and the amount of force required to pro- duce them must be furnished in the generalised terms rather than in precise terms.

AMOUNT OF FORCE

As a general rule, the greater the force of violence, the more extensive will be the bruise. This generalisation is subject to some modifications, i.e.

- If the tissue involved is loose and lax such as face, scrotum, genitalia, eyelids, etc., a moderate blow may result in a rela- tively large bruise as there is sufficient space for the blood to accumulate.
- If the tissues are strongly supported containing firm fibrous tissues and covered by thick dermis such as back, scalp, palms and soles, etc., a blow of moderate violence may pro- duce a comparatively small bruise where dense fibrous tissue and restrictive fascial planes prevent easy accumulation of blood.

PECULIARITIES OF THE VICTIM

- Children bruise more rapidly than adults because of softer tissues and delicate skin.
- Old persons too bruise easily owing to loss of flesh and accompanying cardiovascular changes.
- Chronic alcoholics bruise easily because of cutaneous vasodilatation.
- Boxers and athletes show comparatively less bruising due to good muscle tone, which may prevent easy rupture of blood vessels.
- Women bruise more easily than men because of delicacy of the skin and greater amount of subcutaneous fat.
- Strong healthy persons with active habits may stand consid- erable blow without appreciable bruising.
- Obese flabby persons bruise easily even with relatively lesser amount of violence.
- Naturally, bruises are more easily appreciated in fair skinned people than in heavily pigmented individuals.
- Presence of some disease like scurvy, vitamin K and pro- thrombin deficiency, haemophilia, leucaemia, atheroscler o- sis, etc.

may produce exaggerated bruising. Same may be the case if the person is suffering from toxic manifestations of certain drugs.

- Diet of the individual may also have a bearing on the development of bruising on account of having its effect on bleeding and clotting time and its ability to affect the con- sistency of body fats in supporting connective tissues of the body.

VASCULARITY OF THE AREA

The apparent prominence of a bruise beneath the skin obviously varies with the amount of blood in the extravasation. The size and density of the vascular network varies from area to area and that is why bruising over the areas like face, genitalia, scrotum, etc., having rich vascularity, will be more as compared to other areas.

RESILIENCY OF THE AREA

Resilient areas such as abdominal wall, buttocks, etc. bruise less with a given impact than the region having a bone immediately underneath and with least amount of subcutaneous tissue, like head, shins and areas against iliac crests. Abdominal wall is notorious in this respect and seldom gets bruised even with good amount of violence. Resilient and yielding anterior abdominal wall, giving way to the force, may allow the full brunt of the force to be suffered by the more resistant internal organs, which may get ruptured, without showing any evidence of injury. This is especially seen in vehicular accidents, where grave internal injuries to the organs may be present without any external evidence, particularly when the victim is stuffed with multiple layers of clothing.

DEEP/ DELAYED/ MIGRATORY BRUISES

The depth at which the bruise is placed affects its appearance on the surface. Most bruises are in the subcutaneous tissues above the deep fascia and therefore quite easy to appreciate but others may lie deeper. These deep bruises may not only take a long time to become visible (delayed bruising) but may not appear against the actual point of impact. Blood escaping from the damaged vessels tracks along the fascial or muscu- lar planes and following the path of least resistance may make its appearance hours or even days after the impact, at a place where the tissue layers become superficial. This may be termed as migratory or ectopic bruising. Another factor operat- ing in this context may be haemolysis, when the freed haem- oglobin is able to stain the tissues, which therefore become more noticeable. This latter factor may be responsible for the well-known postmortem phenomenon of bruises becoming more prominent after death and thereby creating differences in opinions, as referred under 'Abrasions' too. Examples of ectopic bruising may be black eye (spectacle haematoma) presenting as haemorrhages into the soft tissues of the eyes and in the eyelids following a blow on the forehead and blood gravitating downwards over the supraorbital bridge; in fracture of pelvis, bruise may appear in the thigh; a kick on the calf muscles of the leg may appear as a bruise around the ankle and so on.

PATTERNED BRUISING

Bruises do not display such a detailed pattern as encountered in abrasions, due to padding action of the skin that causes the force to be distributed diffusely and thus preventing the pro- duction of a distinct outline. However, there may still be cir- cumstances where some recognisable patterns may be produced. Instances may be legion, but a few of common occurrence may be cited as under:

- One particular type of bruise often seen is the so-called 'tramline' or 'railway line' bruise. Here, two parallel lin- ear haemorrhages, frequently resulting from rod, stick or the like object, are produced with an intervening almost unbruised area. The mechanism of its production seems to be that when the rod or stick or the like object forcibly dents the skin and underneath tissues in the area where it makes its impact, the tissue on each side of this impact gets stretched. This stretching of the sides results in rupture of vessels leading to formation of line of bruising on either side. In addition to this, blood from the bed of the dent also gets displaced to the sides with the pressure exerted by the impact by such objects. Thus, as the impact is removed and the skin springs back to its usual position, the two sides of the compressed area manifest as bruised lines.
- In strangulation, the pattern of a necklace or

string of beads may be impressed upon the neck or if some coarse weave of fabric has been used, it may leave a pat- terned bruise.

- Whipping with cords, plated leather thongs, etc. may also leave peculiar traces, which may encircle a part of limb or the trunk of the victim.
- As detailed under 'Abrasions', a cycle chain, a strap or a tyre may produce a patterned bruise in association with the abrasions.
- Intradermal bruises deserve special mention. Ordinarily, the bruise is situated in the subcutaneous tissue, in the fatty layer. However, when it is situated in the immediate subepi- dermal layer, the pattern of the impacting object may be more distinct. This is obviously partly due to its superficial situation and partly due to translucency of the compara- tively thin layer of skin overlying it. Typical examples may be production of tyre marks, impacts from whips or soft canes and rubber soles of shoes.

CASE—'TRAMLINE' BRUISING BY BEATING WITH A CANE

The victim, a married woman of about 28 years, had been running fever for few days prior to her admission to hospital. Before admission, as usually prevalent amongst the village folk, she was taken to some tantrik to effect withdrawal of the 'evil spirit' responsible for causing fever as her husband had lost all his patience and hopes due to her chronic illness. He developed a belief that it was due to some 'evil spirit' hiding within his wife and thereby thought of treatment (withdrawal of spirit) from some tantrik. The tantrik, as we usually observe and see in the cinema and otherwise, commenced his operation by beating her with some specific cane and also slapping her on the face. This was based on the theory that he was beating the spirit within the lady rather than the lady herself. ..s. 14.3A and B, showing 'tramline/railway line' type of multiple contu- sions on the back, distributed in an irregular fashion, some superimposing others; typically consistent with production by some stick or a like instrument. Left side of the face exhibits characteristic linear intradermal haemorrhages with some haem- orrhages lying scattered within these linear haemorrhage.

AGE (FATE) OF A BRUISE

The time taken for a bruise to disappear will depend upon its site, size and constitution of the victim including personal idio- syncrasies towards the process of healing. The more common superficial bruise, however, resolves and disappears after a succession of visible colour changes due to disintegration of red blood cells of the extravasated blood releasing the haemoglo- bin, which is then acted upon by tissue enzymes and broken down into haemosiderin, haematoidin and bilirubin, imparting respective colours to the tissues. These colour changes start at the periphery and proceed towards the centre of the contused area.

Images (A) and (B) show tramline bruising with a cane; image (C) shows intradermal bruising upon the face.

As in case of abrasions, only a general approximation of the interval between the infliction of a bruise and examination may be gathered. Indeed, the degree of reluctance of the doc- tor to label the precise timings for infliction of the injury may be a measure of his/her competence. The colour changes in a common superficial bruise of average size may occur more or less in the following order:

- When fresh, a bruise is reddish in appearance.
- Within a few hours, it becomes bluish and changes to bluish-purple by the second day, bluish-black by the third day and continues as such till the fourth day.
- By the fourth/fifth day, it appears brownish due to presence of haemosiderin, an iron-containing pigment.
- By the fifth/seventh day, it is greenish due to presence of

haematoidin.

- By the seventh/tenth day, the bruise assumes yellow colour due to presence of bilirubin.

- The yellow colour slowly fades in tint, and the normal colour of the skin is restored by about 2 weeks.

In subconjunctival haemorrhages, all the colour changes may not be noticeable due to diffusion of atmospheric oxygen through the conjunctival tissue, and the pigments liberated after the breakdown of RBCs change to bilirubin without show- ing noticeable stages of haemosiderin and haematoidin. More or less similar observations are seen in meningeal haemorrhages, where some oxygen is supplied by the CSF.

CIRCUMSTANCES WHERE EXTERNAL EVIDENCE OF BRUISING MAY BE ABSENT

- Where the site of injury is on yielding part such as anterior abdominal wall, there may not be any external bruising, though internally rupture of viscera may be noticed.

- When the offending weapon is yielding in nature and of flat surface type such as sand bag.

- In case of blow over sole of foot and palm of hand, where subcutaneous tissues are thick with no pliable subcutaneous fat, bruising may be absent notwithstanding application of gross violence.

- Where the body surface to be hit is covered with thick rug, blanket, quilt, etc., there will not be any bruising externally, but deep seated bruising underneath may be evident.

- Bruising may also be absent, notwithstanding the applica- tion of great violence, if the pressure is maintained until death ensues. Spilsbury mentioned a case where continued pressure of a wheel of a vehicle on chest left no external bruising. Similarly, external bruising may be absent when a grip in throttling is maintained until death occurs, particu- larly when some soft material is interposing between the skin of the victim and grip of the assailant.

ANTEMORTEM / POSTMORTEM BRUISING

A certain amount of swelling and colour changes are usually found in a bruise caused during life. Coagulation of the effused blood into the subcutaneous tissues along with infiltration of blood in the tissues is no longer to be seen in postmortem bruises. However, a bruise is likely to be dis.ured by decomposition and then it may pose a problem in its differentiation. Sir Robert Christison proved by experiments that it was possible to pro- duce a bruise within about 2 to 3¼ hours after death which, would be difficult to distinguish from the one caused during life but he observed that great violence would have to be applied and even then the resulting bruise might be smaller than what would have been produced by similar means during life as there would be no internal pressure in the small vessels and bleeding would be a passive ooze rather than active extravasation.

MEDICOLEGAL CONSIDERATIONS

- A bruise is an evidence of application of blunt force and usually the circumstances are of accident or homicide. It is unusual for a suicide to bruise self by blows or some other object because they occasion pain. But with a view to sup- porting a false charge, bruises are sometimes simulated by application of some irritant substance such as the juice of bhilawa (marking nut) or the root of chitra (Plumbago zeylanica) or lal chitra (Plumbago rosea). The marks produced by these substances appear like bruises but are dark-brown in colour with the margins covered by vesicles and the adjoining skin is red and inflamed. Similar marks may also be seen on the tips of the fingers that might have been produced during the process of scratching [see Plumbago rosea (Lal Chitra) and Plumbago zeylanica (Chitra) in the Chapter "Irritants of Plant Origin"].

- The importance of bruising lies in the site and the organ involved and the contusions of various organs, therefore, may assume different degrees of importance. Contusions of vital organs like heart or brain (especially the brain stem) may cause marked derangement of functions, and even death may ensue. In case of heart, larger contusions by virtue of swell- ing and disturbance in muscle action may prevent adequate emptying of heart and lead to heart failure.

Furthermore, as the contusion ages, the area of heart becomes weaker, which may ultimately lead to rupture of heart and loss of blood into the pericardium and death due to cardiac tamponade.

- Since the contusion results from tearing or rupture of blood

vessels with extravasation of blood into the tissues, the volume of the remaining circulating blood gets diminished by each contusion. It has been reported that even a trivial bruise may lock up 20–30 cc of blood.

- Patterned bruising, as stressed already, may be quite helpful in providing clue towards the nature of the agent used in the assault, though they are comparatively less informa- tive than abrasions because they may show delayed appear- ance, ectopic appearance, and unlike abrasions, incapable of indicating direction of application of force.

- Healing of a bruise imparts some help in the broad determination of age.

- Bruising and abrasions of the shoulder blades indicate firm pressure on the body against the ground or other resisting surface.

- Bruising of the scalp may easily be overlooked. It is better felt than seen. Careful search is necessary, and there should be no hesitation to shave the suspected area, if required.

- Like abrasions, bruising of some particular parts of the body may be indicative of some peculiar offences and the descrip- tion need not be repeated. To cite an example, small bruises associated with nail marks on the neck and inner sides of the thighs of a female may be indicative of sexual assault. Typical small bruises, the so-called 'six-penny bruises' (name derived from the size of the small coin formerly used in Britain) may be produced from forcible poking or pressure with the fingertips.

- Some deep seated contusions, especially in the highly pigmented skin of some individuals (swarthy skinned persons or those with deep tans), may escape observation: Incision of the suspected area is a well-recognised and time-honoured technique to locate and demonstrate such deep seated and otherwise poorly appreciable contusions.

LACERATIONS

A laceration is a rupture or tear or a split in the skin, muc- ous membrane, muscle or any internal organ, involving depth more than the covering epithelium of the skin or that of an organ that is produced by application of blunt force.

Lacerations may be produced by any one or more of the following means:

- Passive agents like ground (lacerations due to falls are most frequent), edge of a pavement or stairs, parts of furniture or of a building, etc.
- Vehicles—it may be of any kind, and it is difficult to name them all in the present scenario.

Blunt weapons—it may be any mechanical object/instrument or a part of the body being used as a weapon, which may include fist, hands covered with boxing gloves, feet (usually the soles) or the booted foot, and other easily available materials like sticks, stones, rods, bottles, etc.

TYPES OF LACERATIONS

Many factors influence the formation and appearance of a lac- eration such as the con.uration of the object delivering the force, the type of the tissue, the area of the body involved and the velocity of the offending weapon. If the impact produces bleeding into the surrounding tissues also, it may be termed as 'contused laceration' or a 'bruised tear'. If the margins of laceration are denuded of epithelium by the same impact, it may be called as 'abraded laceration' or a 'scraped tear'.

SPLIT LACERATION

Split lacerations occur when the soft tissues are 'sand- wiched' between a hard unyielding deeper structure and the agent applying the force. Scalp lacerations are the typical examples that occur when the scalp tissue is crushed between the skull and some hard object such as the ground or some blunt instrument so that many blunt injuries of the scalp may present difficulty in their differentiation from the incised wounds. When the skin is closely applied to the bone and the subcu- taneous tissue is scanty, blunt force may produce a wound that by linear splitting of the tissues resembles an incised wound. Such wounds may, therefore, be termed as 'incise looking wounds'. The sites notorious for production of such wounds are scalp, face, eyebrows, zygoma, iliac crests, the perineum, the shin, etc. In general, they should be taken as lacerations unless shown to be incisions by careful examina- tion. The wound should preferably be examined under good light and using a magnifying glass at the earliest available opportunity so that the process of repair may not affect/modify its appearance. With a fall on the knee or elbow with limb in a flexed position, same thing can also occur.

STRETCH LACERATIONS

These may result due to heavy forceful frictional impact by a blunt force exercising localised 'pressure with pull'. Overstretching of the skin and subcutaneous tissues may cause laceration with flapping of the skin. Direction of application of the force may be gathered from this 'flapping'.

GRINDING COMPRESSION OR AVULSION LACERATIONS

The grinding compression by a weight such as a wheel of a heavy vehicle or some heavy part of machinery passing over the limb may produce avulsion of the skin and subcutaneous tissues from the underlying structures (shearing lacerations). Commonly seen in traffic accidents where the rotating force of a wheel of a vehicle tears off the skin over the relatively large area. This is sometimes termed as 'flaying' and most frequently occurs in legs where a heavy vehicle passes over the body that has already been knocked down to the ground. The torn skin may show extensive abrading and bruising of the margins. Internally, the organs can be avulsed or torn off partly or completely from their attachments. Rarely, the skin may not show signs of injury but the subcutaneous soft tissue is avulsed from the underlying fascia or connective tissue, producing a pocket. This is seen usually over the back of thighs of pedestrians struck by motor vehicles.

TEARS

Tearing of the skin and subcutaneous tissue can occur from localised impact by or against some hard, irregular object like motorcar door handle, radiator mascots or from blows by broken glass bottles, fall over rough projected objects, etc.

Many books have described another type, viz., 'Cut Lacerations'. The term, though sounds good theoretically, encompasses two words with contradictory implications. The author has never used this term as it is likely to invite unnecessary questioning in the court. The edges of wounds produced by not so sharp edges of a heavy cutting weapon like axe, chopper, hatchet, gandasa, spade, etc. may not be as sharp as those of a wound produced by a light cutting weapon and usually show evidence of bruising in and around. Such wounds are often associated with injuries to the deeper structures or organs. If the weapon has been struck obliquely, 'bevelling' of the margins will sug- gest the direction of the blow. (Also see Chopping Wounds in Chapter 15.)

FEATURES OF LACERATIONS

The characters of a laceration that may be helpful in distinguishing it from an incised wound include the following:

- The margins are ragged, irregular and uneven and may show tearing of the extremities at angles diverging from the main laceration, the so-called 'swallow tails'.
- As stated earlier, because of crushing and tearing nature of production of lacerations, there is usually associated abrasion or bruising, though the zone may be narrow, if the lacerating force acts at right angles to the surface.
- The edges of laceration may give an indication of direction, in which the blow or force was applied.
- Depth of the wound presents bridges of irregularly torn fibrous tissue, blood vessels and nerves, etc. across the inte- rior of the wound.
- Soiling of the wound by mud, sand, glass, brick particles, vegetation, machine oils, hair, fibres, etc. may cause these materials to

be found embedded in the wounds and is of great medicolegal value.

- Lacerated wounds do not bleed much as the vessels are crushed and torn but not cut evenly, thus facilitating haem- ostasis to some extent. However, as mentioned under 'Injuries to the Scalp', temporal arteries may bleed freely as they are firmly bound and unable to contract.

- Lacerations over the hairy areas will show hair bulbs crushed or torn and the crushed hair bulbs may get thrust into the depth of the wound.

- Wounds produced by the edge of a broken glass, earth- enware, crockery or projecting flints of stones or similar objects are basically lacerated injuries showing jagged, irregu- lar contused margins. Pieces of the material may be found embedded in the wound, suggesting nature of the wounding material.

PATTERNED LACERATIONS

Lacerations do not reproduce the shape of the agent as distinct as are produced in case of abrasions and intradermal bruises. However, rarely the shape may be recognisable wholly or par- tially and, probably, the typical example may be cited in case of a hammer blow upon the head, giving rise to a crescentic lac- eration or the laceration corresponding to varying portion of the circumference of the striking head of the hammer depend- ing upon the manner in which the blow is imparted and the portion of the edge of the hammerhead in operation.

Without going into many other instances mentioned in various books, I would stress that it is unwise to be specific in extending opinion in case of lacerations as the same may be misleading because a metal rod of circular cross-section may cause an injury identical to one with a square cross-section. Further, a single heavy blow with a hard blunt weapon may result in more than one lacerated wounds.

ANTEMORTEM / POSTMORTEM LACERATIONS

The distinction between lacerations inflicted before and after death should depend upon the presence or absence of vital reaction and, of course, the extent of bleeding, coupled with bruising of the margins. However, it may be kept in mind that quite copious bleeding can occur in the scalp even after death, especially when the body is in dependent position.

Eversion and gaping of the margins is usually seen when it has been inflicted during life but here again caution must be exercised as the muscles have the capacity to contract for some- time after death, and further the posture of the body at and after the time of death may cause gaping simply due to passive gravitational effects.

Bodies recovered from water may pose even greater dif- ficulties as any blood will have been washed away and the decomposition, which is usually pronounced in such cases further hampers differentiation. Such bodies may also bear gross lacerations produced after death by striking against some hard pavement or blunt object. The nature and extent of injuries and absence of vital reaction are helpful in these circumstances.

Occasionally, when the wound is inflicted in the perimor- tem period, i.e. immediately before or after death, the distinc- tion may be impossible as no vital reaction is likely to be found. However, general features like extent of haemorrhage, gaping of the margins, bruising of the edges and the experience of the doctor may be called into play for such differentiation.

MEDICOLEGAL CONSIDERATIONS

Lacerations are usually accidental or homicidal and rarely suicidal as in the case of a suicidal fall from a height or suicidal jumping/lying in front of any running vehicle.

- Organs may suffer extensive parenchymal damage beneath intact surfaces. Examples may be subcapsular hepatic lacerations and subpleural pulmonary lacerations. Hence, the absence of external trauma does not preclude the presence of grave internal injuries. In fact, the most common form of 'concealed' fatal trauma, whether involving head, neck, thorax or abdomen, is seen in blunt force impacts. Converse can also be true in some cases, especially in case of chronic alcoholics dying of some other natural causes but may present incidental external injuries.

- Blunt trauma can be fatal with neither external nor any internal evidence of injury. For example, a sudden forceful impact to the chest against the area of the heart may be responsible for immediate death of the victim without any demonstrable damage to the chest wall or the heart. Sudden disturbance in the functions of the heart may be the cause.

- Scalp lacerations, which are often encountered in homicidal attacks, carry great medicolegal importance and may classi- cally be confused with incised wounds. Much has already been talked about on these lacerations.

- Another unusual or unexpected result that may be seen in laceration causing trauma is the delayed tearing or rupture of the organ, occurring after considerable time of infliction of blow. Heart, liver and spleen are likely to behave in this manner.

CASE: BLUNT FORCE IMPACTS UPON THE CHEST

On the night of 31st July, 1998, some altercation took place between two tenants over sharing of the common roof for sleeping. One was at the ground floor and the other at the first floor. Due to hot-humid atmosphere, both the tenants desired to use the common roof for sleeping. Hot exchanges super- vened but they were soon brought to rest by the intervention of the neighbours. On the next day, the tenant of the first floor along with his brother and others beat up the tenant of the ground floor. As alleged, one inflicted a lathi blow on the chest, another dashed his head against the chest and some conveyed blows. The police, on receiving information, reached the scene and transported the victim (about 20 years of age) to a hospital where he was declared 'brought dead'.

Postmortem examination showed presence of a 10 ⊠ 3 cm2 reddish contusion on the front of chest running from a point 3 cm below the angle of the sternum, going obliquely down- wards and to the right, ending at a point 6 cm medial to the right nipple. Heart showed rupture (1.0 ⊠ 0.75 cm2) on the anterior surface, 2 cm above and to the right of the apex, with consequent accumulation of blood in the pericardial and pleu- ral cavity. On 28th October, 1998, a query from the police appeared—whether the injury to the heart as mentioned in the postmortem report was caused by hitting the head or striking a lathi blow upon the chest?

In this context, it has repeatedly been emphasised that organs may suffer extensive damage beneath intact surface. Because of their thinner walls, wounds of the auricles are more danger- ous than those of the ventricles; due to the same reason, right ventricular injuries are more dangerous than those of the left ventricle. In fact, most common form of 'concealed' fatal trauma is usually encountered in blunt force impacts. Traumatic rupture of heart, though it usually involves the right ventricle as it exposes its widest area on the front of the chest, can cause injury to the left ventricle too. Death is usually immediate, but may be delayed for hours or even days in cases where original rupture being small and sealed by blood clot in the state of shock but rent getting increased with the return of blood pres- sure or with its rise or the other situation may be where the rupture incompletely involves the wall and the rent getting enhanced by increase of blood pressure on exertion. Heart can get ruptured even in the intact pericardium; if the pericardium is also involved, heart may herniate through the tear and get self-strangulated.

ASSOCIATIONS OF ABRASIONS, CONTUSIONS AND LACERATIONS

Lacerations may be found in association with abrasions and bruises and, in fact, double or triple lesions are extremely com- mon. The same object/weapon may cause abrasions under one impact, bruises with the other blow and lacerations with the next. Alternatively, a single blow/impact may even result in production of all the three types of lesions.

FALLS

"The higher you climb, the harder you fall"—a Chinese proverb.

In the ordinary course of affairs, falls are of common occurrence; the severity not necessarily being directly related to the distance from which the person falls. Instances are avail- able in the literature wherein skull fractures and brain damage have been reported from trivial falls. A case has been reported in the literature wherein occipital fracture occurred in the drunken person who was being lifted by his drunken friends, his head and shoulders being allowed to fall back on the concrete sur- face from about half sitting position. Falls in old people can lead to fractures of post-cranial skeleton, especially the neck of femur (osteoporosis being the major reason for such fractures). In infants, skulls could be fractured against a variety of floor surfaces from passive falls of only 34 inches (Weber). Falls from a standing position can occur during a drunken state, fainting attack, and of course, from an assault.

In circumstances of assaults, the gravity of injuries produced by direct trauma may be considerably less than the injuries sustained from the indirect result. For example, a blow on the chin (direct impact injury) may cause the victim to fall and receive head injury by striking the head against the ground or some object. Here, it is worth adding that contrecoup cere- bral damage can occur notwithstanding absence of injury to the scalp or skull. The direct impact under such circumstances may be biologically insignificant from the standpoint of caus- ing death, although it is considered as a crucial factor in the legal outcome of the assault. Falls from a height (usually from a building) are common in suicide and in some accidents. Falls from a height resulting from homicide are uncommon and may be associated with defence type or offence type inju- ries while resisting being pushed from a balcony, roof or win- dow. However, such injuries may be absent if the deceased was managed by surprise. Further, when present, they are usually very difficult to be distinguished from the fall injuries unless they are quite distinctive, for example, fingertip pressure marks and other bruises plus abrasions that are inconsistent with an uncomplicated fall. Further, presence of any finding relating to sexual assault should raise suspicion in this direction. It is pru- dent to investigate the possibility of substance abuse when young/young adults fall from a height .Case ahead). Goonetilleke (1980) published some research on the aspect of distance from the wall where the body was likely to land and also showed that the severity of brain damage was not directly proportional to the height of the fall. Much depends upon the fact that whether the victim fell passively from near the wall or projected himself/herself outwards while commencing the fall. According to Isbister and Robberts, it is more common for a jumper from a lower floor to strike the ground feet first and from above the 13th floor to strike the ground head first. Further, the body may strike the ground in a number of differ- ent attitudes, the primary impact usually being exhibited through the area of the most severe injury. However, two areas of the body may strike almost simultaneously—such as head and shoulder.

It is obvious that factors like rate of change of direction and speed of movement are the major ones concerned with the outcome of the injuries to the tissues. Other factors like nature of the surface of impact (the more resistant the surface, the greater are the deceleration forces), the size of the impacted area, and the target factors play their own role. (Energy liber- ated by an impact may be transferred through tissues without producing significant local damage and yet, capable of produc- ing serious injury at a site comparatively remote from the point of contact between the victim and the traumatising surface. Further, violent displacement of gas or fluid within the hollow viscera can result in injuries from explosive pneumatic or hydrostatic forces set into motion by the transmitted energy). According to Knight (1996), a deceleration of up to 30 G can be sustained without injury, while forces of up to 200 G may be survived for a short interval, provided they are applied to the long axis of the body. However, such theoretical consider- ations may be confounded by the following circumstances:

- Tumbling, rotation or spiraling of the body during the free fall resulting in some dissipation of the kinetic energy and therefore, the actual magnitude of primary impact.

- Secondary or even tertiary impact with the ground or other object in the vicinity due to bouncing of the body after the primary impact.

- Collision with intermediary objects/obstructions that is sufficiently sturdy to retard the fall and thereby reduce the final velocity at impact. Further, collision with such struc- tures could also produce serious injuries unconnected with terminal impact. Bernard

Knight reports a case wherein a suicide while falling from the twentieth floor, fell onto a fence and was completely transected at the waist level. However, at the other extreme, biological and circumstan- tial variability may allow for some remarkable escapes.

CHAPTER-15

INJURIES BY SHARP FORCE

Injuries by sharp-edged instruments/weapons result in either 'cutting' or 'stabbing' depending upon whether the instrument has been used in a swiping manner or in a thrusting manner. Information of great importance can be derived from the careful examination of a 'cut' or a 'stab' that can be helpful in reconstructing the events. Therefore, either deserves to be dealt with separately.

INCISION/CUT/SLASH

Accidental incise wounds can occur and usually are not so severe in nature. Home, especially kitchen, or workplace/ industry is the typical place of occurrence of such wounds. Casual use (slippage of blade while sharpening a pencil), misjudgement, lack of skill/inclination, etc. may be the factors leading to an accidental injury by some sharp instrument/tool. Another instance may be seen in the case of burglars who receive injuries from broken window glass while housebreaking. Sheet glass or mirror glass may also prove hazardous in innocent circumstances. Death may result from cut-throat injury or involvement of area of the groin, or from falling or impalement on a large sliver of glass.

There have been occasions when slashes have been deliberately aimed to cause disfigurement and humiliation. Face is the main target for such type of injuries. The ensuing scar may form an important factor towards legal outcome. Wounds may be discontinuous where they cross a natural fold or trench, as may be the case when a single slash involves eyebrow and the summit of cheek. Such disconnected injuries may be misinterpreted as separate passes of the weapon. As a general rule, incisions inflicted by an assailant tend to have a sweeping quality. They usually show rapid deepening. There is seldom any repetition in the same plane, although they may crissross.

FEATURES OF INCISED WOUNDS

MARGINS

As stated above, they are clean cut, regular and well-defined. They are free from any bruising when caused by light cutting weapons, but bruising and some irregularity of the margins may be present when heavy and not so sharp-edged weapons like shovel, kassi, axe, tangi, etc. have been used. The usual incised wound is linear with everted margins but in the areas where the skin is loosely applied to the body as in the scrotum or neck, the margins might appear inverted and jagged because the skin is pushed in front of the blade before it is divided. Even then their true nature can be determined by careful observation or examining under a magnifying glass. Such situations are usually encountered in scrotum, neck, axilla, palm of the hand, and so on. Further, a single strike over the areas where skin is folded and puckered usually produces a series of incised wounds, one separated from the other by a bridge of normal skin.

Length

Being produced by a sweep of blade, the wounds have 'length' as their greatest dimension. It does not bear any relationship with the length of the blade of the weapon.

Breadth

The breadth of the wound will depend upon the extent of 'gaping' of the margins because of the retraction of the divided tissue associated with eversion of the margins .details under 'Stab Wounds').

Depth and Direction

Usually, the incised wounds are deeper at the commencement (as is expected from the process of drawing or sweeping through which they are produced) except in case of suicidal cut-throat injuries with hesitation cuts at the beginning. Towards the termination, the cut becomes progressively shallow, known as 'tailing of the wound'.

Consequently, the depth of the incised wound with the 'tailing' will suggest the direction in which the force was applied.

Shape

Usually, the incised wound is fusiform or spindle shaped due to comparatively more retraction of the edges in the centre. When inflicted upon the convex surface of the body like the occipital region or buttocks, the wound may be crescentic or semilunar in appearance, so also when the blade of the weapon is curved. The shape may be 'V' or 'A' or wound may even assume any bizarre appearance depending upon the changing attitudes of the victim and the assailant as is often expected during struggle.

Haemorrhage

As the vessels are divided cleanly, profuse haemorrhage is frequently a feature of incised wounds. Even minor incision of a vascular part, say a finger tip, may occasion troublesome bleed- ing. An artery 'nicked' or 'incompletely severed' will bleed more freely than one that is cut through and through, because of its inability to contract or retract. Bleeding, however, being exter- nal is more amenable to prompt treatment than the hidden internal bleeding in case of a stab wound.

Bevelled Cuts

In case of an oblique strike by a sharp-edged weapon, bevelling or undermining of the edges may be present indicating the direction from which the slashing stroke was imparted. Occa- sionally, a 'flap wound' may be produced when the stroke is nearly horizontal to the body, particularly when some heavy cutting weapon has been employed.

Hesitation Cuts

The situation and circumstances of incised wounds of the throat deserve separate mention. They are rarely the result of an accident, and therefore differentiation between suicidal and homicidal needs to be established

The self-inflicted wound, when made by a right-handed per- son, normally begins high on the left side and passes downwards across the front to end on the right side of the neck. Some- times, the wound may lie horizontally across the front of the neck. There may be present multiple superficial cuts around the commencement of the main wound. These superficial 'tenta- tive' or 'hesitational cuts' indicate divided state of mind of a person as it is usual human instinct to preserve life. The throat wounds can be accompanied by incised wounds of the wrist or tentative cuts elsewhere. Suicidal cut-throat wounds may lead to instantaneous rigor, when death ensues. Therefore, if the weapon is found firmly grasped in the hands, it is strongly in favour of suicide.

Homicidal cuts lack the presence of tentative cuts and may be accompanied by other wounds upon the body. It tends to lie lower in the neck and assume horizontal position. There may be bevelling of the margins and they are likely to be toothed or may show some irregularity of the margins at places because the skin is thrown into folds before severance. Major blood vessels may be involved in homicidal cut-throat wounds, but they are usually protected by the sternomastoid muscle, when the head is extended by the suicide.

Chopping Wounds

Chopping wounds result from hacking or chopping motion made with a fairly sharp and relatively heavy weapon like axe, hatchet, cleaver, saber, bayonet, etc. The nature of the wound depends upon the sharpness of its blade, direction and angle of the blow, portion of the instrument that actually operated in inflicting the injuries and differences in curvatures of the tis- sues involved.

There is often a spectrum of injuries lying between typical lacerations and incisions, which are determined by the sharp- ness or otherwise of the blade of the weapon/instrument. It is important to make distinction, because it may provide an indi- cation as to the weapon used and may prove crucial to the legal outcome of an attack. Hatchets, axes, spade, etc. are mostly kept unattended—ground but not honed. All such ill-maintained weapons have ground edges and often present some nicks and/or firm rusty deposits on their blade including the edge, preventing the weapon to produce pure incision. When sharp- ened, such weapons produce devastating incised wounds. Even bone may be transected with comparatively little effort. The action of chopping may produce injuries that provide some indication as to the shape and stoutness of the blade employed. (Homicidal axe blows are usually aimed at head, producing trench-like skull fractures with comminuted margins. Repeated blows may produce virtually complete fragmentation of the cra- nium. A near tangential sweep to the head may lift a slice from the outer . of the skull—a circumstance speaking for itself.)

At times, blunt pole at the back of the blade or wooden handle of an axe may be used depending upon the circum- stances. In Babu Loshi vs. State of Uttar Pradesh [(1987) 2SCC, 352], the Honourable Supreme Court held, "When three persons beset themselves on a victim and attack him in quick succession, it is not possible for a witness standing at a distance to say where each cut or stab fell on the body and whether the blade or the handle caused the one or the other of the injuries. It is quite likely that the handle of the axe also came in contact with the body of the victim and likewise the spears had also been used now and then as a lathi to inflict blows. Thus, abrasions and contusions are also possible from axe or spear where more than one person uses them on the victim in quick succession".

Elementary Distinctions between Suicidal and Homicidal Cut Throat

Features/ points	Suicidal cut throat	Homicidal cut throat
Site	Mostly on the left side and front and partly on the right side of neck (in case of right-handed person) and placed high up on the neck	Mostly on the sides of the neck and placed at a lower level
Severity of the wound	One or two are severe, others are superficial, the so-called hesitation cuts	Many of equal severity may be present
Secondar y wounds	Self-inflicted incised wounds may be present on other approachable parts of the body	Other homicidal wounds, defence cuts, marks of resistance usually present on other parts of the body
Direction	From left to right and above to downwards in a right- handed person	Transverse/horizontal and from right to left when the assailant's position is below the level of the neck of the victim (a homicidal wound on the throat may resemble a suicidal one if the assailant has inflected it from behind the victim or by standing on the right side while the victim is lying)
Tailing	Gradual deepening and shallowing with tailing at the right end of the wound (in a right handed person)	Usually exhibits bold cutting at the commencement
Hesitatio n cuts	Marked by tentative hesitation cuts either at the beginning, above or below the main wound	No such cuts
Defence cuts	Absent	Frequent 'protective cuts/defence wounds' on the grasping surfaces of hands or on back of forearms
Vessels	Carotid arteries are usually spared because, before injuring, the victim stretches his/her neck upwards, when these vessels shift behind the sternomastoid muscles	The vessels remain vulnerable due to lack of this manoeuvre
Bleeding	As the wound is usually inflicted during standing or sitting position, a good amount of blood trickles down in front of the chest and abdomen	No particular pattern

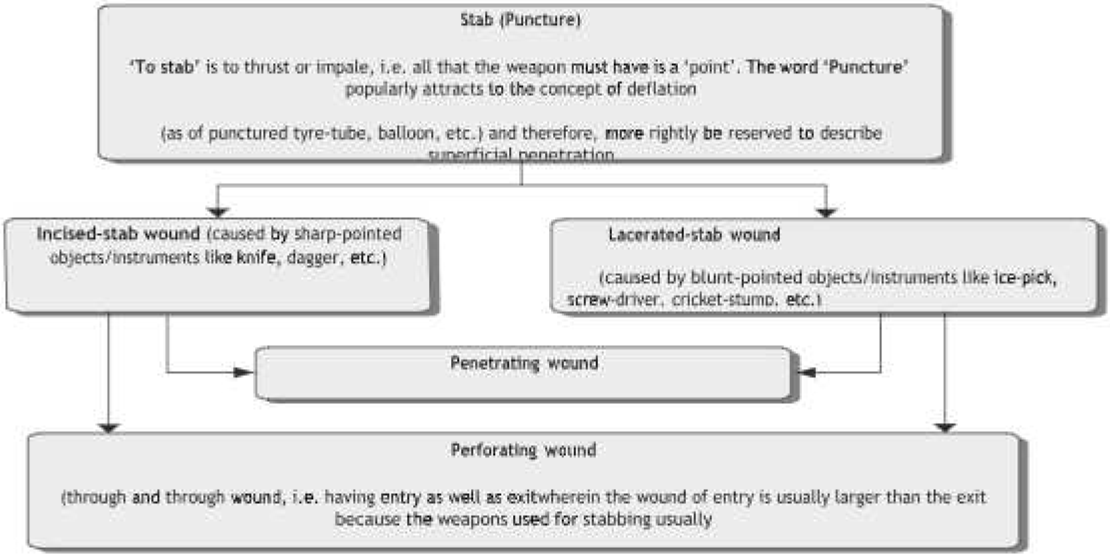
Weapon	Usually present, sometimes firmly grasped by cadaveric spasm	Usually absent. Rarely, an ultracriminal mind may manage to place the weapon in the hand of the victim so as to mimic suicide
Foreign materials like hair, etc.	Substances like foreign hair, button, etc. are not found in the hands of the victim	May be present in the hands of the victim, gripped in a state of cadaveric spasm while exercising resistance
Corresponding cuts on clothes	Absent as the person cautiously removes the clothes to get a clear field of the area	Cuts may be present on clothes as the assailant, being in haste, is unmindful about the clothes
Circumstances	Closed room bolted from inside or bedroom or secluded place, which appears undisturbed. Sometimes, the body may be found in front of a mirror, which may show blood splashes	Considerable disturbance at the scene and even elsewhere is usually found
Suicidal note	May be present	Absent

Stab/ Punctured Wounds

The word 'stab' means 'to wound or pierce with a pointed weapon' and the word 'puncture' also means 'to pierce with a pointed object/weapon/instrument'. Therefore, these words are often used interchangeably. However, the term 'stab wound', in the popular sense, is confined to the wound that is caused by thrusting a sharp-edged and pointed weapon like knife, dagger, etc. Categorisation of the puncture wounds depending upon the nature of weapon, as described ahead, further lends support to this aspect. Since the wound is produced by a thrusting or stab- bing motion, the depth of the wound is greater than the dimen- sions of the surface wound. Depending upon the severity, they may be grouped as follows

- Penetrating wound: Here, the wound into the body cavity or viscus may be a joint cavity or scrotal sac.

- Perforating wound: The wound is called perforating when the weapon pierces through the whole thickness of any part of the body thus producing two surface wounds, i.e. wound of entrance and wound of exit. The wound of entrance is bigger than the wound of exit due to tapering of the blade of the weapon and its margins will be inverted, whereas the margins of exit wound will be everted. The track of the wound, starting from the entrance towards its termination, is convergent in contradiction to the track of a wound pro- duced by a missile at short ranges where it is divergent.



Categorisation of stab wounds.

Depending upon the nature of weapon/instrument (i.e. whether some sharp pointed or blunt pointed weapon or instrument has been used), they may be grouped into:

- Incised puncture/penetrating/perforating: Examples may include wounds produced by knife, dagger, kirpan, etc. In the common usage, such wounds are designated as stab wounds as described earlier.
- Lacerated puncture/penetrating/perforating: Examples may include wounds produced by icepick, screwdriver, pointed end of the cricket wicket, etc.

FEATURES OF A STAB WOUND

When a sharp-edged weapon (like a clasp knife, dagger, ballam, etc.) is used, the wound is usually produced by the combined action of the tip and the cutting edge. Various features may be as follows:

Stab/ Punctured Wounds

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Length

The length of the surface wound will be slightly smaller than the width of the weapon up to which it has been driven in because of gaping of the wound margins, unless rocking of the weapon or lateral movement of the victim or assailant enlarges it. Repetition of stabbing without complete withdrawal may double the entry wound or may produce an erratic surface wound. The length of the wound should be measured by gently opposing the skin margins, which more accurately approximates to the length when the blade of the weapon was in situation (.. 15.1). The component of gaping may be exaggerated depending upon the plane in which the muscle fibres have been cut and modifying the length accordingly. This has been discussed in detail under heading 'Shape'.

Breadth

The breadth of the surface wound usually does not have any approximation to the thickness of the blade of the weapon, again due to gaping of the wound margins (.. 15.1). In the dead bodies, putrefaction may cause eversion of the edges and increase in breadth of the surface wound.

Depth and Direction

The depth of wound (i.e., the length of the track) is a guide to the length of the blade in operation, but this is not by any means infallible as multiple factors are involved.

Actually, the depth of wound may frequently exceed the length of the blade that caused it. Essentially, this is due to the indentation or caving-in of the body surface as a result of thrust. Abdominal wall is the most glaring example in this concern where the yielding anterior abdominal wall during the exercise of bearing the impact of the force and the pressure of the hand or fist may cave-in considerably so that the tip of the weapon (though relatively small length of the blade of the weapon has actually been in operation), can reach quite deep into the abdominal cavity. The abdominal wall will come to its original state after withdrawal of the weapon. Even the chest wall is no exception as the rib cage is amenable to considerable caving-in. The movements of chest, i.e. expansion and retraction during the process of breathing, should also be taken into account. Stab wounds of 6 inches and 7 inches depth have been reported with a 4-inch pocket knife. Further, the lung, if punctured, may collapse and be drawn upwards and backwards when the impact is from the front side of the chest, thus giving increased measurements at autopsy. Conversely, if the stabbing is from the back of the chest resulting in puncture and collapse of the lung, then due to shift of the lung posteriorly to the point of its attachment, diminished measurements result from the wound of entrance to the wound of termination in the lung as compared with the length of the blade of the weapon actually in operation.

An additional factor that may also be given due consideration is that the relationship of intra-abdominal organs at the time of assault in a living individual in erect or bent posture is not same as is observed during postmortem on the autopsy.

Traits	Lacerated wound	Incised wound
Weapon/ agent	Caused by blunt weapons or fall against hard objects/surface	Caused by weapons with sharp cutting edges
Situation	Usually against bony prominences or projecting areas	Anywhere on the body
Shape	Usually irregular (varies as per causative agent)	Usually linear or fusiform/spindle shaped
Margins	Ragged, irregular, uneven and often accompanied with bruising and abrasions. Retraction and eversion of margins are not usual	Always regular, even clean cut and everted with no bruising or abrasions when caused by light sharp cutting weapons (bruising usually present when caused by heavy cutting weapon)
Dimensions	Varies with the nature of offending weapon/object/ surface, or the mechanism of infliction. Usually shallow in depth	Usually length is greater than the depth and breadth (breadth is greater than cutting edge of the weapon due to gaping)
Condition of surrounding or underneath tissues	Soft tissues underneath show evidence of tearing and splitting with bruising in and around. There may be some loss of tissues with exposed hair and hair bulbs crushed or torn	Soft tissues underneath clean cut. Hair and hair bulbs clean cut. No loss of body tissues unless a 'flap' is sliced off
Bleeding	Not pronounced, spurting of blood is uncommon, except in case of temporal arteries because of anatomical disposition	Bleeding is usually profuse (incompletely cut or 'nicked' artery will bleed more freely because of its comparative inability to contract or retract)
Foreign matter	Trace evidence often left in the wound will help to connect the crime with the offending object and place of occurrence	These are not commonly noticed
Wearing apparels	Coverings over the affected site may be torn	Coverings over the affected site usually show corresponding cuts (when garment is loose or folded, there may be multiple cuts on the clothing)
Multiplicity	Multiple lacerated wounds with bruises and abrasions over different parts of the body indicate traffic accident or fall from height. Bevelling of margins is not noticed (though tissues may get lacerated in a flap like fashion)	Multiple superficial incised wounds over accessible body parts suggest self-infliction. Presence of 'tentative/hesitation' cuts at the neck region with one or more deep wound(s) having distinct tailing indicate suicidal phenomenon. Multiple deep incised wounds over different body parts with defence wounds indicate homicidal phenomenon

Differences between Lacerated and Incised Wounds

Direction is indicated by the track of the wound but evidence of undercutting, if present, will also give an idea about its direc- tion. The track can be well-demonstrable when it has passed through a solid organ like liver or hard tissues like bones. Care must be exercised in interpreting the circumstances from the direction of the wound. Factors like lateral deviations of the weapon, left or right handedness of the victim as well as the assail- ant, the stature of the individual and, above all, the constantly changing postures of the victim and the assailant (as is often expected during the stabbing incidence) need to be evaluated carefully.

Probing of the stab wound is not advisable as it may lead to fatal haemorrhage by dislodging some clot or creating false passages or injuring some organ. The depth should be determined during operation or during the postmortem examination by dissecting the track of the wound in layers. In the living, injec- tion of dyes or radiopaque material into the wounds to enable the demonstration of the wound track by X-rays has been attempted and claimed to be advantageous by some.

The operating surgeon should not disturb the surface wound and should simply stitch the same while taking other necessary measures so that it can be evaluated in its proper perspective by the autopsy surgeon in the unfortunate event of death of the victim.

Margins

When a sharp cutting weapon has been thrust, the margins will be clean cut and without any bruising. Margins of the wound are inverted. The exit wound, if present, will show everted margins. The margins of the wound of entry can be everted when the wound is situated over the fatty area such as protu- berant abdomen or the gluteal region.

Abrasion or bruising of the margins of a stab wound sug- gests that the blade had been completely inserted. In such cases, the suspected weapon, if available, must be examined to observe the compatibility of the shape of abrasions/contusions around the wound with the handle of the weapon in question. In this context, it may be kept in mind that unless the blade penetrates the body at right angle, all sides of the hilt may not be equally imprinted upon the skin. Therefore, depending upon whether the weapon has been inflicted in a downward or upward direction, the impressions of the hilt will be conveyed accordingly.

SHAPE (CONFIGURATION)

Although ellipse is the most common shape, there is a wide range of shapes of these wounds. Strangely shaped surface as well as the visceral wounds may be observed such as 'A' or 'V' or '¥' or some may be square or diamond shaped and still others like cruciate, stellate, etc. The size, shape and configuration of these wounds are influenced by a number of endogenous and exogenous factors as under:

FACTORS ATTRIBUTING TO THE WEAPON

The external appearance of stab wound does not depend solely upon the cross-sectional configuration of the weapon, as already described; it is influenced by the following also:

- The site of injury and the plane in which the weapon struck the target.
- Whether the weapon is single-edged or double-edged, etc.

To discuss these one by one, there is no denying the fact that the site of the wound in relation to tissue planes may have a modifying effect on its pattern. Traction of the tissues may cause the wound to appear to have been caused by a blade having a thick back, when it was in fact a thin sharp blade that would have produced an elliptical wound elsewhere. Further, the elastic tissue of the dermis, the deeper layer of the skin, has a considerable bearing upon the shape of the wound. It should be realised that the dermal collagen and elastic fibres are arranged in a definite pattern and are flowing in all areas of the body. The pattern of fibre arrangement is called the lines of cleavage of the skin, and their linear representations on the skin are generally known as 'Langer's lines'. These cleavage lines correspond to the creases of the body surface. Surgeons do take into consideration the orientation of these lines because an incision parallel to these lines heal with a fine linear scar, whereas an incision across these lines may result in an ugly looking scar. A stab wound with long axis at right angles to the cleavage lines of Langer will gape open with the edges pulled apart, whereas one that runs parallel to these lines will appear slit like or wedge shaped and will represent with fair degree of accuracy the dimensions of the blade with which it was pro- duced. If the weapon is inserted in an oblique fashion, the skin gap may be of the dimensions intermediate of those described earlier. In some instances where the skin wounds are gaping widely, injuries in the underlying viscera like heart, liver, etc. may be slit like. The converse may also be true, i.e. skin wound on the anterior thorax may be narrow slit if its long axis run parallel to the lines of Langer, but the defect in the underlying intercostal musculature may gape widely due to the retractive effect of the muscular fibres.

In context with the single-edged or double-edged blade, the opinion is divided—whether or not this instrumental char- acteristic can be ascertained with accuracy depending upon the con.uration of injuries. Most observers feel that skin wounds have two well-defined marginated acute angles even when pro- duced by a single-edged weapon. However, a skin stab wound, which closely parallels the cleavage lines, may exhibit one well- defined and another blunt extremity corresponding to the sharp and dull edges of a single-edged weapon. To be more critical, the blade of the weapon may be double-edged along its entire length or it may be double-edged for a variable distance or it may have one cutting edge.

One explanation for the presence of bilateral acute angles in the wounds inflicted by a single-edged weapon is that the ini- tial penetration by the extreme tip of the blade of the weapon creates a dermal defect with acute angles at each extremity, and the cutting edge of the blade continues to operate while the opposite extremity of the wound which is in contact with the blunt side of the blade of the weapon remains sharply angu- lated as was created initially as the dull side of the instrument hardly receives any opportunity to play its role. Exceptions may arise depending upon the manner in which the weapon is being thrust, i.e. whether the cutting edge is moving forward or the blade is being thrust quite perpendicularly to the body surface extending due consideration to the direction of the cleavage lines of Langer as stressed earlier.

FACTORS ATTRIBUTING TO VICTIM AND THE ASSAILANT

During the process of stabbing, there are often relative movements between the victim and the assailant. If the victim twists or turns the target portion of the body either during the in- stroke or during the out-stroke, the external wound may get irregularly distorted. Moreover, the weapon may be manipu- lated by the assailant in different ways. Countless possibilities exist, all capable of producing bizarre or atypical wounds. To cite a few examples:

- The instrument is thrust in, partially out and in again along a different track. Here the external wound may be of com- pound nature and more than one track may be seen in deeper tissues and organs.

FALSE EDGE

- the instrument is thrust in and is withdrawn with the cut- ting edge dragging against one extremity of the wound so as to extend the wound superficially.
- The instrument is thrust in and then, while still in, is pulled in the direction of the cutting edge so that the track and the skin wound both get enlarged.
- The instrument may be twisted during in-stroke or during withdrawal or during both. The margins of the external wound will be irregular and varying in dimensions.

Amount of Force Required to Inflict Any Particular Stab Wound

This question may be raised in some fatal stabbings. This query cannot be answered absolutely but only in comparative terms as it is a subjective phenomenon. The medical witness may use the terms 'slight', 'moderate' or 'considerable force'. For exam- ple, it is reasonable to conclude that considerably less force is required to inflict a deep stab wound with a fresh surgical scal- pel blade than is needed to produce same wound with a dull knife of equal size and similar shape. Experiments conducted by Bernard Knight and many other investigators in the animals, cadavers and in the surrogate tissues, suggest the following useful generalisations:

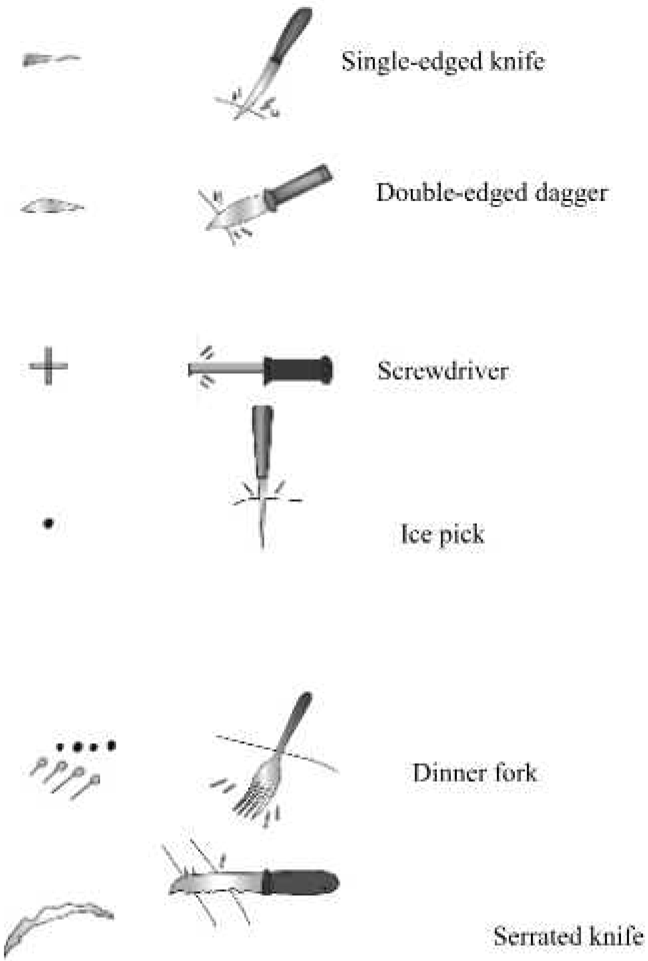
- The amount of force required to produce a particular wound varies inversely with the sharpness of the extreme tip of the knife and the keenness of the edge of the weapon
- The general character of the blade of the weapon also matters. A thin, slender double-edged knife will penetrate more deeply than an equally sharp, wide single-edged blade inserted with the same force.
- Toughness of the target area/tissue also matters. Apart from bone and calcified cartilage, the tissue offering most resis- tance is the skin. Once the resistance of the skin has been overcome, the knife slides through the underlying tissues with out much effort.
- Another important factor is the velocity of knife at the time of impact, as fast moving knife would penetrate the tissues with greater ease than one exercising slow steady pressure.
- Victim may contribute to the force involved in the fatal thrust by running into or hurling himself on to the blade.
- The stretched skin is easier to penetrate than the lax skin. The chest wall, where the skin is stretched over intercostal spaces, is easier to penetrate.

WOUNDS BY BLUNT PENETRATING/ DULL INSTRUMENTS

Penetrating wounds inflicted with comparatively dull instruments like scissors, screwdriver, poker, chisel, etc. frequently demonstrate lacerated marginal cuticular wound . The skin is split as well as penetrated, and there may be marginal bruising too. The characteristic feature of wounds produced by open scissors is a pair of wounds with one wound above and somewhat oblique to the other. The distance between the two wounds differs with the angle of penetration.

WOUNDS BY GLASS

Wounds produced by glass can pose difficulty in the interpretation in absence of information concerning the circumstances. Basically, they are all lacerated wounds but if spicule of glass enters by its point, the wound is then stab-like in appearance. When applied tangentially or at a small angle to the skin, undercutting may be a marked feature. Though the glass may be used for slashing, long slivers of glass can act as stabbing agents. The sliver may break off and remain in the wound. Side cuts are also likely to be seen and, when present, are characteristic of wound by glass. Search should be made for flakes or particles of glass in the wound.



Skin wounds produced by different weapons carrying blunt/sharp pointed blade.

CONCEALED/ OBSCURE PUNCTURE WOUNDS

Rarely, the site of puncture wound may be relatively inconspicuous. Puncture wounds in hairy areas (scalp and/or pubes) can be located by visual and palpable search. Among other sites not anticipated as the points of occurrence of puncture wounds are the ears, nostrils, medial canthus of eye, fontanelles in the newborn, nape of the neck, axilla, underfold of female breast, vagina, rectum, etc. Extreme difficulty may be faced in locating wounds at such sites. The difficulty may get compounded because of the surface of the body being smeared with blood. The agent/instrument involved in such cases may be small in cross-section, like knitting needle, safety pin, etc. At times, pointed instrument may enter the peritoneal cavity through vagina during attempts for procuring abortion. Hendry and Stalker reported a good example where the agent was an unusual one, namely, part of an aluminium 'tail' comb.

ACCIDENT, SUICIDE OR HOMICIDE

Though the stab wounds are usually homicidal in origin, yet the issue of suicide/accident can creep up under certain circumstances. Following points may be helpful:

- Multiple stab injuries scattered over various parts of the body, accessible or inaccessible, covered or uncovered, indicate homicide. Although homicide may be accomplished by a single stab (.. 15.5), it is more usual to find many. It may be on these occasions that even after a lethal stab has been given, the assailant continues to stab or returns later to resume the activity, the so-called 'overkill homicide'.

- Thrusts by homicide are all likely to penetrate deeper, and more than one may be lethal. There may be a few outlying strokes beyond the target area. On the other hand, a suicide is likely to confine his thrusts to a smaller and restricted area, and only one or about a couple of them is likely to be deeper and lethal.

- At occasions, interpretation of a single stab may pose difficulty as the usual defence against the homicidal stabbing is to allege that the deceased 'ran on to the knife'. In this context, the most important consideration is the firmness with which the weapon was held. It may be argued that the impetus of the moving body is more than enough to impale it on suitably pointed object. However, there may be occa- sions where some stab injuries result from the combined movements of a stab thrust and an approaching or falling victim. Direction of the track within the body may lend some help in resolving the issue, viz.,

- a downward track might be in keeping with impalement during a head-down eventuality of the victim;
- an upward track may suggest falling of the victim or jumping down into the fray from a height; or
- a horizontal track may suggest turning of the victim into an unseen weapon.

Factors like firmness of grasp of the weapon, nature of the weapon especially of its tip (blunt point will glance off the skin more readily than will a sharp one) and other subjective plus extraneous factors need appreciation in such a context.

- Suicidal injuries are commonly situated over front of body on easily accessible sites, especially over throat, precordium, abdomen or wrists and rarely found on unusual locations as cannot easily be reached by the victim.

- A couple of characteristic features of suicidal stabbing include the following: Firstly, presence of 'tentative wounds' that are superficial and unlikely to penetrate beyond muscu- lar layer. The finding of tentative wounds (hesitation cuts) is a useful observation in helping differentiate suicide from homicide. Indeed, 'Hesitation marks' can be considered the 'trade marks' of suicide. The name is derived from the fact that cutting/stabbing oneself is painful and the would be suicide frequently makes several half-hearted, superficial cuts/ stabs before he/she gathers sufficient courage to unleash the sufficiently forceful stroke, which is able to cause fatal dam- age. Another basis for hesitation marks may be the subject's ignorance as to how tough and resistant the tissues are and how much force is needed to produce the fatal injury with the weapon at hand. Secondly, suicides almost always inflict wounds over the uncovered parts of the body. Thus, wounds over the parts of the body that ordinarily remain covered by clothing, without corresponding cuts/rents upon them, are indicative of suicide. This observation is again a potentially useful factor in differentiating suicide from homicide because a homicidally inclined assailant does not ordinarily take time or trouble to expose the site of injury (..15.4).

- Hara-kiri: It is an unusual type of suicide, usually seen in Japan, in which the victim inflicts a single large incised penetrating wound over the abdomen with a short sword or falls upon the ceremonial sword and pulls out the intestines. The sudden evisceration results in sudden decrease in intra- abdominal pressure and cardiac return, producing sudden cardiac collapse.

- Defence wounds, like cuts and/or lacerations/bruises, etc. on or in-between the fingers and palms, back of hands, wrists, inner aspects of forearms or any other part of the body,

I if present, are strongly suggestive of homicide as these are produced during attempts by the injured to seize the weapon in instinctively defending himself or in an endeavour to ward off the attack on the head or some other vital part of the body.

- Accidental stabbing/puncturing is an unusual event but may be encountered in case of accidental fall over the pro- jected ends of railings, spikes of garden walls or house walls or from falling against broken glass/earthenware fragments, which may often get embedded in the deeper parts of the wound. Difficulty may arise in cases where the injury is received during a .ht, and the defence counsel tries to take shelter in arguing it to be of accidental origin. Here, factors like presence or absence of defence wounds, the angle, situa- tion and direction of the wound, the condition of area adjoin- ing the surface wound, detailed examination of the clothing and the circumstances of the injury will be helpful in solving the problem.

CHAPTER-16

INJURIES BY FIREARMS

A firearm is any instrument or device designed to propel a projectile by means of expansive force of gases generated by combustion of an explosive substance. Forensic ballistics may be considered as the science dealing with investigations of firearms, ammunition and the problems attending their use. For a doctor, elementary knowledge of structure of a firearm, composition of ammunitions and mechanism of discharge of a firearm is necessary for proper understanding and interpreta- tion of the injuries produced by them. However, at the very outset, I must convey that the medical experts are not bal- listic experts and, therefore, should confine themselves while giving evidence in the court to the interpretation of injuries upon the body and that too in broad generalisation. It is for the ballistic expert to opine about the precise range of fire, the nature of weapon involved in the crime, the nature of ammu- nition, etc. to great density of the tissues as compared to the air. When a bullet is fired down a rifled barrel, the rifling imparts a number of markings to the bullet that are called 'class characteristics'. These markings may indicate the make and model of the gun from which the bullet has been fired. They result from the specifications of the rifling, as laid down by the individual manufacturer. These characteristics include (i) number of lands and grooves, (ii) diameter of lands and grooves, (iii) width of lands and grooves, (iv) depth of grooves, (v) direction of rifling twist and (vi) degree of twist. In addition to these class charac- teristics, imperfections on the surfaces of the lands and grooves score the bullets, producing 'individual characteristics'. For lead bullets, these individual characteristics are more pronounced where the grooves score the bullet. In contrast, for jacketed bullets, the land markings are the most pronounced. These individual characteristics are peculiar to the particular firearm that fired the bullet and not to any other. They are as individual as fingerprints. No two barrels, even those made consecutively by the same tools, will produce the same markings on a bullet.

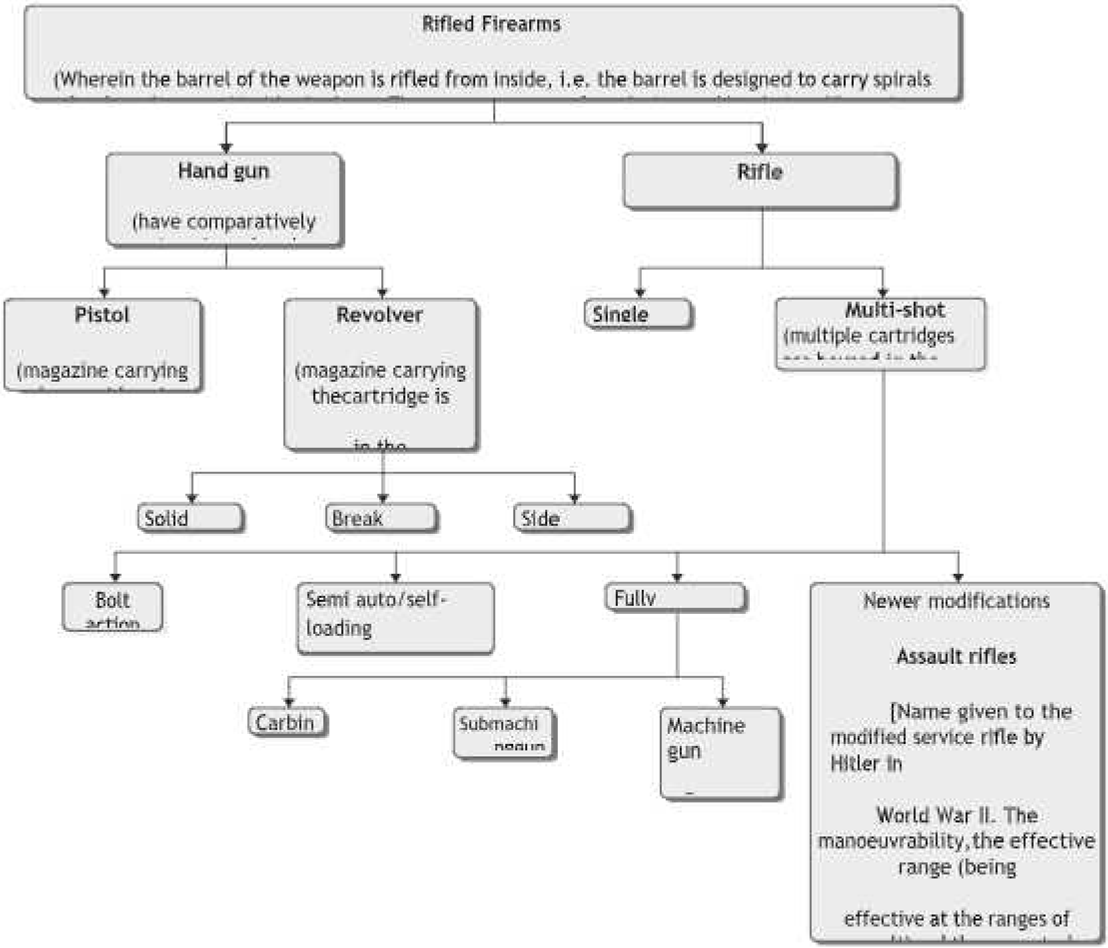
TYPES OF FIREARMS

RIFLED FIREARMS

These weapons discharge a single projectile or missile through a 'rifled' bore and hence the name. Rifling means the inner surface of bore of the weapon from breech to the muzzle end is thrown into spiral grooves, varying from 2 to 22 or more (usually 4–7), which run parallel to each other but are twisted spirally. These 'grooves' are called 'rifling' and the projecting ridges between these grooves are called 'lands'. Riflings vary in number, direction, depth and width. The purpose of rifling is to impart rotational spin to the bullet along its long axis. The gyroscopic effect stabilises the flight of the bullet through the air, preventing it from tumbling end over end. This spin does not, however, stabilise the bullet after it enters the body due

Different types of rifled firearms have been described in Flowchart

Calibre of a rifled firearm is measured between a pair of diametrically opposite 'lands' across the bore. In the United States and all English-speaking countries, the diameter of the bore of rifled small arms is designated in hundredths or thousandths of an inch. Thus, we have rifles, carbines, pistols and revolvers of .22, .30, .32, .38 and .45 calibre or .220, .257, .357 and .405 calibre. The European system of cartridge designation is more thorough and logical than the US system. It uses the metric system. For example, the Russian rimmed-service round is designated as 7.62 ⊠ 54 mm2 R, i.e. 7.62 refers to the diameter of the bullet, 54 mm indicates the length of the cartridge case and R indicates that the round is rimmed. The letters SR are used for semi-rimmed cases, RB for rebated cartridge cases and B for belted cases. No letter is used to describe rimless Firearms cartridge cases. The term 'magnum' is used to describe a cartridge that is larger, carries more propellant and produces higher velocity than the standard cartridges.



Categorisation of rifled firearms.

SMOOTHBORE FIREARMS

These belong to the category of shoulder-arm, having smooth-bore barrel and are intended for firing lead shots (pellets) or sometimes a single ball (slug), etc. Some shotguns having small part of their bore rifled near the muzzle end are known as paradox guns. Different types of smoothbore firearms have been described in Flowchart 16.2.

BORE / DIAMETER

Diameter of the barrel of a shotgun can be expressed in any of the three systems. In the United States, the most commonly employed system is that of gauge. The origin of this system is archaic. It refers to the number of lead balls, each fitting the bore, which can be made from 1 pound of lead. Thus, a 12-gauge shotgun has a bore diameter such that 12 balls of lead, each fitting the bore, can be made from a pound of lead. The smaller the gauge designation, the larger the bore. The second system is the expression of bore diameter in inches. The modern .410 bore shotgun is the only shotgun to be so designated. The third is the metric system, where the bore diameter is expressed in millimetres. A 10-mm shotgun has a bore diameter of 10 mm.

Choking is a device employed in smoothbore firearms

where the terminal few centimetres of the bore near the muzzle end is partially constricted so as to control shot pattern. This device, therefore, holds the shot column together for a better distance as it moves away from the muzzle. The choke may be permanent and built into the barrel or the barrel may accept choke tubes of different degrees. The degree of choke is based upon the percentage of pellets that will stay inside a 30 inch circle at 40 yards as given in . 16.1.

MISCELLANEOUS TYPES

AIR-POWERED WEAPONS

In these weapons, expanding force of compressed air or gas is used to propel a projectile down a rifled or smoothbore barrel. Pellets/projectiles, because of their extremely light weight, loose velocity rapidly, becoming harmless in less than 100 yards. Weapons include air rifle, air pistol, air gun, etc. These are used for target shooting, sport activities, firearm training, etc. (Austrian armies used air rifles against the French during the Napoleonic wars from 1799 to 1809).

CATTLE GUNS/ HUMANE GUNS (CAPTIVE BOLT DEVICES)

Specially made firearms used to kill animals. Discharge of blank cartridge drives a captive bolt, 5 to 10 cm in length, out of the muzzle. The end of the bolt is usually circular (7–12 mm diameter). It enters into the head of the animal against which the muzzle is kept pressed. In Western countries, butchers and farmers used them to slaughter animals.

STUD GUNS

These are industrial tools wherein special blank cartridges are used to push metal nails or studs into the wood, concrete, or steel (accidental deaths have been reported after the nails or studs have either perforated walls or ricocheted off a hard surface, striking and killing workers).

BANG STICKS

A device used by skin divers and fishermen to kill sharks, large fish or alligators. Also called 'fish popper'/shark stick. Bang sticks may be acquired in various calibres including centrefire handgun. A number of suicides have been reported using bang sticks.

IMPROVISED/ COUNTRY-MADE FIREARMS

Called by different names, these are somewhat similar to 'zip guns'; the term 'zip gun' usually indicates either a crude home- made firearm or a conversion of a blank pistol to a firearm. The calibre, shape and size of the firearm depends upon the availability of the ammunition, the barrel tube and the skill of the blacksmith (even household plumbing pipes have been used for the barrel in some cases). Consequently, the range, the wound- ing power and the reliability vary so much that no generalisa- tions about the nature of the effect can be made safely.

AMMUNITION

The ammunition for the various types of firearms is spoken of in several different ways. The word 'ammunition' means any unfired assembly of primer, powder and ball, but today the word is generally used when referring to a supply of assembled cartridges in bulk. The term 'round' refers to a single cartridge. With the coming up of wrapped powder-ball assembly, the Firearms word 'cartridge' came into use. The 'bullet' is only the solid portion of the loaded rifled weapon. The other common des- ignations for the bullet are projectile, missile and ball, etc. The term 'ball' is a relic of old muzzle-loading days when all the projectiles were round lead balls.

In case of a smoothbore firearm, the mass of small round lead projectiles is referred to as 'shot' or 'charge' or the 'load', while the individual round projectile is termed as 'pellet'. Although the use of round single lead ball in shotguns has been restricted, but is still peculiar to a degree in some countries, where such loads are often locally referred to as 'punkins' or 'punkin balls'.

CARTRIDGE

The cartridge, as stated earlier, denotes an assembled complete round of ammunition comprising

(i) cartridge case;

(ii) percus- sion cap, containing primer; (iii) powder or propellant charge;

(i) projectile (which may be a bullet in case of rifled weapons and pellets in case of smoothbore weapons); and

(ii) (v) wads (only in case of smoothbore weapons)

CARTRIDGE CASE

It is the outer covering of the cartridge that contains and keeps the inner components in position, prevents the backward escape of gases and also provides protection to the contents. After firing, empty casing is left behind, which is called empty shell.

In case of rifled weapons, this casing is composed of metallic case, usually of brass. Although brass is the traditional metal, steel is also used. However, steel must be coated to pre- vent it from rusting. Plastic varnish is the most usual method today. Brass is preferred for commercial ammunition and steel is almost entirely confined to military ammunition. The cartridge cases are classified into five types according to the con.uration of their bases, namely: rimmed, semi-rimmed, rimless, rebated and belted. Virtually all cartridge cases have head stamps on their bases. The head stamp consists of a series of letters, numbers, symbols and/or trade names. They are either imprinted or embossed on the cartridge case-head and help in identification. Caseless cartridge is one in which the conventional metal case is not employed. Here, the propellant is mixed with a binder to make it a hard paste, which can be shaped as required. A cap, made up of combustible material, is fitted into the base and a bullet is recessed into the other end. The object is to eliminate the extraction and ejection of the empty case after firing and therefore to speed up the action of the weapon. It also has the advantage of lightening the round (brass or steel cases are heavy). However, the disadvantage is that it does not seal the breech and it does not provide an insulating 'heat sink' between the propellant and the hot chamber of the gun. Germans devel- oped 4.7 mm G11 Hecker and Koch rifle and the 4.73⊠33 mm2 DM 11 caseless cartridge. The first production weapons were probably issued to German Special Forces in 1990. The end Cold War, the unification of Germany, defence cuts and the availability of a large number of arms at cheaper rates has apparently led to the demise of such cartridges.

In cartridge case of a shotgun, the longer anterior part is made up of cardboard or plastic and the posterior part is com- posed of brass. Usually this posterior part (base) is rimmed to position the cartridge correctly in the chamber and to help its extraction after firing. The base has the percussion cap at its centre.

PERCUSSION CAP

It is formed of either zinc or copper or a compound of both, so as to be malleable and easily deformed under the blow of the firing pin. Beneath the metal is a layer of sensitive cap- composition, which is sealed in place by a layer of varnish that also waterproofs the composition. The impact of firing pin nips the composition against anvil and the resulting flash travels into the body of the cartridge case and ignites the propellant charge. Presently, the primers are composed of lead styphnate, barium nitrate and antimony sulphide. Most centrefire primers are composed of all the three compounds. The detection of these compounds constitutes the basis for the tests to deter- mine whether an individual has fired a firearm. In case of rim- fire ammunition, the primer composition is spun into the rim of the cartridge case with the propellant in intimate contact with this composition. On firing, the firing pin strikes the rim of the cartridge case, compressing the primer composition and initiating its detonation.

PROPELLANT CHARGE

The principal requirement of propellant is that it should explode rapidly generating a mass of gas, but it should not detonate because this would damage the weapon. It may be of following types:

BLACK POWDER (GUNPOWDER)

The black powder or the gunpowder was the first propellant and remained the only one until the discovery of smokeless powder in the later half of the nineteenth century. Average composition of black powder is:

Potassium 75% nitrate (saltpeter)	
Charcoal	15%
Sulphur	10%

Charcoal is the fuel, potassium nitrate is the oxygen supplier, while sulphur gives the mixture more density and makes it more readily igni.

The speed of burning of black powder is regulated by the size of granulation. As the size of the granules decreases, the strength of the powder increases. However, when a powder is made very fine like dust, the speed of burning is reduced as all the spaces between the grains are filled up and there is no way for the flame to communicate and ignite the whole charge rapidly. Black powder is made and sold in the form of irregular shiny metallic-looking black grains designated as to the size by the letters FG, FFG, FFFG, etc. The more the number of Fs, the finer are the grains. One gram of powder produces 3000–4500 cc of gas.

SMOKELESS POWDER

Smokeless propellants come in a variety of shapes and sizes. Most pistol propellants are in the form of thin flakes; rifle propellants may be in short cylindrical or tubular form or may be composed of small spheroids, known as 'ball powder'. The shape and size has a bearing on the rate of burning. Simple shapes like flakes, cylindrical grains or balls, etc. burn with a gradually decreasing surface. A tubular grain, burning inside and outside, has a burning surface that remains almost same since the decreasing external surface is almost balanced by the increasing internal surface and thus can develop a near con- stant pressure. One gram of powder produces 12,000–13,000 cc of gas. It may be of following types:

- Single base powder: The term used to describe propellant powders that are made from nitrocellulose with the addi- tion of small amounts of chemicals to promote chemical stability. It is probably the most common type of commer- cial powder because of its simplicity, adequate power, good keeping properties and a low flame temperature that does not cause excessive erosion in the barrel of the weapon. However, single base powder is more susceptible to damp and therefore needs to be adequately protected during storage.

- Double base powder: In this, the principal constituents are nitrocellulose and nitroglycerine. It is more powerful than single base because of the presence of nitroglycerine but for the same reason, it is also much hotter and has a flame tem- perature that melts away the steel of the barrel of the weapon more rapidly. Double base propellants are no longer used these days having been replaced by triple base propellants.

- Triple base powder: This is a type of propellant in which three principal ingredients are used nitrocellulose, nitroglyc- erine and nitroguanidine. It was devised in an attempt to com- promise between the low power of single base powders and the high power (but excessive heat) of the double base pow- ders. Therefore, the quantity of nitroglycerine is small but sufficient to give added power; the nitroguanidine lowers the flame temperature while still adding an active explosive constituent.

PROJECTILE

RIFLED WEAPONS

In case of rifled weapons, there is a single projectile or the bullet.

The traditional bullet is made up of soft metal and has a rounded nose. The metal is lead with varying amount of anti- mony added to provide hardness. This missile (bullet) is gener- ally known as round-nosed soft bullet and is frequently used in small arms. Rifle bullets are usually ogival and may be stream- lined. There are some variations in the size and shape of the bullets:

- It may be square-nosed soft metal bullet known as 'wad cutter'.

- The second may be hollow point, which has a depression in the nose of the soft metal. This bullet is designed to expand or 'mushroom' upon impact.

All these soft metal bullets cause 'leading' of the bore of the firearm. This wiping of lead on to the bore causes a decrease in the accuracy of the firearm; to overcome this, the bullet may be lubricated. The lubricant may be applied over the entire surface except the base or may be applied in the small grooves or cannelures cut circumferentially into the bullet near the base. The second way to overcome this shedding of lead from the surface of the soft metal bullet is to cover the bullet with a jacket. The jacketed bullets are of two types:

- Full metal jacket bullet in which tough heavy jacket covers all except the base where the soft metal interior is exposed.

Such bullets were designed for military purposes. The tough jacket may be made up of steel, copper, nickel and zinc.

- Semi-jacketed bullets are provided with relatively thin but tough jacket, covering the base and the cylindrical portion of the bullet, leaving the nose partially or fully exposed. This type of bullet was designed to expand or 'mushroom' like the soft metal hollow-point type.

Having considered the basic types, some specific types need to be discussed, which are as follows.

DUM DUM BULLETS

A type of bullet developed at Dum Dum Arsenal in India in 1890s by Captain Bertie Clay. They were first used at the battle in 1898, but displayed a serious defect in that because the jacket did not cover the base, there was tendency for the core to blow and leave the jacket in the rifling of the barrel of the weapon that hindered the loading of the next round. The design was there- fore neglected and replaced by the 'Ball Mark III' bullet that had a full jacket with a hole bored in the nose and filled with a short metal tube. In 1899, the Hague Convention outlawed the use of any expanding bullets in military service and the Dum Dum bullet and Ball Mark III were abandoned.

EXPLOSIVE BULLETS

These bullets, apart from causing extensive damage to the victim, pose considerable potential danger to the surgeon and doctor conducting autopsy, because the bullet may explode during emergency surgery or might detonate during diagnostic techniques involving ultrasonography, if it had failed to detonate in the body. In the assassination attempt on the President, Mr. Ronald Reagan, who had been shot with an exploding bullet that failed to detonate, though some of the lead azide from the charge had spilled into the surrounding tissue of the lung and was removed surgically. Such bullets are modified by drilling out bullet tip and inserting a tiny canister containing lead azide charge and the aim is to impart the missile greater stopping power so as to enable the bullet to transfer massive kinetic energy to the tissues. In suspected cases involving such ammunition, the autopsy surgeons wear goggles and use long-handled instru- ments to manipulate the missile during autopsy. The recovered bullet should be kept in a padded container to protect it from extra impact, vibration and heat, etc. The Hague Convention of 1899 forbade the use of all such bullets and they fell into disuse.

FRANGIBLE BALLS

A type of ball bullet made from compressed particles of metal and paint. Used in US Army and Air Force as a training bullet for aerial gunners. When fired at an aircraft, the bullet will get disintegrated to dust like particles on impact, causing no dam- age but leaving a paint mark so that the trainee's gunnery could be evaluated.

BATON ROUND

Popularly known as 'rubber bullet'. It is riot control projectile, usually a cylinder of rubber or plastic of a size to suit 12-bore, 26-mm or 37-mm gun and fired by a low powered charge to attain a muzzle velocity of about 60 metres per second and a range of about 100 metres. The first baton rounds were devel- oped for Hong Kong police and were of wood but proved to be liable to splinter on impact. It was therefore replaced by rubber batons. Rubber batons, however, were found to bounce indiscriminately and were superseded by PVC type of plastic batons that are more predic. in their behaviour.

ARMOUR-PIERCING BULLET

It is a type of military bullet designed to penetrate light steel armour. It is formed of a hard steel core surrounded by a lead sleeve, both carried in the usual type of jacket. On impact, the lead sleeve and the jacket are arrested, while the piercing core continues to penetrate through the target. Today, it is mainly used against light armoured vehicles.

INCENDIARY BULLETS

A type of army bullet used to cause fire in the target. Usually confined to use in the aircraft armament in order to ignite fuel tanks. Commonly, it is in the form of a jacketed bullet with the front half of the core removed and the space filled with white phosphorus, which possesses property of ignition on coming in contact with air. During 1939–1945, incendiary composition of barium nitrate and powdered aluminium and magnesium were developed because phosphorus was disliked due to its tendency towards leakage and causing fires in ammunition dumps.

TRACER BULLET

This type of bullet leaves a visible mark or 'trace' while in flight so that gunner can observe the strike of the shot. They resem- ble ball but have the rear portion of the core removed and the space filled with a chemical compound, a mixture of barium nitrate and powdered magnesium with strontium nitrate added to give it a red colouring. The mixture is ignited by the flash of the propellant and burns during the flight of the bullet shedding red sparks.

SMOOTHBORE WEAPONS

There are usually multiple projectiles in the form of spherical pellets, called the 'shot'. The shot consists of up to several hundred small lead pellets, the number depending upon the size of the indi- vidual pellet. Three general classes of shots are used in the shotguns—bird shot, buck shot and individual projectiles (usually termed as rifled slugs) with the frequency of use in the given order: Bird shot is generally used for hunting fowl and small animals. The shots are small ranging in diameter from 1 to 3.5 mm. A 12-bore shotgun shell will contain 200–400 shots depending upon their size.

Buck shot is larger than bird shot being 6–8 mm in diameter, and in a 12-bore shotgun they are nine in number. It derives its name from its original use against large game such as deer. Terminology differs according to the country of origin.

Rifled slug is lead or steel and lead projectile for a shotgun with wing-like helical ribs on its outer surface that, due to the passage of air during flight, give it a rotational movement and so produce a spinning projectile from a smoothbore weapon. The foster type of rifled slug is usually used in the United States. The rifled slug is intended for large games such as deer. A num- ber of devices are available. One of the older ones is solid round 'pumpkin ball' or the 'Brenneke rifled slug', but more recent types include the Foster rifled slug and the French Blondeau, which is dumb-bell shaped.

WAD

It is present only in cartridge of smoothbore weapons. The wad is made of some soft material like felt, cork, plastic, straw or rug. The cardboard disc behind the shot charge prevents the pellets from getting lodged in the felt wad, separates the pro- pellant from the projectiles, seals the bore effectively and pre- vents the escape of gas from the breech end. Some wads are disc-shaped, others cup-shaped and still others having bizarre shapes. Certain modern modifications that may be seen in the imported weapons include the increased use of plastic espe- cially to replace traditional wads. Some of these may be 'power piston' where the shot-mass is contained inside the polythene cup, which may also be responsible for producing injuries. In some modern cartridges, plastic granules may be used as filler between the lead pellets, and this highly coloured material may also be found within the wound or upon the skin. Deliberate tampering with the cartridge contents may also include removing the top closure card and fusing the shot with melted paraffin wax or even black pitch in order to prevent dispersion. This may be called as 'balling or welding of shot'. The balling of shot may also result from faulty manufacture or deterioration of old ammunition but mostly it is due to deliberate interfer- ence with the intention to increase the lethal power. Balling of shot may sometimes lead to complex injury, i.e. a part of picture may resemble that of a shotgun injury at distant range (caused by individual pellets that have not fused) and the other showing circular or oval wound (caused by the welded/balled shot-mass) resembling that of a rifled weapon.

Such a situation came to be seen in a case wherein during an assault, one party successively fired upon the other. The victim received lacerated puncture wounds upon the right fore- arm (caused by pellets, the so-called 'kachi goli' in the language of police) and distinct wounds of entry and exit on the front and back of lower abdomen measuring 1.5 ○ 1.5 cm and 1.75 □ 1.5 cm, respectively (caused by welded/balled shot-mass, the so-called 'pakki goli ' in police language). It was being argued that two persons were involved carrying different weapons. However, the police asserted that there was only one person carrying some country-made weapon. And, it was possible to produce two types of wounds by deliberate tampering with the cartridge contents.

BLANK CARTRIDGE

A cartridge without a bullet/missile contains a charge meant for generating a loud report on firing. Employed for theatrical performances, training game dogs and for military training, etc. The cartridge often contains black powder, as it produces gas at an extremely rapid rate so as to generate the noise. In the military, special grading of smokeless powder is used in such cartridges in order to produce the desired effect. The powder is retained in the cartridge case by means of wadding; the mouth of the case being folded or crimped to retain the wad. This wadding therefore can cause injuries, when ejected, up to 5 metres from the gun. Military blank cartridges have the mouth of the case extended and folded so as to mimic a missile, but so designed as to split open on firing. More recently, blank car- tridges are being made of plastic material with the nose weak- ened so that it splits under pressure but does not eject any solid material.

General Makeup of A Firearm

STOCK OR BUTT

This is the rear part of gun, which is held in hand (in case of short barrelled or hand rest gun) while firing one round of shot.

BARREL

It is the hollow cylindrical length of gun, which has the following functioning parts:

- Chamber: It is the posterior part of the barrel that accom- modates the cartridge to be fired. The posterior wall of the chamber has a metallic plate (breach plate), which has a central hole for the percussion pin of the hammer, to strike the percussion cap at the centre of the back of the cartridge, which initiates the process of firing of a round.
- Taper/leed: The inner diameter of the chamber part of the barrel is wider than the rest. The part of the barrel, anterior to the

chamber, tapers anteriorly. This part of the barrel is known as taper or leed. In a smoothbore gun, this part of the barrel is termed as the chamber cone.

- Bore of the barrel: The vast length of the hollow barrel anterior to the chamber cone or the taper is called the bore.

- Muzzle: The anterior end of the bore is the muzzle end of the barrel.

BREACH MECHANISM

- Hammer: Behind the chamber, there is a hammer with a pointed pin (percussion pin) at the centre of the anterior surface of the hammer.

- Trigger: Below the chamber there is the trigger that, when pulled, cause the hammer to advance and the percussion pin of the hammer to pass through the central hole of the breach plate of the chamber to strike the centre of the poste- rior surface of the cartridge (percussion cap).

- Trigger guard: The trigger is surrounded by a metallic trigger guard, so that the trigger will not be pulled accidentally.

MECHANISM OF BULLET WOUND PRODUCTION

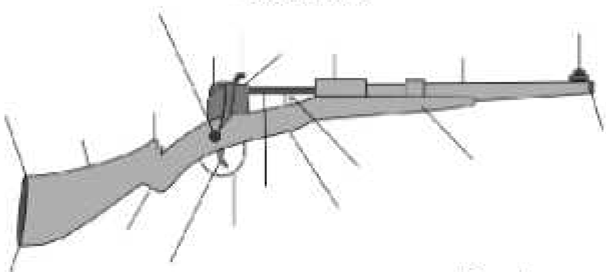
Leaving the decelerating injuries, all mechanical trauma is caused by transference of energy from an externally moving object to the tissues, and the injuries produced by missiles are the clas- sical examples. Bullet wound production depends upon the combined action of different factors. Some are inherent in the missile itself—speed, size, shape and character of its motion in flight at the time of hitting the target. Other factors depend upon the nature of the target—the density, cohesion and char- acter of tissues struck and the rate of energy transmission from the missile to the tissues.

SHAPE, SIZE AND VELOCITY OF THE MISSILE

Large bullets cause greater damage than the small ones. Round bullets produce larger wounds than conical ones. Round bullets may show deflection in their course by coming across some solid object, may be some body structure or some object being worn or carried by the victim. Berg reports a case in which a metal trouser button was hit by a bullet and while the bullet itself after hitting the button fell to the ground, the button was drawn into the abdomen.

Modern steel-jacketed bullets used in army weapons have the shape of an elongated cone and owing to their great velocity, usually pass straight and direct through the body tissues without any deflection and without causing much damage. The wounds of entry and exit may be similar in appearance in such cases.

Velocity of the missile is a significantly important factor as the wounding power of the missile is directly related to its kinetic energy (KE), i.e. E ⊠ mv2/2gm. Therefore, it is obvious that the KE increases in direct proportion to weight (mass) and square of the velocity of the missile. A bullet, travelling at twice the speed of another bullet of equal weight and similar shape possesses four times as much energy (wounding power) as compared to the other. Modern experts dealing with the production of ammunition take advantage of squaring of the velocity and prefer to develop weapons having missile of small mass but exceedingly high velocity to provide the maximum kinetic energy for tissue damage.



Velocities are usually classified as 'low' when below the speed of sound in air (340 metres per second or 1100 feet per second) and 'high' when above this speed. Missiles having 'low muzzle velocity' like handguns mechanically thrust the tis- sues along with track that is only slightly wider than the missile and secondary damage occurs from rupture of blood vessels and other structures. Missiles with 'high

Muzzle

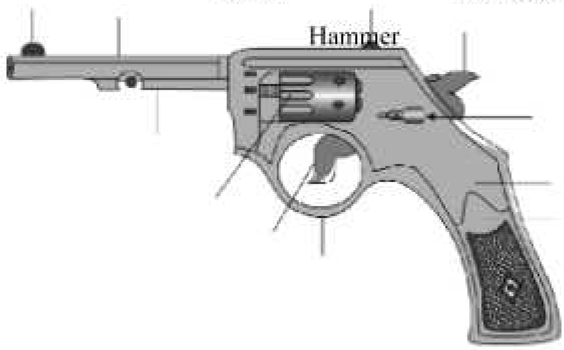
Toe of stock

B

Trigger

Front sight Barrel Rear sight

Hammer



Ejector rod

Cylinder

Trigger

Trigger guard

Thumb piece of cylinder latch

Frame Grip

C

Frame

Hammer Rear sight

Barrel Slide

Front sight

Grip safety

muzzle velocity',

i.e. above the speed of the sound in air, transmit a 'shock wave' of compression, ahead of the laceration track—this wave being propagated at about the speed of the sound in water (1500 metres per second or 4500 feet per second). Though this wave lasts for a brief period, it raises tissue pressure up to thousand of kilopascals. It can, therefore, cause damage within a wide zone of bullet track and can be propagated through hollow fluid containing vessels to cause distant vascular damage.

High-velocity projectiles also produce cavitation. It acceler- ates the molecules of the tissues close to the bullet track so that they continue to move centrifugally onwards even when the projectile has gone further. Thus, due to this radial displacement of the soft tissues, a cavity is produced around the track of the bullet. It reaches its maximum size within milliseconds and then decreases in size, ultimately leaving a fusiform cavity in the wake of the bullet, even when the bullet has left the body, i.e. the track of damage persists that is wider than the actual missile. This may be termed as permanent cavity, while the initial cavitation may be called as temporary cavity. High-velocity bullets, therefore, create so much expansion and tearing of the tissues incident to the temporary cavity formation that they give rise to explo- sive type of changes. The term 'explosive' here is descriptive of appearance of the wound and not indicative of its origin. Rapid and tremendous transmission of energy by high velocity projectiles can fracture bones and can cause severe soft tissue damage, at considerable distances from the direct bullet path. Passage of projectile through the chest produces compara- tively little cavity formation, because the thorax is fundamentally an air-filled enclosure. In case of head, the situation is different. Here the brain is surrounded by unyielding bony framework,

i.e. the cavity expansion is confined within the skull with resul- tant development of markedly increased intracranial pressure. Therefore, in case of high-velocity missiles, even brain pulpefac- tion can occur and the cranium may literally be 'blown apart'.

CHARACTER OF MOTION IN THE FLIGHT

The trajectory of the missile also determines how much and how fast its energy is being distributed to the target area. With lead shots of smoothbore firearms being spherical, the orientation of impact is immaterial; the bullets from rifled firearms may assume an erratic course and may 'wag' or 'yaw' from side to side or may even tumble end on end, or may 'mutate' resulting in unexpected complex movements about the axis. Obviously, such movements will provide more contact with the tissues, allowing more transference of energy and thereby more tissue damage.

DENSITY OF THE TISSUES

Tissue density can be critical in evaluating the degree of damage occasioned by the missile. The greater the tissue density, the greater the amount of energy discharged by the bullet while passing through that structure. A bullet passing through soft tissues may affect relatively little damage, but the same bullet travelling at the same speed can produce extensive comminu- tion while striking some bone. This variation in destruction and disorganisation is attributed to the fact that considerably more energy is liberated by the projectile in penetrating firm or solid tissues than it is liberated in traversing soft tissues. Soft tissues tend to dissipate the transmitted energy in radial waves, whereas solid bone shatters as the energy radiates from the site of impact.

HYDROSTATIC FORCES

Hydrostatic forces are responsible for apparently extensive degrees of damage observed in some visceral injuries due to blunt force including the bullet injuries. When a missile travels through a fluid-filled hollow organ such as food-filled stomach, urine-filled bladder, cerebrospinal fluid-filled cerebral ventricle or a cardiac chamber distended with blood in diastole, the liquid contents within these organs are displaced violently in all direc- tions away from the bullet path, producing extensive lacerations.

ENERGY TRANSMISSION RATE

Rate of energy transmission from missile to tissues is another important factor in influencing the extent of damage produced by the missile. To ensure effective transference of energy to the tissues, some bullets are especially designed or modified to slow down or abruptly stop within the body. Soft-nose bullets get flattened on impact and some may be designed to fragment just to increase the rate of transference of energy. Dum-Dum bullets are more destructive as they burst into the tissues because of crossed-grooves at their tips. Cupronickel or other jacketed bullets may produce mushrooming effect from the exposed lead-core at the tip of the bullet, which expands on striking and thus producing enormous lacerations. Some military missiles have an air-cavity within the tip that, therefore, is intended to splay open on impact to multiply the deceleration effect, thereby transferring greater energy for disruption.

WOUNDS PRODUCED BY RIFLED FIREEARMS

The injuries produced by these weapons depend upon multiple factors as detailed above. However, there are some characteris- tics common to all. Therefore, they may be considered together. It must be kept in mind that when a firearm is discharged, a tongue of flame and hot gases follows the missile/lead shots. The gases are at high pressure and temperature at the muzzle (the gas may be heated to 5200° F and the pressure exerted may vary from several thousand to 50,000–60,000 pounds per square inch), but rapidly expand and get cooled, producing the 'report' or 'noise' associated with the discharge. The flame is of significance in contact or near-contact wounds where it may sear the skin around the entrance wound. The 'ball of fire' emerg- ing from the muzzle consists of oxygen-deprived gases like oxides of nitrogen, carbon dioxide, carbon monoxide and other com- pounds. When they emerge from the barrel at extremely high temperature, they react with the oxygen in the atmosphere pro- ducing what is commonly known as 'muzzle flash', particularly well appreciated at night or in a dark room. Other effects that are expelled are the 'soot' from the combustion of the propellant along with some semi-burnt or unburnt flakes or grains of the propellant. The gas, with its contained soot, is very light and therefore travels a short distance measurable in inches. The powder grains being heavier travel further; the distance travelled depends upon the type of powder and kind of weapon. Here, it may be reminded that the amount of unburned or partially burned powder exiting depends largely upon the burning prop- erties of the powder and the length of the barrel. The rate of burning can be controlled by the manufacturer by means of varying the size and shape of the powder grains as well as by coating them with substances that retard combustion. The size and shape affect the burning rate by controlling the amount of surface area exposed to the flame. As far as the length of the barrel is concerned, it is obvious that shortening the barrel will cause more unburned powder to emerge and lengthening of the barrel will cause the reverse. Chemical traces of elements in the detonator or the priming mixture also accompany the discharge but are not visible. However, they can be demonstrable in the laboratory, in case the samples of tissues/clothing(s) from the wound/defect of entrance are sent to the laboratory. Hangfire may be caused by contamination and/or degradation of either the primer or the propellant. In a series of experiments attempting to induce hangfires, Haag was unable to do so by contamina- tion or degradation of primers. The primers either discharged or misfired, i.e. failed to fire. Contamination of propellant, however, resulted in both misfires and hangfires. Haag con- cluded that with the modern ammunition, hangfires were rare. The wounds may be categorised on the basis of muzzle– victim distance because this factor is the most critical feature, primarily responsible for the production of their characteristic appearances. A useful and simple classification of entrance

wounds is as follows:

- Contact wounds
- Close-range wounds
- Intermediate/short-range wounds
- Medium-range wounds
- Extreme-range wounds

CONTACT WOUNDS

The following three types of contact situations may be described:

- Firm contact with skin over shallowly situated bone: The prime example of such a situation is the contact wound of the head. Here, the gas and the other effects are forced through the scalp, but the shallowly situated bone serves as a barrier to the rapid deep expansion of gases. Therefore, the skull tends to turn back the ever expanding cone of gases that then tends to blast out around the muzzle of the firearm, everting the tissue and imparting it an 'explosive' or 'eruptive' appearance. When the gas volume is large, the dome may then split, resulting in a cruciate, stellate, triradiate or ragged wound with skin flaps.

As the contact with skin is firm, an effective seal is formed between the muzzle and the skin that prevents much escape of gases, soot and powder, so that soiling, burning and powder deposition around the margins of the entrance wound will be minimal or absent. However, if the blast is powerful enough, it usually shatters the bone and hence most of the effects of discharge will be blown into the track of the missile. The entrance wound will, however, usually show searing and powder blackening of the imme- diate edge of the wound and in case of death, the autopsy will reveal soot and unburnt and/or semi-burnt powder particles in the wound track. Drying haemolysed blood and decomposition can simulate or mask soot. Generally, blood can be removed by running or spraying hot water over the wound. Clots resistant to hot water can be dissolved with hydrogen peroxide. Neither hot water nor hydrogen perox- ide will remove the soot. In case of any discrepancy as to the entrance wound and where no powder particles can be identified, the use of energy dispersive X-ray (EDX) or scanning electron microscope-energy dispersive X-ray (SEM-EDX) should be employed. These devices can enable one to analyse for the vaporised metals from the bullet, cartridge case and the primer.

If the skull gets fractured, the wound of entrance shows a punched-in (clean) hole in the outer ., and inner . shows a bevelled crater; whereas reverse will be the effects at the exit (if present), i.e. punched-out opening is produced at the inner . and bevelled opening at the outer .. The crater effect is produced when the unsup- ported diploe everts and fragments on the side where the bullet leaves, this is in contrast to the approach side where the rim of the defect is supported by the underlying bone. Associated linear fractures are common, radiating from the bullet holes. Sometimes, bullets entering the cranial cavity have insufficient energy to make their exit on the other side, may ricochet from inside of the skull and cause secondary track of damage or even skid around the inside of the skull in a circumferential manner. Occasionally, in the bullet wounds of the head, it may be possible to ascertain the sequence of shots by the pattern of fracture lines that radiate from each defect. The fractures that extend from second bullet hole are arrested by those which originated from the first (Puppe's rule). This rule is applicable to any multiple blunt force impact causing skull fractures.

High-velocity projectiles may cause gross damage to the

head by virtue of total release of their kinetic energy. The effects may be so destructive as to cause virtual decapitation, and the injuries may sometimes be confused with those due to explosives rather than due to simple projectile. The facial fea- tures may be distorted to a considerable extent. Restoration of skull by replacement of bone fragments may be helpful in localising the entrance defect created by the missile and direction of discharge from the direction of bevelling.

- Firm contact with skin but not over shallowly situated bone: Here there is no layer of bone to divert the expanding cone of gases and therefore the various effects of discharge continue to penetrate deeper and get dissipated in the sur- rounding soft tissues. As the contact is firm, there will be little or no sideways escape of flame, gas, smoke and powder par- ticles, etc. There may be abraded-bruised area in the imme- diate vicinity of the wound edges. The wound will not be of eruptive or explosive type but will usually be circular or oval.

- Loose contact with skin: Here some of the gases escape with the resultant scattering of the muzzle blast and an unusual arrangement of soot is seen on the skin surrounding the entrance wound. This is known as 'corona'. The corona consists of a circular zone of soot deposit surrounding the missile defect but separated from it by a band of normal skin. This is due to the fact that the gas expanding about the muzzle, initially is at too high a velocity to allow for the settling of the soot, but at a short distance away, as the velocity gets reduced allowing the soot to be deposited at a short distance away from the missile defect. The blast effect is not as pronounced as in case of firm or tight contact, and splitting of the wound margins usually does not occur. A few unburnt and/or semi-burnt grains of powder may also escape out of this gap and be deposited on the skin interspersed in the band of soot. Particles of powder, vaporised metals and soot will be deposited in the track along with carbon monoxide.

Under all these contact situations, carbon monoxide combines with the haemoglobin and myoglobin of the tissues of the track and thereby imparts pinkish colouration to the interior of the wound track and the adjacent tissues. This con- centration goes on diminishing along the track. Presence of carboxy haemoglobin and myoglobin has been suggested as a test for distinguishing entry wound from that of exit, particu- larly where the decomposition has affected the morphological characters of the wounds. Even if the cherry-red hue of the muscles in the wound track is not appreciable, elevated levels of carbon monoxide may be detected on chemical analysis. Control samples of muscle should always be taken from another area of the body if such determinations are to be undertaken. By using gas chromatography, carbon monoxide has been detected in wounds inflicted up to 30 cm from the muzzle. The presence of both powder particles and carbon monoxide in a gunshot wound would seem to leave no doubt as to the fact that one is dealing with the entrance wound. Very rarely, both the carbon monoxide and powder may be found at the exit, particularly where ball powder is involved that possesses more penetrating capability as compared to flake or cylindrical powder.

MUZZLE IMPRINT

There may be muzzle impression in tight contact wounds, most frequently, when the shot is in the area overlying shallowly placed bone but sometimes may also be seen over the area having no shallowly placed bone. Such an impression or imprint results when the skin is slapped against the muzzle due to rapid and extensive expansion of the gases within the tissues deep to the skin. Many muzzle impressions fail to be recorded because of the rapid removal of the weapon by recoil. The imprint may be incomplete and indistinct and rarely may be a perfect impres- sion of the muzzle in the form of abraded-contused area. In rifled weapons, especially hand guns, there are more features at the end of the barrel than the shotguns. Therefore, complex imprints may be made of foresights and the mechanisms for self-loading in the automatic weapons. Similar patterns may occasionally be noticed upon clothing especially when viewed through special techniques such as infrared photography. The interposition of clothing may, of course, prevent any distinct skin mark being made in a contact wound.

BLOW BACK INTO THE BARREL

Contact wounds may cause blood, fragments of tissues, hair and fibres of clothing to enter the muzzle, sometimes penetrat- ing for several centimetres. This is due to negative pressure cre- ated following the discharge and is known as back spatter. Occasionally, pieces of skin and/or adipose tissue have been found inside the weapon. The occurrence and degree of back spatter depends upon the anatomical location of the wound and range and calibre of the weapon. A contact wound of the head from a large calibre weapon is more likely to produce back spatter than a wound of the trunk from a small calibre weapon. Back spatter is important because the resultant stains may be found on the weapon, the shooter and the objects in the vicinity.

CLOSE-RANGE WOUNDS

Entrance bullet wounds are characterised as close range when the muzzle to target distances are such that the target surface is still within the range of flame and muzzle blast (which is usually not more than 1–2 inches in case of handguns). The entrance wound is usually circular or oval with inverted mar- gins, but the rebounding gases may sometimes get levelled up and evert the margins. All the effects of a discharge will be appreciated at such ranges, namely:

SKIN BURNING AND HAIR SINGEING

Within a few centimetres of the bare skin, there is likely to be burning of the skin and singeing of the hair, if no clothing are interposed. The surface hair, if present, may be either com- pletely removed by burning down to skin level or may be blown away by the gases or may be shrivelled, blackened and clubbed owing to burning and melting of the keratin. The skin may show scorching of the epidermis and if the victim survives for any length of time, reactive hyperaemia, swelling and probably blistering may also be seen.

SOOT OR SMOKE SOILING/ BLACKENING

This is also called 'smudging'. Deposition of soot is far more marked with the black powder than with the modern nitrocel- lulose type of propellants.

POWDER TATTOOING

Alternatively it may be termed as 'stippling' or 'peppering'. These marks are due to semi-burnt or unburnt powder particles and again far more common with black powder than with modern propellants. Individual tattoos are caused by individual semi- burnt or unburnt powder particles/grains being blown into the skin of the victim. Physical forms of propellant powder exert their influence in the production of powder tattooing. Usually, there are four forms of propellant: flake, spherical, ball and cylindrical powder. Ball powder is favoured in high-pressure loadings and provides consistent homogenous ignition. Flake powder usually is in the form of discs. The sphere has a better aerodynamic form than a flake, thus ball powder can travel farther retaining more velocity and enabling it to mark the skin at a greater distance. Due to the same reason, ball powder can readily perforate hair and clothing at close and medium range. In contrast (except at close range), flake powder usually does not produce powder tattooing through clothing or dense hair.

The presence/absence of powder tattooing and also of smoke effects can be more readily demonstrated by infrared photography. If the firearm is discharged on the clothed part of the body, clothing may filter out soot and powder particles so that none may be seen on the skin. Measurement of spread of particles on the target is necessary for the subsequent com- parison with the patterns obtained by test shots to evaluate the range of firing. Scaled photography, if available, is recommended. In case of survival, evidence of powder tattooing becomes accentuated due to inflammation associated with the process of healing. This is in contrast to soot, which is easily removed by improper handling.

FOULING

It refers to tiny lesions around the entry wound, caused by metal fragments expelled by the discharge. These fragments may come either from the surface of missile or from the inte- rior of the barrel. Friction between the bullet and the rifling may scrape pieces of lead or steel barrel and hurl them on to the skin where they become embedded. These particles, like powder particles, will not be wiped off whereas the soot soiling can easily be removed with a wet sponge.

As in case of contact wounds, the carboxy haemoglobin and myoglobin will be present in the wound track in diminish- ing concentration as the range increases.

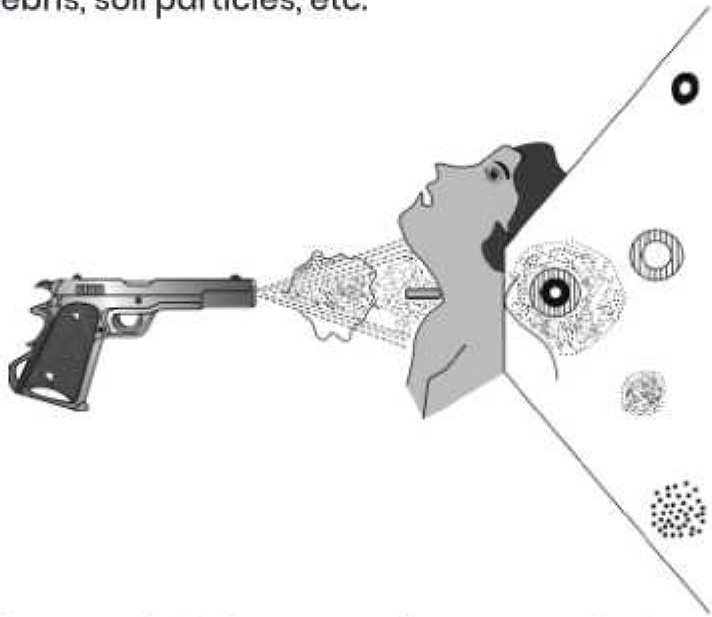
Abraded collar and grease or dirt ring may be present though not distinctly appreciable due to dominance of other effects of the discharge. Therefore, these will be described in detail under medium-range wounds.

INTERMEDIATE/ SHORT-RANGE WOUNDS

This term may be applied when the victim is within the range of powder disposition but outside the range of flame and muzzle blast. When the discharge occurs at a distance of few centimetres, the lacerating and burning effects of gases and flame are usually lost due to dispersive cooling of gases before they reach the skin. The entrance hole is seen as round or oval about the size of the missile with abraded-bruised margins and with a distinct zone of blackening and tattooing but absence of burning/singeing, etc. The production of 'powder tattooing' is the sine qua non of the intermediate-range gunshot wounds. In addition to the powder tattooing, there may also occur blackening of the skin or material around the entrance site from soot produced by combustion of the propellant. The size and density of the area of powder tattooing vary with the cali- bre of the weapon, the barrel length, the type of the propellant and the distance from the muzzle to the target. As the distance increases, the intensity of the powder blackening and tattooing decreases and the size of the soot or powder pattern increases. For virtually all handgun cartridges, soot is absent beyond 12 inches (30 cm). Although soot can be easily wiped away either by copious haemorrhage or by intentional wiping, but powder tattooing cannot. Powder tattooing consists of numer- ous reddish-brown to orange-red punctate lesions surrounding the wound of entrance. The distribution around the entrance site may be either symmetrical or eccentric, depending upon the angle of gun to the target at the time of discharge, the nature of the target (flat or otherwise) and any covering of the skin, e.g. hair or clothing that may prevent the powder grains from reaching the skin. Powder tattooing is an antemortem phe- nomenon indicating that the individual was alive at the time of discharge of the weapon. If the individual was dead before being shot, although the powder may produce marks upon the skin, these marks will show moist grey or yellow appearance rather than reddish-brown to orange-red colouration of ante- mortem tattooing and moreover, they are usually less numer- ous than markings produced in the living subject at the same range. Punctate abrasions of tattooing usually heal completely if the victim survives. In the region of palms and soles, the vital reaction involving punctate abrasions due to penetration of the powder particles may not be easily appreciable and this is prob- ably due to the fact that the thickness of stratum corneum pro- tects the dermis from the impact of powder grains at such sites. It may be stressed again that the maximum range at which the tattooing occurs as well as the size and density of the powder tattoo pattern depends not only upon the form of the powder but on a number of other factors, including barrel length, calibre, individual weapon and the presence of intermediary objects such as hair, or clothing, etc. Silencers will filter out a great propor- tion of soot and powder particles, thus making the range appear greater than it actually was. The size and density of the powder tattoo pattern on the body around the wound of entrance can be used to determine the range at which the weapon was dis- charged by the replication of this pattern on the test material, using the same weapon, the ammunition identical to that of the fired round and the similar background. Although isolated powder grains may travel much farther, patterns of tattooing are usually not to be seen at a range of over 4 feet.

In addition to soot and powder grains, other materials are also deposited on the body at such a range. These mate- rials include antimony, barium and lead from the primer; copper and zinc vaporised from the cartridge case; copper, aluminium or lead stripped or vaporised from the bullet that was fired and the grease and oil coating the barrel or the bullet before discharge. The metallic elements can be detected on the body or clothing(s) by soft X-ray if they are sufficiently large. Trace metal deposits can be detected by EDX and SEM-EDX.

Dirt ring/projectile wipe ring due to wiping of the substances from the bullet surface as it passes through the skin like grease, barrel debris, soil particles, etc.



It is appreciable inner to or interwoven in the substance of the abraded/abraded-contused ring (mainly on the primary entry hole, i.e. the target hit first)

Abraded collar/abraded contused ring due to impact of the bullet coupled with abrading of the skin through its gyrating movements against the indented skin

Soot or smoke soiling /blackening/smudging due to deposition of smoke. These particles being light, do not travel afar (for virtually all hand gun cartridges, soot is absent around the entry wound/hole where the muzzle-to-target distance is beyond one foot) Tattooing/peppering/stippling due to embedding of semi-burnt and/or unburnt powder particles in the skin (patterns of tattooing are usually not to be seen around the entry wound/hole where the muzzle-to-target distance is over four feet) .. Diagrammatic as well as descriptive representation of formation of various effects and deposition of extraneous deposits around the entry wound of a bullet at appropriate range(s). The extent of such deposit depends upon the weapon, the ammunition, the range plus angle of fire, and the target characteristics.

MEDIUM-RANGE WOUNDS

Once the discharge of rifled weapon is greater than 5–6 feet, there is nothing to indicate increasing range. Consequently, the appearance of the wound inflicted from a distance of 5 feet or 50 feet will be similar unless at extreme ranges when the erratic appearance of the wound may occur due to instability of the bullet.

The entrance wound at such ranges is usually circular or oval, and the margins are driven inwards by the passage of missile. The size of the hole is rarely equal to the size of the diameter of the missile and therefore the calibre of the weapon cannot be determined from the inspection of the wound. The reason for noncoincidence of skin puncture and the missile size is that the projectile indents the skin before penetrating it, so that perforation is effected with the skin under tension. After the bullet passes through the skin, the skin tends to return to its former size and edges of the wound contract and the resulting hole is smaller than the diameter of the missile.

ABRASION COLLAR (MARGINAL ABRASION)

The skin immediately around the central aperture shows abrasions and even bruising. It is, therefore, also called as abraded-contused collar . This results from abrading of the skin around the entrance wound due to rubbing of the gyrating body of the bullet against the indented epidermis. This abraded zone is reddish at its commencement but becomes brown and then brownish-black as it dries. This dried and discoloured abra- sion collar may not be confused with the blackening or marks of powder because it provides no indication as to the range.

Apart from being a proof of an entrance wound, its distribu- tion around the margins of the wound is also helpful in deter- mining the direction of fire. If the weapon has been discharged perpendicular to the body surface, the abrasion ring is circular and uniform but if the weapon has been discharged from the side (i.e. obliquely), it presents an elliptical shape, the longer axis pointing towards the direction of approach of the missile (.. 16.4A and B). This, however, assumes that the body surface, where the bullet strikes, is flat. However, where the body surface shows curve, depression or projection, the results will need cau- tious interpretations. Occasionally, an entrance wound may not have an abrasion ring. This can be due to the nature of the bullet or the location of the entrance wound. Wounds from high-velocity centrefire rifle bullets may not show abrasion ring but exhibit small splits or tears radiating outwards from the edges of perforation. These usually involve the complete circumference of the entrance wound though like abrasion ring, they may only involve a part of the circumference. If the projectile approaches at a very small angle to the skin, there may be a furrow ploughed through the epidermis before com- plete entry occurs. Occasionally, a bullet may strike the body tangentially and never actually enter, so that an elongated fur- row is left.

GREASE OR DIRT RING

In addition to the abrasion, a coating of foreign material may be found around the margins of the wound. It is due to removal locate. Among the areas not anticipated as the sites of entrance are the nostrils, ears, mouth, axilla, vagina, anus and the perianal/ perineal areas. Difficulty may further be accentuated if the area is smeared with blood and thereby obscuring the wound. Entrance wounds in the hairy areas such as scalp, pubis, etc. can be located by careful visual search coupled with gentle pal- pation. Autopsy surgeon may sometimes discover gunshot wounds missed by the police or the doctor in the emergency room. The likelihood of missing head wounds (particularly on the back of the head) is more because of thick growth of hair concealing the wound and lack of diligent search. In the emer- gency room, there may even occur confusion over the entrance and exit wounds. This may be partly due to massive bleeding and partly the chaos created by the relatives/attendants.

EXTREME-RANGE WOUNDS

For most of the distance of travel, the bullet remains steady with only minor variations from axial stability. When the extreme range is achieved, the reduced velocity may result in instability of the flight path. The bullet may begin to wobble and yaw and may even tumble, i.e. turn end-over-end. If the bullet strikes the body during this phase, the impact may be sideways or even backwards. The wound accordingly will be irregular and may present difficulty in its differentiation from a laceration by other means.

CONCEALED ENTRANCE WOUNDS

Bullets striking at the unusual locations may cause injury and death but the wound of entry may be extremely difficult to

EXIT WOUNDS

The bullets that pass through the body cause exit wounds, some- times known as 'outshoot wounds'. The exit wound commonly presents a larger and more ragged appearance than the corre- sponding entrance wound, though exceptions are numerous, particularly depending upon the range of fire and other factors described in the beginning (.16.2).

Outshoot wounds may be of varying shapes and can be described as slit-like, stellate, cruciate, irregular or gaping. The reasons for marked variations in the shape of exit wounds are following:

- Deformation of the bullet during its passage through the body and thereby presenting an irregular wound at exiting.
- Tumbling of the bullet in the body and therefore it may not be

able to exit with nose end first.

- Breaking up of the bullet in the body after striking bone. The bullet therefore exits not as a single mass but as many pieces. If jacketed, the jacket may get separated completely or partially. Conversely, the bone may get fragmented and the pieces (secondary missiles) may be imparted sufficient velocity so that they make individual exits.

- The bullet on leaving the body on farther side tends to produce an everted wound and there may well be enlargement and tearing of the margins due to disturbance of the steady gyroscopic path of the bullet at the exit. Because the unsup- ported skin is struck from within, the wound tends to burst outwards and frequently, fragments and tags of tissues may be seen either at the margins or actually extruded. An important exception to this, which is of considerable medicolegal importance, is the exit of a bullet at a point which is well supported. Such exit wounds are called 'shored or supported gunshot wounds of exit'. The support to the skin necessary to cause an exiting bullet to make a 'shored out- shoot wound' may be afforded by the following:

▪ Certain items of clothing such as the waistband of trou- sers, the side-panels of brassiere or a man's collar and tie.

Certain anatomical portions of the body, i.e. the bullet exiting from the side of the chest at a point where the inner surface of the arm is being held closely against the chest wall.

▪ Position of the body in relation to the substances in the surroundings, i.e. when the victim is leaning against some firm object like a wall.

Entry wound	Exit wound
The wound is usually smaller except in 'contact' discharge when the skin is torn erratically. May also happen at 'close range' too, where rebounding gases may get levelled up and produce larger, ragged wound. Ricochetting, wobbling of the bullet may be the other reasons for producing larger wound of entrance	The wound is generally bigger than the corresponding entry wound except in the situations as described here
Edges are usually inverted as the missile penetrates the body from the outside. Deviation may be seen in 'contact' wounds.	Edges are usually everted as the missile forces its way out of the body
Abrasion collar/abrasion-contusion ring is an essential feature of the wound of entrance	Abrasion collar/abrasion-contusion is absent except in 'shored' exit wounds
Burning, singeing, blackening and tattooing may be seen at appropriate distances	Burning, singeing, blackening and tattooing cannot be there. (Blackening and/or tattooing may rarely be seen where the exit wound is present in proximity with the wound of entrance)
Grease or dirt ring may be present inner to or interwoven in the substance of abrasion collar, which may be demonstrable on micro-chemical or other tests in the laboratory	Not so
In 'contact' and 'close-range' wounds, the track near the entry wound may be bright pink due to carboxy haemoglobin. (Diminishing concentration of carbon monoxide along the track has been suggested as a test for distinguishing entry from that of exit wound, particularly where the decomposition has affected the morphological characters of the wounds)	Not so
Clothing may be turned 'in' and shreds carried into the wound to a varying distance	Clothing may be turned 'out'

In these situations, the margins of the exit wound may not be everted and there may even be a spurious 'abrasion col- lar' that may be produced by the emerging bullet slamming the wound margins against the resisting surface and the wound may sometimes be indistinguishable from the entrance wound. Examination of the clothing and the circumstances may pro- vide the answer.

WOUNDS PRODUCED BY SMOOTHBORE WEAPONS

With the discharge of a shotgun, the following constituents emerge and all or a varying combination may contribute to the production of wound depending upon the range of fire:

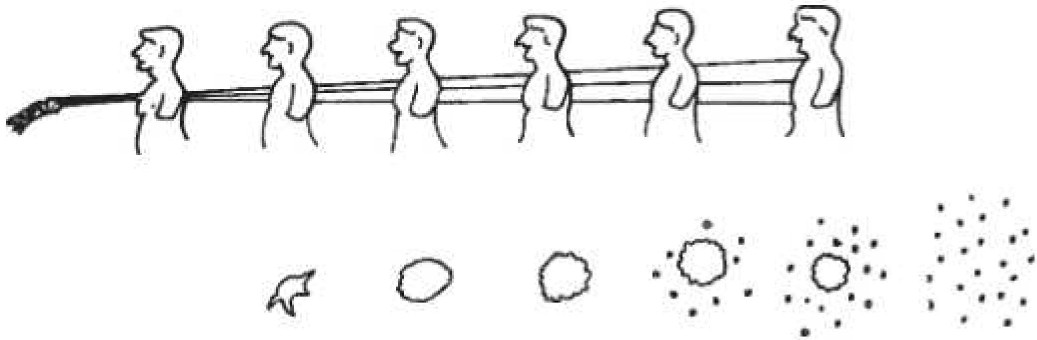
- Lead pellets/shots
- Flame and hot gases under pressure
- Soot in the form of smoke and debris
- Unburnt and semi-burnt propellant particles
- Wads (cardboard, felt or plastic)
- Constituents of detonator
- Fragments of cartridge case

Resting on the same justification, as described under 'Wounds Produced by Rifled Weapons', it is convenient to describe them in terms of increasing range of discharge (.. 16.5). (It must be kept in mind that factors like gauge of the weapon, degree of 'choke' size plus number of pellets and muzzle-victim distance, all play their role in determining char- acters of a shotgun injury.)

CONTACT WOUNDS

As written under 'Wounds Produced by Rifled Firearms', three situations may arise:

- Firm contact with skin over shallowly situated bone: The characters already described under 'rifled weapons', par- ticularly those of contact and close-range wounds, are also observed in shotgun wounding. In this situation, where the gases have restricted space for expansion, extreme mutilation due to explosive effect may occur. Destruction of the entire contour of the face and head may occur and actual point of muzzle impact or entry may be difficult to locate. There is usually greater disruption of the margins that may often show subsidiary linear tears in the skin extending from the margins of the main wound. Skull shows large irregular hole with fis- sured fractures running from its margins. The margins of the skin wound may show minimal degree of soiling, burning and tattooing as the firm contact prevents the sideway escape of the effects of discharge and therefore the tissues of the track and its vicinity show burning, blackening and tattooing, etc. as the various effects are blown into the track.



Contact wound (usually a ragged tear)

- Firm contact over an area without shallowly situated bone (like abdomen, thorax, etc.): The consequent wound will be single and circular or oval. The edges of the wound may be crenated by the individual shot. Here there is no bone to divert the expanding cone of gases and therefore various effects of discharge will continue to penetrate deeper and get dissipated in and around the tissues of the track. Soiling, burning and tattooing, etc. on the margins of the skin wound will be minimal or absent.
- Loose contact' with skin: Here there will be effective

deposition of various effects of discharge around the mar- gins of the skin wound, though the tissues in and around the track will also exhibit blackening, burning and tattooing. Typical deposition of smoke in the form of 'corona' may also be present.

Other features like muzzle imprint, back spatter and absorption of carbon monoxide deserve the same mention as described under 'rifled weapons'.

CLOSE-RANGE DISCHARGE OF A SHOTGUN

When the muzzle is held close to the body, i.e. one between actual contact and about 15 cm (6"), is likely to show the fol- lowing features:

- Burning of the skin and singeing of the hair: There is burning of the skin and singeing of the hair by the flame and hot gases, within this range. Hair may be completely burnt away. Some may get blackened, shrivelled and clubbed, due to melting of keratin and later on solidifying on cooling.

- Soot or smoke soiling/blackening: There is usually a wide zone of carbon deposition surrounding the wound. This spreads more widely than the powder tattooing. This effect is much less to be seen with the modern propellants.

- Powder tattooing: Also called 'stippling' or 'peppering' is the deposition of unburnt and semi-burnt powder particles surrounding the wound, as described in detail earlier.

The wound usually appears largely on the pattern of con- tact wound, though there is more extensive smoke soiling and powder tattooing. 'Nibbling' or 'Crenation' of the edges of the wound may be seen. There may also be annular abrasions and bruising. The tissues within and around the wound may be cherry-red due to absorption of carbon monoxide.

Any felt or cardboard overshot wads or plastic cups from the cartridge are usually encountered within the depths of the wound at such a range.

INTERMEDIATE/ SHORT-RANGE DISCHARGE OF

A SHOTGUN (Within about a Yard or so)

The shorter range nearing the distance of close range will provide the similar picture as described under 'close range'. If the wound inflicted is outside the range of flame and gases but within one yard, the effects like burning/singeing will be absent but others will be present. Up to about 1 yard, the wound is likely to be single as the shotgun charge enters the body as a single conglomerate mass producing an irregularly circular or oval defect and contused/lacerated, inverted margins, somewhat larger in diameter than the bore of the barrel. The margins of such wounds may also exhibit some scalloping. A zone of black- ening and tattooing will be present around the wound. The overshot cards may be seen within the depth or just underneath the entrance of the skin wound. Carbon monoxide may be pres- ent in the blood and tissues damaged near the entry wound.

MEDIUM-RANGE DISCHARGE OF A SHOTGUN

(1–5 Yards or so)

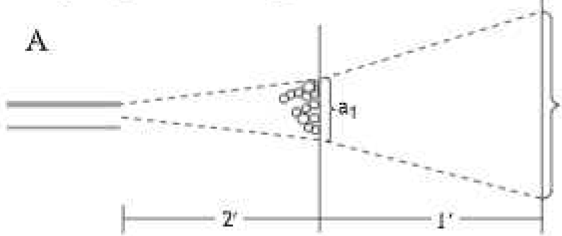
Beyond about a yard or so, satellite pellet holes begin to appear around the main entrance wound. This spread of pellets increases progressively, the central principal wound diminishing at the same speed. The approximate formula of 'total diameter of spread in inches is roughly equal to the range in yards' may be applied very loosely (one-third of the spread in centimetres equals the range in metres). As a rough rule, the hair singeing occurs over the first 30 cm; soot staining can be seen for the first half metre and powder tattooing rarely to be seen beyond 2 metres. However, the only reliable method of determining range is to secure the actual weapon and the same brand of ammunition used and to conduct a series of test shots so as to reproduce the pattern of fatal wound on the body. It need not be stressed again that ammunition plays a great role in the size and pattern of wounding. Different brands of ammunition, even when loaded with the same shot size, produce different pat- terns at the same range. Another factor that can lead to errone- ous results of range determination involves the measurement of shot pattern upon the body. Here, it may be reminded that occasional 'flier' may be ignored and only the main mass of pellet-pattern should be considered.

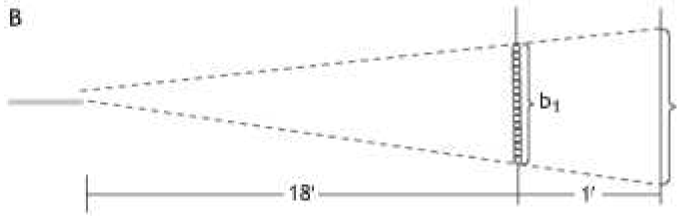
The wads may still be present in the wound up to a variable distance, usually up to about a couple of yards and occasionally as far as several feet. Therefore, the presence of a wad in the depth of the wound or even embedded in the tissues underneath the entrance wound will indicate something about the range of discharge. Often the wad assumes a lower trajectory and may strike the body below the shotgun wound. It may penetrate the skin causing a separate wound or may only bruise the skin.

DISTANT-RANGE DISCHARGE OF A SHOTGUN

Beyond about 5 yards or so, the spread of pellets becomes greater depending upon the choke of the barrel and other factors until the central (principal) hole vanishes at around 8–12 yards, and is replaced by holes created by individual pellets. At still longer ranges, the pellets begin to fail to penetrate the skin, leaving small abrasions with occasional pellets embedded in the skin. Obviously, there will be no wad injuries, no smoke black- ening and no tattooing, etc., and no way of ascertaining range except to say that it is beyond the distance from which the complete dispersion of pellets usually occurs.

Regarding dispersion of shots, one misconception may be kept in mind, i.e. at close ranges, when the shots are bunched, they strike one another upon hitting the skin/clothing of the victim and may fan out in a wide pattern as they continue to travel into the body. This may lead to erroneous conclusion. The same holds true if the shot happens to strike any intermediary object, such as a door or a window, before reaching the victim. This occurs secondary to the 'billiard ball' effect described by Breitenecker (.. 16.6A and B). Here, the foregoing pellets strik- ing the intermediary object are delayed allowing the following pellets to catch up and impact the preceding pellets, thus causing dispersion of the pellets. This phenomenon has been thought to occur with intermediary targets as thin as a pane of glass or a window screen. Coe and Autin, however, demonstrated that for the dispersion to take place, the intermediary targets should have sufficient thickness and tensile strength to slow down the motion of the foregoing pellets striking the target. However, the practicality lies in the fact that if the intermediary target is of sufficient thickness as to cause dispersion of pellets prior to striking the victim, estimates of range from the pattern on the body may be erroneous unless the effects of dispersion are taken into account. The only way to determine the range cor- rectly is to interpose a similar intermediary object during test





Types of ricochet effect: (A) billiard ball ricochet effect at close range of firing. Note the bunched shots at primary target (a1) tending to fan out by striking with one another upon hitting the target. (B) No billiard ball ricochet effect as range of firing increases. Note the spread-out shots at primary target (b1).

firings. At occasions, attempts have been made to estimate the range of the shotgun pattern within the body by X-rays when the body has been burnt or markedly decomposed. Experiments have revealed that this method is not reliable. Both close-range wounds and wounds of several yards' distance can give rise to similar patterns on X-rays because of billiard ball effect of the pellets on entering the body in close-range shotgun wounds. However, old poorly constructed shotguns with degraded ammu- nition may not show such variations where the corroded pellets often adhere to each other and may not get separated on striking an intermediary target.

SHOTGUN EXIT WOUNDS

Shotgun exit wounds are uncommon, especially when the areas involved are the wider ones, i.e. chest, abdomen, etc. This is due to the fact that the residual energy of independent pellets is usually insufficient for them to emerge through such wider parts, owing to their meagre mass and relatively low velocity. Large shot sizes tend to pass through the body somewhat more frequently due to the greater mass and energy.

Practically speaking, the appearance of shotgun exit wounds is absolutely random, depending upon the part involved and the nature of tissues encountered during the passage in the body. Usually, when present, it is in the form of jagged irregular laceration with everted margins through which some tissues or bone fragments may sometimes be seen protruding. However, it is not uncommon to observe accumulation of pellets immedi- ately beneath the skin opposite the wound of entrance after they have travelled through the body and have been trapped by the skin. The best way to trace them is acute visual observation and gentle palpation upon the area described. (Tangential wounds can pose considerable difficulty in the interpretation. Some may erroneously be attributed to knives or blunt injuries. The com- mon situations may be the side of the chest, side of the face, etc. In the chest, severe damage may occur to the contents of chest, even if the penetration is minimal and death may ensue occasionally. When the side of the head is hit tangentially, shatter- ing of skull may occur and intracranial damage is usually present, even though no metallic shots enter the cranium. Rifled weapons can also produce tangential wounds, and the lateral transference of energy can cause severe internal damage in both skull and chest, even though the missile does not enter the cavity.)

Unusual Circumstances Encountered in Firearms Injuries

There are many misconceptions concerning the trauma inflicted by the firearms. (Space does not permit the inclusion of an exhaustive catalogue of circumstances resulting in unexpected/ unusual outcome.) Some frequently encountered situations may be listed as follows:

ATYPICAL WOUND OF ENTRANCE

There is a general belief that the entrance wound is always circular or oval with inverted margins and smaller than the wound of exit. This may not hold true under the following situations:

- At close range, the entrance wound may become atypically large and margins may even get everted especially when the wound is upon the area lying against shallowly situated bone. This is due to the presence of 'tail wag' or 'tail wobble' at such close range, before the bullet settled down into a steady gyroscopic progression. The tip of the bullet may follow the axis of the trajectory but the tail of the bul- let may describe a circle or spiral, around the line of flight. If the bullet strikes the body during this phase, i.e. during the first few microseconds after leaving the muzzle, the entrance wound may be larger than the exit and the wound margins may even be everted as said earlier.

- Such a phenomenon of a large, irregular and jagged inlet wound may also be seen at extreme ranges where steady gyroscopic spin of the bullet is being lost and the bullet may begin to pursue an erratic path with tail-wag and even tumbling, the bullet turning head over heels and striking the target. In this situation, it may cause an irregular wound.

- Entry wound of a ricochet bullet is often ragged and larger as the bullet gets distorted and loses its initial velocity after the primary impact.

- Bullet while grazing the skin may produce a longitudinal furrow known as bullet slap.

- Firing the blank cartridge close to the body can also cause fatalities, when the wadding or gun powder cause irregular entry wound and laceration of the tissues.

- In case of duplex or tandem cartridge, a given round contains two bullets that will enter the body at two different places, thus causing two wounds from one fire.

RICOCHETTING OF BULLET

A ricochet bullet is one that gets deflected or deviated from its course by striking an intervening object in its way before strik- ing the body. It may even ricochet inside the body by striking some hard/firm tissue. This deflection of the bullet on encoun- tering slight obstacles has been ascribed partly to the obliquity with which it strikes and partly to the rotary motion on its axis (..16.7A).

A ricochetted bullet may only glance or gutter the body surface producing abrasions and/or bruising and sometimes may fall to the ground without entering the body. Bullet may also simply strike the body with 'side-on' and produce an elon- gated wound of entrance looking like 'key hole'.

Particles of paint, mud, fibres, etc. may get deposited on the surface of the bullet when it strikes any object bearing these things. Such things may occasionally be carried into the track of the wound. Such trace evidence on the surface of the pro- jectile may be identifiable with the help of SEM. In the case described by Di Maio et al. (1987) limestone was detected that had originated from the stone surface from which the bullet had ricochetted. Another interesting case has been cited in the literature where an individual shot himself while lying next to his wife. The bullet passed through his body, entering his wife's body where it was subsequently recovered. Tissue of his blood group, which was different from that of his wife's, was recovered from the tip of the bullet. This authenticates the proposition bullets may carry materials from an intermediary object into a body as well as material from a body to the outside (atmosphere) while exiting.

While ricochetting inside the body, the bullet may som- ersault in the tissues when the nose of the bullet may even face the entrance wound. The phenomenon of 'billiard ball ricochet effect' in case of internal ricochetting in the cranial cavity has already been described. Therefore, a ricochetted bullet may assume a devious and circuitous course inside the body and may ultimately be found in an unexpected situation.

He was managed conservatively and discharged. Here, one gets reminded of a news report wherein it was reported that a vic- tim, who was standing at some 'paan shop', was attacked by some assailants by firing indiscriminately. The only bullet that hit the victim happened to strike against the 'five rupee coin', which the victim was carrying in the left pocket of his shirt. The bullet fell apart, but the coin got badly deformed leaving some bruised skin underneath (Contributed by Dr. Parmod Goyal, Associate Professor of Forensic Medicine at AIMSR, Bathinda).

SINGLE ENTRANCE AND MULTIPLE EXITS

It may result in the following situations:

- The bullet, on hitting some hard object like bone, may get fragmented and each fragment making its own way out of the body. In the jacketed bullets, fragmentation may not be ordinarily expected unless it strikes some hard object. In case of head, metal fragments may be found scattered in the brain and on X-ray may occasionally resemble a shot- gun injury. Bullet may even disintegrate from the effects of its own centrifugal force. A striking case has been cited in Taylor's Principles and Practice of Medical Jurisprudence, 12th ed. where a deserting soldier was shot by a service rifle at a range of about 15 yards. The bullet travelled through the fleshy part of the left thigh making its exit on the opposite side and then entering the inner side of the right thigh, shattering the right femur, destroying the femoral artery on this side and made its exit on the outer side. Numerous fragments of bullet were demonstrable in the tissues showing that the bullet had disintegrated in the muscles before it smashed the bone.

- Sometimes the bullet striking the bone may break it into fragments, each fragment being imparted sufficient veloc- ity to make its own exit. These are termed as 'secondary missiles'.

- Sometimes the jacket of the missile may get separated and adopt its independent path and exit. Sometimes, the core may leave the body but the jacket may not. Recovery of the jacket is of importance as it carries marks/striations upon its surface, which help in identification of the suspect-weapon.

MULTIPLE WOUNDS OF ENTRANCE AND EXIT FROM A SINGLE SHOT

This occurs when the person is running or sitting or leaning in an unusual position so that several re-entries and exits can take place. Examination of clothing is important in such cases. Production of six wounds by the same bullet has been reported in a man who was bending 'on his haunches' at the time of being hit. The bullet traversing through the chest, thigh and lower leg produced the said wounds. Dupuytren cited an instance in which a bullet, after striking the tibial ridge, divided into two parts that traversed the calf of one leg and penetrated the calf of the opposite leg. Thus, five wounds were produced by a single bullet—three of entrance and two of exit.

ENTRANCE WOUND PRESENT, BULLET ABSENT

In some cases, despite the presence of entrance wound, the bullet is not traceable in the body. This may occur in the following situations:

- The bullet entering the stomach but may be vomited out and similarly entering the wind pipe may be coughed out. A case has been reported wherein an individual sustained gunshot wound of the chest. During hospitalisation, bullet was seen on X-ray apparently lodged in the right lung. The victim, however, expired after some days. At autopsy, the bullet was found in the bronchus of the left lung. Apparently, the bullet entered the bronchial tree on the right side and subsequently was coughed up and aspirated into the left bronchial tree.
- The bullet entering the gastrointestinal tract may be passed in the faeces.
- When it is so deviated, it passes out through the same wound of entrance.

TANDEM (PIGGY BACK) BULLET

Occasionally, more bullets are found than the entrance wounds. This may be on account of some defect in the weapon or due to faulty ammunition or where the loaded firearm has not been used for a considerable period or prolonged exposure to high environmental temperature or humidity. On firing, the bullet may fail to be ejected and on firing second time, the second bullet may go off carrying the lodged bullet with it and both may enter the body through the same entrance wound. This is called 'tandem' or 'piggy back' bullet. The bullets may get sepa- rated inside the body or before they hit the target. Unless it is realised, the presence of two bullets in the body of the victim may cast doubt on the version of firer that he had fired but once. The ballistic expert can evaluate that the bullets had trav- elled in tandem. Michaux and Thiodet (1960) reported the case of a woman who had been shot in the right breast. A bul- let was recovered from the base of right side of her chest. However, subsequent X-ray examination revealed the presence of another bullet that was extracted through the same incision. The examination of the bullets showed that they had travelled in tandem.

SOUVENIR BULLETS

Long presence of bullet inside the body may be accompanied by encapsulation, and the body surface may show the original entrance wound in the form of a tiny scar that offers no clues as to the agency that produced it. The long time presence of the bullet is indicated by absence of fresh haemorrhage in the vicinity and inability to locate the recent track from the site of lodgement of the bullet to the entrance wound upon the surface of the body.

Lead poisoning from a retained bullet is very rare. As of 1994, there were 35 laboratory-documented cases of lead toxicity from a retained lead bullet in the English literature. Onset of symptoms has occurred from months up to 27 years after being shot. It has been recognised that synovial fluid is capable of dissolving lead. A rich vascular supply to the tissues surround- ing the bullet and prolonged bathing of the bullet with syno- vial fluid makes the development of acute lead intoxication more likely.

BULLET EMBOLISM

Bullets entering large blood vessels may behave as emboli and be carried to distant places and, therefore, may be found far from their expected sites of lodgement. Bullets entering lung and penetrating large pulmonary vein may be carried in embolic fashion back to the heart and be swayed peripherally as an arte- rial embolus. The most common sites of entrance of bullet into the arterial system are the aorta and the heart. In a review of 153 cases of bullet emboli in the English literature, 100 cases of embolism involved the arterial system and 53 were attributed to the venous. The source of embolism to the arterial circulation was the thoracic aorta in 37.9% of cases, the heart in 34.4% cases and the abdominal aorta in 15.5% cases. The sources of emboli to the venous circulation were the vena cavae, the iliac veins and the heart. Although the embolisation often occurs immediately following entrance of the bullet into the circula- tion, delays as long as 26 days have been reported.

FIREARM RESIDUES

The term 'residue' simply means something 'left over'. The term has several meanings as applicable to firearm resi- dues. For example, the law enforcement agencies may be inter- ested in the residues left on the hands of the suspect/assailant in firearm assaults, the ballistic expert may be looking for the residues in the firearm itself and the doctor may be craving for the residues on the victim's body in association with the firearm injuries upon the body.

The residues of a discharge of a firearm have traditionally been described as powder particles and soot produced by burning of the powder. There are actually many more residues left after the discharge of a firearm, namely residues found on the bullet, in and on the cartridge case and on the firearm itself. For a doctor, residues upon the target carry special significance. Some of these are visible but some, comprising elemental components of cartridge, primer and bullet, may be invisible as they are deposited in very minute quantities. A potpourri of residues may be expected at shorter ranges. However, a detailed analysis of whatever present is usually rewarding in determining range of fire and in distinguishing inlet from out- let. In determining range of fire, Forensic Laboratory Testing includes test firing the suspected weapon into cloth or paper or like material at known distances using same type of ammu- nition as was used in inflicting the original injury and compar- ing the results with the characteristics of the pattern upon the clothing or skin of the victim. This calls for the imperative necessity of having accurate documentation of wound pattern including the distribution of various elements of discharge as early as possible and prior to any major alteration resulting from any medical/surgical intervention.

FIREARM RESIDUES ON SUSPECT'S HANDS

Residues on the hands may be visible, in which case their pres- ence needs to be observed and described. More frequently, the residue is not visible to the unaided eye. Special techniques should be employed to demonstrate invisible residues. The first such test was the 'paraffin test' also known as the dermal nitrate test/diphenylamine test. This was introduced in the United States in 1933 by Teodoro

Gonzalez of the Criminal Identification Laboratory, Mexico City Police Headquarters. In this test, the hands were coated with a layer of paraffin. After cooling, the casts were removed and treated with an acid solution of diphenylamine, a reagent used to detect nitrates and nitrites that originate from the gun powder and may be deposited on the skin of the person who has fired the weapon. A positive test was indicated by the presence of blue flecks in the paraffin. However, false positive results were also obtained on the hands of the individuals who had not fired the weapon because of widespread distribution of nitrates and nitrites in the atmosphere. Therefore, this test was discarded.

In 1959, Harrison and Gilroy introduced a qualitative colourimetric chemical test to detect the presence of barium, antimony and lead on the hands of the individuals who fired the firearms. These metals, originating from the primer, get deposited on the back of the firing hand. In revolvers, these metals come primarily from the cylinder–barrel gap and in automatic pistols from the ejection port. In this test, a square of white cotton cloth was moistened with hydrochloric acid, and the hand was swabbed with it. The swab was treated with triphenylmethylarsonium iodide for the detection of antimony and sodium rhodizonate for the detection of barium and lead. The limited sensitivity of this test prevented its widespread adoption.

NEUTRON ACTIVATION ANALYSIS

It was launched during the 1960s. A sample is obtained from the hands by the use of paraffin or by washing the hands with dilute acid. It is then exposed to radiation from a nuclear reactor emitting neutrons. Secondary radioactivity is induced in the materials removed from the hands and by making appro- priate counts at different energy levels, the elemental composi- tion of the residues can be determined with precision. The technique is extremely sensitive and very minute quantities can be estimated.

By the 1990s, neutron activation had been discarded as a method of analysis. This was due to its limitation that it could analyse only for antimony and barium but not lead and thus had to be used with FAAS and secondly, it was expensive too because of involvement of nuclear reactor to perform this test.

FAAS

This method is easy for analysis, carries adequate sensitivity and low cost. FAAS will detect antimony, barium and lead from the primer as well as copper vaporised from either the cartridge case or the bullet jacketing. In this method, palms and backs of the hands are swabbed with four cotton swabs moistened with hydrochloric acid. A fifth swab is moistened with acid and acts as a control. The metallic elements are then detected. Based on distribution and amounts of antimony, barium and lead detected on the four surfaces of the hands, one may conclude whether the deposits are consistent or inconsistent with gunshot residues and thereby firing of a weapon. Typically, the residue is deposited on the back of the firing hand of the suspect who fired the gun. Detection of primer residues on the palm of the hands is suggestive of defensive gesture rather than of firing a gun. In suicides with handguns, primer residue on the palm may be due to cradling the gun with this hand at the time of firing. With rifles and shotguns, residue is often detected on the non- firing hand that has been used to steady the muzzle against the body. For correct interpretation of the result, one must take into account the surface area of the hand which is positive, the quantity of metals deposited on different areas, the nature of the weapon, etc. In living individuals as the time interval between firing and taking of samples increases, there may occur loss of residue from the hands. This can be produced not only by washing of hands but also just by rubbing them against different materials.

SEM-EDX

Here, the gunshot residues are removed from the hands using adhesive lifts. The material removed is scanned with SEM for the gunshot residue particles. The X-ray analysis capability is used to identify the chemical elements in each of the particles. The analysis by this method is not as time-dependent as FAAS and neutron activation analysis. Analysis of the hands of the firers by SEM has been positive up to 12 hours after they fired the weapon. However, the weakness of this method was reflected in the intensive labour required for the analysis and inability to quantitate.

FIREARM RESIDUE ON THE VICTIM ASSOCIATED WITH THE WOUND OF ENTRANCE

The visible residue, as noted earlier, consists of soot deposits, bullet lubricant, powder tattooing and occasionally lead stippling. The invisible residue consists of primer constituents and vapo- rised metal from the bullet, its jacket (if any).

Ordinarily, the visible residue is noted in the immediate vicin- ity of the entrance wound. Detection of such residue is best accomplished by removing the skin (2.5 cm ○ 2.5 cm ⊠ 5 mm) surrounding the defect and searching for powder grains, pref- erably with the dissecting microscope. The wounds of inlet and outlet can be distinguished in this manner, particularly in the decomposing bodies or whenever there is an issue whether the wound is of contact type or distant range. When searching for the invisible residues, in and surrounding the wound of entrance, the examination of the tissue by energy dispersive X-ray appa- ratus is rewarding.

CARBON MONOXIDE

Carbon monoxide also needs to be mentioned as a firearm residue. At contact and close-range wounds, carbon monoxide combines with haemoglobin of the blood and myoglobin of the muscle to form carboxy haemoglobin and carboxy myoglobin, respectively. Demonstration of these in the tissues surrounding the surface wound and the track of the wound has been advocated as a help- ing criterion in distinguishing inshoot wounds from the outshoot ones. This has been stressed at appropriate places.

DIRECTION OF FIRE

RIFLED WEAPONS

The direction of discharge of a firearm may be derived from the relationship of entrance to the exit wounds, though due consid- eration to internal deviation, if present, be given. Distinguishing entry wound from the exit wound may not pose any difficulty in contact or short-range wounds because of geometry of effects like blackening, tattooing, etc. surrounding the wound of entrance. However, in case of distant shot, this distinction may be difficult and the characteristic feature of circumferential marginal abra- sion around the wound of entrance may come to help. This results from scraping of the wound margins by the gyrating motion of the penetrating missile. This abrasion becomes darker and con- sequently more conspicuous when drying of the area sets in. The width of this abraded area surrounding the wound is uniform, if the bullet strikes the body perpendicularly and if it strikes the body at an angle, the wound of entrance may be round or oval but the marginal abrasion will be of unequal distribution, measuring more on the side of approach of the missile (indicating direction of discharge of firearm). Sometimes, the bullet may be lodged in the body itself without exiting; in that case, the path from the entrance towards the lodgement of bullet inside the body is to be evaluated for determining the direction of discharge. Further, bullet may undergo disintegration or, occasionally, the jacket of the bullet may get separated from the core on impact over the hard object like bone and may assume a separate track. The core may leave the body but the jacket seldom does so and may be recovered from the body itself. All these possibilities emphasise the need of X-raying the corpse in order to avoid unnecessary dissection and to have better interpretation of the path of the missile/fragments, etc.

Bizarre or very rarely patterned abrasions adjacent to the wound of entrance may be caused by the coarse articles of clothing scraping on the skin, which probably is the outcome of percussion wave produced by the missile upon striking the target. Pieces of fabric may be driven into the wound track and found in proximity of the entrance wound. Careful examination of the clothing will facilitate the proper interpretation of the findings under such circumstances. Marginal abrasion of an exit wound is rare and occurs only under those circumstances as described under 'shored exit wounds'. Hence, circumstantial evidence will come to the rescue in such cases. In questionable cases, laboratory examination will resolve the issue.

Once the differentiation between an entry and exit wound has been effected, the trajectory between an entry and exit establishes the direction. However, again a caution is to be exercised providing due weightage to the phenomenon of ricochetting, if there seems any possibility and, secondly, the attitude of the victim's body at the time of impact also deserves evaluation. For example, a horizontal wound track usually results if the victim is standing upright when confronted by the assailant or if the victim is lying on the ground and the assailant is standing over him. Many bizarre examples can occur and, therefore, it is advisable to be conservative in extending opinions.

SMOOTHBORE WEAPONS

It has already been stressed that when the discharge has been at right angles to the body surface, the wound is almost circular and symmetrical; in all other situations, an elliptical wound will be traced out, its elongation increased as the angle between them diminishes. This pattern also applies to the spread of soot and powder, giving an easy indication to the direction of fire.

Wound margins may be shelved, the tissues being acutely lacerated below the margins distal to the origin of discharge. This may be better appreciated in the injuries from rifled weapons where the wound has been produced by a single projectile than from the more diffuse mass of pellets. The track of the wound may be traced, which will help in determining the direction of discharge of fire. Here again, a missile from a rifled weapon provides a more clear picture than the shot-mass from the shotgun. However, a general idea can be gathered from the knowledge of the position of the surface wound and the mass of pellets. Examination by X-rays will avoid the laborious search for pellets at autopsy.

Autopsy

Postmortem examination of a firearm victim presents some peculiar problems over and above those of the usual medicolegal autopsy. Needless to say that careful and detailed examination is invited in all such cases with particular attention to collection, preservation and dispatch of certain evidence for the forensic science laboratory. Decomposition of the body, which usually poses problems, will not prevent the recovery of bullet/pellets and also powder residues on the skin or clothing of the victim. In case of decomposition or bodies recovered from water, though it is likely that surface details may have deteriorated, effects of powder or carbon monoxide into the deeper tissues may survive much longer. A case has been reported by Taylor in his Principles and Practice of Medical Jurisprudence where the evidence of carbon monoxide colour changes over a radius of some 4–5 inches in the subcutaneous muscles around an entry wound over the mid-frontal chest could be demonstrable in the body of a Pole recovered from a pond several weeks after death. Spitz and Fisher reported that they had observed deposits of soot on the bone in a young woman who had survived 3 months after she had shot herself in the temple.

The examination should include:

- Clothing
- X-ray examination
- Pertinent findings regarding injuries showing:
- External evidence of injuries
- Internal evidence of injuries
- Collection, preservation and dispatch of exhibits
- Cause of death

CLOTHING

Examination of a victim of firearm injury is grossly incomplete without a detailed scrutiny of clothing for any defect made by the missile/missiles and for deposition of any firearm residue. The doctor must be attentive to the possibility of finding bullet or some other residues on the clothing. Any distortion of cloth- ing, extent and manner of blood staining, or their smearing with mud/grease, etc. should be noted. Number and location of defects produced by missiles need detailed description. The location of these defects may be described in relation to the distance from collar, seams, pockets, buttons, etc. Several holes may result by a single bullet due to presence of creases in the garments, thereby simulating more than one shot. The defects in the clothing ordinarily correspond with the wounds upon the body, but this may not necessarily be so since the clothing often get disarranged in the process of struggle or in the pro- cess of fleeing, leaning or tossing, etc. during the defence or escape, usually seen in acts of firing.

There may be the following objectives for the proper scrutiny of clothing:

- Helping to establish the range of discharge of firearm: The extent and manner of distribution of soot and/or powder is obviously indicative of range of fire as already explained. It should be measured to enable the laboratory people to com- pare with the test-shot patterns. Since the garments may totally filter out these residues of discharge of a firearm, their relation with the body surface is essential so as to have an under- standing of the range at which the firearm was discharged.

- Helping to determine about the wounds of inlet and outlet upon the body: This may be possible because of deposition of various residues/bullet-wipe surrounding the entrance defect at appropriate ranges. Further, the direction of the bullet travel may be suggested by insertion of the fabric surrounding the inlet wound and eversion at the out- let wound. This may, however, be altered under numerous circumstances.

- Helping to locate the bullet/missile: If no exit defect exists in the clothing while it is present upon the body, either the clothing did not cover the area of the exit or the bullet left the body with insufficient velocity to pass through the clothing. The bullet may, therefore, be either lying loose in the clothing or might have dropped during transport or during management in the emergency wing of the hospital where the victim is usually supported/handled by many attendants/ relations, etc.

The importance of clothing in cases of firearm victims need not be stressed in cases where unambiguous identification of entry and exit wounds is not possible. Indeed, the task of car- rying out an autopsy is lightened by an adequate examination of the clothing before the autopsy is commenced. However, there may be situations outside the control of an autopsy sur- geon that may interfere with the proper interpretation of the findings upon the clothing, e.g.:

- The defects made by the firearm may be in the line of the cuts made to open the garments.

- Fragile residues may be flipped off the clothing.
- The area of the defects may be soaked with blood, body fluids, intravenous fluids and the like.

All this, therefore, calls for the examination of clothing by several different techniques. Infrared photography can be used to reveal soot deposits on the dark-coloured or black fabrics. Ordinary X-rays can be applied to search for larger metallic fragments of the bullets and other missiles. Soft X-rays may be employed to demonstrate only mildly radiopaque materials like powder grains, etc. Energy dispersive X-ray techniques can be used to analyse metallic fragments for elemental control.

X-RAY EXAMINATION

Usefulness of X-ray examination of the dead body of a gunshot victim is undeniable, since the missile or more often the pellets may lodge in the most unlikely and distant places. Instances are not uncommon where the bullet entering the shoulder region has been eventually recovered from the pelvis and the like. Therefore, subjecting the body to X-ray examination prior to autopsy will prevent undesirable mutilation and also save the time.

Importance of X-rays is depicted from the following:

- It helps in locating the missiles/pellets, fragments or jac- kets, etc.
- It helps in determining the track of wound as stressed earlier under 'Direction of Fire'.
- It helps to determine defects in bones in the areas not easily approachable on direct examination.
- It helps to delineate air embolism accompanying large vessel damage by the missile.
- It helps to scan the body in instances of bullet embolism or where the missile has been propelled along the gastrointestinal tract through peristaltic movements.

- It helps to provide documentation that the body was examined.

Use of X-rays to locate a bullet will save valuable time at autopsy. In instances of bullet embolism, X-rays are invaluable in locating the bullet. X-rays should always be conducted even when there apparently exists an exit wound too, because an exit wound does not necessarily indicate that the bullet did indeed exit. A bullet making an exit in the skin can rebound back into the body through the same wound after meeting resistance from the overlying clothing. Moreover, exit can also be due to a fragment of bone being expelled through the skin while the bullet itself remaining inside the body. A particular situation can arise in case of partial metal jacketed bullets. Here, separa- tion of jacket and the missile can occur as the missile moves through the body. This jacket carries valuable evidence in the form of markings upon its surface and will be available for bullet comparison. Sometimes, both the jacket and core after separation in the body may remain inside the body. These two can be identified on X-rays where they will be distinguishable by different densities.

In through-and-through gunshot wounds, small fragments of metal from the bullet may be deposited along the wound track or in the bone fractured by the bullet. These metallic traces, otherwise invisible, can be analysed by SEM-EDX. If the frag- ments are large enough, they can be submitted for quantitative compositional analysis by inductively coupled plasma atomic emission spectroscopy. A comparison can then be performed with the missile recovered at the scene and suspected to be the lethal missile.

Occasionally, routine X-rays in deaths from gunshot wounds may reveal old bullet(s)/pellet(s) or bullet fragment unrelated to the death of the victim. Such old bullets are encapsulated in fibrous scar tissue and usually have black colour due to oxidation of lead. Black discolouration can occur in recent bullet, if the bul- let has been exposed to the contents of the gastrointestinal tract. Lesser information can be had by X-rays in case of shotgun wounds. Determination of range cannot be made from the spread of pellets on X-rays because both close-range wounds and wounds of several yards' distance can give similar patterns on X-ray because of billiard ball effect of the pellets on entering the body in close-range shotgun wounds.

However, X-rays have some limitations. The exact calibre of the bullet cannot be determined by use of X-rays. This is due to magnification of the bullet image depending upon its distance from the source of X-rays. Bullets close to origin of X-rays will appear larger and have fainter appearance than those close to the film. Secondly, there may be situations where some arte- facts can be misconstrued as bullet. Dislodged crown from a tooth may appear as flattened bullet. X-rays should always be taken while the deceased is fully clothed. This practice will be helpful in revealing bullet(s) that exited the body but got entangled in the clothing.

PERTINENT FINDINGS REGARDING INJURIES

The body should be thoroughly examined to look for the wounds of entrance and exit. If they are multiple, it is advisable to assign them number and describe the wound of entry, the track on dissection and the wound of exit in one section so as to avoid confusion.

Location of each wound should be described in relation to its distance from the top of the head or from the heel as well as from some recognised and fixed landmark upon the body. Hairy areas such as scalp may be shaved to appreciate the wound. Each wound should be described with measurements in respect of size, shape and location. In case of wound of entry, entry hole should be measured first and then the mar- ginal abrasion. The difference in width of the abraded collar at different parts around the wound of entrance is very signifi- cant and helps in determining the direction of fire, as detailed already. However, where the wounds have been debrided or extended or otherwise interfered with, the medicolegal evalua- tion may not be possible. Where there is dispute between entry and exit, the skin and the subcutaneous tissue measuring 2.5 cm × 2.5 cm × 5 mm around the wound of entry and exit, may be excised for examination and packed separately in recti- fied spirit, labelled properly and sent to the forensic science laboratory under sealed cover. The examination of the tissues at the entrance and from the track of the wound for the evi- dence of carbon monoxide may be fruitful in some cases. This will almost certainly be higher in concentration near the entrance wound, and this phenomenon may even be recognised after putrefaction or immersion in water.

How to describe the wound? The wound of inlet is usually described as a 'lacerated puncture/penetrating wound' with inverted margins, measuring (1 ⊠ 3/4 cm2), oval in appearance present on left side of chest, 2 cm below the left nipple. It is surrounded by a rim of abrasion collar measuring (3 ⊠ 2 mm2), the greater width being on medial/lateral aspect. The presence or absence of blackening/tattooing, etc. should be specially measured and mentioned. Other effects, like muzzle imprint, singeing/burning of the hair, etc., if present, need to be described. The wound of outlet will be written as 'lacerated wound' mea- suring (2 ⊠ 1.5 cm2) with everted margins present on the right lateral aspect of front of chest, 4 cm below the 2nd space in the anterior axillary line. However, it is not necessary that the wound of outlet is always greater than the wound of inlet. The reverse may be there under a handful of circumstances that have been described at appropriate places.

INTERNAL EVIDENCE OF INJURIES (TRACK OF WOUND)

Each track must be described separately by layerwise dissection of the tissues. Probes should not be introduced as there is every likelihood of creating false passages and thereby drawing errone- ous interpretation as to the direction of firing. The path may be traced from entry to exit or to the lodgement of missile/pellets, etc. Here again may be stressed the importance of X-ray exami- nation of the body prior to conduction of autopsy. Ricochetting of the bullet/shot mass may be kept in mind for proper evalu- ation. The distance of entry and exit wounds from the respective heels will provide inclination of the track and will help in know- ing the attitude of the victim at the time of firing. The path of the missile through the body should be described in relation to the planes of the body, i.e. 'the track passes from front to back or from left to right and somewhat downwards'. Angular esti- mates with respect to the horizontal, vertical or sagittal planes of the body are also useful in completing the description.

COLLECTION, PRESERVATION AND DISPATCH OF EXHIBITS

Clothing, as described earlier, carry importance and must be handled with particular care because of the possibility of projectiles, powder residues or similar materials being lost by mishandling or rough handling. They must be retained as described and sent to laboratory as detailed earlier.

The bullets/fragments should be recovered as complete and intact as possible, either with the gloved fingers or with rubber-tipped forceps to avoid any scratching or defacing done inadvertently during handling. In the present scenario, the risk is enhanced and made more serious by dangers of blood borne pathogens, viruses and human immunodeficiency virus (HIV), which may occur in blood or body fluids that are present on the bullets. Therefore, in addition to usual precautions, follow- ing guidelines may be kept in mind while extracting the bullet/ fragments, etc.:

- Double heavy duty gloves should be worn while handling projectiles or other foreign objects.
- Prior radiography should be conducted in order to localise bullets/pellets and to evaluate likely ensuing hazards.
- Rubber-tipped extractor for recovery and handling of the bullets/fragments should be employed.
- Projectile should be examined for any trace evidence, such as fibres, glass pieces, paint, etc. Then it may be dried in open air, if need be.
- Pack the bullet/fragments, etc. into a hard plastic container padded with any soft material like tissue paper or paper towels rather than an envelope to prevent accidental punc- ture through the envelope and consequent injury.
- Before packing, bullet should be marked on its base for future identification.
- The container should bear the particulars of the case and the warning, 'Biohazard' may be written upon it.

Similarly the pellets, in case of shotgun injuries, should be track simply passes through the chest and does not directly involve the heart. Further, death may sometime ensue merely because of concussive effects of the impact, though the missile/ slug never penetrates the cranial/chest cavity. At this juncture, some estimate of the rapidity of death may be made. Depending upon the organ and blood vessel involved, death from bleeding may occur within a few minutes to several hours. The limiting factor for consciousness is the oxygen supply to the brain. When the oxygen in the brain gets con- sumed, unconsciousness supervenes. Experiments have shown that an individual can retain consciousness for at least 10–15 seconds after complete occlusion of the carotid arteries. Thus, if blood supply to the brain is prevented because of extensive gunshot wounds of the heart, an individual may remain con- scious for at least 10 seconds before collapsing. Sudden blood loss causes interference with activity when it exceeds 20–30% of the total blood supply. Loss over 40% is assumed to be life- threatening. The rate of bleeding, the amount of blood loss, the nature and extent of injury, individual's prior physical status and, of course, individual's physiological response determines the time from wounding to incapacitation and death. Here, the degree of vulnerability of cells to the lack of oxygen and their potential for recovery needs some mention. As documented, nerve cells are highly sensitive to oxygen and ischaemia; further, there are regional differences within the central nervous system. In total ischaemia, cessation of nerve cell function has been reported to commence in the cerebral cortex after 8–15 seconds and in the brain stem ganglia after 25–35 seconds. Irreparable structural damage occurs in the cells of the cortex after about 3 minutes, in the basal ganglia after 6–7 minutes, and after about 9–10 minutes in the vagal centre. In contrast, myocardial cells have a considerably higher tolerance for oxygen deficiency (this accounts for the sustenance of heart beat for some minutes after complete ischaemia of the brain occasioned through hanging or some other cause).

The collection may present a tedious job of recovery, where again X-raying the body before examination is of paramount help. Cards and wads from shot- gun cartridges should be retained and sent in envelopes after drying them in open air and wrapping them in cotton or gauze. The envelope must bear the particulars of the case including the site of location of these exhibits.

Collection of exhibits may also include the analysis of blood for alcohol or some other drug and blood for blood grouping, etc.

CAUSE OF DEATH

The cause of death is usually relatively straightforward, and haemorrhage is by far the most common cause of death in victims of firearm injuries. Total amount of tissue damaged and vascular damage should be considered in evaluation. Here, it may be added that gaping tears of heart may occur where the missile

CHAPTER-17

INJURIES BY EXPLOSIVES

The recent upsurge of terrorism for political and other purposes in many parts of the world has brought with it the use of explosives. It seems that in the general political unrest, which is prevalent in the world, the bomb will continue to be used to reinforce direct and indirect political objectives and therefore, a medicolegal expert needs to be conversant with some basic knowledge about the effects contributing towards injuries/death, etc. Identification of the material used in the manufacture of the bomb and mechanism of its explosion, etc. are the domains of the forensic scientists.

Most of our knowledge of explosions has been gained through wartime events. There have also been some no. explosions affecting civilians such as the one in Texas City in 1947 when a ship loaded with ammunition exploded at the docks killing about 560 people and injuring over 3000. Following an explosion, a person can be injured/killed in a number of ways:

- If he is quite near to the explosion, he can be blown to pieces.
- He can be injured by a wave of pressure, called the 'shock wave', which spreads concentrically from the seat of the explosion. When the explosion is in air, the pressure wave is referred to as air blast.
- He can sustain 'flash burns' from the momentary heat radiation or, if his clothing or other material is set on fire, he can sustain ordinary burns.
- He can be struck by 'flying missiles' propelled by the explosion.
- He can be injured or crushed by debris, usually of building(s) demolished by the explosion.
- He can be overcome by fumes generated as a result of the

explosion.

The above factor(s) may operate solely or in varying combinations, and the relative importance of each will depend upon the type of detonation, the distance of the victim from the seat of explosion and the location of the explosion. Each factor is being discussed.

Disruptive Effects

If the victim is almost in contact with a large bomb, usually when he is carrying it or sitting with it in some vehicle, he may be blown to pieces. A premature explosion, sometimes during the act of setting the timer, may cause disruptive injuries. With smaller explosions or when the victim is a few feet away, disruption is limited to the blowing off of head or limb or the mangling of a localised area. Therefore, sometimes a part of the body may be totally destroyed, while the remainder of the victim being remarkably intact. The pieces can get scat- tered over an area of 100 metres or more from the seat of explosion. Many parts of the body may never be found having mixed with the masonry and other debris of the blast site.

Air Blast (Shock Wave)

A blast comprises a wave of compression, which spreads concen- trically from the blast centre. The velocity of the shock wave depends upon the distance from the epicentre, being many times the speed of sound in the air at the start but rapidly decreases as it spreads out. This wave of compression/high pressure is fol- lowed by a weak wave of negative pressure (below atmospheric), so that a rapid double change in pressure is suffered by the victim. The magnitude of the blast varies with the energy released and also with the distance from the epicentre. As the distance from the explosion increases, the peak pressure falls rapidly, almost exponentially. About 100 lb/sq inch (690 kPa) is the minimum threshold for producing serious damage to human beings.

EFFECTS OF BLAST WAVE/ SHOCK WAVE

The high pressure shock wave generated by an explosion can knock a person down and thus cause injury but the specific injury associated with blast is due to the shock wave being propagated through the body. It causes most damage at an interface between tissues in contact with the atmosphere and that is why the lung is usually the worst sufferer. The shock wave can pass through solid homogenous tissues like muscle and liver, causing little or no damage but in the lungs the damage is caused owing to marked variation in density between the alveolar walls and the contained air so that damping of shock wave occurs leading to disruptive effects. Its transit through the lungs can tear the alveolar septa and give rise to alveolar haemorrhage. Other findings in the lungs may include subpleural patchy haemorrhages (often in the line of ribs) and intrapulmonary haemorrhages. The air passages may be filled with bloody froth causing airway obstruction and hypoxia in addition to the primary damage. Later, neutrophilic reaction may develop around the haemorrhagic areas and those can progress onto bronchopneumonia. The pulmonary injury is a specific injury of the air blast and is sometimes called as 'blast lung'. However, the lungs can also be bruised by direct blows on the chest, and haemorrhagic areas can arise by aspiration of blood or regurgitation of stomach contents down the trachea. Rarely, when the victim dies soon after the explosion of a bomb, this finding may not be seen, presumably due to relatively small amount of explosive detonated and the victim being somewhat away from the seat of explosion so that the blast wave is unable to exert any serious effect.

Blast may also cause damage to the ears. Its effects tend to be capricious, because the pressure on the tympanic membrane is modified by many factors but when the pressure rises excessively above the atmospheric, rupture is likely.

Gastrointestinal system often suffers from the effects of a blast because like lungs, it contains air and gases and is thus not a uniform medium for the transit of shock wave. The caecum and colon are more often hurt than the ileum, jejunum and stomach, presumably because they are larger and often contain more gases. Occasionally, ruptures of the gut can occur if the blast is violent and the victim is situated nearby.

BURNS

When a bomb explodes, the temperature of explosive gases can exceed to 2000° C, and the heat radiated momentarily can cause 'flash burns'. The amount of thermal radiation received decreases with the square of the distance from the explosion and the intensity of explosion.

The burns sustained are usually extensive and mostly affect the exposed areas of the body. Areas protected by a footwear or a brassiere tend to be spared as do areas shielded from radiation by solid objects. The body contours also exert shielding effect so that the front of the chin is burnt but the part underneath is usually spared. After death, burnt areas become reddish brown and parchmentised.

Objects in the vicinity and the clothing may be ignited and the victim is then burnt by contact with the flame. These burns usually involve irregular areas of the skin to a different degree, and this feature differentiates them from the flash burns. Other burns may be caused by ignition of building material or vehicle catching fire from the effects of bomb or from gas or petrol ignition, etc.

FLYING MISSILES

Although the blast is the specific hazard of an explosion, it is only important when some large explosive device has been used or the victim is virtually adjacent to the lower energy bomb. Smaller explosions usually injure and kill by propelling solid objects/materials in all directions. The fragments may originate from the bomb-casing or container or from the vehicle in which the bomb was concealed.

Fragments may vary in size, ranging from tiny splinters to large chunks, which are projected at high speed. The smaller ones may not be able to travel longer but larger, heavier fragments can fly over considerable distances and may cause serious or fatal damage in just the same way as missiles from a firearm.

In the open, debris is scoured away, which can impinge upon the body to injure and discolour the area of the body. A more common appearance is that of a sort of 'peppering' resulting from numerous small missiles/fragments producing varying sized/designed abrasions, bruises and puncture lacerations of varying sizes and depth, intimately mixed on the skin. Some of the puncture lacerations may contain fragments of metal, stone, wood or a piece of clothing. Metallic fragments usually are of interest to the forensic scientists because they can be pieces of the bomb mechanism. This triad of injury is usually con- sidered to be diagnostic. While abrasions and bruising can occur beneath clothing, dust tattooing usually remains confined to exposed skin showing abrupt demarcation close to the areas like collar or sleeve, etc.

Sometimes, the explosion might be specifically meant to propel missiles as with the hand grenade, the casing of which is specially designated to fragment into shrapnel and the nail bomb in which many nails are bound round a stick of gel ignite.

FALLING MASONRY

When a bomb demolishes a building/porch, etc., the persons inside the building or underneath the porch receive multiple injuries from the collapsing structures; on many occasions, these injuries may be the only effects of the explosion on the body. The victims are often heavily soiled by blood, dirt, dust and oil, etc. In some cases, there may be signs of crush asphyxia (purple discolouration of upper part of body with petechial haemorrhages into the skin and the conjunctivae; some conges- tive haemorrhages from the ears and nose may also be present).

FUMES

Sometimes, explosion fractures a gas-main and the people injured or trapped get poisoned before they are extricated. Poisoning by fumes is most prominent in mine disasters. Gaseous products, called 'after damp', usually comprise carbon monoxide, carbon dioxide and hydrogen sulphide.

IDENTIFICATION OF THE VICTIM(S)

Usually, a major initial problem is to discover how many bodies are involved and to try to allot the correct fragments to the right individuals. Where there are a number of victims and the small fragments are scattered over a wide area, the task may be extremely difficult or impossible. However, this is largely an anatomical exercise, similar to the sorting out of multiple skeletal remains. Complete body X-rays of the victim(s) are imperative before the clothing is removed. Fragments of the bomb may be trapped within the body tissues or the clothing (..17.1C). Clothing must be retained for chemical analysis, since this too may reveal the presence of some trace evidence with respect to the type of explosive used. However, if the victim was quite close to the explosion, his/her clothing might have been blown off by the blast and may be recovered in shreds at a considerable distance from the victim. Victim in such cases may be found partly or completely nude. Tight articles such as a belt, a buttoned collar or lace-up shoes are commonly retained on the body.

Apart from assisting in locating the trace evidence pertaining to the explosive device as detailed above, radiology will also go a long way in detecting other radio-opaque objects/findings like stone(s) or pacemaker or some old fracture/bony changes that the alleged victim was known to have. The dentition and artificial teeth can also help considerably in establishing identity if a recent dental record is available. This aspect of identity has been dealt with at length in the chapter on 'Identification'.

Finger, printing must never be omitted wherever possible, since it can prove or confirm identity in many cases. Even if the victim's prints are not available in the police records, prints can be compared with those on articles handled at work or at home once the person's identity has been suggested.

ENLISTING THE INJURIES

The external as well as internal lesions must be described in detail. If possible, photographs may also be taken. Nature and extent of external injuries has been mentioned above in detail. The diagnostic triad, i.e. varying sized/designed abrasions, bruises and puncture lacerations intimately mixed on the skin, has already been highlighted.

This is produced by the flying missiles including splinters of wood, stone, dust, dirt, etc., as outlined above. Signs of crush asphyxia may be characteristi- cally found when the death occurs due to some falling masonry. Internally, damage to the lungs, gastrointestinal tract, ears, etc.

Postmortem examination of an explosion victim involves the following major objectives:

- Identification of the victim(s).
- Enlisting the injuries.
- Cause of death.
- Medicolegal considerations.

CAUSE OF DEATH

Death may result from a variety of causes depending upon the nature and intensity of explosion, the distance of the victim from the seat of explosion and the location of explosion, i.e. whether in a confined space or in open. The body may be completely disintegrated as a result of blast effect when the victim is in the vicinity of the blast. If the victim is at some little distance away from the explosion, death may result from burns, blunt force injuries and falling debris. Crush asphyxia may be the cause in some cases dying of being buried under falling masonry. At times, death may occur due to inhalation of toxic fumes, especially in mine disasters.

Sometimes, the victim may die within a short period after an explosion with no more than a slight injury and no contributory disease. Some of these deaths may be due to systemic air embo- lism from air, which has gained access to the pulmonary veins after blast-damage to the lungs. In other rapid deaths, it appears that death is due to profound circulatory changes resulting from lethal reflexes, the so-called 'blast shock'.

MEDICOLEGAL CONSIDERATIONS

Injuries from the explosions are usually accidental. Homicidal cases are infrequent. (A time bomb may be left at some place to coincide with someone's arrival at a particular time when it may explode.) Alternatively, an impact bomb may be thrown or left at a venue of a meeting where it may explode as a result of friction. Of late, human bombs are being used for attaining specific political ends.

Reconstruction of the scene and circumstances of death can be gathered from the type, severity and distribution of the injuries upon the body. Various pointers, as given below, may help in this direction.

EXPLOSIVE FORCE DECLINES RAPIDLY

As stressed in the beginning, the intensity of blast varies with the energy released and the distance from the seat of explo- sion. The velocity of the shock wave is many times the speed of sound in the air at the start but rapidly decreases as it spreads out. Therefore, for a person to be blown to pieces, he/she must be in contact with the bomb, i.e. either carrying the bomb, sitting with it or arming it. Persons can be injured by flying mis- siles and collapsing structures when at distances from the bomb.

Explosive Force is Extremely Directional

The parts of body directly exposed to explosive force are most often involved, i.e.:

- Explosion at ground level usually injures lower legs and feet.
- When the person is bending over the bomb, the face, chest, waist and upper limbs may be blown away.
- Legs may be blown off or the abdomen disrupted or the hands and arms torn away in a person who was implanting the bomb.
- If the bomb explodes at the back of a person sitting in a chair, injuries are likely to be distributed on the back of legs, thighs and on the back of the trunk.
- At occasions, bomb may go off prematurely whilst being made, in the transit, whilst being planted, while setting the timer or while being diffused, causing localised injuries. Such localised severe trauma may be able to assist in the reconstruction of the events as it indicates the relative position of the bomb and the victim at the time of

detonation. This was unambiguously exemplified in a sensational political kill- ing, where the perpetrator was allegedly carrying explosive around his waist (the so-called human bomb) and thereby had undergone remarkable disruption of the upper and middle portions of the body. Only lower legs were available from the scene, which went a long way in helping towards identification (from DNA profiling).

Case: Assassination of Rajiv Gandhi and the Birth of 'Human Bomb'

Rajiv Gandhi was the ninth Prime Minister of India from 31st October 1984 until his resignation on 2nd December 1989 following defeat in the general elections. He remained Congress Party President until the elections in 1991. While campaigning, he was assassinated by Liberation Tigers of Tamil Eelam (LTTE) group. When he reached the venue, he got off his car and began to walk towards the dais to deliver the speech. Along the way, he was garlanded by many party workers and school children. At 10.10 p.m., the assassin Tanu approached him and greeted him. She then bent down to touch his feet and deto- nated an RDX explosive laden belt tucked below her dress. Rajiv Gandhi, along with many others, was killed in the explo- sion that followed. The assassination was caught on film through the lens of a local photographer whose camera and film were found at the site. The cameraman also died in the blast. Certain medicolegal aspects emanating from such sce- narios may be as under:

- Identification is usually extremely complex in large scale explosions that cause mass casualties with dismemberment or fragmentation of the body .text). This was a typical feature in the instant case.

- Histopathology may help in detecting injuries caused by shock wave being propagated through the body, lung tissue being the worst sufferer. The injury is sometimes called as blast lung .text). Myoglobinuric renal failure resulting from crush syndrome is another entity diagnosable through histopathology.

- Blood tests for carboxy haemoglobin, cyanides, and phos- phorus may be necessary, particularly when the blast has occurred in closed space or in fire-related blasts.

- Explosive residues need to be collected and dispatched for subsequent examination by experts in the field of explosives.
- The possibility of contamination of the body with chemical or radio-active material needs to be kept in mind at the time of conducting autopsy.

REGIONAL INJURIES

Of all the regional injuries, those of head are most common and account for about one-fourth of all deaths due to violence, and responsible for 60% of fatal road accidents. Even in the author's own series, head injury cases comprised of 69.5% of all the fatal road traffic accident cases. Reasons for their dominance, as furnished by Adelson, are listed below:

- The head is the target of choice in the majority of assaults involving blunt trauma.
- On being pushed or knocked to the ground, the victim usually strikes his head.
- The brain and its coverings are vulnerable to that degree of trauma as would rarely prove fatal, if applied to other parts of the body.

The underlying approach of this chapter is to deal with the most common problems of forensic concern rather than to discuss the subject from the clinical aspect. The diagnosis and treatment of head and spinal injuries are considered in the modern textbooks of neurology and neurosurgery.

unnecessary theorising among the doctors as well as lawyers. These are as follows:

- Any type of craniocerebral injury can be caused by any kind of blow on any sort of head.
- No form of craniocerebral injury is too trivial to be ignored or so serious as to be despaired of.

SCALP INJURIES

Scalp is often, though not invariably, damaged in the trauma that causes injury to the underlying skull and/or brain. In order to appreciate the injuries efficiently from the medicolegal angle, anatomy of the various layers of scalp is being furnished as follows:

FORENSIC ASPECTS OF ANATOMY OF THE SCALP

The scalp is the portion of the soft tissues of the head extending from the eyebrows anteriorly to the superior nuchal line posteri- orly and laterally from one temporal line to the other. Its primary function is to protect and insulate the skull. The scalp consist of five layers of tissues arranged in the following order.

HEAD INJURIES

'Head injury', as defined by the National Advisory Neurological Diseases and Stroke Council, "is a morbid state, resulting from gross or subtle structural changes in the scalp, skull, and/or the contents of the skull, produced by mechanical forces". To be complete, however, it should take into account that the impact, responsible for the injury, need not be applied directly to the head.

A couple of important dicta should always be remembered in relation to craniocerebral injuries, which would prevent any such as:

- The skin
- Dense connective tissue
- Galea aponeurotica
- Loose connective tissue
- Periosteum (pericranium)

The skin is normally hair-bearing, a feature that enhances protection and insulation. The dense connective tissue layer can further be subdivided into fatty layer and a deeper membranous layer that contains the major feeding vessels of the scalp. Due to the density of the subcutaneous tissue, inflammatory The skin is firmly united to the epicranial aponeurosis by fibrous strands in the superficial fascia.

Contraction and retraction of the arteries is impeded by this tissue, and haemorrhage from the scalp wounds is often copious. The galea, a freely movable aponeu- rosis of dense fibrous tissue, is structurally designed to absorb the force of external trauma. It is pierced by numerous emissary veins that connect the veins of the scalp with the intracranial venous circulation, providing an easy pathway for the propaga- tion of infection from the scalp to the intracranial structures. The layer of loose connective tissue between the galea and the periosteum has been aptly termed as dangerous layer of the scalp. The loose composition of the connective tissue permits collection of blood or pus in conjunction with the local haem-orrhage or infection. It is through this layer that avulsion occurs and surgical exposures are made. The thickness of the scalp in adults is variable, ranging from a few millimetres to about a cen- timetre, depending upon the location of the head, age and sex of the individual. In infants, the thickness may be less, but the scalp is highly elastic. Scalp thickness increases with age so that by puberty it approaches the thickness of the adult scalp. From the traumatological point of view, it forms the first barrier to the impact and serves to widen and lower the peaks of transient impacts. The intact scalp over the skull increases resistance to skull fracture by nearly ten times, as has been observed in exper- imental models. Similarly, presence of mat of hair over the impact site also affords an added protection.

SCALP ABRASIONS

Abrasions are less common than on other sites because of the presence of thick hair, which also tend to prevent or blur the patterned effect of blunt force injuries. Abrasions, although minor injuries in themselves, may carry medicolegal importance out of keeping with their lack of severity and may be the only representation of some severe deep-seated lesion. The follow- ing case amply substantiates this:

Two young boys entered into altercation with a middle-aged person on account of a wrongly parked car. Heated exchanges were soon followed by blows causing the middle-aged man to fall on the pacca pavement, striking the side of his head. He immediately became unconscious and was transported to hos- pital, where he was declared dead after sometime. Injuries, present on the person of the deceased, were:

- 0.75 ⊠ 0.5 cm2 abrasion on left temporal region at the junc- tion of the upper part of pterion.
- 0.5 ⊠ 0.5 cm2 abrasion over the front of left knee.
- Subdural haemorrhage over the left temporal region.

The deceased, a Sikh gentleman, was wearing turban at the time of assault. The presence of turban along with thick long hair of the scalp probably prevented severe surface injuries. The case, however, sends a wave of caution, viz., any external injury of the head, even if per se insignificant, may constitute important medicolegal evidence and may be the only clue towards some graver damage underneath.

SCALP BRUISES

Bruising of the scalp may occur anywhere. It is usually difficult to be detected because of the presence of thick hair. The only appreciable evidence may be the swelling, as the spilled blood is incapable of extending downwards owing to the presence of bone underneath. After death, difficulty in detecting a bruise may further be enhanced as swelling gets diffused. Commonly, deeper bruising in relation to fibrous galea beneath the skin becomes visible on dissection of the scalp. The bleeding may often be followed by marked oedema, and layers of the scalp may be greatly swollen and thickened by a jelly-like infiltration of tissue fluid. Blood may get collected beneath the pericra- nium, as is often found in infants receiving head injuries with fractures of the skull. In relation to contusions of the scalp, it has been observed that they are better felt than seen. It is always advisable to palpate the entire scalp and shave the sus- pected area for better appreciation of the bruise.

Bleeding under the scalp may be mobile, particularly under gravity. Thus, a bruise or haemorrhage under the anterior scalp may slide downwards to appear in the orbit, simulating a black eye from direct trauma. Black eye (bruising of the eyelids) should be differentiated from blood seeping passively into the orbit. A black eye may be caused by:

- Direct trauma such as punch upon the eye.
- Gravitation of blood over the supraorbital bridge from an

injury on the frontal area.

- Entrance of blood into the orbit from behind or above, due to a crack in the walls of the orbit, usually a fracture of the roof of the anterior fossa of the skull (such fracture is often produced from a contrecoup injury caused by a fall on to the back of the head, leading to the secondary frac- ture of the quite thin bone of the orbital roof).

SCALP LACERATIONS

Scalp lacerations may be found in association with bruising and abrasions and double or triple lesions may frequently be present.

Lacerations of the scalp are classically confused with incised wounds due to splitting of the tissues as the scalp is being sandwiched between the hard underlying skull and the external blunt impact. Distinction between the blunt splits and knife slashes may be difficult but usually possible by careful examination of the margins of the wound and, if need be, examination under the magnifying glass. Presence of foreign bodies like a piece of glass, a piece of stone or fragment/trace of some other material will lend an additional help in deter- mining the kind of weapon involved. A laceration in the scalp is usually characterised by the following:

- Bruising of the margins, although the zone may be narrow
- Head hair crossing the wound are not cut
- Fascial strands, hair bulbs, nerves and vessels, running in the depth of the wound, are irregularly torn.

Many factors influence the formation and appearance of lacerations upon the scalp, such as the contour of the object delivering the force (whether blunt object/instrument/weapon or fist or shod foot or any part of the vehicle), the type of the tissue, position of the body and the velocity of the impact. For instance, a blow on the scalp is far more likely to cause laceration than a blow of similar violence on the abdomen or buttocks, where bruising is more likely to result.

Scalp lacerations may bleed profusely. In lacerated wounds of the scalp, the temporal arteries may spurt as freely and forcefully as when may cut cleanly. These arteries being firmly bound are unable to contract and may, therefore, spurt and con- tinue to bleed for a relatively longer period. In a quarrel with her husband, a woman sustained several injuries on her face and head. One of these was a lacerated wound on the right temple. Blood stains were found on the ceiling at a distance of four feet from her bed. They were caused by the spurting of the divided right temporal artery. A young man had been struck on the right temple causing a lacerated wound. Blood spurted to a distance of three feet and a quarter from the place where he was standing at the time of the assault (Peterson, Haines and Webster, Legal Medicine and Toxicology, 2nd ed., Vol. I, 294).

Lacerations of the scalp may follow the pattern of the inflicting object, though a random splitting is more common leading to stellate, linear, Y-shaped, V-shaped or crescent-shaped appearances. Severe impacts from shaped objects like hammer or some other heavy tool with specific striking area may repro- duce the profile of the weapon totally or partly. A blow with an 'angle iron' may provide a resembling shape to the wound imparted by the angle of the metal, just as the etched lines of a file will leave a replicated imprint in the skin where it strikes. Under some situations, where the victim has been kicked or 'stomped', replica of the pattern of a heel may be produced on the scalp. It is obvious that proper documentation of these injuries, including photography, may be of immense help to the law enforcement agencies in linking an assailant with the crime, by comparing patterns of shoes, belts and/or other confiscated weapons to the impressions/marks on the victim.

When the injuries are due to fall(s), the pattern(s) may be highly variable. There may be no laceration of the scalp or there may be simple linear tear or jagged wound, etc. However, in some cases, the falling victim may strike a projecting object such as the edge of a . or a stone/brick lying on the ground/floor. These 'interfering objects' may produce lac- erations or even patterned injuries, which might lead to misin- terpretation. Under such circumstances, the witness account and an examination of the scene may provide the background information for proper analysis. Dirt/sand/pieces of stone/ brick, etc. may be carried into the wound and might be detected with the aid of ultraviolet light in the gross state or by scanning electron microscopy/polarising microscopy in the tissue spec- imen. Such findings may carry particular significance in lacera- tions following a street brawl because a question may arise here—whether the laceration occurred due to a blow or a fall. However, one must keep in mind that an agent/weapon may bear grit or dust and thus soil the wound or else the victim may fall after receiving a blow. Furthermore, site of laceration may also be a material factor at such occasions.

Laceration(s) of the vertex of the skull are mostly the result of fall from a height or striking the area against some projection; for example, when the victim suddenly stands from a stooping or kneeling posture and strikes his head against the corner of a mantle piece or a door of an open cupboard. In other circum- stances, the wounds of the vertex are almost certainly inflicted by an assailant.

INCISED WOUNDS OF THE SCALP

These wounds may be produced by cutting instruments such as a gandasa, a spade, a khurpi, an axe, a sword, a hatchet, a shovel or a chopper. The wound margins and the tissues running in the depth of the wound will be helpful in determining the nature of the weapon, as stressed earlier.

The edges of the wound produced by heavy cutting weap- ons may not be as smooth as those of wounds caused by light cutting weapons like razor or knife, etc., and often show bruis- ing of the margins. If the wound is inflicted obliquely, there will be bevelling of one edge of the wound, which may be helpful in indicating the direction of application of the force. While, if the sharp edge is struck almost horizontally, it produces a wound with a flap.

Wounds of the scalp usually heal rapidly, though in occa- sional cases fatal results may ensue from the supervention of infection or suppuration may set in and spread into the brain through the emissary veins or through the necrosis of the bone resulting from infection or through a neglected fissured frac- ture. Thus, cases have been reported where scalp wounds had apparently healed, and yet, death ensued from septic meningi- tis or brain abscess, after a few days or weeks.

SKULL INJURIES

Forensic Aspects of Anatomy

In discussing the different patterns of skull fractures, Burns arrived at the conclusion that if all skulls were equally thick and equally elastic, the lines of fracture could be calculated on mathematical formulas. In reality, the skull is not a homogenous body, but is composed of panels of bone that differ in thick- ness and elasticity from individual to individual, and in the same individual in the different portions of the skull. The thickness of the calvaria ranges in adult from 3 to 6 mm. It is thin in the squamous portion of the temporal bone and much thicker in the midfrontal, midoccipital, parietosphenoid, and parietope- trous buttresses. The skull is somewhat thinner in females than in males, and the outer . is always thicker than the brittle inner .. Bone density also varies. Areas of decreased density are frequently seen in the frontoparietal region, in the neighbour- hood of the coronal suture, above the roof of the orbit, and in a small segment above the internal occipital protuberance. In con- trast, an area of increased density is usually present between the squamous portion of temporal bone and the parietal bone. This explains how skull fractures, although subject to some extent to the laws of mechanics, are so varied and unpredic..

In foetus, skull consists of fibrous membrane that becomes ossified through a process of cellular differentiation (intra-membranous ossification). Ossification starts in individualised centres that make their appearance around the 7th week. In early infancy, the bones of the skull are thin and pliable, and the differentiation between inner and outer .s can hardly be seen. A distinct inner . does not become apparent until the age of 2 years. Patency of the fontanelles adds further protection from trauma. The anatomical con.uration and its relatively smaller size in proportion to the skull capacity permit the infant brain to withstand greater trauma than would be possible later in life. As Jackson says, "in an infant, a blow that would perhaps fracture an adult skull often produces only a dent, like that seen in damaged ping-pong ball".With closure of the fontanelles and union of the sutures, the skull becomes a rigid cavity that gradually enlarges from a capac- ity of about 350 ml at birth to 1400 or 1500 ml at maturity. With advancing age, partial closure of the sutures takes place, and in the later decades of life, it is not uncommon to find complete bridging of at least some of the sutures. The considerable varia- tions in the sequence with which obliteration of the sutures takes place further prevent prediction of the effects of trauma. In contrast to the vault, the base of the skull presents many jagged areas. In the anterior fossa, lesser wings of the sphe- noid, the cribriform plate of the ethmoid bone and the crista galli represent threats to the integrity of the brain when it is pushed forward in accelerated motion. In the middle fossa, equal threats are provided by the clinoid processes and in the posterior fossa by the foramen magnum.

SKULL FRACTURES

More than one forensic meaning is assigned to the term fracture. As usually used, it implies a break or disruption of bone. Surgical classification of types of fractures has little forensic import. 'Simple fracture' and 'open or compound fracture' are the usual surgical terms. The former refers to a fracture of the bone with intact skin overlying it, and the latter refers to the fact that the fracture site has an open pathway to the atmo- sphere or that the ends of the fractured bone have penetrated the overlying skin.

It has been reported that in one of four fatal head injuries, skull escapes fracture. The practical implication is that radio- logical evidence of absence of skull fracture is no indication as to absence of any injury to the brain. The presence of skull fracture is, however, an indication of the severity of force applied to the head.

Mechanism of Skull Fracture

The subject has been extensively studied by Gurdjian, Webster, Lissner and Rowbotham. These and other authors observed as follows:

- When skull receives a focal impact, there is momentary distortion of the shape of the cranium. Infant skulls, which are more pliable and have flexible junctions at suture lines, may distort much more than the more rigid skulls of adults. The area under the point of impact bends inwards and as the contents of the skull are virtually incompressible, there must consequently be a compensatory bulging of other areas, the well-known 'struck hoop' concept. Both these intruded and extruded areas can be the site of fracturing, if the distortion of the bone exceeds the limits of its elasticity.

- In more common circumstances of a wider impact from

blunt injury, deformation of skull is less localised but, where the force is sufficient, fractures can still occur from the same mechanism of exceeding the elastic limits. The fractures may be remote from the area of impact or may accompany the focal depressed fracturing as described.

- When the focal impact is severe, the depressed fracture may follow the actual shape of the offending object, such as a hammer head. The shape may follow only that part of the object that drives into the skull; for example, the circular head of the hammer may strike at an acute angle, so only a part of the circumference of the weapon may operate and produce a corresponding punch in the bone.

- The presence of hair and scalp markedly cushions the effects of a blow, so that a far heavier impact is required to cause the same damage, compared to a bare skull. The pat- tern and nature of the skull fractures are, however, the same. Here, it may also be worth mentioning that skull fractures may sometimes be caused without any contusion or any other wound on the scalp, though there may be extravasation of blood on its undersurface, as the force of violent impact may be cushioned by multiple layers of a pugree or abundant growth of hair on the head.

Types of Skull Fractures

Basilar Fractures Basilar fractures are relatively frequent and often radiologically occult. The relative frequency of such fractures may be attributed to irregular shape and presence of several foramina, making the base of the skull relatively weak. At autopsy, dura needs be stripped thoroughly from the basal calvarium so as to verify or exclude such fractures. Anterior fossa fractures are usually due to direct impact. A heavy blow on the chin sustained in boxing may transmit the impact through maxilla to the base of the skull and may result in con- trecoup fracture of the cribriform plate of the ethmoid .under 'Contrecoup Fractures' also). Blood, in such cases, may spread along the tissue planes around the eyes, resulting in peri-orbital ecchymoses that resembles black eyes/spectacle haemorrhage/raccoon eyes (raccoon is an American nocturnal mammal having a distinct peri-orbital colouration). However, the former arises from head injury with internal bleeding, whereas the latter results from bruising of the orbital and peri-orbital tissues from direct impact injury. Such fractures usually manifest by escape of blood and cerebrospinal fluid (CSF) from the nose (CSF rhinorrhoea). Middle fossa fractures usually result from direct impact behind the ear or crush injuries of the head and are followed by escape of blood and CSF from the ear (CSF otorrhoea). Occasionally, it may cause an arteriovenous commu- nication between carotid artery and cavernous sinus. Mastoid haemorrhage from a fracture of middle cranial fossa may be confused with retroauricular scalp bruise, called as Battle's sign (William Henry Battle, a surgeon at St. Thomas Hospital, London, 1855–1936). Posterior fossa fractures commonly result from direct impact on the back of the head, for example, striking the back of the head on the ground. It may be followed by escape of blood and CSF into the tissues of the back or neck. Fractures around the foramen magnum, especially the ring fracture, have been described ahead. Sometimes, a fracture extends transversely across the middle region of the base of the skull, along the region of the petrous ridges. The two components/fragments may be able to be brought together and displaced, as if on a hinge. This is referred to as a hinge fracture. The common mecha- nism for its production is severe hyperextension injury of the neck. Such fractures are commonly associated with injuries of the brain stem, especially pontomedullary tears.

Linear Fractures Also called 'fissured fractures', these are linear cracks without any displacement of the fragments and may involve whole thickness of the bone or one or the other . only. They are notoriously difficult to be detected and may not be demonstrable by X-rays. The line of fissured fracture is like that of a hair's breadth and usually follows a devious course along the line of dissipation of the force.

Linear or fissured fractures are likely to be caused by a forc- ible contact with a broad resisting surface like the ground, blows with an agent having a relatively broad striking surface. When the blow is struck on the side and the head is free to move, the fracture usually starts at the point of impact and runs parallel to the direction of the force. If the head is supported when struck, the fracture may start at a counter pressure; for example, in bilateral compression, the fracture often starts at the vertex or at the base. In case of a blow over the head and subsequent fall resulting in linear fractures, fracture lines produced by the fall are usually arrested by those produced by the blow. Similar may be the situation if two blows are struck one after the other.

In children and young adults, a linear fracture may pass into a suture line and cause 'diastasis' or opening of the weaker seam between the bones. In infants, particularly in the child abuse syndrome, a linear fracture of a parietal bone may reach the sagittal suture and continue across it into the opposite plate. The continuation may be direct or may be 'stepped', i.e. the two fractures are not in line.

Depressed Fractures Depressed fractures usually result from focal impact of a moving object on the cranial vault. The area struck is driven along the same line of force into the sub- jacent structures; the depth varying according to the velocity with which the impact is delivered. Thus, an object moving at a high velocity, such as high-powered projectile, will not only perforate the skull but may also cause fragments of the bone to be driven into the substance of the brain. In contrast, any blunt object moving at a lower velocity, such as a hammer or a brick, may create only a simple area of depression that absorbs most of the energy.

Rarely, only the inner . may get fractured and the outer remain intact, and vice versa may also be true. A violent blow with full striking area in operation, such as with a hammer, may detach almost the same diameter of the bone, which is driven inwards, thus often producing a pattern consistent with the offending object. This is why these fractures are also called 'fracture signature' or 'signature fracture'. A less violent blow or an oblique blow may produce a localised fracture with only partial depression of the bone. A glancing or tangential blow or a grazing bullet may produce gutter cum depressed fracture, with or without comminuted or fissured fractures.

Impacts with axe or chopper, etc. may leave characteristic lesions in the bone, whether skull or elsewhere. The shape of the fracture produced by such weapons may, to some degree, reveal the direction from which the blow was struck. This is particularly true when a chopping instrument is applied. The undermined edge of the fracture defect is the direction in which the lateral force vector is exerted, and the slanted edge is the side from which the force was transmitted.

Comminuted Fractures Here, the bone gets broken into multiple pieces and they usually occur as a complication of fis- sured or depressed fractures. The fragmentation of the depressed part of the bone occurs, which are often driven into the subjacent structures. They may be produced in vehicular accidents, or by repeated blows, more or less over the same area, by weapons having relatively small striking surface.

When there is no displacement of the comminuted fragments, the area looks like spider's web or mosaic, with fissured frac- tures radiating for varying distances along the line of dissipation of the forces. But when the violence applied is enormous, the comminuted fragments may get disturbed and, in fact, some of them may be recovered from the surface or substance of the brain.

Pond or Indented Fractures These may be seen in infants where the skull is elastic and usually is produced by forcible com- pression of the skull by obstetric forceps or impact against some protruding flat object. Fissured fractures usually occur around the periphery of the dent. The fracture is in the form of indentation or simple in-buckling of skull.

Gutter Fracture It is the name used to indicate a furrow in the outer . of the skull, ordinarily the result of a glancing blow by a missile from a rifled firearm. These are frequently accompanied with comminuted depressed fractures of the inner . of the skull.

Ring Fracture This is a type of fissured fracture that encir- cles the base of the skull around the foramen magnum, usually running 3–5 cm outside the foramen magnum at the back and sides of the skull, passing forward through the middle ears and roof of the nose.

Such types of fractures are usually noticed in the following cases:

- Fall from a height on to feet or buttocks, when the force of fall is transmitted upwards through the spinal column.

- Vault of skull being driven against the spine by falling of heavy load over the vertex or fall from a height on the head or heavy blow over the vertex.

- Violent twisting of the head on the spine, shearing the vault from the base.

- A heavy blow directed underneath the occiput or chin causing the fracture by violently lifting the skull from the spine and thereby breaking it away from its basal attachment.

Separation of Suture (Diastatic Fractures) Diastatic frac- tures are those in which the fracture line involves separation of one or more cranial sutures. These are most often seen in chil- dren and are commonly associated with epidural haemorrhage. They occur as a result of large/broad impact to the head with the blows, falls, industrial/vehicular accidents or under circum- stances where the victim, usually a child, is swung by legs against a wall or other immovable object. Expressed Fractures These are rather uncommon but may occur as massive fragmentation/shattering of skull where the pieces may come to lie outside the normal curvature of the cranium in the pericranial tissues, in the orbits, or physically outside the head. Such fractures can occur due to massive trauma often involving contact/close-range firearm injuries or injuries due to blasts.

Contrecoup Fractures These are mostly seen in orbital portions of the frontal bones as simple linear fractures or sometimes in more complex form as stellate fractures. Bilateral orbital contrecoup fractures are uncommon but may rarely exist as separate fractures. These fractures presumably arise from the pressure differentials between the intracranial orbital sur- face and the intraorbital space as in occipital falls or heavy blows at the back of the head. The involvement of frontal region may be explained because of development of 'negative pressure' within this region resulting from differential movements of brain versus skull following occipital impact that leads to implo- sion of the relatively thin and weak orbital roof. It is unlikely that sufficient forces can be built up in other areas of the skull so as to permit implosion fractures, but presence of some pathological condition or some unusual situation may permit contrecoup fractures to occur elsewhere.

While evaluating the presence of skull fracture at the autopsy, care should be taken against indiscrete use of chisel and ham- mer. It is preferable to stripe away dura, especially to appreciate linear fissured fractures at the base of skull. Tapping of the skull to elicit a 'cracked pot' sound is a time-honoured and still beneficial method for appreciating the skull fractures.

MENINGEAL HAEMORRHAGES

The extreme fragile nature of the contents of skull invites their closure in the strong bony box of the cranium. Damage may occur either to the neural tissue or to the vasculature, which surrounds and penetrates the neural tissue.

Forensic Aspects of Anatomy of the Coverings of the Brain

The brain is invested in three separate layers of tissue. The out- ermost layer, dura mater, is formed of two layers of tough collagenous tissue, the external layer of this dura being firmly in apposition with the inner surface of skull and the internal layer merges with the arachnoid. Between the skull and dura, there is a potential space, the so-called epidural or extradural space, which carries considerable forensic importance. The dura forms the falx cerebri and the tentorium cerebelli, and the cranial venous sinuses run within this dura. Polypoid invaginations of the dura penetrate the inner walls of the venous sinuses to form the 'arachnoid granulations'.

The arachnoid is a thin vascular meshwork, which is closely applied to the inner surface of the dura. The name has been derived from the Latin term for the spider because of the spider-web appearance of the tissue. The arachnoid closely follows the contour of the brain but does not dip like the pia mater. Separating the arachnoid layer from the dura is a space termed as the subdural space. Further, arachnoid is separated from the underneath pia mater by a space known as subarach- noid space. This space is filled with cerebrospinal fluid, and the width of the space varies from few millimetres in the young to a centimetre or so in the old where there has been development of cerebral atrophy. (CSF is produced by the choroid plexus of the lateral, third and fourth ventricles. The fluid leaves the ven- tricles through a small opening in the roof of fourth ventricle, called the foramen of Magendie and the lateral foramina of Luschka and circulates through the subarachnoid space towards the pacchionian granulations, from where it joins the venous blood in the dural sinuses.)

The pia is not a true membrane but is a surface feltwork of

glial fibres, which are inseparable from the underlying brain. The layer has little forensic importance.

Any force that succeeds in deforming the skull or changing the position of the brain in relation to the skull may produce damage to the meninges, the cerebral or meningeal vessels and nerves and may contuse and/or lacerate the brain substance or sometimes may only induce a neuronal injury of microscopic dimensions. In fact, many disorders of the central nervous sys- tem caused by mechanical trauma are due to injury to the acces- sory elements, i.e. meninges and blood vessels, and the changes in the nervous tissue are of secondary nature.

Bleeding or haemorrhage may occur in any of the three spaces discussed earlier under the 'Forensic Aspects of Anatomy of the Coverings of Brain'. If the bleeding is small and thin- layered, it is called 'haemorrhage' and if it is in the form of space-occupying lesion because of its large mass, it is termed 'haematoma'. According to the relationship of these haemor- rhages to the meningeal coverings and the brain itself, they can be studied under the following subheadings:

EXTRADURAL (EPIDURAL) HAEMORRHAGE

Bleeding between the inner surface of the skull and the dura mater is the least common of the three types of brain mem- brane haemorrhages. Generally, the haemorrhage is associated with linear or fissured fracture of skull that crosses the grooves of the meningeal vessels on the inner surface of the skull. About 15% haemorrhages may occur in intact skulls (Mc Kissock). Only in persons with rather elastic skulls, especially in children, a skull deformation may separate dura and cause extradural bleeding without a skull fracture being present. It may occur in association with the subdural haemorrhage. Usually, it is unilat- eral but bilateral epidural haemorrhages have also been reported. There were only three bilateral haemorrhages in the 175 cases reviewed by Mc Kissock et al. (1960).

Cause and Source

Rupture of the middle meningeal artery or its branch or the accompanying veins or both is the most common cause, and this explains why the region most often affected is the tempo- roparietal area. Less commonly, the posterior meningeal artery near the foramen magnum or the anterior meningeal artery near the cribriform plate may get involved and consequently the site of the haemorrhage may be parieto-occipital or fronto- temporal. However, it has been claimed that almost all ruptures take place at a site where the artery is roofed over in a bony tunnel so that it is unable to escape damage from a fracture but as stressed in the beginning, responses can be varied. These haemorrhages are rare during the first 2 years of life due to greater adherence of dura to the skull and the absence of bony canal for the artery.

Other sources of bleeding in this space are the emissary veins and the dural sinuses, mostly the sagittal and lateral. Haemorrhage from diploic venous channels and lakes may also occur but rarely becomes large enough to be significant.

As bleeding commences, it strips off the dura from the undersurface of the skull with progressive accumulation of blood. There is often a free interval of varying duration prob- ably related to a delay in the onset of bleeding due to spasm of the injured artery. This latent interval (lucid interval) may not occur if the concussion is prolonged or there is associated brain damage. About half an hour may be sufficient to form a significant arterial haematoma but in Rowbotham series, the range varied from 2 hours to 7 days, but most were apparent after 4 hours.

SUBDURAL HAEMORRHAGE

Subdural haematomas tend to occur most commonly in fifth and sixth decades as compared with epidural haematomas that peak in the second and third decades. Further, subdural haema- tomas have a less clear association with impact injuries than do the epidural ones. In fact, there need to be no impact upon the head, as it can sometimes occur in infants solely from vigorous shaking. Subdural haemorrhage is probably the most common lesion in fatal child abuse, being that described by Caffey in the classic early descriptions of the 'battered baby'. Acute, sub- acute and chronic varieties are recognised, but only acute and chronic deserve description because a clear distinction exists between their clinical features and medicolegal importance.

ACUTE SUBDURAL HAEMATOMA

It is an acute accumulation of blood in the subdural space, being almost always traumatic in origin. Subdural haemor- rhage, unlike extradural, is essentially venous in origin and the various causes may be following:

- Rupture of the bridging or communicating veins: Bridg- ing or communicating veins traverses the subdural space to drain into the parasagittal sinuses, but those present on the inferior surface of the brain drain in the sinuses at the base of the skull following injury. Rupture may occur in case of rota- tional movement of the brain in relation to the skull, in accel- eration or deceleration injuries, without any injuries of the scalp or fracture of the skull. The locations where these com- municating or bridging veins are most frequently encountered include the lateral frontal region, the apex of the temporal lobe and the subtentorial region. Lack of muscle fibres and thinness of fibrous walls and elastic lamina predispose these categories of veins to rupture as the brain slides within the skull. Furthermore, it has been reported that parasagittal bridging veins have viscoelastic properties that govern the vessel rupture and depend upon the rate at which the vessels are strained and the direction of strain. Yamashita and Friede have shown that bridging veins appear to be ultrastructurally stronger circumferentially than longitudinally and, therefore, are more resistant to displacements than elongating strains. The lesion is often solitary, being associated with the closed head injury where the only other sign may be the bruising of the scalp or even nothing at all—as when an infant is violently shaken.

- Tears in the dural venous sinuses, following a blow.
- Laceration of the dura and tear of middle meningeal artery, with bleeding occurring into subdural but not in epidural space.
- Fresh tear occurring in an old adhesion between the dura and the brain with consequent bleeding.

As the name implies, this lesion is an acute accumulation of blood at the interface between the dura and arachnoid mem- branes. It is mostly unilateral. Not infrequently, it is associated with injury to the underlying brain substance. Blood tends to accumulate in the base of the skull, especially in the middle fossa. Its distribution will be determined by the position of the head, blood collecting by gravitation in the then dependent part of the skull. In the acute form, blood usually is red, partly fluid and partly clotted. If sufficient interval elapses between injury and death, a fibrous membrane usually spreads over the inner surface of the clot, enclosing it. This layer is usually detec. at about 10 days.

On most occasions, bleeding is slight but fatal compression of the brain by a large subdural haemorrhage can occur within a few hours. It has been suggested that about 100–150 ml is usually the minimum associated with fatalities. Fatality is frequently associated with some concomitant brain injury. If there is no primary brain damage, the mortality from the subdural haem- orrhage is usually related to the victim's age, neurological status and delay from the time of trauma to the surgical evacuation of the haematoma.

CHRONIC SUBDURAL HAEMATOMA

(PACHYMENINGITIS INTERNA HAEMORRHAGICA)

These haematomas blur with the subacute subdural haematomas of older age, but may form a distinct phase when a cellular organising membrane gets formed over the undersurface of the haematoma. Such haematomas are more often encountered in the old persons and in chronic alcohol abusers. The factor responsible may be the increasing subarachnoid space that occurs with diminution of brain size in old age. This increased space with corresponding decrease in the size of the brain allows greater movement of the brain within the cranial vault, even with incidental acceleration/deceleration. Another factor play- ing a part is the pseudo-elongation of the cortical veins leaving the cortical surface to enter the venous sinuses which, therefore, are likely to be under strain and thus more susceptible to tearing. An amount of subdural blood insufficient to cause a mass effect may accumulate following minor trauma. This is especially prone to occur in victims with cerebral atrophy due to reasons described above. Although small amounts of subdural blood are usually spontaneously reabsorbed, the haematoma may occa- sionally become encapsulated by a membrane of fibrous tissue and friable capillaries emanating from the dura mater. Small recurrent haemorrhages from the thin-walled vessels within the membrane cause collection of liquefied blood to enlarge. Another explanation for this enlargement may be that as the membrane envelops the haematoma, it becomes semipermeable to water. The contents of haematoma become significantly liquefied by about 2–3 weeks, and is said to contain high levels of proteins and are, therefore, hypertonic to surrounding tissues. This hyper- tonic fluid compartment, encased in a semipermeable mem- brane, enlarges as the water moves into it, to dilute the liquefied clot still further. This chronic subdural haematoma may come to clinical attention months or years after the initial insult when it presents as an intracranial mass and may create features of brain compression ultimately leading to death.

Organisation of Subdural Haemorrhage

The subdural space has no mesothelial lining, and its walls have a limited absorptive capacity, due to which reparative reaction to the presence of blood in it is unique. Further, a subdural haematoma being located beneath the dura, transmits its compres- sive forces fairly equally onto the gyri and sulci, resulting in an 'undulating' appearance of the compressed surface of the brain, whereas the epidural (extradural) haematoma being located outside the dura, pushes on the thick and fibrous dura, trans- mitting the compressive forces evenly over a large flat surface area, resulting in an appearance described as 'ruler-straight' sur- face of the compressed brain. Grossly, acute subdural blood appears as a maroon coloured film of blood or gelatinous clot- ted mass that can readily slide off the leptomeninges on sur- face of the brain. As the subdural blood autolyses and becomes organised, following changes, reportedly, may be demonstrable microscopically (these changes need be interpreted cautiously and not rigidly, as there can occur variation in the evolution of changes from individual to individual. At autopsy, detailed description and photographs may invite documentation):

- Within a couple of days or so, macrophages migrate to the area and engulf red blood cells and therefore, haemosiderin is identifiable through iron stains.
- Macrophages and haemosiderin gradually become more prominent as the organisational process progresses.
- Within a week or so, endothelial cells form capillaries and the granulation tissue begin to thicken considerably. Early fibro- blastic membrane, the so-called neomembrane (composed of fibroblasts, macrophages, and collagen) is formed. This mem- brane originates from the dura at the edge of the haematoma, spreads over the inner (i.e., nondural) surface of the clot, inter- posing itself between the clot and arachnoidal surface.
- After 1–2 weeks, granulation tissue gets more organised with abundant young fibroblasts, macrophages, and blood vessels.
- Eventually, the autolysing blood gets resorbed and a well-developed membrane of fibrous tissue shows its appearance, a development usually requiring an interval of 3–4 weeks. (The centre of the haematoma is likely to show predominantly autolysing blood and therefore, one must obtain sample from the edge of the lesion as the organisational changes here are most prominent and predic..)

Medicolegal Considerations

As with other injuries, the mechanical cause is the change in the velocity of head, either acceleration or deceleration, almost always with a rotational component. Where a blunt impact is given to the head, subdural bleed need not be situated directly under the area of impact or on the same side of the head. Secondly, it is quite mobile and therefore a lesion originating high on the parietal area may drain down under gravity and cover varying portion of the hemisphere and may even go into the posterior fossa through the tentorial opening.

As in the extradural haemorrhage, there may be lucid inter- val (latent interval) before clinical signs and symptoms appear. Associated brain damage may, however, cause uninterrupted coma from the time of injury. When there is lucid interval, it may be longer than the average 4 hours of faster arterial bleed- ing of the epidural haemorrhage. In fact, there is no upper limit to this interval as the acute subdural haemorrhage may merge into chronic condition, which may recur after weeks or even months. In rare cases, they may develop as fast as an extradural haematoma and become fatal by the same mechanism of brain displacement within hours.

Chronic subdural haematomas provide a fertile field in forensic pathology and for legal profession because of special character of this lesion. It frequently occurs without known trauma or other historical cause, often evolves silently, mimics a number of other conditions and is easily missed clinically. Therefore, linkage of haemorrhage with the temporal event and the appropriateness and timeliness of therapy or the lack thereof may become the focus of attention for medical negligence suits, insurance claims and also in criminal cases.

Sometimes, when a collection of recent blood is discovered inside an obviously old subdural haematoma, controversy may arise—whether the recent blood deposition is due to recent trauma. However, it may be kept in mind that it is a part of natural history of such lesions that they bleed of their own accord. In such cases, it is important to determine if there are any other signs of recent traumatic lesions in the brain.

Explanation for sudden decompensation and death in the individuals carrying subdural haematoma may be sought in the rather delicate equilibria existing in the intracranial space amongst the cerebral volume, cerebral blood flow, CSF volume and intracranial pressure. When haematoma has achieved its maximum size—which can be accommodated by egress of CSF, by adjustment of CSF production, transport and absorp- tion as well as by compensatory shift of brain structures—any additional mass effect because of new haemorrhage may be dis- astrous leading to evolution of coma and death within hours.

SUBARA CHNOID HAEMORRHAGE

It is the most common intracranial lesion observed following blunt trauma to the head and occurs almost invariably with cerebral contusions and lacerations, but shows mixed aetiology

Following are the usual causes, traumatic as well as nontraumatic:

- Nontraumatic subarachnoid haemorrhage:

▪Rupture of an aneurysm of an artery supplying the brain

▪Rupture of an intracerebral haemorrhage of nontrau- matic origin (apoplectic haemorrhage or stroke) into the subarachnoid space.

- Traumatic subarachnoid haemorrhage:

▪Direct trauma to the brain with focal areas of subarach- noid haemorrhage

▪Trauma to the side of the face and neck with fracture of a cervical vertebra with tearing of the enclosed portion of a vertebral artery

▪Tearing of one of the thin-walled arteries at the base of the brain due to sudden hyperextension of the head upon the neck.

Salient Features of Epidural, Subdural, and Subarachnoid Haemorrhage

Features	Epidural (extradural)	Subdural	Subarachnoid
Location	Between skull and dura	Between dura and arachnoid	Between arachnoid and pia
Cause	Head injury	Mostly due to injury (massive leakage through meninges can also occur)	Natural: aneurysm, high blood pressure, angioma Traumatic: cerebral contusions, damage to internal carotid, vertebral or basilar artery
Confusing entity	Can be confused with heat artefact	Seldom confused with other bleeding	Can be artefact from rough opening the skull
Aetiology	Mostly middle meningeal artery or its branches are ruptured	Mostly due to rupture of bridging (communicating) veins that traverse the subdural space to drain into the parasagittal sinuses	Due to natural vessel leakage from vessels on brain surface, or vessels from within brain, or from injury
External manifestation	Often blood under the scalp	Often no external manifestation	No external manifestation unless other injuries are present
Gravity	Can be space occupying	Often space occupying	May be space occupying if source is arterial
Distribution	Usually on one side but can be both	Unilateral or bilateral	Focal, semi-localised, diffuse, or bilateral
Brain surface	Being located outside the dura, it pushes on the thick and fibrous dura transmitting the compressive forces almost evenly over a large flat surface area resulting in an appearance, the so-called 'ruler straight' appearance of the compressed surface of the brain	Being located beneath the dura, it transmits its compressive forces fairly equally onto the gyri and sulci resulting in an 'undulating' appearance of the compressed surface of the brain	Brain surface usually not distorted

ACUTE NONTRAUMATIC (SPONTANEOUS) SUBARA CHNOID HAEMORRHAGE

Spontaneous subarachnoid haemorrhage is almost always due to rupture of a berry aneurysm, though at occasions the origin of the haemorrhage may be difficult to detect if the rupture and con- sequent haemorrhage has destroyed the greater part of the aneurysm (berry aneurysm—a saccular aneurysm of the cerebral artery usually at the bifurcation of the vessels in the circle of Willis. Its narrow neck of origin and larger dome resemble those of a 'berry', hence the nomenclature. Thomas Willis, an English anatomist and physician, 1621–1675). The aetiology of saccular aneurysms is uncertain. However, some genetic factors are con- sidered to be important in their pathogenesis. Cigarette smoking and hypertension are expected predisposing factors for their development. Although they are sometimes referred to as con- genital, aneurysms are not present at birth but develop overtime owing to the underlying defect in the media of the vessel wall. They may occur singly or multiply and may rupture spontaneously or upon head trauma. Even the emotional upset that accompanies trauma (in fact, the blow may never be struck, but only threatened) can trigger cardiovascular changes such as sudden increase in blood pressure, precipitating rupture of the aneurysm. It has also been forwarded that berry aneurysms seem to rupture more often in intoxicated persons. However, the fact that many assault situations occur in an alcoholic environment suggests that the association may be parallel rather than causative. Polson and Gee (quoting Knight) described a case wherein two British sailors got involved in a drunken .ht, when one was kicked on the head. He went into coma and died several days later. Autopsy revealed a ruptured berry aneurysm on the circle of Willis. The defence counsel maintained that in the deceased drunken sailor, rupture of aneurysm was far more likely to have occurred from the raised blood pressure (including an increased pulse pressure between the systole and diastole) than from the actual blow. However, the view was accepted neither by the trial court nor by the subsequent Appellate Court.

The legal problem exists as to the relationship of the trauma to the fatal bleed. The time interval is naturally extremely impor- tant. The acid test is—would death have occurred when it did, if the assault had not taken place? The law says that an assail- ant must "take his victim as he finds him" and that if a sick man is assaulted and dies (while the same assault upon a fit man would not have killed him), that is the misfortune of the assail- ant as well as for the victim. Occasionally, when little or nothing appears to complicate the injury at the time, and even more, when a long symptom-free interval ensues before frank rupture and bleeding, doubt as to connection between injury and dis-ease should rank high. Blood under arterial pressure is forced into the subarachnoid space, and the victim is stricken with a sudden, excruciating headache and rapidly looses consciousness. Rapid death from bleeding around the base of the brain can be attributed to some brain stem affectation, causing immediate cardiorespiratory arrest. However, at occasions, death may be delayed for minutes, hours or days. Microscopic examination of the aneurysmal tissue may be rewarding in this context. Presence of degraded haemoglobin in its wall and in the sur- rounding tissues suggests previous leakage, helping to establish the relationship of leakage to the alleged traumatic event.

Degenerative or inflammatory changes in the wall of the lesion will be demonstrable depending upon the duration of survival. Angiographic study before removal of the brain will be helpful in locating the site of bleed. Common sites of involvement in order of frequency are shown in .ure 18.2.

ACUTE TRAUMATIC SUBARACHNOID HAEMORRHAGE

Bleeding from subarachnoid space is caused by the same mech- anism as that in the subdural space, i.e. shear stresses and rota- tional movements of the brain leading to tearing of bridging (communicating) veins that leave the cortex and cross the arachnoid space to open into the dural venous sinuses. But where laceration, contusion or infarction of the cortex is pres- ent, the bleeding will come from the cortical veins and small arteries, directly into the subarachnoid space. It may also arise from the intracerebral bleeding breaking through the cortex into this space.

The site of appearance of traumatic subarachnoid haemor-rhage is influenced by the nature and extent of injury. Where it is produced as a result of blunt force impact with or without meningeal bleeding or cortical contusion/laceration, etc., it occurs either where the bridging veins within the subarachnoid space are most numerous, or where rotational forces are most likely to cause tears. Therefore, the usual sites of appearance of this haemorrhage will be parietal and temporal lobes, the undersurface of the frontal lobes and the cerebellum. But when the subarachnoid haemorrhage is secondary to the laceration/ contusion of the brain, then its localisation and extent depends upon the primary injury.

Acute subarachnoid haemorrhage may at occasions be due to traumatic avulsion of an otherwise normal intracranial vertebral artery. Contostavlos, Mant and others described a circumstance wherein a blow to the high neck (such as with a fist), critically localised immediately below the mastoid process and behind the mandible, could fracture the transverse process of the atlas resulting in damage to the wall of the vertebral artery within the foramen transversarium. This could lead to haemor- rhage dissecting along with the wall of the artery and eventu- ally forcing its way into the posterior fossa. Careful dissection of the high posterior neck and exposure of the vertebral artery in its extracranial course over the arch of the atlas is warranted in such cases, since the external local evidence of the blow/ cutaneous mark may be inconspicuous. Sudden death of four ice hockey players with massive basilar subarachnoid haemor- rhage was attributed to presumed injury of the vertebral artery due to blow by a puck driven at high velocity to the high neck. In the same report, another player collapsed and died when struck with a fist in an altercation (Maron BJ, Ploiac LC, Ashare AB, Hall WA. Sudden death due to neck blows among amateur hockey players. JAMA 2003:599–601).

CEREBRAL INJURIES

The neuropathology of brain damage is a complex subject but a forensic expert has to be conversant with the general principles of causation in order to offer some interpretation of the injuries. There may be a wide range of results from a given insult to the head and as already stressed in the beginning of this chapter, unnecessary theorising about the relationship of extent of trauma to the lesion produced must be discouraged. Well- known aphorism of Munro and the other dictum cited earlier speak highly of this caution to be exercised by all concerned.

Mechanism of Cerebral Injury

Damage to the brain may occur in any one or more of the following ways:

- By direct intrusion of any foreign object such as a penetrating weapon, bullet or some other projectile or fragments of skull in a compound comminuted fracture of the skull.

- By disruption of brain in closed head injuries. Here the mechanism of injury is complex and variable. Brain is almost incompressible, and purely axial impact may give rise to little or no damage. But the impact is almost always accom- panied by some rotatory component also, which is now considered to be primarily instrumental in causing brain damage. It is the change in velocity, acceleration or decel- eration, with a rotational component, that leads to damage. It follows that no actual blow or fall needs to be suffered by the head to cause brain damage.

- Sliding or 'shear strains', which move adjacent strata of the tissues laterally as may be seen when a pack of playing cards being displaced, each card sliding upon its neighbour. Holbourn defines 'shear strain' as, "a strain produced to cause adjoining parts of the body to slide relative to each other in a direction parallel to their places of contact".

COUP AND CONTRECOUP DAMAGE TO THE BRAIN

This aspect of brain damage is of considerable practical importance, and the neuropathology of its production may be sum- marised as under:

- When an impact is imparted to a mobile head, the site of maximum cortical damage is most likely to be underneath or at least on the same side as the impact. This is so called, 'coup lesion'

- When a moving head is suddenly decelerated as in case of a fall, though there might be a coup lesion at the site of the impact, there is usually cortical damage on the opposite side of the brain—'contrecoup lesion'

Taking into account the forensic aspect of anatomy of the skull (particularly the interior con.uration), forensic aspect of anatomy of its meninges dividing the cranium into three compart- ments and the mechanism of production of the cerebral injuries (all have been discussed in detail earlier), various points of prac- tical implications emanating from the prior discussion in relation to coup and contrecoup damage of the brain may be as follows:

- There may occur only contrecoup damage without any coup lesion.
- vere coup and/or contrecoup lesions may be present with or without fracture of skull.
- The common sites of cerebral damage, as explained earlier, are the tips and under-surfaces of the frontal and temporal lobes.
- It is virtually unknown for a fall on the frontal region to produce occipital contrecoup, probably due to the relatively smooth internal surface of the posterior cranial fossa of the skull.
- In a temporal impact, the contrecoup lesion may not appear on the contralateral hemisphere but on the opposite side of ipsi- lateral hemisphere from the impact against the falx cerebri.
- The extent of contrecoup damage may be disproportionately related to coup damage.
- A fall on the occiput may transmit a sufficiently severe force so as to fracture thin bone in the anterior fossa.

Case: Medicolegal Importance of Contrecoup Injuries

On 19th October, 1996, the victim had a scuffle with some miscreants and allegedly received lathi blows on his head. He was then admitted to a hospital, where he had to undergo sur- gery apart from other conservative management but eventually death ensued after about 3 weeks. The intriguing aspects of the injuries were:

- A vertically placed healed wound, 6 cm in length, involving left frontal and parietal area. Anterior extremity was seated 6 cm above the lateral angle of left eye and posterior extrem- ity at a point 6 cm posterior to this. Impressions of the stitches were appreciable running across this scar. On dissec- tion, no bony or cerebral injury was detected.

- On the opposite side of the above mentioned scar, i.e. on the right frontoparietal area, a curved (C-shaped) healed wound with impression of the stitches was discernible. The anterior extremity was placed 4.5 cm above the lateral angle of right eyebrow, marching upwards towards midline in a curved fashion and then running some distance along the midline, proceeding posteriorly over the parietal region and then extending downwards and laterally, ending against the right parietal eminence. On dissection, a piece of bone (8 ⊠ 7.5 cm2 involving right frontoparietal sites, lying loose in its place) and underneath a subdural haemorrhage measuring 6.5 ⊠ 5.0 cm2 were revealed. Obviously, this C-shaped scar with underlying loose piece of bone was of surgical origin in an attempt to evacuate the haematoma. This was the first clarification sought by the defence counsel. Next, he pleaded his point that the injury to the brain on the right side was due to contrecoup effect originating from the coup impact on the left side, i.e. blow with a blunt force (say with a lathi blow) on the left side could be responsible for causing injury to the brain and its meninges on the opposite side.

Here, the injury on the left side was simple as no bony or cerebral injury was demonstrable, but the right side showed the presence of cerebral injury that had been turned complex by the surgical intervention. Surgeons should clearly lay down the initial status of the area inviting surgery (both external as well as internal) vis-á-vis the details of the intervention. The contention of the defence counsel, probably, was to suggest to the honour- able court that his client (assailant) never intended to kill the victim but merely to harm him, and unfortunately the death occurred due to indirect effects (contrecoup effects) rather than the injury itself.

CEREBRAL CONCUSSION (COMMOTIO CEREBRI)

Historically, the term 'concussion' was used to describe a 'revers-ible traumatic paralysis of nervous function'. The term was introduced by Pare (a French military surgeon, 1510–1590) and has been derived from the Latin 'concutere' meaning 'to shake'. It is popularly known as stunning. Trotter (1914) described it as, "a transient paralytic state due to head injury, which is of instantaneous onset, does not show any evidence of structural cerebral injury and is always followed by amnesia from the actual moment of the accident." The condition has also been referred to imply an immediate but transient loss of consciousness asso- ciated with short period of amnesia. The mechanism of loss of consciousness in concussion is believed to be a transient electro- physiologic dysfunction of the reticular activating system in the upper midbrain caused by rotation of the cerebral hemispheres on the relatively fixed brain stem. (Angular or rotational accelera- tion of the head must be present to produce the clinical entity known as concussion—Genarelli TA, Spielman GM, Langfitt TW et al.). Gross and light microscopic changes in the brain are absent. However, biochemical and ultrastructural changes, such as mitochondrial-ATP depletion and local disruption of blood- brain barrier, have been reported. Courville (1953) has discussed the condition in depth. Changes in nucleus and cytoplasm of neurons, the composition of the cerebrospinal fluid and in the electroencephalograph have been reported sometimes .also 'Diffuse Axonal Injury' ahead).

The condition may be produced by direct violence on the head or by indirect violence as a result of a violent fall upon the feet or nates from a height or by an unexpected fall on the ground as may be seen in traffic or industrial accidents. In severe cases, brief convulsions may occur, or autonomic signs such as facial pallor, faintness, bradycardia with hypotension, etc. may be seen. The extent of retrograde amnesia usually correlates with the severity of injury. It carries medicolegal importance and may be associated with automatism wherein the individual may not remember any event relating to criminal or violent behaviour. As reported, memory is regained in an orderly fashion from the most distant to recent times, with islands of amnesia occasionally persisting in extreme cases. It seems to be a protective mecha- nism, caused by loss of sensory input before the latter is trans- ferred to permanent memory storage in the brain. Though it is usually of minutes' duration, it can extend up to several days before the head injury. Other symptoms may include throbbing headache, vertigo, giddiness, or transient blackout, mental irrita- bility, etc. DJ Reddy reports that gross intracranial damage could exist with an intact skull, remaining clinically symptom free and still prove fatal (JIAFS, January 1964, 17).

Damage to the structures may take place depending upon the severity of inertial loading of the head. However, in this type of injury, most of the strain is insufficient to cause struc- tural damage. It seems appropriate to recognise mild concus- sion as the first step on the scale of the continuous spectrum of brain injury and therefore, concussion may be considered as a mild form of diffuse axonal injury. It has been advocated that the effects of classic concussion may actually involve the same disruptive axonal phenomenon in proportion to the degree of inertial force traumatising the brain. Evidences are surfacing that the severity and duration of functional impairment may be governed by repeated concussions and that the effects of minor head trauma may be cumulative. This explains the condition of 'punch-drunk syndrome/traumatic encephalopathy or dementia pugilistica' seen in professional boxers ."Head Injuries in Boxers" also). This may also be a problem in other contact sports that engender blows to the head (in American football, cerebral concussions account for 9 out of 10 head injuries, and 1 in 5 university football athletes each season). Cerebral concussion may be followed by post-concussion syndrome, which refers to a constellation of symptoms inde- pendent of objective findings on neurological examination. Usually, there is a complex of symptoms persisting months after the head injury and shows various combinations of head- ache, irritability, anxiety, lassitude, vertigo, blurred vision, easy fatigability and insomnia, etc. Based largely on experimental models, some believe that subtle axonal shearing lesions or some biochemical alterations may account for the cognitive symp- toms even when the brain imaging shows normal findings. In moderate and severe trauma, neuropsychiatric changes like dif- ficulty in concentration, memory, and other cognitive deficits may be present. As reported, in mild head injury, these symp- toms last for an average of 2 weeks; whereas in moderate head injury, they have higher incidence and longer duration.

DIFFUSE AXONAL INJURY

Diffuse axonal injury (DAI) was first described under the heading of 'diffuse degeneration of white matter'. Since then, a variety of terms have been used to point out the nature of the entity, viz., by mechanism—'shearing injury'; by location of the underlying damage; and by combination of mechanism and location of the principal changes—'diffuse white matter shear- ing injury'. The entity was originally described in a series of patients in whom there was diffuse brain injury without an associated intracranial mass lesion. Adams et al. (1989) intro- duced the grading, i.e. Grade I—presence of axonal swellings and axonal bulbs throughout the white matter; Grade II—presence of a focal lesion in the corpus callosum in addition to widely distributed axonal injury; Grade III—represents worst injuries characterised by diffuse axonal damage in the presence of focal lesions in both corpus callosum and brain stem. On the other hand, diffuse vascular injury (DVI) has been iden- tified as widespread, multiple peri-arterial, perivenular, or peri- capillary haemorrhages in the cerebral white matter, cerebellar white matter, cerebral cortex, basal ganglia, thalamus, and brain stem. Both DAI and DVI are produced by acceleration of the head, but axon injury occurs at lower acceleration levels than those required to cause vascular rupture (experimental studies have shown that there is a direct response of the cerebral microvasculature to the lateral head acceleration). Therefore, it has been suggested that DAI and DVI depend upon the same mechanism, with the degree of axonal and vascular damage being determined by the intensity of the head acceleration.

The formerly held view that axons were ruptured/damaged at the moment of injury (primary axotomy/immediate axonal disruption) no longer seems to be appropriate. Now it is con- sidered that other processes also take place leading to delayed axotomy wherein the affected axons undergo lobulation in about 6–12 hours and secondary axotomy occurring after 24–72 hours, which may be influenced by the species, nature and intensity of injury.

Immunohistochemistry has added much knowledge in explaining the axonal damage. By using antibodies against beta-amyloid precursor protein (βAPP), axonal damage has been found in a small series of patients with mild head injury, but death occurred from unrelated causes (Blumbergs et al., 1994). Blumbergs and co-workers derived a 'sector scoring method' through which they could recognise variable amounts of axonal injury and other abnormalities in patients with any of a wide range of Glasgow Coma Scores. As reported, the aging of the axonal injury can be approached as under:

- Identification of dystrophic axons through H & E stained sections usually requires a post-injury survival time of at least 18–24 hours. Further, in case of a few days' survival, the injured axons become progressively widened and assume a varicose appearance. Eventually, they will appear as 'bulbs' or 'spheres' demonstrable with H & E staining techniques.

- Immunohistochemistry reveals axonal injury sooner. ⊠APP immunochemistry is a useful marker of axonal injury in formalin-fixed paraffin-embedded human brain. It labels injured axons and can reveal axonal injury after 2–3 hours of survival [⊠APP is normally present in nerve cell bodies and in axons, but not detec. because of its small quan- tity. However, under acute injury to the axon (injury may be due to a variety of reasons, namely any infection causing destruction of brain tissue, toxins including carbon monox- ide and ischaemia/infarction, etc.), ⊠APP acts as an acute phase reactant and accumulates in the axons, thereby dis- tending them and allowing their visualisation].

- Evaluation of DAI at autopsy needs critical histological examination of brain tissue. For this purpose, brain needs fixation in 10% formalin prior to processing fragments for paraffin embedding. Preparation of blocks from arterial boundary zones, the parasagittal white matter, the internal capsule, the corpus callosum, the hippocampi, the cerebel- lum and various levels of brain stem has been advocated. Such sectioning is advocated for differentiating axonal injury arising out of ischaemic complications due to raised intracranial pressure.

CEREBRAL CONTUSIONS

Application of linear or more commonly laminar stresses to the head may disrupt the soft tissue of the brain, especially the cortical region associated with damage to the blood vessels. If the integrity of the cortex is maintained but there occurs extravasation of blood into its substance of the affected area, the region gets bruised and swollen and constitutes 'contusion'. The area of contusion may vary from tiny punctate haemor- rhagic spots in the grey matter to large areas involving white matter including cerebral convolutions spreading over sulci.

In usual type of cortical contusion seen in a closed head injury, the cortex appears blue or red or brown due to extrava- sation of blood into its substance. If the victim survives for sometime, there may be added discolouration from the associ- ated cortical infarction. The lesion is often wedge-shaped, having base on the surface and tapering away into the deeper layers.

Lindenberg and Freytag introduced new names for contu- sions in the brain that do not fit into coup or contrecoup. Contusions found in deeper structures of the brain along the line of impact are called intermediary coup contusions. Contusions caused by skull fracture are called fracture contu- sions. Contusions in the cortex and white matter of the fron- tal and central convolutions near the upper margins of the hemispheres show no relationship to the area and direction of impact. They are called gliding contusions and are caused by stretching and shearing forces occurring in the region of arachnoid granulations, during to and fro gliding of the brain within the skull in moderately severe impact. Contusions in the cerebellar tonsils and the medulla oblongata produced by momentary shifting of the brain towards the foramen mag- num are called herniation contusions.

CEREBRAL LACERATIONS

A greater degree of disruption, producing macroscopic tearing of the substance of the brain, results in 'laceration'. Therefore, it may be considered as an extension in severity of contusion in which the mechanical separation of the tissues can be seen. In cerebral lacerations and most of the contusions, the pia and often the arachnoid matter are disrupted, so that the blood from damaged cortical vessels leads into the subarachnoid or even into the subdural space. Lacerations and contusions are most often encountered in those areas of the brain where the cortex is likely to come into contact with the irregularities in the internal profile of the skull. Therefore, tips and undersur- faces of temporal and frontal lobes are the common sufferers.

INTRACEREBRAL HAEMORRHAGE

Intracerebral haemorrhage, either infiltrating the brain tissue or forming actual haematoma, is common in severe head inju- ries. They may occur at the time of impact or soon afterwards (primary) or may occur during the succeeding period due to changes in the intracranial pressure (secondary). The latter are seen more often as the victims of head injuries now survive longer due to availability of modern life-saving facilities, so that there is time for the secondary lesions to creep in. These haemorrhages may rupture through the cortex into the menin- geal spaces, which may be termed as 'burst lobe'.

Differentiation, whether the haemorrhage has been caused by head injury or a 'sudden stroke' due to natural cerebral haemorrhage resulting in fall and consequent head injury, is extremely difficult; particularly in elderly subjects with hyper- tension and cerebral atherosclerosis. Presence of left ventricu- lar hypertrophy, history of hypertension, site and extent of haemorrhage may provide useful parameters for such differentiation . Furthermore, consistency/ inconsistency of the haemorrhage with the degree of head injury is another guide in this regard. Various differentiating points, as gathered from the literature, may include the following:

- In traumatic intracerebral haemorrhage, the interval between the injury and onset of 'stroke' is usually a week or less, rarely longer than 2–3 weeks.
- Present information indicates that the injury to the head must be sustained with the head in motion, for traumatic intracerebral haemorrhage results from the coup-contrecoup mechanism.
- The location of typical post-traumatic effusions into the brain is in the central white matter of the frontal or, more often, the temporo-occipital regions. Spontaneous haemo- rrhages due to hypertension are more commonly found in basal ganglia, thalamus, pons and cerebellum, which are uncommon sites for post-traumatic damage.

- A history of arterial hypertension in a florid, overweight individual prior to the onset of 'stroke', evidence of degen- erative arterial disease (either clinically or postmortem), and particularly the discovery of degenerative changes in the arteries at the margin of the haemorrhage would favour the conclusion of a spontaneous rather than a traumatic aetiology.
- Secondary post-traumatic haematomas are more common in young healthy individuals, while apoplexy incident to hypertension is more common in adults past middle age. However, age alone is not a criterion in either one or the other, for relatively young adults may have arterial hyperten- sion, and older individuals are not immune from traumatic intracerebral haemorrhage.

HEAD INJURIES IN BOXERS

A wide range of injuries may be produced in boxing contests but head is frequently involved. Boxers are at risk of both the acute and chronic damage to the brain. By far the most com- mon injury is the subdural haemorrhage, as is obvious from the mechanism discussed earlier in this chapter.

Punch-drunk syndrome (punch drunkenness/traumatic encephalopathy; also known by names like 'slug happy', 'slug nutty' or 'goofy', etc. amongst the boxers) refers to chronic changes in the brain of boxers, which usually manifest after many episodes of minor head injuries. The lesions may include subdural, subarachnoid and intracerebral haemorrhages, diffuse axonal injury, focal ischaemic lesions, cortical atrophy, slight hydrocephalus, thinning/tearing of corpus callosum, scars or patches of gliosis and brain contusions. The chief symptom of its onset is the deterioration in speed and coordination, seen more readily in properly trained boxers than in crude .hters. This may be followed by slurred speech, slow thought process, expressionless face, stiff limbs, defective memory, and occasional outbursts of violence.

A few of the victims may demonstrate pontine haemorrhage, the so-called 'boxer's haemorrhage'. Brain stem haemorrhage may occur because at the extreme of .ht, musculature usually gets relaxed and muscle tone is decreased; therefore, the motion of the head is more pronounced. Consequently, acute flexion or extension can readily occur, and thus the brain stem can be pinched over the tentorium.

CEREBRAL SWELLING/ OEDEMA

Following trauma, swelling or oedema occurs either in a focal pattern around an intracerebral haematoma or diffusely throughout the cerebrum or cerebellum. The pathological pro- cess probably involves disturbance of vasomotor tone causing vasodilatation and disturbance/loss of autoregulation with an increase in both intra- and extracellular fluid.

RAISED INTRACRANIAL PRESSURE: PATHOPHYSIOLOGY AND SEQUELAE

The adult skull may be regarded as a rigid unyielding box contain- ing brain, CSF and blood. An increase in the volume of any one of the components will result in an increase in intracranial pressure (ICP), unless there is a proportionate decrease in the volume of one or the other components (Monro-Kellie doctrine). This is the so-called 'autoregulation process', which comprises of maintaining a constant cerebral blood flow wherein the brain adjusts the intracranial vascular resistance by altering the vessel diameter and tone. However, the limit of compensatory volumet- ric changes can be exceeded by a too rapid or too great a change in the volume. After initial compensatory/adaptation mecha- nism occurring through shifting of CSF and displacing blood from venous structures, a critical point is reached when even small changes in volume cause exponential increases in ICP.

In a normal adult, ICP is usually in the range of 0–10 mmHg. Pressure over 20 mmHg is considered abnormal and as reported, rise of ICP above 40 mmHg is manifested by neurological dysfunction and impairment of electrical activity of the brain. If not corrected, the increasing ICP is likely to cause death by deformation of tissue plus shifting of the structures, development of herniae, and secondary damage to the brain stem. Development of these herniae leads to obstruction of CSF flow and develop- ment of pressure gradients between the various intracranial com- partments. Blood vessels crossing the sites of such herniations may become pinched, leading to vascular complications. Vascular damage to the midbrain and pons is thought to be due to down- ward traction on the central perforating branches of the basilar artery. In general, the more slowly a focal mass expands, the more likely it produces distortion of the brain without resulting in an early rise in ICP. On the other hand, if the lesion/mass expands rapidly, death usually follows soon from high ICP, and the effects like distortion and herniation of the brain hardly have time to take place.

Manifestations of increased ICP will depend upon the extent of compression and the availability of space for displace- ment of structures in the various compartments (fossae) of the cranial cavity, i.e. in the middle fossa; structures lying in relation with the sharp edge of the tentorial hiatus are the usual sufferers. Increased pressure in this area leads to the following:

- Herniation of the uncus of the medial temporal lobe that leads to compression on the brain stem. (Further rise in ICP may lead to even lateral displacement of the brain stem causing contralateral corticospinal tract to impinge against the opposite tentorial edge. This may become responsible for a localising pseudo-ipsilateral hemiparesis, the so-called 'Kernohan notch' phenomenon.)

- Compression of the ipsilateral corticospinal tract in the crus cerebri causing contralateral hemiparesis.

- Compression of the ipsilateral third nerve and oculomotor nucleus in the midbrain causing pupillary dilatation and failure of reaction to light.

- Displacement of cingulate gyrus under the free edge of the falx producing a subfalcine hernia.

In the posterior fossa, increased pressure will result in herniation of cerebellar tonsils into the foramen magnum and compression of the medulla. This can lead to rapid respiratory failure. Progressively increasing pressure may lead to further downward displacement of tonsils (coning) leading to sheering of the vasculature supplying the brain stem, causing haem- orrhages known as Duret haemorrhages. Rarely, a posterior fossa mass may displace cerebellar tissue upwards through the tentorial opening to produce a 'reversed tentorial hernia'.

Evidence of cerebral oedema may be noted in the form of flattening of gyri, filling of sulci, evidence of grooving of one or both unci (sometimes, unci may be discoloured as a result of incipient infarction), or in the severe cases, hippocampal hernia- tion through the tentorial opening, etc. For examination of brain at autopsy, it is better to fix it where neurological issues are involved, either traumatic or from disease process (there may not be any need for fixation if no cerebral lesions are expected or apparent on external examination of the brain wherein 'wet cutting' usually serves the purpose). Fixation of brain provides firmness to the tissue, which allows thinner and more accurate sections to be made, as well as better histological preservation. For fixation, brain is suspended in a specially designed tank made of fibreglass containing 10% buffered formalin (buffer is a substance/chemical/device used for lessening the effect of a blow/collision/impact, etc.). The quantity of the solution should be sufficient to allow the brain to float clear of the bot- tom of the receptacle. There are lugs moulded into the sides to hold the suspensory strings, which support the brain by means of a paperclip hooked under the basilar artery. An alternative method of suspension is to leave the falx intact and use it to suspend the brain down in formalin.

SPINAL INJURIES

The spine and head should be considered as part of the same system in relation to trauma. Spicer and Strich have shown that haemorrhage into the spinal root ganglia may be associated with head injury. Electroencephalographic changes have been shown to occur in about half of the victims of cervical spine injuries. From the functional point of view, the upper two cervical vertebrae provide most of the rotational movements and the lower five, flexion and extension.

CONCUSSION OF SPINE

This condition can occur without any evidence of external injury to the spinal column, from a forcible blow on the back or a fall from height or a bullet injury but is commonly seen in railway accidents and motor car collisions, hence also known as railway spine. Signs and symptoms may appear immediately or delayed for hours or days. There may be paralysis of upper and lower limb or lower limb alone with the involvement of bladder and rectum. The individual may present with headache, giddiness, restlessness, neurasthenia, loss of sexual power and weakness in the limbs. The paralysis is of temporary nature and recovery may occur within about 48 hours.

The condition may be attributed to the mechanism similar to that seen in the brain in closed head injuries and may be due to some momentary collision of the cord against the wall of the canal or a transient deformity in the profile of the canal due to violent acceleration/deceleration or rotational strains.

Injuries to the spine/spinal cord may be studied under the following subheads.

INJURIES TO THE UPPER CERVICAL SPINE

The first cervical vertebra (atlas) supports the occiput and is held in place by a number of ligaments. The transverse ligament of the atlas encloses and restricts the motion of the odontoid process of the second cervical vertebra (the axis). Disruption of this ligament may occur in rotational injuries of the upper cervical spine resulting in atlanto-axial subluxation with or with- out odontoid fracture, which may damage the pons or medullary pyramids. Vertical impacts to the head with a straightened neck may lead to compression fracture (Jefferson's fracture) of the anterior and posterior arches of the atlas with the lateral displace- ment of the lateral masses onto the axis. Another common frac- ture, the so-called 'hangman's fracture' consists of fracture of the pedicles of axis resulting in anterior dislocation of C2 on C3 with or without odontoid process fracture. This injury is typically met in judicial hangings and vehicular accidents in which the neck is forcibly hyperextended and rotated.

MIDDLE AND LOWER CERVICAL INJURIES (HYPEREXTENSION AND HYPERFLEXION INJURIES)

Injuries to the cervical spine and cord between spinal segments C4 and C8 occur with greater regularity and constitute the most common type of immediately nonfatal spinal injuries. Cord lesions may occur with or without spinal fractures but injuries to the spinal ligaments may be encountered almost invariably. The motions responsible are hyperflexion, hyperextension, hyper-rotation and/or compression of the spinal column. Hyper- flexion injuries may result from blows to the back of the neck, shallow water diving injuries and in vehicular accidents (frontal impact). Hyperextension injuries may again be seen in wrestling matches or Fights where a forceful 'hammerlock' is used. Rotational forces may produce subluxation with facet interlocking and/or other forms of dislocation with impingement of the cord. Out of the hyperextension and hyperflexion injuries, hyperextension is more dangerous because weak anterior longitudinal ligament is incapable of maintaining the integrity of the cervical spine during hyperextension whereas during flexion, the strong mus- culature of the posterior part of neck is capable of protecting the spine. The term 'whiplash injury' has been assigned to these hyperextension and hyperflexion injuries encountered in vehicular accidents. Middle-aged and elderly with pre-existing spondylosis are particularly vulnerable. Same condition may occur following a violent blow (rabbit punch) over the spinous process of upper cervical vertebrae. Fracture, dislocation or subluxation of middle cervical spine, usually results in more severe injury to the cord than similar injuries sustained to the upper cervical region where there occurs sufficient space about the cord to accommodate encroachment on the spinal canal.

THORACIC AND LUMBAR SPINAL INJURIES

The upper thoracic spine from T1 to T10 enjoys more resistance to injuries than does the cervical spine because of added stability of the thoracic rib cage and costal vertebral ligaments. Fracture or dislocations and rotational injuries require great force and consequently are comparatively uncommon. The lower thoracic and lumbar spine, however, is quite vulnerable to injury because of increased flexibility in this region and lack of lateral stability of the ribs.

Fractures and/or dislocations can occur here with or without injury to the spinal cord. Rotational and flexion forces seem to be more important in the production of injuries in this region. In the lower lumbar and lumbosacral region, compression injuries with 'bursting' fracture of the vertebral body(s) are most common but may not necessarily involve the cord.

INJURY TO THE SPINAL CORD

Spinal cord injury may result in clinical state of quadriplegia or paraplegia. Quadriplegia (tetraplegia) is the paralysis of all the four limbs and usually indicates an injury above the level of emer- gence of the roots serving the brachial plexus (fourth cervical). It is possible that some function may be preserved. Paraplegia is the paralysis of the lower extremities and variable portion of the trunk due to injury to the spinal cord below the emergence of the brachial plexus (first or second thoracic segment). The spinal cord injured person may suffer either complete or partial loss of function below the level of injury. In the latter, in which some motor and/or sensory function is preserved, prognosis is usually better. Some experts use the terms quadriparesis and paraparesis to describe the incomplete paralysis while reserving quadriplegia and paraplegia for the complete motor paralysis. Ducker and Walleck (1985) indicated that 85% of those who show an immediate complete injury will tend to retain a com- plete symptomatology at the end of 1 year, whereas those with immediate incomplete signs and symptoms have a greater ten- dency to show some additional neurological recovery by the end of a year.

PATHOLOGY OF SPINAL CORD INJURY

At the very outset, it may be kept in mind that the victim dying of acute spinal cord injury may exhibit little or no change in the spinal cord tissue itself. The usual types of pathological changes seen in impact injury to the cord are usually consistent, regard- less of the mechanism of the injury. Even in clinically complete traumatic spinal cord injury with total loss of function below the level of lesion, the cord is functionally but not usually phys- ically transected. Actual physical transection only occurs in extreme cases where massive fracturing and distorting of the spine, penetrating injuries, crush injuries or other devastating injuries have occurred. Spinal cord involvement is usually encoun- tered in association with fracture and/or dislocation of the spi- nal bone(s). However, it has been recognised that cord may be traumatically injured in the absence of the said injuries to the spinal bones. It has been indicated by Davis et al. (1971) that soft tissue disruption and haemorrhages are frequently encoun- tered at the site of the fracture and/or dislocation or liga- mentous tears. Bleeding can occur into the spinal meninges (haematorrhachis) and/or into the substance of cord (haemato- myelia) and this may extend along the axis of the cord, upwards as well as downwards. Therefore, it becomes imperative to examine the spinal column by X-rays and to examine the soft tissues, bones and canal carefully. In this regard, it is important to know the relationships between the level of vertebrae and the spinal cord.

PENETRATING INJURIES OF THE SPINAL CORD

Penetrating injuries of the spine and spinal cord are entitled to separate discussion. These may result from missiles and by some other penetrating instruments/weapons. Regarding pen- etrating wounds by missiles, it may be borne in mind that they can cause paralysis without grossly obvious damage to the spi- nal cord. This is probably due to the effect of 'shock wave' and large temporary cavity which accompanies the high velocity missile, even if the missile does not happen to make a 'direct hit' on the cord itself. A major difficulty in evaluating the spinal cord injuries is that the level of cord injury may not correlate with the level of external wound. In addition to shock wave and temporary cavity effects of high velocity missile, other fac- tors responsible for such incompatibility may be as under:

- There may exist some individual variations in the relative position of the cord.
- Mature spinal cord is anatomically shorter than the axial skeleton and the disparity progresses at lower levels of the cord. For example, conus medullaris injuries correspond to a level of about the first lumbar vertebra.
- The position of the cord within the spinal canal usually

changes with body posture and movements. Hence, the exact stance of the victim at the moment of injury matters much in the proper evaluation.

Penetration of the cord by a knife or other sharp/blunt pointed instruments may occasionally be encountered. Stab wounds may show the same anatomic and coincidental disparities of relationships of the level of neurological damage to the wound on the vertebral column as do the missile injuries. However, it may seem surprising how the weapon should pass into the cord with complete bony encasement. It is obvious that only very heavy blade can fracture and depress the lamina. However, even a light blade may be able to effect its penetration towards the cord, if it enters between the laminae, as when the victim is bending when struck or the blade may be directed from below upwards to penetrate between the overlapping laminae. In the cervical region, the laminae are narrower, and a horizontal thrust can penetrate. A puncture wound (even by a needle) in the space between the first and third cervical vertebrae may cause almost instantaneous death due to injury to the medullary centres or upper part of spinal cord. The process of such killing is known as 'pithing' and this type of puncture wound can easily be overlooked. Also noteworthy may be the 'ice pick' wound created by some small narrowly pointed instrument which can penetrate dorsolaterally at the intervertebral foramina. As considerable force is usually required to achieve penetration, it may result in the blade being broken off. After the blade has entered the canal, it may penetrate the cord or push the cord aside. The latter situ- ation may be ascribed to the tough fibrous capsule that accom- panies the pia mater of the spinal cord. If pushed aside, the cord may get contused due to its collision against the bony wall, and this may explain unexpected clinical symptoms as compared to the anatomical injury.

Medicolegal Considerations of Spinal Injuries

Forensic issues revolving around the spinal injuries may include aspects like mortality, morbidity, quality of life and survival potential. With modern techniques for maintaining nutritional support, bowel and bladder functions and respiratory support, etc., long-term survival for such victims may be expected. The most critical period for survival is usually the first 3 months after injury. Factors influencing survival include the level of spinal injury, residual degree of respiratory control, degree of sensory and motor disabilities, age and prior status of the victim and degree of associated systemic injuries. In the individuals having injuries below the fourth cervical level, stabilisation of respiration may be a lesser issue than the bowel and bladder function. The personal idiosyncrasies may outweigh the physical injuries and the victim's own response to his injury may play a significant role in the outcome. Depression and suicide may be the other complications of spinal injuries. Other circumstances inviting forensic considerations may include spinal injury during surgery or administration of spinal anaesthesia, in connection with child abuse, gymnastic or other exercises and in karate training or demonstrations.

TRAUMA

FACIAL TRAUMA

As a rule, facial wounds heal rapidly owing to their great vascularity. However, they are grievous if they are severe and cause permanent dis.uration or deformity. Such permanent dis.ura- tion may be due to scar or keloid formation, or due to derange- ment or loss of tissues. Pulping of face can result from vehicular run over injury or blunt impact by a heavy brick/stone or some other object. Complex contours of the face may intercept impact with consequent characteristic damage.

Abrasions and contusions in or around the mouth and nose could suggest forceful opening of the mouth to administer something, or forcible closure of mouth and nose as may be encountered in smothering. Superficial lacerations of inner aspects of lips can occur due to forceful apposition of lips against teeth. Injuries to lips can also result from blunt impact such as fisting. A blow on the head sometimes causes bleeding from the nose due to partial detachment of its mucous mem- brane without any injury to the nose. The bone is usually frac- tured at its junction with the frontal bone. Blood from fractured site may be inhaled or swallowed. During a fainting attack, a person may strike his nose against the ground or some object and sustain a fracture of nasal bone.

Penetrating wound of the nose caused by thrusting a pointed instrument up the nostril may result in death by injuring the brain through the cribriform plate of the ethmoid bone, though no sign of external injury is evident (concealed puncture wounds). Left nostril or the septum of a woman is liable to be injured by pulling out the nose ring worn by her. Occasionally, the lips or nose may be cut off or bitten off as a revengeful act. As reported by Lee et al., there have been instances where the nasal aperture has been the site of gunshot suicidal fire.

Injuries to the eyes and ears are not uncommon. Injury leading to permanent loss of vision of either eye or loss of hear- ing of either ear constitutes grievous hurt. They may occur from blunt trauma as in the case of a fall or blow, or from penetrating trauma as well. During a quarrel, ears may be bitten off or cut off, and their lobes may be torn by pulling out the earrings either with the intention of causing hurt or committing theft. A severe/ hard blow over the external ear may cause rupture of tympanic membrane. Abrasions, contusions and/or lacerations can occur to one or both ears, from accidents or from deliberate actions. The term black eye refers to accumulation of blood around the eyeball and eyelids, which manifests as a darkish discolouration around the eye. This can be resulted directly from blunt trauma over the eye or from indirect force. Gravitational seepage of blood from injury higher up in scalp may lead to ectopic contusion/bruising of eyelids. Percolation of blood into the orbit may be due to a contrecoup injury of head. A simple fall on the face on a flat surface does not usually cause a black eye, because the prominence of the eye brow, cheek- bone and nose prevent damage to the orbit. Penetrating wounds of the cornea are also relatively common, causes being numerous; therefore, types of wounds encountered may vary considerably. Incisional and punctured wounds are quite common and show greater variability. Sometimes, there may be haemorrhage in the anterior chamber of the eye due to blunt trauma (hyphema). The eyes may be gouged out with the fingers. However, it needs to be kept in mind that birds of prey generally first attack the eyes of a dead body, when exposed in a field or jungle.

Injuries to the teeth are encountered in varied circumstances.

They may get dislocated or fractured either by a fall or by a blow with a blunt weapon, such as a fist, a shoe, the butt end of a lathi, etc. According to Andreasen and Schutzmannsky, most dental injuries occur shortly before school age and are primarily due to falls. Playground injuries are quite common after the child is of school age. Bicycle accidents resulting in fractured teeth and injuries to surrounding areas are also common in school-age group. In teenage group, oral trauma is frequently associated with athletic activities and automobile accidents. Oral injuries sus- tained during .hts are common in older age group. Addicts have more dental disease than normal individuals. It is believed that bruxism frequently is a contributing factor in the relatively large incidence of fractured posterior teeth noted in narcotic addicts. Injuries caused by mechanical violence, in all probability, leave abrasions, contusions, and/or lacerations on the lips and/ or on the gums, etc. The dislocated tooth/teeth may at times get aspirated or be swallowed. Cases of false reports about the loss of a tooth are usually encountered with a view to charging the accused with an offence of grievous hurt. It is, therefore, neces- sary that the following points should be taken into consideration when reporting on a person who alleges to have his/her tooth knocked out:

- The number of teeth present in each jaw.
- The condition of the neighbouring and other teeth as to whether they are firm, shaky or diseased.
- The condition of the socket of the missing tooth, as to whether there is any stump left if a tooth is fractured, whether there is any bleeding/laceration, etc.
- The condition of the lips and gums as regards the presence of injury.
- If a tooth is sent with the injured person, it should be exam- ined to ascertain if it corresponds to the missing tooth. After examination, the tooth should be sealed in a packet and handed over to the police personnel accompanying the injured person.

- X-ray examination of jaw may reveal fracture of alveolar margin from the site of dental injury. Root of the con- cerned tooth could also be examined under X-ray.

Majority of facial bone fractures result from automobile accidents. Not unusually, however, they result from violent forces exerted on the face by assault either with a fist or with a heavy object. Mandible, though the strongest of all the facial bones, gets involved too often. Mandibular fractures can be typically divided into two types, i.e. closed (no break in the skin) or open/ compound (in which skin and mucosa are also damaged). Symptoms usually include pain, malocclusion and trismus. Respiratory distress due to displacement of tongue into the throat may result from fractures of symphysis. In both types of fractures, the jaw usually remains wired until clinical evidence of stability rather than X-ray evidence determines healing. Frac- tures of zygoma (cheek bone) usually occur as a result of vio- lent blow to the face from a fist or heavy object. They are most commonly seen in assaults or athletic injuries. Because of the thickness and heaviness of the body of the bone, blows to the zygoma usually lead to fracture at three weak areas about its periphery, i.e. frontozygomatic, zygomaticotemporal and zygo- maticomaxillary sutures. Due to such involvement, the zygomatic fracture is often referred to as a 'tripod fracture'. Maxillary frac- tures, on the other hand, more often result from an automobile accident in which the driver or passenger is thrown up against the dashboard or steering wheel, or through the windshield.

CERVICAL TRAUMA

Superficial wounds of the neck may or may not cause serious bleeding, but penetrations, incisions and deep lacerations usu- ally produce copious bleeding due to severance of carotid and/ or jugular vessels. A forceful blow over the neck can cause a fracture of the larynx, involving thyroid cartilage or rupture of the trachea to cause death either by spasm or oedema of glottis or by suffocation due to internal bleeding into the larynx or due to surgical emphysema. However, a skillfully delivered karate- type blow may not leave more than a minimal local evidence of damage.

Wounds of the sympathetic and vagus nerves may be fatal, and those of the recurrent laryngeal nerves cause aphonia. In case of a wound of the larynx, speech is usually not possible, if the wound is below the vocal cords. However, a person may be able to speak in whisper if the wound is not gaping. Occasionally, the question whether or not a person with 'cut throat injury' can speak assumes immense importance. This may supplement or negate the contention that whether the victim was/was not able to call for assistance or whether the persons in an adjoining room heard any noise or not. Harvey Littlejohn cites a case (Forensic Medicine, 1925, London: J & A, Churchill) wherein a woman, in an attempt to get away with the thyroid gland tumour divided windpipe below the vocal cords. On the arrival of the doctor, she was conscious, and narrated that she had torn the tumour out of her neck as the same was choking her and that she wanted to die. In another case (Lancet 1909;1:1501), a boy's throat was cut across and the larynx divided just above the vocal cords. Facial and lingual arter- ies were also severed. After receiving the injury, he was alleged to have made a statement involving certain persons. The doctor stated that the wound would not have prevented the boy from speaking though the voice would obviously grow fainter during the gradual succumbing of the boy to injuries.

Wounds of the neck are mostly incised and rarely punctured. They are more often homicidal than suicidal and rarely acciden- tal. In a suicidal case, the person usually holds the weapon in his right hand and starts the incision from the left side of the neck drawing it to the right. Tailing of the wound is therefore seen on right side. Carotid arteries are not frequently injured as they slip backwards when the head is extended. Bleeding is usually venous, and loss of consciousness is gradual. However, death may take place quickly from air embolism, due to air being sucked in by negative pressure in the veins. A person attempting suicide generally makes repeated horizontal, parallel, shallow, half-hearted cuts on the neck initially before he gathers enough courage to make the final lethal cut. These preliminary shallow cuts are called as hesitation cuts/exploratory cuts/feeler strokes/ tentative cuts. A homicidal cut throat wound is invariably quite deep, and obviously lacks hesitation cuts. However, cases have been reported where superficial cuts resembling hesitation cuts were present along with the main wound. (For differences between suicidal and homicidal cut throat injuries, see the Chapter on 'Injuries by Sharp Force'.)

The chief danger in incised and stab wounds of the neck is from haemorrhage due to an injury to blood vessels. Death is due to haemorrhage, air embolism consequent upon the entry of air into the venous system, or due to asphyxia from filling of air passages with blood. Wounds of the large vessels may not necessarily be rapidly fatal, and an individual so wounded may be capable of physical and volitional acts.

Sometimes, air from wounded respiratory passages enters into the subcutaneous space resulting in subcutaneous emphysema, which may dissect down into the mediastinum and is responsible for subsequent respiratory obstruction. Hyoid bone can get fractured from blunt impacting force, or from blunt constricting force, as in manual strangulation. Scratch abrasions and/or contusions are suggestive of throttling, while a pressure abrasion in the form of a ligature mark is indicative of hanging or strangulation.

THORACIC TRAUMA

Chest carries a semi-rigid bony case, enveloping vital organs that are softer, more mobile and deformable. The scope and extent of injuries to the lungs vary with the degree of violence/ impact and other attending factors. Injuries may range from simple bruising or laceration to massive damage or collapse, with or without fracture of ribs. Most cases of lacerations of lungs are due to traffic accidents, fall of heavy object on the chest, compression of the chest (traumatic asphyxia), and uncommonly assault. Generalised trauma to the chest (blast lung) may cause multiple contusions and tears to the lung substance due to linear and rotational strains. Details of blast injury to the lung have been given in the Chapter 'Firearm Injuries'.

Trauma to the chest usually challenges the integrity and viability of the individual. As in other cases, severity of the injury is related to magnitude of the kinetic energy delivered, which can be expressed by the formula $KE = \frac{1}{2}MV^2$. It is apparent that the velocity of the wounding object is the most important factor in determining the extent of the tissue damage. When velocity is doubled, kinetic energy or the destructive force is quadrupled. The energy may be exerted by a moving or accelerating object on a stationary victim, or the damage is of the deceleration type in which a moving victim collides with another moving or stationary object, e.g. a vehicular accident.

A compression of chest may lead to disturbance in cardiac function, and even death may follow with little or no evidence of external injury to the chest wall. Surface injuries may include slashes, lacerations, bruises or abrasions. Blows on the chest may produce concussion of the chest causing shock, and rarely death. Simple contusions of the chest wall may be followed by pleurisy or pneumonia. Blunt injuries on areas lying against bones, such as shoulder and shoulder blades, may sometimes cause linear lac- erations that may be confused with slashes. A close and careful inspection will usually suffice to resolve the issue. Nonpenetrat- ing wounds, at occasions, may cause free bleeding from the divided mammary or thoracic arteries.

Traumatic fractures of the bony rib cage are usually pro- duced by blunt trauma and rarely, by a missile. The severity of these injuries ranges from simple fracture of a rib to the involve- ment of several ribs at multiple points producing the so-called flail chest or stove-in chest. In direct violence, such as by blows, stabs or pressure with the knee, the broken ends are likely to be driven inwards; whereas in indirect violence, such as by muscular contraction during violent coughing or convulsions, fractured ends are likely to be driven outwards. The ribs more vulnerable to fractures are fourth to eighth ribs, as they are attached at both the ends, and are comparatively more unpro- tected. Bilateral symmetrical rib fractures in front near the costal cartilages and at the back near the angles may occur in traumatic asphyxia. Such fractures may also occur when a person sits on the chest and compresses it considerably by means of knees or elbows, by trampling under feet or by means of bamboos. They may not always be accompanied by external injuries or ecchymoses of blood in the soft tissues over the ribs. Nobbing fractures, commonly found in 'battered baby syndrome', are due to holding of the child with both hands and shaking it violently. Fractures of ribs on both sides close to the spine may occur in this process, imparting a nobbing appearance.

As mentioned earlier, flail/crush/stove-in chest is the result of fracture of several ribs in more than one place or simultaneous fracture of the sternum and several ribs. A portion of the chest wall loses connection with the rest of the rib cage, and moves independently and paradoxically from the intact portion. In addition, the to and fro motion of the chest wall with each respiratory cycle leads to mediastinal instability. Thus, a flail chest involving a large portion of the chest wall can be lethal because of the combined cardiac and pulmonary dysfunction. Fracture of the sternum is rare. It is ordinarily due to direct violence, and usually occurs transversely either between the manubrium and body or a little below. The fragments usually remain in apposition or the upper portion passing backward. It may be fractured by indirect violence as a result of forcible flexion or extension of the body, or a forceful direct impact of the bone against the steering wheel of a vehicle. The arch of aorta being quite near the surface adjoining the sternal border may also get involved. (Obviously, due to such placement, the vessel may also get involved with an instrument/weapon of small dimen- sions, leading to fatal consequences.) The sternum may rarely be fractured spontaneously by muscular spasm caused during vio- lent coughing. Fracture may also occur following external cardiac massage. Fractures of the ribs (usually of 3rd to 5th), particu- larly at costochondral junctions on the left side, may also occur, with minimal surface bruising.

In case of penetrating injury of chest by sharp penetrating weapons, pointed ends of fractured ribs or gunshot wounds, there may be little or no external bleeding but profuse and fatal internal haemorrhage. This may be due to valve-like overlap of tissue at the wound. Collected blood may be liquid, clotted or usually a mixture of both. The tissue damage inflicted by a stab wound is largely determined by the size of the weapon and the course it travels, whereas in case of gunshot wounds factors like velocity of the missile, the course of the missile through the tissues and presence or absence of dissipating energy usually determine the tissue damage. As a general rule, low-velocity missiles/bullets tend to confine their destructive effect to the trajectory, whereas high-velocity missiles produce far greater tissue damage, even at distant places due to dissipating forces. Due to the large and accessible target area, the chest is very frequently the site of a homicidal stabbing. Serious injury or death is common because of seating of vital structures within the thorax. Common target area is the region against the heart on the front of chest. Involvement of back of the chest is infrequent because of protection afforded by muscles and shoulder blades at the back. Sides of the thorax are not so often stabbed due to hindrance afforded by the protecting arms. Although the knife is the most common weapon involved, the type of the weapon may vary depending upon region to region. Sharpened iron rods and even pointed sticks or other pointed instruments may be employed. The weapon almost always makes its way through an intercostal space, though not infrequently a rib or costal car- tilage may be 'nicked' or even completely transected. Sometimes, the weapon may be deflected upwards or downwards into adja- cent intercostal space after impacting against the rib.

Once within the thorax, the pleura often gets involved; thus, pleural space becomes open to the external environment. Pneumothorax is the usual outcome. (There are three types of pneumothorax, i.e. simple, open and tension. It may be caused by penetrating or blunt trauma, or iatrogenically during minor surgical procedures like thoracentesis or during pleural or lung biopsy. In simple or closed pneumothorax, a wound in the chest wall or lung permits air to escape and to collect in the pleural cavity. The wound may become sealed spontaneously or it may necessitate tube thoracotomy with water-seal drainage. Open pneumothorax is usually associated with a large defect in the chest wall that permits air to enter freely from the atmosphere into the pleural cavity. That is why it is often referred to as 'suck- ing chest wound'. Cardiopulmonary function can severely be affected due to this coupled with instability of the mediastinum. Tension pneumothorax is resulted when air is under extreme pressure within the pleural cavity. The wound acts as a one-way valve allowing air to enter the pleural space without an avenue for its escape. This produces progressively increasing intrapleural pressure leading to collapse of the lung and mediastinal shift). The heart may be injured from nonpenetrating or penetrat- ing trauma to the chest. Blunt trauma leading to involvement of heart is relatively infrequent. Involvement may be encountered following steering wheel injury in which the heart is compressed between the chest wall and the vertebral column. A violent blow on the chest with a fist or some heavy object can also damage the heart. The myocardial damage from blunt trauma may range from superficial contusion to full thickness rupture. Rarely, ventricular septum, pupillary muscles, chordae tendinae or the valve leaflets may be involved during blunt trauma. At occasions, pericardium may get ruptured, and if the defect is large enough, the heart may herniate and get strangulated. (The traumatic rupture of heart needs to be differentiated from spontaneous rupture. In traumatic rupture, the heart is usually ruptured on the right side and towards its base. The ribs and overlying tissues are often damaged. Rarely, the rupture may occur without leaving any external mark of violence damage. Spontaneous rupture of heart may occur in circumstances where the organ is already weakened by some disease injury. Elderly are the usual victims, and the rupture in such cases occurs mostly in the lateral, anterior or posterior wall of left ventricle. Sudden exertion and increased

blood pressure may be the accompanying factors.

Penetrating wounds of the heart are extremely serious and usually fatal. A rupture or penetrating wound of the atria is more dangerous than a wound of the ventricle because the auricular wall is thin and less contractile and therefore, bleeds profusely. On similar lines, a penetrating injury to the right ventricle is more dangerous than that of the left. It is possible that foreign bodies, such as bullets, or fragments of shells, may remain embedded in the myocardium for months or years without pro- ducing symptoms. In such cases, missile may act like a plug, effectively checking any severe haemorrhage.

Rupture of the diaphragm is commonly caused by decelera- tion type of injuries. Also, a blow to the abdomen or chest, a crushing injury, or jackknifing of the body may cause a sud- den increase in intra-abdominal pressure and produce disrup- tion of the diaphragm. The most commonly involved site is the central portion of the left side of diaphragm. Rupture may also follow herniation of the intra-abdominal viscera into the thorax. Penetrating trauma, as mentioned earlier, may also involve diaphragm.

Intrathoracic vessels may get injured because of sudden deceleration in an automobile collision, a fall from height or an air crash. Disparity between the speeds of a fixed and a mobile portion of the involved vessels is the usual mechanism of pro- duction of injuries, i.e. the fixed portion coming to an abrupt halt whereas mobile segment continues on its path. Thus, shearing force causes disruption of the vessel. Thoracic aorta is the com- monest victim of this type of injury. Disruption occurs most often at the aortic isthmus, distal to the origin of the left subcla- vian artery, where the aorta is fixed by the ligamentum arteriosum. Usually, the vessel wall is circumferentially transected and death occurs from exsanguination.

Foreign bodies may get lodged anywhere in the respiratory tract. They can be aspirated or enter as missiles. With time, the foreign bodies usually get encysted and fixed by fibrous tissue. Aspiration of foreign bodies into respiratory tract occurs mainly in children. Peanuts, marbles, coins, bunttas, buttons are among the frequently aspirated items. Occasionally, it may be seen in an adult. Occlusive foreign bodies in the trachea are likely to cause death by asphyxiation. Partially occlusive foreign bodies in the airway may behave as one-way valve, permitting entry of air, but impeding its exit. Organic foreign bodies in the respiratory pas- sage absorb water/fluid and swell up. Thus, they may get impacted at one location. Nonorganic foreign bodies, on the other hand, do not change size and therefore tend to move unless they are wedged. Foreign bodies within the cardiovascular system are usually bullets or fragments of bullets. These may get lodged in an artery, vein or the heart and may remain fixed or embolise. It is possible that foreign bodies, such as bullets or fragments of shell, may remain embedded in the myocardium for months or years without production of significant symptoms. Missile may act as a plug, effectively checking any severe embarrassment.

ABDOMINAL TRAUMA

In the so-called 'magic box' of the body, structures can be injured by a variety of traumatic insults. At times, no surface lesion may be evidenced in spite of severe or fatal internal haemorrhage. Nature and extent of clothing may contribute to this absence of surface injuries. Since the origin of recorded history, abdom- inal trauma has had dire implications for survival. Like the Greek warrior of the wall of Troy, the

American Marine in Vietnam wore body armour to minimise the effects of abdominal and thoracic insults. In general, the damage following trauma depends upon the consistency, mobility, state of distension of organs, the type of the force, the site of impact and the resistance offered by the abdominal wall under a particular situation.

Solid organs such as liver and spleen rupture more readily than hollow organs like stomach and intestines.

Liver is the quite frequently involved organ in vehicular accidents and in falls. Its large size, fixed location and solid consistency make it an easy target for blunt injury to the upper abdomen and thorax, especially on right side. Nonaccidental rupture of the liver may be caused without a weapon. Harvey cites a case where it was ruptured by a kick, and two others in which the rupture was caused by kneading with the knees and elbows or 'kil kani'. Substance of the liver may be involved while the surface remains intact. Similarly, liver injury may be seen without any external marks of violence. Subcapsular tears produce intra- hepatic haematoma, which may eventually rupture into peritoneal cavity, causing death hours or days after the injury. Stab wounds of the liver often provide clues about the nature of the weapon as the organ is fixed and of solid consistency.

Spleen, because of its thin capsule, weak supporting tissue and friable pulp, is easily susceptible to blunt injury to the left hypochondrium and left lower thoracic wall. The injury may vary from minor laceration of capsule to fragmentation. Lacerations with capsular tears will lead to bleeding into the peritoneum. Subcapsular lacerations may result in the accumulation of blood in the parenchyma, which may lead to delayed rupture and intraperitoneal bleeding. According to Clark et al. (1975), delayed rupture may occur at any time after abdominal trauma, but 75% cases of delayed rupture occur within 2 weeks after the trauma. Taylor mentions a case in which rupture of both stomach and spleen occurred from a fall of about 20 feet, and in which no bruises or other external signs of injury were evident. Stomach, in its distended form is more liable to be involved.

It may get bruised or lacerated following blunt trauma. In adults, rupture is usually situated at the pyloric end along the lesser curvature because of reduced elasticity due to a deficient muscular layer and paucity of mucosal folds. In children, however, the greater curvature is most frequently involved in rupture. Delayed rupture may occur at the site of bruising involving the entire thickness of wall. Accidents during anaesthesia have some- times led to stomach rupture. Spontaneous rupture of the organ is quite rare as the smooth muscle coat is able to accom- modate pressure and volume changes to a considerable extent. Kidney injuries are rare, as they are deeply situated in the abdomen. However, direct trauma to flanks and lumbar region and indirect trauma such as fall can injure the organ. A sudden impact from behind can push the lower ribs forward and can cause contusion and/or laceration of the kidney. In violent impact from front against flanks, the kidney may be pushed against the ribs or transverse processes of vertebrae. Lacerations are common with right kidney as it is relatively more fixed in children, and scanty perinephric fat may be a contributory factor for the increased incidence of renal injuries. Perinephric haematoma without renal injury can occur with blunt trauma.

Pancreatic injuries are rarely an isolated phenomenon. They are usually associated with injury to the other abdominal organs. Pancreas, as a rule, tolerates injury poorly. Local injury such as caused by a penetrating instrument may evolve into a pseudocyst or abscess. Larger injuries such as large scale disrup- tions may evolve into massive haemorrhagic pancreatitis and death from exsanguination. The insulting nature of pancreatic injuries is attributed to the release of digestive enzymes that digest the pancreatic lobules with devastating consequences. Because of its placement across the vertebral column, the pancreas is fixed in position and thus, gets involved by compress- ing abdominal trauma. Lacerations frequently occur across the mid position of the body of the gland at the junction of the head with the tail. However, a kick or punch in the upper abdomen may also injure the organ. External injury to the abdominal wall may not be visible in such cases. Metabolic by-products of the enzy- matic breakdown of the substrate of pancreatic tissues may result in far reaching haemodynamic changes like profound vasodilata- tion, hypotension, etc. The most helpful diagnostic clue to the pancreatic injury is an elevation of the serum amylase level.

Small bowel (intestines) injuries mostly result from automo- bile accidents and impact against the steering wheel. Injury may occur due to crushing of the bowel against the lumbosacral spine or due to shearing of the bowel and its mesentery at points of fixation. The most common sites are the first portion of the jejunum and the terminal portion of the ileum. Bruising of a distended or kinked loop of intestine is rare. Damage by blunt force may range from bruising lacerations to avulsions or intra- mural haematomas.

Colon and rectum injuries are rare. However, various cir- cumstances leading to injuries to these sites may be like wounds through the perineum, forcible thrusting of blunt or pointed objects through the anus, accidental swallowing of pins and needles (especially in tailors, carpenters and cobblers, etc.). Rarely, forcible injection/introduction of air/gas/liquid as a practical joke may be encountered. Diagnostic and therapeutic instrumentation such as proctoscopy and enema may be other causes of injury.

Considerable force is required to damage the large bowel; therefore, it is obvious that associated injuries are often present. The bowel may be compressed against the vertebral column or burst by a sudden blow against a distended loop. The site of injury is usually near the junction of mobile and fixed portions of the bowel, such as junction of the sigmoid and descending colon, or at the junction of the caecum with the ascending colon.

Injury to the extraperitoneal rectum is usually incidental to fractures of the pelvis as this portion of the rectum is more or less fixed to the pelvis. Thrusting of a stick or other similar object into the anus is a mode of torture occasionally practiced. In majority of such cases, other injuries also accompany this type of violence. Sometimes, injury may be connected with sodomy. Bladder injuries may occur due to blunt trauma to the lower part of the abdomen, pelvic fractures, obstetrical trauma and some endoscopic procedures. A full/distended bladder is decid- edly more susceptible to injury. When the bladder enlarges, its wall becomes thinner and less able to withstand pelvic fractures and usually ruptures intraperitoneally through the weakened dome.

The empty bladder enjoys the relative protection afforded to it by the pubic arch and gets usually damaged extraperitoneally in association with pelvic fractures.

In intraperitoneal ruptures, the urine leaks into the peritoneal cavity producing chemical peritonitis. Extraperitoneal ruptures, as written earlier, are most commonly associated with pelvic fractures involving pubic rami and symphysis pubis. The mech- anism of rupture usually operates either through the stresses placed on the lateral ligaments anchoring the bladder base or through direct injury by the bony fragments. Under such situa- tions, urine enters the space of Retzius and thereafter may dis- sect along with abdominal wall into the inguinal canal, scrotum and through the obturator foramen into the thigh, or through the sciatic notch into the buttock region leading to tissue necrosis along such paths. Rupture of the bladder can also occur due to accidental trauma such as fall from height or on a projecting object or sometimes by some instrument while procuring abor- tion. Pre-existing intrinsic bladder disease, growth or diverticula, etc. increases the susceptibility of the bladder to rupture with lesser degrees of trauma.

Limbs/extremities may be the victim of any type of injury. Arms are often involved in knife wound, either as defence wounds of hands or lower forearms or from deeper slashes or stabs sustained in a scuffle. Unless some major blood vessel is involved, such injuries are rarely dangerous. Blunt injuries to the limbs are extremely common; particularly in vehicular accidents, any combination of injuries may be encountered. 'Brush burns' are frequently seen in vehicular accidents where the body is skidded across some rough surface. 'Flaying' of the skin of legs due to rotatory injury from wheels has been described under 'types of lacerations' in the chapter 'Injuries by Blunt Force'.

Injuries to the extremities necessitating amputation or per- manent impairing their power constitute grievous hurt. As regards injuries inflicted by others, it may be pointed out that severe injuries to the extremities may be produced without a weapon. Violent twisting of a limb, for instance, may cause dis- location of a joint. Further, though crushing by ropes or cords may produce comparatively slight injuries to the extremities, yet indicate infliction of severe torture.

Trauma to the external genitalia is not uncommon. These were encountered with considerable frequency during the Vietnam

Conflict, owing to the prevalence of 'booby trap' land mine devices employed in that war. In general, male external genitalia may get traumatised by kicks or fisting to the perineum or squeezing the scrotum and penis. Severe contusions may lead to death, or severe compression of the testes may prove fatal from shock.

Penile strangulation may occur due to voluntary or invol- untary placement of a constricting apparatus around the penis. Young adults may employ a number of devices for masturbatory activities. The more elderly males may employ such devices to increase potency. Once the penis is incarcerated, eventual development of oedema in the distal portion prevents removal of the device. Penile skin injuries may include abrasions, contusions or lacerations. Zipper represents a frequent source of cutaneous injuries. The trouser zipper may entrap penile skin (usually in the region of the foreskin). Circumcision injuries may also be seen. Loss of penile skin may occur in either the child or an adult because of overzealous traction on the prepuce prior to excision of the foreskin. The presence of cremasteric reflex almost always preserves the testes. Testicular and scrotal injuries usually occur in young adults. Scrotal lacerations may result from gunshot or other piercing instruments. Blunt trauma resulting in testicular contusion, laceration or dislocation may occur in sports activities, falls or saddle injury from bicycles or motorcycles, etc. Seizing by the testicles is a common method of assault in India. Chevers mentions a case in which a man dragged another in this way with such violence "that the whole preputial integument was torn away". Incised wounds may be attended with severe haemorrhage. An individual may mutilate himself by cutting off a portion of the penis. In India, removal of the male organs was formerly being practised in order to produce eunuchs for immoral purposes. Rarely, incised wounds may be inflicted from a sexual motive/revenge, or during self-defence to thwart the designs of the assailant. Harvey cited a case wherein a woman at Kachar inflicted a deep and severe wound on the penis of her father-in-law, who wished to take liberties with her.

Undoubtedly, majority of traumatic lesions of the vulva and vagina are originated from sexual activities. It may appear sur- prising that injuries may well result from intercourse between consenting parties. In unprepared and unaroused tense part- ner, damage is much more likely to occur than in one who has reached the excitement phase of human sexual response. Many predisposing factors have been forwarded as contributing to vulva-vaginal injuries from coitus. These may include prepu- berty or virginity, recent vaginal surgery, pregnancy, alcoholic/ drug intoxication, genital health status of vulva and vagina, clum- siness, vaginismus, undue active involvement of the female, exceptional coital positions, postmenopausal stage of the female, multiple consorts, male brutality during the coitus, etc. The extent and location of coital injuries vary. Minimal hymenal laceration may result in only minimal blood loss in one virgin, whereas another may experience an excessive tear accompanied by profuse haemorrhage. Similarly, vault injuries may show wide range of severity. However, majority of vaginal coital lesions involve the fornices, dominantly the posterior fornix, more often on the right side. This may be due to the larger size of the right fornix leading to greater incidence of lacerations on this side.

Female genitalia can also become the target for an assault. Fisting/kneeling/kicking against the area have been reported. Thrusting a stick or some other pointed object/instrument into the vagina is not uncommon. At occasions, attention also needs to be drawn to the surprising situations where victims of rape or other sexual assaults manifest trauma to other parts of the body in the absence of demonstrable damage to the genitals. At one time, several cases of murder by wounding female genitals occurred in Scotland. In one of these, death occurred in 10 minutes; in another, a wound of the labium (three-quarters of an inch long and three inches deep) proved rapidly fatal from loss of blood. Taylor mentions a case wherein a woman, about 36 years of age, was kicked by her husband in lower abdo- men while she was in a stooping posture. She died in about an hour from loss of blood. A wound measuring about an inch in length and half an inch in depth was observed at the edge of the vulva, extending from the pubes along the ramus. The left crus clitoridis was crushed throughout its length, leading to fatal haemorrhage.

Accidental trauma to the vulva is frequent. Children appear to be especially prone to such injuries, which generally originate from falling astride gates, bars, chairs or pointed/projecting objects. Although the vascularity of vulva and perineum is less in children, extensive bleeding can occur. Ezell et al. report that the most common agents responsible for such injuries are the open dresser drawer and the tricycles. In adult females, direct trauma to vulva is likely to be complicated by the development of a distinct haematoma because of presence of large venous plexus and loose areolar tissue. However, injury with a sharp or pointed object is more apt to produce external bleeding. The absence of any evidence of external trauma, however, does not preclude injury to the pelvic organs. Hakanson describes a case of a 5-year-old child who presented with haematuria, but with no evidence of external injury. The child had reportedly received injury while sitting on a pointed phonograph spindle; the spindle entering the anal canal, perforating recto-vaginal septum, and proceeding through the vagina entered the bladder.

Genital self-mutilation is rare in either sex. In the past, many

women used to suffer from inadvertent injuries during attempt towards abortion. Deliberate mutilation of genitals may occa- sionally be seen in patients carrying hostile-dependent relation- ship with others. The purpose may be to attract attention. French and Nelson described a case wherein a woman had injured her- self creating superficial lacerations of genital tract. It was alleged that the trauma was directed to express hostility towards her husband, who was always showing only sexual interest in her, to the exclusion of her other attributes. Goldfield and Glick described the case of a 19-year-old patient wherein the diagnosis of self-mutilation was approached by finding the gentian violet dye under the patient's fingernails (she had painted her genitalia with gentian violet that led to vaginal bleeding). Finding of foreign bodies in the vagina can have different interpretations. Out of mere curiosity, younger children some- times insert candy, toys and pencils into the vagina. In an adult female, obviously, it is not always a chance happening and usually bears some relationship to individual's sexual behaviour. All man- ners of objects have been removed from the vagina. Hawkins and Bourne quote the famous case of Bland Sutton, which involved the removal of a small bust of Napoleon from the vagina, presumably introduced as a supreme act of hero worship. In the past, use of a variety of household devices by the unskilled individuals was responsible for accidental retention of foreign bodies in the genitals.

Chemical agents have been reported to be responsible for injury to the female genitalia. Various douche solutions can act as irritants and in the ongoing era of female hygiene spray deodor- ants, such injuries are not uncommon. Erythema and inflamma- tion of external genitalia are common due to use of such agents. The use of potassium permanganate as douching agent dates back to the turn of century. In the late 1940s and in the 1950s, numerous reports of injuries by this agent were available in the developed countries.

Intrauterine contraceptive devices can also lead to injuries to the genitalia. From ancient times, people have been using all sorts of barrier contraceptives to prevent pregnancy. Women used vaginal pessaries made of crocodile and elephant dung, pomegranate seeds, bee's wax and numerous other plant and animal materials. Similarly, men used to wear condoms made of intestines of animals. These ancient methods have been replaced by vaginal diaphragms, caps and condoms, now mostly made up of rubber and latex materials, and by spermicides. [Invention of condom is attributed to a physician named Dr. Condum, who recommended it to Charles II (1660–1685) to prevent illegal off-springing. More probably, the term 'condom' that appeared in print for the first time in 1717 was derived from the Latin word 'condus', which means a receptacle.]

TRANSPORTATION INJURIES

Problems related to transportation injuries and eventually to the death of the victim of the accident may call upon the entire spectrum of forensic expertise. The injuries may occur in any form of transportation, viz., roads, railways, vessels and avia- tion. Numerically, road traffic accidents account for the great majority worldwide.

A retrospective study carried out by Dr. Vishal Garg and Dr. SK Verma at AIMSR, Bathinda (Punjab) during (1st April 2007 to 31st March 2009) revealed that out of 784 cases stud- ied, 59.4% comprised of road traffic accidents, 12.1% of poi- soning, 9.4% of fall from height, and 8.3% contributed towards suicidal attempts plus assaults/homicidal cases. Male prepon- derance was quite evident, and age group commonly affected was 21–30 years. Rural victims surpassed urban ones. The study concluded that road traffic accidents and poisoning cases continue to be a growing menace, incurring heavy loss of man- power and human resources in the form of death and disabil- ity along with a corresponding drain of potential economic growth.

MECHANISHM OF VEHICULAR INJURY

The dynamics involved in any injury by mechanical force have been thoroughly studied by De Haven. Although it is not within the scope of this presentation to discuss the physics that plays a role in the road crashes, a few basic concepts may help to clarify the nature of the lesions associated with trauma and their underlying mechanisms:

- The extent of an injury sustained is directly proportional to the degree of acceleration or deceleration to which the occupant of the vehicle is subjected. A constant speed, however rapid, has no affect whatsoever as is evident from the space travel or the rotation of the earth. It is the change of rate that is traumatic, i.e. the acceleration or the decel- eration. The 'G' formula is used to calculate the mean force involved in a 'real life' accident. Impact of deceleration forces may be calculated from the formula:

$$G = \frac{Kv^2}{d}$$

Where G is expressed as gravitational force, v is the initial

impact of speed, d is the stopping distance and K is the constant (0.034) with speed in miles per hour and distance in feet. With kilometres per hour and metres, K is 0.0039.

- During acceleration or deceleration, the tissue damage produced will depend upon force applied per unit area. De Haven's study of survivors of free falls up to 150 ft has shown that the body may tolerate and expand a force of 200 times the force of gravity for brief intervals, during which the force acts in transverse relation to the long axis of the body. When the forces are not evenly distributed over the entire body (as in traffic accidents) extensive injury may result from the forces concentrated on a few square inches of the body.

- In the common 'frontal impact' there never instant arrest of the vehicle, even when it runs into a huge immovable structure, the vehicle itself deforms from the front so that there is always some deceleration distance and time. This emphasises provision for the crumpling of the front and rear of the car, leaving the central rigid cell that comprises the passenger compartment. The aim is to extend the stop- ping distance and time, so that the G value acting on the occupants is reduced.

The type of vehicle (other than the motorcycle) makes little difference to the mechanism of injury but most statistical sur- veys divide them into cars and light vans under 1.5 tonnes on the one hand and heavier vehicles such as trucks and buses on the other. Heavy vehicles naturally suffer less than cars and vans because of their greater mass and strength and also their height above the ground. Attending to the motor cars, the injuries may vary according to the position of the occupant.

INJURIES TO THE DRIVER

When the most common frontal impact occurs, the unre- strained driver first slides forwards so that his legs strike the facia/parcel shelf area and his abdomen or lower chest contacts the lower edge of steering wheel. The body then flexes across the steering wheel and begins to rise, the heavy head goes for- wards and there is flexion of the cervical and thoracic spines. The upward and forward component causes the head to strike the windscreen, the upper windscreen rim or the side pillar. The windscreen is often broken by the head and the whole body may be ejected through the broken glass, to land on the bonnet or sometimes on the roadway ahead or on the side (..19.1).

Depending upon the above events, the injuries encoun- tered in the drivers may be:

- Impact against the facia may produce abrasions, lacerations and fractures of the legs around knee or around the upper shin level.

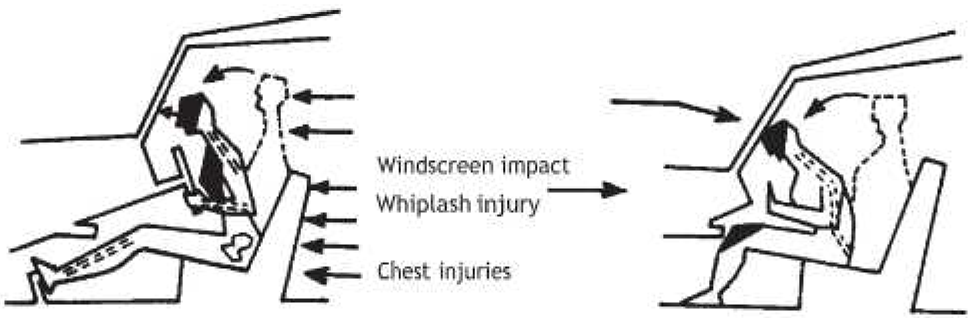
- Pressure of feet upon the floor, especially when it is intruded by any structural component, can cause fracture anywhere from foot to femur. Hip joint may be dislocated posteriorly and even the fractures of pelvis are not uncommon.

- Impact of the abdomen and chest against the steering wheel may cause severe internal injuries. Trauma associated with an impact on the chest by the steering wheel or column is often severe, yet external evidence of injury may be minimal, or absent, particularly if the victim is wearing a number of clothings as in the winter season. There may be bruising of the skin surface, but this may not be evident even in the presence of severe internal injuries, again the winter season is notorious for such possibilities. Lacerations of the skin are uncommon unless the steering wheel snaps producing such injuries. Other steering wheel lesions may be bruising of the lungs, fractures of ribs and/or sternum, cardiac contusions and haemothorax or pneumothorax or both.

In the abdomen, liver rupture is frequent involving any part. Subcapsular tears can occur with the formation of sub- capsular haematoma, which can rupture later on. Spleen may show tears in some cases, often around the hilum and rarely, it may be avulsed from the pedicle. The mesentery and omentum may show bruising in some cases and rarely there may be lac- eration and fenestration sufficient enough to cause a lethal haemorrhage.

In the chest, lungs may get injured, either from intrusion of the fractured ribs or from the otherwise blunt impact. There may be air bullae under pleura or collection of blood and a pneumothorax or haemothorax may result. The interior of the lung may be involved even in the presence of intact visceral pleura from the transmitted force or extreme varia- tions in intrathoracic pressure accompanying the impact. Heart may get damaged even in the absence of external marks or thoracic cage fractures. Bruising of the epicardium and underlying myocardium is not uncommon. Avulsion of heart may be seen in high speed impacts. Less severe damage may lacerate the ventricles or atria and cause gross haemor- rhage. Coronary artery thrombosis has been described follow- ing contusion over a coronary artery. Penetrating injuries from sternum, ribs or external objects may lacerate the heart directly. A more common thoracic injury, associated with the decel- eration, is the laceration of aorta. The mechanics involved may be through the severe whiplash effect on the thoracic spine. Another probability is the 'pendulum' effect of the heart within the relatively pliable thoracic contents. When the thorax is violently decelerated during an accident, the heavy cardiac mass attempts to keep moving ahead and may literally snatch itself from its basal mountings, the most rigid part of which is the aorta. Separation usually takes place at the point where the aorta is attached to the spine, at the extremity of the arch. Sometimes there may be additional transverse intimal tears adjacent to the main tear, the so-called 'ladder tears' as they may resemble the rungs of a ladder.

Head, neck and face involvement in the drivers is rela- tively frequent as a result of projection against, and/or ejection through the windscreen. The face often suffers multiple lac- erations from contact with the shattered windscreen glass. These lacerations are usually bizarre shaped or 'sparrow-foot' patterned. Injury to the head may be caused by the impact of head against the windscreen rim or corner pillar or after ejec- tion. The injuries may include scalp contusions, lacerations, fractures of skull, intracranial haemorrhage/ haemorrhages or damage to the brain.



Usual injuries to the driver and front seat passenger.

Injuries to the neck, the so-called 'whiplash injuries', have been stressed recurrently. There is often a double component in that the hyperflexion of deceleration is followed by a rebound hyperextension when the head meets an obstruction in the front. Rear impacts also cause the double whiplash effect. The injuries may result in fractures and/or dislocations, especially at the level of 5th and 6th cervical vertebrae. Rigid head restraint can reduce injuries from hyperextension. Other injuries may be atlanto-occipital dislocation with or without laceration of tendons, ligaments, separation of cartilaginous

EJECTION CRASH INJURIES

Ejection from the vehicles results in severe and multiple inju- ries to the driver as well as the occupants. Ejection was found to be second only to the steering wheel as a major cause of injury in the large series of cases studied by the Cornell group. Ejection occurs mostly in the roll-over accidents. According to the Cornell group, the risk of fatal injury as related to ejection or non ejection is five to one.

Less common injuries are the injuries to the upper limbs that may occur from the transmitted force through gripping the steering wheel or from impact against the windscreen, pil- lars, intrusive roof, bonnet or ground when held up in a reflex protective position.

INJURIES TO THE FRONT SEAT OCCUPANTS

The position of front seat passengers in the car is even more dangerous. Though there is no steering wheel to impact against the chest or abdomen, its absence also denies the little protec- tion offered to the driver in reducing the collision with the windscreen possibly by giving him something to brace against. Another factor may be the fact that the driver usually pays attention constantly to the road and so is better placed in appreciating the impending crash, compared with the occu- pants who may be unaware of the approaching danger and fail to 'brace up' any nearby structure. Any range of injuries may be seen in the occupants and no specificity can be assigned.

INJURIES TO THE REAR SEAT OCCUPANTS

During the forceful deceleration impact, the unrestrained rear seat occupants are projected forwards and strike the back of the front seats. They may be thrown over the seats, striking and contributing further injuries to the front seat passengers and may even be ejected through the windscreen, which is smashed by them or by the people in front. In roll-over accidents, they may get churned up inside the vehicle, when multiple injuries may occur by hitting against the various structures.

INJURIES TO THE PEDESTRIANS

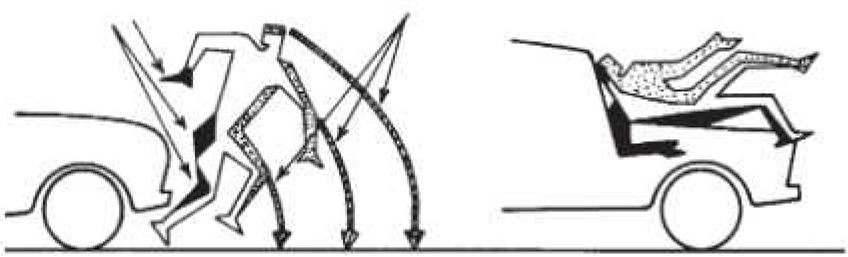
These are probably the most common fatalities worldwide. Most pedestrians are struck by motor cars and the type of vehi- cle makes a difference in the production of injuries which, unlike the injuries to the automobile occupants, are an accelera- tion process and not a deceleration one. Injuries may be grouped as (..19.2).

PRIMARY IMPACT INJURIES

These include the injuries that are sustained when any part or parts of the victim first strike the vehicle. Such injuries carry importance in the sense that they may bear design of the part of the vehicle causing the injury in the form of imprint abrasion and/or patterned bruise, etc., thereby helping in reconstructing the events. The part of the body involved will depend upon the position of the person in relation to the vehicle when struck, i.e. whether crossing the road or walking with or against the traffic, etc. The position of the injuries will be further modified by the fact whether both feet were on ground or one was raised, the nature of surface of the road and the footwear of the victim.

SECONDARY IMPACT INJURIES

These injuries are the result of impact between the body part(s) and the vehicle for the second time as when the victim after striking against the vehicle is further scooped up/or otherwise hurled up on the vehicle resulting in injuries to the other parts of the body by the same vehicle.



Usual pattern of pedestrian injuries.

SECONDARY INJURIES

These are sustained by the victim after being knocked down by the vehicle and striking the ground with the subsequent risk of being harmed by some different vehicle, thus receiving the injuries by striking against the ground or some object on the ground as well as those sustained through some other vehicle.

CRUSH INJURIES

These may be seen when the person has been run-over, the severity depending upon the weight of the vehicle and its clear- ance from the ground. Cases have been reported in which 'jumping' of the wheels has occurred, thus reducing the extent of crush injuries to the minimum and involving only one side of the body.

As there is considerable variation in the automobile models, there is little point in mentioning specific names and, there- fore, mechanics of usual injuries met in a common type of vehicle (say, a car) may be described. In a typical case, the first impact tends to knock the legs and rotate them to the oncoming vehicle resulting in the so-called 'bumper injuries' on the legs (fractures of tibia and fibula, often compound and comminuted). If the leg is weight bearing at the time of impact, the tibial fracture tends to be oblique whereas if not stressed, as may be during walking, the fracture line is usually transverse. In such a case, the leg with higher placed injury usually represents the one in contact with the ground support- ing the body weight at the moment of the impact. Sometimes, the level of injuries may be low as compared to the height of the bumper, suggesting application of the brakes at the moment of the impact thereby causing dipping down of the bonnet.

Depending upon the profile of the front of the vehicle, the hit pedestrian is either thrown forward or scooped up onto the bonnet top. If thrown forward, secondary injuries will be suf- fered as a result of striking the ground. A further hazard may be the danger of being run over by the vehicle, if the victim is projected directly in front of the vehicle. Sometimes he/she may be dragged by the underbelly of the vehicle and seriously soiled and injured. If thrown to the side, the victim may be run-over by other vehicle overtaking the vehicle in question. If scooped up, the victim may land on to the bonnet or against the windscreen or corner supporting pillar. The flat bonnet usually does relatively little harm, though some abra- sions, minor lacerations or friction burns may be the result. Striking against the windscreen or the side pillar is the most frequent cause of severe head injury. In case of high speed collision, victim may be thrown up on the roof and sometimes somersaulting so that the head strikes to the roof and finally to the ground, with the subsequent risk of being harmed by some other vehicle. In general, the severity of the injuries will depend upon the magnitude of impact. But it is virtually impossible to estimate the speed from the nature of injuries. These can be fatal even at slow speed and yet, occasionally, high speed impacts may follow only insignificant injuries. In Ashton's series, half the deaths ensued at speeds less than 30 miles per hour.

Soft tissue injuries may include abrasions, bruises lacera- tions and crushing injuries. Typical 'brush-burning' may be found when the pedestrian is dragged or scrapped against the rough surface. These are usually superficial abrasions without significant haemorrhage into the skin and subcutaneous tissue. Due to the friction-type force responsible for brush-burning, protuberant parts of the body are predominantly involved. A characteristic lesion is 'flaying injury' encountered in run- over cases. The rotator effect of the wheel against a fixed limb or head may strip-off almost the entire tissue down to the bone. When the wheel passes over the abdomen or pelvis, multiple parallel striae or shallow lacerations may result owing to the ripping tension in the skin (.. 19.3A and B). Great internal injuries may be caused with little surface injuries. Some 'patterned injuries' may sometimes be observed involving soft tissue, which may help in identifying the vehicle in a 'hit and run' accident. The most common is the 'tyre marks'

A peculiar phenomenon, called the 'under-running' or 'tailgating', may rarely be seen in the motorcyclists, where a rider drives into the back of a truck or some other heavy vehicle. This may occur due to sudden and unexpected stop- page of the heavy vehicle. In such cases, motorcyclist's head and shoulders are smashed against the tail-board.

Injuries to the Motorcyclists

The motorcyclists are much more prone to receiving serious injuries, and this vulnerability may be due to the inherent insta bility of the two-wheeled vehicle. Generally, the behaviour of may result in extreme cases. Falling from the vehicle, particu- larly at high speed, may result in the injuries to the extremities as well as the chest and abdomen. The younger age group involved in rash driving and greater acceleration capacity of the vehicle are the other contributing factors.

The two extremities are the commonly affected, though any part of the body may be involved. As the rider almost invariably falls to the ground, head injuries are common and often grave, leading to 80% of deaths according to Bothwell. A typical fatal injury is the fracture usually from secondary impact with the ground. Temporoparietal fractures are common often with contrecoup brain injury. In violent accidents, a basal skull fracture is usually seen. This exhibits as a transverse crack across the floor of the skull, crossing behind the greater wing of sphenoid bones, through the pituitary fossa to the opposite side. This may also be associated with fissure fractures passing upwards to the temporal bones. At autopsy, the base of the skull may be appreciated to have divided into two halves, each moving independently of each other like a hinge, the so-called 'motorcyclist's fracture'. Neck suffers quite often and Mant found cervical spine fractures in over a quarter of his series.

'Ring fracture' around the foramen magnum may be encountered in some cases, caused by an impact on the crown of the head. Ring fracture of the base of the skull and atlanto- occipital avulsion due to anteroflexion on the motorcycle riders have been reported by H Maeda, T Higuchi and K Mognchi. In their case, the driver of the motorcycle sus- tained a 'ring fracture' and the pillion rider an atlanto-occipital avulsion, dural tear, etc. Mode of action of the accelerating forces to the heads of the victims along with their physiques may explain the mechanism that caused different injuries.

The role of 'safety helmets' in the prevention of head injuries cannot be overlooked. The severity of the impact may defeat the protective role of the helmet. However, these hel- mets act by providing a rigid barrier against the impact and allowing the protected head to skid across the road surface, thus prolonging the stopping distance and time to reduce the G force of deceleration. Vulnerability to fatal injuries is much more with helmetless motorcyclists than the helmeted ones. Rarely, at high speed impacts, helmet may be penetrated or the head and brain may be damaged by the transmission of blunt force. Crash bars are another safety measures provided in some cases, to protect the legs. Unless extremely strong, these crash bars may sometimes themselves trap the legs if they happen to bend on impact.

INJURIES TO PEDAL CYCLISTS

A pedal cycle carries the same instability but has far less speed. Again, head injuries are common due to the fact that height above the ground is significant, and the rider meets a passive fall this may be complicated by any forward motion or projec- tion from impact by the motorcycle. Secondary damage to the shoulders, legs, anus may also occur. A peculiar injury, i.e. the entrapment of the leg between the wheel spokes, has been described by Strauch.

AIRCRAFT ACCIDENTS

Medicolegal expert and forensic pathologist have a large role to play in aircraft accidents. Their role is particularly valuable in evaluating the injuries and also in identification of the dead. The latter exercise requires combined efforts of aircraft investigators, forensic odontologists and pathologists. Needless to say that it is a wide field and anyone interested in details may consult particu- lar books and writings dealing with the mechanics of air crashes, types of injuries sustained and the mass casualty aspects, etc.

Sustenance of injuries in aircraft crashes vary widely, from total disintegration of the body to relatively insignificant ones. Where crash occurs at relatively high altitude, fragmented bod- ies may be distributed over a wide area, especially if the aircraft suddenly depressurises and there is massive ejection. Some of the circumstances influencing injuries and/or deaths may include the following:

Failure of aircraft at high altitude is usually associated with total casualties. However, there may well be some survivors where a landing or taking-off accidents occur. (Mechanical failure of the pressurization system of the aircraft results in rapid or explosive decompression. Such decompression may also result from external or internal perforation of the plane's hull. Loss of pressure in less than a second is referred to as explosive decompression, and if longer, it is referred to as rapid decompression. The classic examples of air crashes involving explosive decompression were in the 1954 Comet disasters in the sea of Italy. In these disasters, a defective part in a portion of the fuselage had provided a point of weakness.)

- Fire is obviously a major hazard; therefore, death may at occasions be due to burning, smoke inhalation or carbon monoxide poisoning. A raised carboxy haemoglobin may indicate:
  - burning as a cause of death or survival in fire;
  - sublethal incapacitation of the pilot as the cause of an accident;
  - an abnormality of the engine leading to accident; and
  - postmortem artefact. Dominguez (1962) concluded that fragmentation due to explosion and postmortem incin- eration do not raise tissue carboxy haemoglobin.
- Alcoholic intoxication of the pilot may be the other source. In International Regulations, commercial pilots must not drink within 8 hours of flying. Toxicological analysis, there- fore, should always be a part of the exercise.
- A look for some natural disease in the pilot needs apprecia- tion. In one survey in UK, 8.5% of the aviators were found to be suffering from coronary artery disease and another 15% from moderately severe coronary stenosis. The circumstances of aircraft travel are such that a fatal accident is likely out- come from even a minor acute disability. As pathognomonic changes of cardiac ischemia take some time to appear, actual coronary heart disease can only be inferred from the presence of the precursor condition. Mason et al. (1963) reviewed nine aircraft accidents attributed to coronary dis- ease in pilot, based on dual evidence of pathology and his- tory. They opined that four of these

accident were almost certainly to have been so caused, four were very likely, and one was assessed as likely, and it was considered impossible to be dogmatic. Occasionally, accident may be due to some functional disease which cannot be documented at autopsy. Idiopathic epilepsy may be an obvious example. Hence, the autopsy surgeon may extend his inquiries into the medical and personal history of an accident fatality.

- Availability/non availability of medical facilities, ambulances and trained medical staff remains an important factor.

The high altitude at which the aircrafts operate, presents a special problem. The cabins are pressurised to prevent hypoxia. Death resulting from altitude problems can be due to hypoxia, hypothermia or dysbarism. However, such deaths being physiological in nature are usually not obvious and may be masked by superimposition of trauma. Presence of fat or bone mar- row emboli in the lungs or in other tissues is usually a convinc- ing finding for a functioning circulation for at least a brief period following trauma. Where hypoxia is suspected, lactic

impact and those arising from a catastrophe at high altitude. Philp and coworkers suggest that gaseous emboli and trau- matic shock are operating jointly in the genesis of fatal post- descent shock. They report that presence of gas in the circulation leads to the formation of microthrombi and blood sludging at the blood–gas interface.

TYPES OF INJURIES

As stressed earlier, injuries vary very widely, i.e. from total dis- integration of body to relatively insignificant ones. However, some commonly occurring injuries may be as under:

- Leg injuries are extremely common, the passengers being crushed against the seats in front.

- Fractures of spine are also common, especially the fractures of thoracic spine. Up to 78% of such injuries have been reported in some disasters. These are mainly hyperflexion injuries due to massive deceleration when the aircraft strikes the ground. Cervical spine injuries associated with facial injuries may be encountered due to hyperextension when the face is flung against the back of the seat in front of the victim.

- Intrathoracic injuries due to squeezing of the chest by pressure against the sternum may also occur.

The issue of identification of the victims is of critical importance. Victims may run into hundreds and therefore, causing a major organizational problem for the authorities. As stressed in the beginning, efforts of many experts are required for such purposes. Naturally, age, sex, race, stature as well as personal details like surgical scar, other scars, tattoos, surgical prosthesis like artificial limbs and congenital deformities carry importance. (The task may be eased by the availability of an accurate passenger manifest. The subject had been discussed by Stevens and Tarlton (1963), who estimated the relative W values of visual recognition, possessions, clothing, pathology, dentistry, X-rays, and the like as aids to identification.)

Dental aspects carry unique significance. Teeth are one of the few parts that resist conflagration. Dentures, metal fillings, special dental work, extractions and other dental attributes all constitute important evidence leading to identification, if pre- existing dental records can be made available. Provisions for accommodating bodies, adequate facilities for postmortem examination with photography and radiography are necessary under such situations.

Acid estimation is of utmost significance (brain lactic acid levels exceeding 200 mg% are indicative of hypoxia). Predisposing factors influencing the outcome of injuries could include age, obesity, exercise, ascent rate, attained altitude, nitrogen pres- sure before ascent or descent, previous injury and of course the temperature.

RAILWAY ACCIDENTS

India carries one of the largest railway networks in the world and accidents from rail operations may not be unexpected. Children playing in the vicinity of the rail track or pedestrians using the track as a convenient route for walking may get accidentally involved. Persons leaning too far from the windows may strike their head upon passing railway fixtures, bridge abutments, tunnel sides or electric poles, etc. Suicides have also been reported where a determined suicide will deliberately lie across the line or even place his/her head for achieving self-destruction. A peculiarly puzzling situation may be there when a person is pushed or thrown from the speeding train, putting the doctor in a dilemma to categorically opine about the manner of death.

Railway accidents may be broadly classified into the following groups:

- Accidents where the casualties are actually to the people on board the train.
- Accidents where the people other than on board are involved.
- Accidents where the people on railway-premises are involved. Such people usually include staff and can be directly or indirectly connected to numerous occupations relating to railway affairs. (Workers working in close proximity to the high volt- age overhead cables are usually at risk. Head may touch the live conductor and the current directly involving the brain, uncommon in other types of electrocution.)
- Collision between a train and another vehicle at a road-railway crossing (commonly called a 'level crossing') is another source of injuries and even deaths. Such crossings where a public road crosses a railway track are usually poorly manned with either no barrier at all or with only a flimsy lifting pole. (As per news item, 'The Tribune' dated 3rd February, 2004, a ghastly mishap occurred when an express train ploughed through a crowd of people at the level crossing killing five persons. The gateman after managing the gate for some particular train, had to immediately down the barrier for another train that was already on the way for which, probably he had no information. This led to the trapping of persons who were crossing the track and thereby resulting in fatalities.)
- High winds, heavy rain, heavy fog and other vagaries of the

weather also occasionally lead to train accidents. Rain and floods may loosen the foundation of the track and lead to accidents. Landslides may present an additional hazard.

- Hooliganism and vandalism affecting the rail track or moving trains has also been observed in the recent years. Deliberate laying of the objects on the rail tracks or throw- ing of objects at passing trains may form a part of the mali- cious strategy.

In general, any type of trauma can be seen in such accidents. However, some kinds of injuries may be more commonly seen. Extremely severe destruction of the body may occur with separation of the limbs and extrusion of organs. It may sometimes be possible to estimate distance between two sets of wheel injuries to show that the person might have stretched his body across the entire width of the standard gauge track. Certain features like wheel marks upon the body, dirt and grease contamination, and manner of severance of tissues deserve special observation. Possibility of a murdered person being placed across the tracks needs to be kept in mind. Forensic

laboratory evidence can sometimes reveal a non accidental cause. The usual search of alcohol and other drugs must be made, as suicides often resort to multiple means to ensure self-destruction.

VEHICULAR CONFIGURATIONS

In crashes involving fire, victim's body frequently undergoes advanced burning until it is extracted. Tasks of the medicolegal experts under such circumstances usually include (i) identifica- tion of the decedent, (ii) evaluation of blunt and other trauma and (iii) evaluation for smoke inhalation or other indicators showing that the person was alive and/or conscious during the fire (circumstances may be there when the victim dies immedi- ately from severe blunt force injuries, only to have the vehicle subsequently ignite and become engulfed in flames). It is diffi- cult, if not impossible, to grossly distinguish antemortem from postmortem burns, especially in charred bodies. Pre-autopsy X-rays must be obtained in order to assess for the unexpected foreign objects like bullet or some part of the blade of some weapon, etc. X-rays will also be helpful in the identification of the decedent if some unique orthopaedic hardware or some surgically implanted devices are demonstrable. As thermal injury is notorious in modifying or destroying pre-existing inju- ries, one needs to exercise caution in their evaluation (heat is known to shrink tissues as the water is released and the proteins get coagulated). Ultimately, the evaluation of the fire's contribu- tion towards death rests in the documentation of severity of injuries balanced against evidence of smoke inhalation, which is assessed by the presence and quantity of carbonaceous material in the airways and carboxy haemoglobin concentration in the blood. One should also keep in mind that other toxic gases may be produced as a by product of burning vehicular components.

Medico Legal Considerations

The goal of any criminalistic examination is to provide scientific and factual data that can link a suspect to a case or exonerate the suspect. Edmond Locard—an early 20th century criminalist—postulated, "when objects, persons or surfaces come in contact with each other, there is a mutual exchange of materials. This transfer may result in identifiable trace materials that can be used to link the objects, persons or surfaces to each other". Such trace/ transfer evidence is amongst the most diverse and the most useful types of physical evidence available in the field of criminology, transportation accidents ranking high. Though the fact that death has been the result of multiple injuries is often obvious, yet the extent of litigation cannot be gauged at the time of autopsy. A driver may perpetrate a homicide against pedestrian or occupants of another vehicle by using the vehicle as a weapon or may cause the death of a passenger in his vehicle in the context of a suicide-homicide. Psychological autopsy and postmortem toxi- cology may assist in the diagnosis of "traffic suicide"/"autocide". In general, a mix of factors may be operating in a given scenario, viz. (i) factors attributable to the scene of accident (nature of the surface, material lying there and the nature of material, etc.); (ii) factors attributable to the vehicle (condition and design, speed, supervening factors like running over by another vehicle or conflagration etc.); (iii) factors attributable to the environmental condition (extreme hot weather, heavy rains, too cold and foggy weather, etc.); (iv) factors attributable to the victim (location and seating of the victim in the vehicle, ejection/nonejection of the victim, etc.); and (v) eventual role played by some disease in the driver including toxicological evaluation. It may be worth mentioning that absence of signs of ill health, even the absence of physical signs of disease, By no means exclude the possibility of its presence and, indeed, may have been there for sometime and may become revealed by some accidental happening. Peptic ulcer, hypertension, coronary artery disease, diabetes, neoplasm, etc. may be a few examples wherein the disease may have progressed for some period in the past without giving rise to symptoms or attracting attentions of either the victim or of those with whom he has been in contact.

CHAPTER-18

MEDICOLEGAL EXAMINATION OF THE LIVING

Forensic medicine may be considered as the medical science that applies the principles and practice of medicine to the elucidation of various queries in judicial proceedings. It means that there must be as many specialities as there are in the medical practice. It would, therefore, not be apt to view the subject of forensic medicine from the autopsy table alone. There are numerous occasions when a doctor is called upon to examine a living person, for medicolegal purposes, sometimes for the benefit of the examinee but sometimes to his disadvantage, such as examination of an accused person. Whatever may be the case, the question of consent should never be forgotten and only in exceptional circumstances it may be dispensed with, as enumerated in the Chapter, 'Consent to and Refusal of Treatment'. This aspect of examination of a living person for medico- legal purposes may be termed as Clinical Forensic Medicine, as there exist a number of circumstances for his medicolegal examination. The victims of an assault, sexual offence, accidents, drunkenness, etc., all require examination and a report upon their conditions so that the legal proceedings may be initiated. In accidents, examination is invited for the injuries suffered and the opinion on prognosis, so that the matters of insurance and compensation may be evaluated. Insurance companies in many cases require a medical examination in order to assess the insurance risk of an applicant. Examination of the suspected malingerers and examination for issuing certain certificates like age certificate, certificate for disability, certificate for entry into service, for driving purposes, for taking part into national and international games, for certain admissions and certificate for illness, all add to the numerous cases for which the medical examination is required for legal purposes.

At the very outset, it needs be stressed that the record must be complete and the report must be prepared after acute observation because record is the 'measure' by which it is judged at a later date, may be after years in occasional cases.

MEDICAL EXAMINATION IN ASSUALT CASES

CONSENT

Examination of a patient or a victim of assault should not be made without his permission or of parent/guardian. However, a person accused of criminal offence may be medically exam- ined without his consent on the request of the police (Section 53, CrPC, 1973).

HISTORY

It may include general history in the form of any past or present illness, any medication, any history of operations and the usual questions relating to matters of occupation, hobbies, height, weight, family history, etc. It also includes the specific history relating to the particular situation for which the examination is being undertaken. Some kind of story is normally supplied by the agency requesting the examination, but it is always prefer- able to take it from the concerned individual or his/her close relatives, and the doctor should amplify it as much as possible by putting them questions. It must include exact nature, place and the associated factors of the incident. The question of admissibility of evidence is a matter for legal authorities, but the doctor is entitled to write down in his report anything that he thinks relevant.

GENERAL PHYSICAL EXAMINATION

General physical examination should be complete from 'top to toe' including observations of height, weight, general built and appearance, skin of the entire body surface showing any trace evidence or any superficial injury, healing injury or old scar, deformity/congenital defect, etc. Size, site and orientation of the injuries must be described with reference to the well-known surface landmarks. It is preferable to have photographs or at least sketches, which may be of great value at a later date when the case is being dealt with in the court. It is not advisable for any doctor to pounce upon the specific part involved in the incident without carrying out complete general examination.

EXAMINATION OF SPECIFIC AREA

Examination of the specific area involved in the incident should follow the general physical examination. It may range from mere palpation of any fracture/deformity, measurement and detailed description of the injuries including their exact location and orientation, taking all relevant specimens and advising neces- sary investigations.

REFERENCE TO A SPECIALIST

No doctor can be an expert in every field and the modern ten- dency is to achieve specialisation in the various branches of medicine. Thus, a doctor should preferably refer the matter to a surgeon or orthopaedician or neurologist, etc., depending upon the merits of each case to have a comprehensive view of the case. Many medicolegal issues, especially concerning com- pensation for accidents or insurance matters, depend heavily upon the future outcome of any disability and it is always advis- able to have the advice of a specialist in such cases.

OPINION

It is to be given at the end of the examination and must be based upon its findings. It may sometimes be withheld till the reports from the specialist (in cases where something has been referred to some specialist) or reports of the X-rays or laboratory investi- gations are at hand. The opinion consists of three constituents:

- Nature of injuries
- Probable duration of injuries
- Kind of weapon used in inflicting injuries

NATURE OF INJURIES

Nature of injuries needs to be classified as simple, grievous or dangerous. Some books have mentioned that a doctor need not classify the injuries in the report and his opinion on them is only to guide the investigating officer, but the author is of a different view. The injuries should better be classified and men- tioned under the proper column of the medicolegal report, after taking all findings into consideration. Agreed that the ulti- mate outcome rests with the court, but the court in turn is to be assisted by the evidence of the doctor. Not classifying or declar- ing the injuries can raise many undesirable queries or assume unpleasant situation in certain cases, and the doctor may invite unnecessary pressure/counter pressure. Therefore, it would be in the fitness of things to declare the nature of injuries after con- sulting the entire record and if need be, after consulting some senior colleague or the literature available on the subject.

APPROXIMATE DURATION OF INJURIES The approximate duration of injuries should be mentioned after observing the age-related changes in the injuries. The age of the injury is important, because its appearance may or may not correspond to the time when it is alleged to have been inflicted and furthermore, all the injuries found on a person may not have been produced on the same day. The words 'approximate' and 'duration' are significant, as there is no scientific method available that can yield precise results. Indeed, the degree of reluctance of the examiner to pinpoint the time interval may be a measure of his/her competence.

KIND OF WEAPON

The kind of weapon in many cases does not pose any problem. Examination of the wounds on the body and defects on the clothing sufficiently speak of the kind of weapon, i.e. whether blunt or sharp or blunt-pointed/sharp-pointed or firearm or dry/moist heat and the like. In some cases, wounds produced by broken pieces of glass/earthen wares or by teeth, etc. or wounds produced on body prominences may present some dif- ficulty but examination by a hand lens and the experience of examiner will help to resolve the issue.

DISPATCH OF SPECIMENS/ ARTICLES

Manner of collection of specimens and their proper dispatch is also vital, which ensures the 'pedigree' of any specimens taken, and maintains the chain of events for that particular specimen.

EXAMINATION OF EXHIBITS

WEAPON

If a weapon alleged to have been used in producing injuries is brought by the police, its length, breadth, shape etc. need to be documented. Particulars of the handle and blade (wherever necessary) should be noted down in details. It should be exam- ined for marks of bloodstains or fragments of hair, fibre, pieces of clothes, etc. adhering to it and be returned to the police in a sealed parcel/packet duly labelled with the particu- lars of the case under due receipt mentioning date and time.

FOREIGN BODIES

When any foreign body such as some splinter of broken glass, a piece of some stick/rod, broken point/portion of some instrument/weapon, bullet (whether deformed or broken), pellet (whether deformed or broken) or wadding of a firearm or remnant of some clothing found lodged in a wound or in its surrounding tissues, it should be carefully documented, preserved and sent to the forensic science laboratory (FSL).

CLOTHING

Clothes need to be examined for any blood/other stain, cuts, rents, tears, soiling, or burning etc. coinciding with the wound(s)/damage(s) on the underlying parts of the body. However, these might not coincide with the wound(s)/ damage(s) if the garment worn at the time of assault was very loose and was disarranged during the struggle. Care needs to be exercised in distinguishing fake firearm burns or holes prefer- ably by having an opinion from the FSL. Clothes then be prop- erly marked, signed and handed over to the police in a sealed cover with particulars of the case under receipt mentioning date and time (if clothes are wet, the same need be air dried before sealing).

MEDICAL EXAMINATION IN SEXUAL OFFENCE

Sexual offences may be considered as acts of sexual intercourse and/or sexual interference with a person or animal against the provisions of law. These may be classified into three groups:

Natural Sexual Offences

- Rape
- Incest
- Adultery

Unnatural Sexual Offences

- Sodomy
- Buccal coitus (oral coitus)
- Lesbianism/tribadism
- Bestiality

Other Sex-linked Offences

- Indecent assault
- Some unlawful perversive acts, the so-called sexual perversions
- Offences under the Immoral Traffic Act, e.g. kidnapping of a woman, unlawful prostitution, etc.

RAPE

From the medicolegal point of view, a doctor is expected to exam- ine both the alleged victim and the alleged assailant. The routine of examination should not vary from the other cases, but it is preferable to follow some schedule rather than proceeding hap-hazardly, in which case some important aspects may be skipped. The word 'rape' is derived from Latin term 'rapio', which means 'to seize'. Thus, rape literally implies forcible seizure. In other words, rape is violation with violence of the private person of a woman, or it may be considered 'as the ravishment of a woman without her consent, by force, fear or fraud'. Here, it would be in the fitness of things to write detailed provisions regarding 'rape' as given under the IPC. It would enable the doctors/students to appreciate the jugglery of the legal language vis-á-vis the medical findings.

Section 375 (Rape)

A man is said to commit 'rape' who, except in the case herein-after excepted, has sexual intercourse with a woman under cir-cumstances falling under any of the following descriptions:

- Firstly Against her will. Secondly Without her consent.
- Thirdly With her consent, when her consent has been obtained by putting her or any person in whom she is interested in fear of death or of hurt.
- Fourthly With her consent, when the man knows that he is not her husband and that her consent is given because she believes herself to be lawfully married to that man.
- Fifthly With her consent, when, at the time of giving such consent, by reason of unsoundness of mind or intox- ication or the administration by him personally or through another of any stupefying or unwholesome substance, she is unable to understand the nature and consequences of that to which she gives consent.
- Sixthly With or without her consent, when she is under 16 years of age.

Explanation: Penetration is sufficient to constitute the sexual intercourse necessary to the offence of rape.

Exception: No Court shall take cognisance of an offence under Section 376 of Indian Penal Code, where such offence consists of sexual intercourse by a man with his own wife, the wife being under 18 years of age, if more than 1 year has elapsed from the date of the commission of the offence [CrPC (Amendment) Act, 2008 (w.e.f. 31.12.2009)].

Section 376 (Punishment for Rape)

(1) Whoever, except in the cases provided for by Subsection (2), commits rape shall be punished with imprisonment of either description for a term that shall not be less than 7 years but that may be for a term that may extend to 10 years and shall also be liable to fine unless the woman raped is his own wife and is not under 12 years of age;

in which case, he shall be punished with imprisonment of either description for a term that may extend to 2 years or with fine or with both.

The court may, for adequate and special reasons to be mentioned in the judgement, impose a sentence of imprisonment for a term of less than 7 years.

(i) Whoever

(ii) being a police officer commits rape

(iii) within the limits of the police station in which he is appointed; or

(iv) in the premises of any station house whether or not situated in the police station to which he is appointed; or

(v) on a woman in his custody or in the custody of a police officer subordinate to him; or

(vi) being a public servant takes advantage of his official position and commits rape on a woman in his custody or in the custody of a public servant subordinate to him; or

(vii) being on the management or on the staff of a jail, remand home or other place of custody established by or under any law for the time being in force or of a woman's or children's institution takes advantage of his official position and commits rape on any inmate of such jail, remand home, place or institution; or

(viii) being on the management or on the staff of a hospi- tal, takes advantage of his official position and com- mits rape on a woman in that hospital; or

(ix) commits rape on a woman knowing her to be preg- nant; or

(x) commits rape on a woman under 12 years of age; or

(xi) commits gang rape

shall be punished with rigorous imprisonment for a term that shall not be less than 10 years but that may be for life and shall also be liable to fine.

The court may, for adequate and special reasons to be mentioned in the judgement, impose a sentence of imprisonment of either description for a term of less than ten years.

Explanation 1: Where a woman is raped by one or more, in a group of persons acting in furtherance of their common intention, each of the persons shall be deemed to have com- mitted gang rape within the meaning of this Subsection.

Explanation 2: 'Women's or children's institution' means an institution, whether called an orphanage or a home for neg- lected women or children or a widows' home or by any other name, which is established and maintained for the reception and care of women or children.

Explanation 3: 'Hospital' means the precincts of the hos- pital and includes the precincts of any institution for the recep- tion and treatment of persons during convalescence or of persons requiring medical attention or rehabilitation.

Section 376 (A): Intercourse by a man with his wife during separation—whoever has sexual intercourse with his own wife, who is living separately from him under a decree of separation or under any custom or usage, without her consent, shall be punished with imprisonment of either description for a term that may extend to 2 years and shall also be liable to fine.

Section 376 (B): Intercourse by a public servant with a woman in his custody—whoever, being a public servant, takes advantage of his official position and induces or seduces any woman who is in his custody as such public servant or in the custody of a public servant subordinate to him to have sexual intercourse with him, such sexual intercourse not amount- ing to the offence of rape shall be punished with imprisonment of either description for a term that may extend to 5 years and shall also be liable to fine. Section 376 (C): Intercourse by a Superintendent of a jail, remand home, etc.—whoever, being a Superintendent or Manager of a jail, remand home or other place of custody established by or under any institution takes advantage of his official position and induces or seduces any female inmate of such jail, remand home, place or institution to have sexual intercourse with him, such sexual intercourse not amounting to the offence of rape shall be punished with imprisonment of either description for a term that may extend to 5 years and shall also be liable to fine.

Explanation 1: 'Superintendent' in relation to a jail, remand home or other place of custody or a women's or chil- dren's institution includes a person holding any other office in such jail, remand home, place or institution by virtue of which he can exercise any authority or control over its inmates.

Explanation 2: The expression 'Women's or Children's Insti- tution' shall have the same meaning as in Explanation 2 to Sub- section (2) of Section 376.

Section 376 (D): Intercourse by any member of the management or staff of a hospital with any woman in that hospital—whoever, being on the management of a hospital or being on the staff of a hospital takes advantage of his position and has sexual intercourse with any woman in that hospital, such sexual intercourse not amounting to the offence of rape shall be punished with imprisonment of either description for a term that may extend to 5 years and shall also be liable to fine.

Mechanism of Erection and Orgasm

The homologous structures of the male and female reproductive systems respond to sexual stimulation in a similar fashion (Figs. 20.1 and 20.2). The erectile tissues of a female, like those of a male, become engorged with blood and swollen during sexual arousal. During sexual excitement, the hypothalamus of the brain sends parasympathetic nerve impulses through the sacral segments of the spinal cord, which cause dilatation of arteries serving the clitoris and vestibular bulbs. The increased blood flow causes the erectile tissues to swell. In addition, the erectile tissues in the areola of the breasts become engorged.

The deep recess surrounding the protrusion of cervix into the vagina is called the fornix. Vagina (The vagina is a tubular organ about

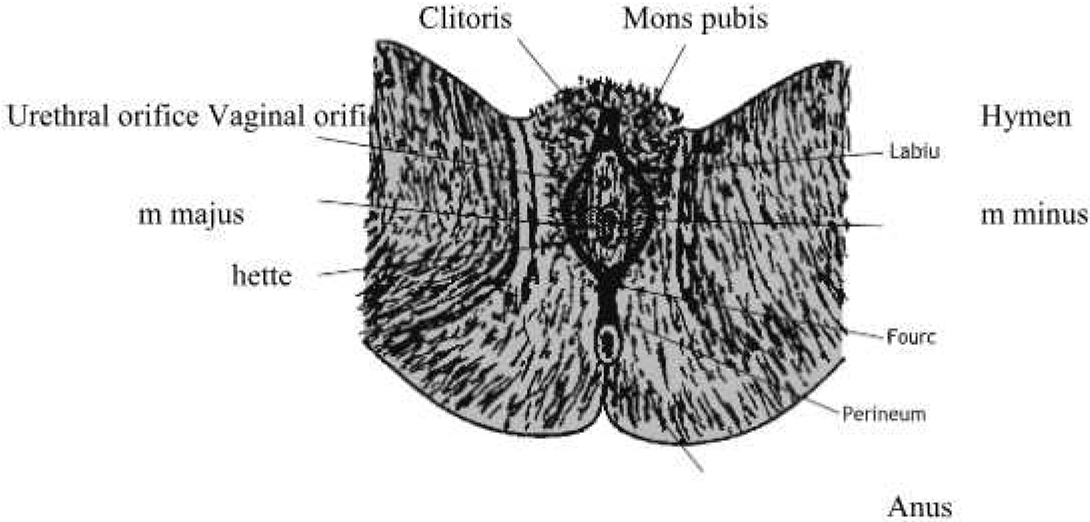
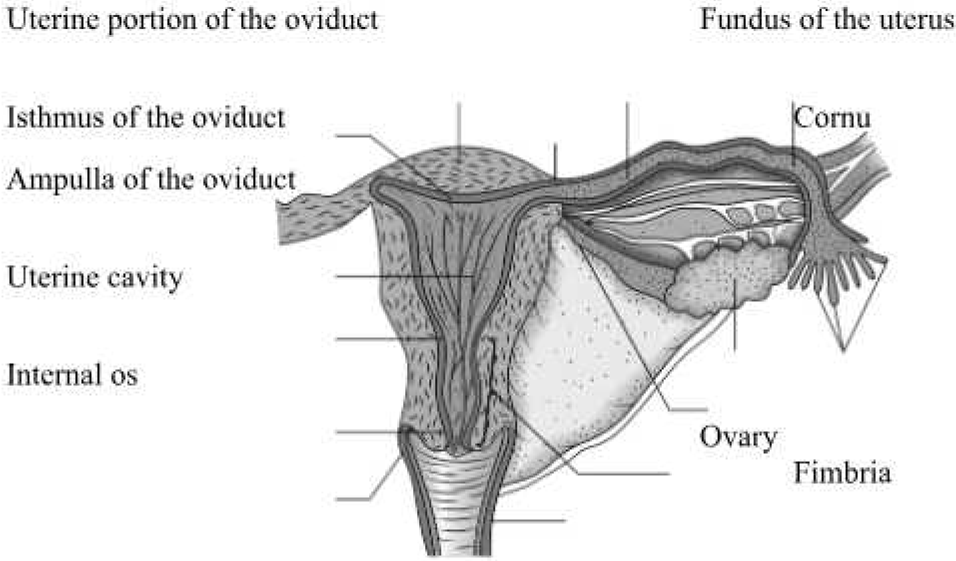


Diagram showing external female genitalia referred collectively as vulva.



9 cm long, passing from the cervix of the uterus to the vestibule. The vaginal wall is composed of three layers: an inner mucosa, a middle muscularis and an outer fibrous layer. The mucosal layer consists of stratified squamous epithelium, which forms a series of transverse folds called the vaginal rugae.

The vaginal rugae provide friction ridges for stimulation of the erect penis during sexual intercourse and progressively become less pronounced after repeated sexual intercourse.)

Simultaneous with the erection of the clitoris and vestibular bulbs, the vagina expands and elongates to accommodate the erect penis of the male, and parasympathetic impulses cause the vestibular glands to secrete mucus near the vaginal orifice. The vestibular secretion moistens and lubricates the tissues of the vestibule, thus facilitating the penetration of the erect penis into the vagina during coitus. Mucus continues to be secreted during coitus so that the male genitalia do not become irritated as it could if the vagina became dry.

The position of the sensitive clitoris usually allows it to be stimulated during coitus. If stimulation of the clitoris is of sufficient intensity and duration, a woman will experience a culmination of pleasurable psychological and physiological release called orgasm. Associated with orgasm is a rhythmic contraction of the muscles of the perineum and the muscular walls of the uterus and uterine tubes. These reflexive muscular actions are thought to aid the movement of sperm through the female reproductive tract toward the upper end of uterine tube, where an ovum might be located.

General Considerations

In the English law, the rule that a boy under the age of 14 is incapable of performing sexual intercourse was abolished by the Sexual Offenses Act, 1994; and 'doli incapax' (incapable of committing a crime or tort) presumption is also abolished by

the Crime and Disorder Act, 1998. In India, a boy of any age will be equally liable for committing the offence of rape like a man of any age unless it is proved that the boy was incapable of committing the offence medically (under the IPC, the word 'man' denotes a male human being of any age; and the word 'woman' denotes a female human being of any age). In award- ing punishment, courts are guided by Sections 82 and 83 of IPC. Secondly, in India, only man can be held guilty of com- mitting rape on a woman while in some developed countries like UK and USA, the majority of rape laws are gender blind, allowing inclusion of males too. In India, a woman may be charged to have committed 'indecent assault' on a man.

The crux of the offence of rape is the sexual intercourse against the will and without the consent of a woman. The use of two phrases 'against her will' and 'without her consent' denotes different concepts. Every act done against the 'will' of a person is done without his 'consent', but an act done with- out the consent of a person is not necessarily against his 'will'. A woman may be 'willing' for sexual intercourse but may not give consent for fear of detection or social stigma. Sexual intercourse with an unconscious woman cannot be said to be against her will but will be without her consent. The woman must have voluntarily participated in the sexual act after exer- cising her intelligence and clearly differentiating as to the resis- tance and assent. Whether the alleged consent by the victim was a mere submission or a 'willing consent' depends upon the circumstances of each case. However, when the victim is below 16 years of age, sexual intercourse, in any case, amounts to rape and the question of consent or nonconsent does not arise. Some authors describe this as statutory rape.

CHANGES IN THE LAW

- Recording of statement of the victim shall be con- ducted at the residence of the victim or at the place of her choice in the presence of her parents or guardian or near relatives or social worker of the locality and as far as prac- ticable, it should be recorded by a woman police officer. Further, the statement may also be recorded by an audio- video electronic means.

- When the trial relates to an offence under Sections 376 and 376-A to 376-D of the IPC, the trial shall be conducted as far as practicable by a court presided over by a woman.

- Attaching report of medical examination of the woman has been made mandatory while presenting the report/challan to the magistrate empowered to take cogni- sance of the offence relating to Section 376 and 376-A to 376-D of the IPC.

- Trial in camera: Section 327 of the CrPC has been amended making the provisions for trial of rape cases or an offence under Sections 376-A to 376-D of the IPC in camera and prohibition of publication of trial proceedings in such cases without the prior approval of the Court or subject to main- taining confidentiality of name and address of the parties.

- Presumption as to absence of consent in certain prosecutions for rape: The Evidence Act was amended by inserting Section 114-A, which lays down that in a prosecu- tion for rape under Clause (a), (b), (c), (d), (e), or (g) of the Subsection (2) of Section 376 of the IPC, where sexual intercourse by the accused is proved and the question is that whether it was without the consent of the woman alleged to have been raped and she states in her evidence before the Court that she did not consent, the Court shall presume that she did not consent; thus shifting the burden of proof of innocence on the accused.

- Character assassination of prosecutrix prohibited: Through amendment of 2003 (Act 4 of 2003), a provision to Section 146 of Indian Evidence Act was inserted reading as, "in a prosecution for rape or attempt to commit rape, it shall not be permissible to put questions in the cross-examination of the prosecutrix as to her general immoral character".

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I Intercourse by public servant with woman in his cus- tody: Section 376-B to 376-D of the IPC were introduced to comprise a group of Sections creating a new species of rape, the so called custodial rape wherein the offence is committed by those persons who happen to occupy super- visory positions indulging in having sexual intercourse with a woman in his custody (or in the custody of a public ser- vant subordinate to him) by inducing or seducing the woman after taking advantage of his official position.

PRE-REQUISITES FOR THE EXAMINATION OF VICTIM

Some pre-requisites must be met before marching to the actual examination. The Supreme Court disapproved the refusal of some government hospital doctors (particularly in rural areas, where hospitals are few and far between) to conduct any medical examination of a rape victim unless the case of rape is referred to them by the police. Such a refusal to conduct the medical exami- nation necessarily results in a delay in the ultimate examination of the victim by which time the evidence of rape may have been washed away by the complainant herself or be otherwise lost:

- A requisition for the examination of the victim should come from an authorised person (if the victim reports directly, she needs to be examined after obtaining due consent and the police information to be sent immediately afterwards).

- An authorised person should identify the victim about whom there should be a mention in the request. Two iden- tification marks should be noted in addition.

- Consent should be obtained if the victim is of 12 or above 12 years of age but if she is below 12 years or is of unsound mind or is intoxicated, consent should be obtained from her parents or legal guardians. Further, the consent must be 'informed consent' as she must be told that any evidence obtained may be used in the court and may go for or against her.

- Presence of adult female attendant/nurse during the entire examination. Sometimes, the victim may request to be examined by a female doctor. This is understandable as the victim having undergone horrible experiences may behave inimically being intimately examined by a man. However, due to insufficient number of female doctors, particularly in peripheral areas, the victim can be examined by any registered medical practitioner preferably employed in some government hospital (Section 164A of CrPC; see under the Chapter, 'Consent to and Refusal of Treatment').

HISTORY TAKING OF VICTIM

It should include general as well as specific history.

GENERAL HISTORY

- Any history of past operations.

- Details of any medication or alcoholic intake during the past 24 hours.

- Enquiry as to the past sexual experience, particularly acts of any consenting sexual intercourse because finding of evi- dence of recent sexual activities, especially semen, might have been due to this legitimate sexual activity during the previous few days and may pose a problem in interpreting findings in the present case.

- Menstrual and obstetrical history with special reference to the last menstrual period, the type of menstrual protection normally used, use of any hormonal or contraceptive medi- cation, any surgical involvement in the past delivery (episi- otomies, forceps delivery, etc., may alter the normal genital anatomy and may have some relevance to the pattern of genital injury).

SPECIFIC HISTORY

- Place, date and time of alleged act.
- Date and the time of instituting the complaint, and an explanation of any delay in the complaint.
- Clothing: whether same or changed. If same, careful obser- vation must be made. And if changed, by whom and whether washed or not?
- History of ejaculation.
- Did the victim struggle, scream or injure the assailant in any way.
- Has the victim taken bath or washed any part of her body since the alleged act.

A general observation must be maintained as to the patient's/ victim's demeanour as it may play an important role when all the findings are weighed together. It may also help in evaluating the mental status of the victim.

EXAMINATION OF VICTIM

It may also be subdivided into general and specific. The vic- tim should be made to stand upon a white sheet of paper so that anything that falls from the clothing or body surface can be collected and preserved for further investigations. Any area of soiling or damage should be noted. If garments are wet, it is better to hang them in a safe place for drying because packing wet garments may affect subsequent laboratory investigations. They should be packed in a clean paper bag without undue folding so that the soiled areas remain safe.

GENERAL EXAMINATION

It should include the patient's height, weight, general built, routine examination of all the systems. Examination of teeth and secondary sex characters is of particular importance in assist- ing the determination of approximate age and general charac- ter of the victim.

Skin Skin needs to be examined carefully from the top of the head to the soles of the feet. Any soiled area should be cleaned with cotton swabs, moistened with sterilised water. They should be air dried before being packed in sterilised con- tainers for laboratory investigations. The use of ultraviolet lamp will reveal the areas of fluorescence on the skin that may represent areas of seminal soiling, and all such areas also need swabbing.

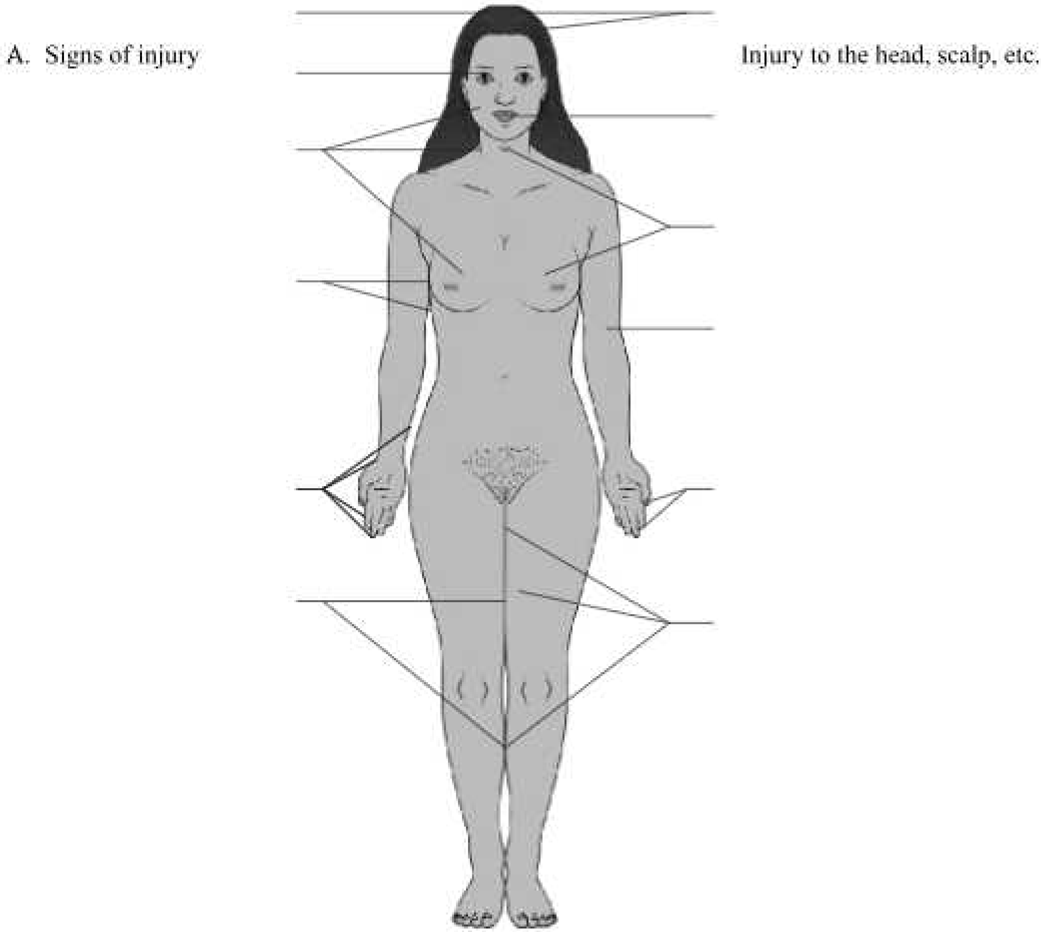
During the examination of the skin, search is required to be made for any loose hair or any other foreign substance on the skin surface. If found, should be collected and preserved for further investigations.

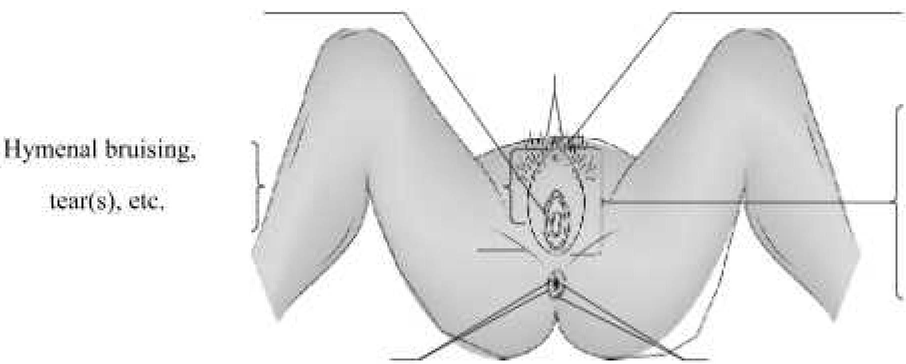
Fingernails demand close examination. Presence of ragged or broken nails, any chipping of nail polish/varnish, etc. should be observed. General shape and configuration of the nails should also be noted. Blood or even skin tags may be found under the nails, which need to be scrapped out carefully and sent to the FSL for blood grouping or even DNA profil- ing, which may match a suspect later in the investigations.

The whole body surface must be scrutinised for injuries including any old injury (Fig. 20.3A). Specific attention should be paid to the recent injuries. The following injuries, in isola- tion or in varying combinations, may be encountered:

Abrasions, although minor injuries in themselves, may carry importance. These injuries may be the result of fingernail marks or frictional movements against some hard rough sur- face or of scratches by thorns, grass or other foliage. Abrasions on the flanks may be the result of forcible and rough pulling down of underclothing of the victim by the assailant.

Bruises are often considered an important corroborative sign of use of force, and their exact size, shape and position should be recorded. The fact that they change their colour with the passage of time and also that they may not appear on the skin surface for up to a few hours after the injury should be kept in mind. Of particular importance are the small, roughly circular or oval fingertip type bruises consistent with grasping injury and may sometimes be associated with an opposing bruise on the opposite side of the limb or neck, caused by contralateral digital pressure. Bruising on the inner surface of the thighs or knees, if seen, may be suggestive of victim's legs being forced apart by the pressure exerted by the assailant. Ultraviolet lamp has a place in the examination of bruising too. Before the colour changes are apparent, areas of extravasated blood beneath the skin can be appreciated if the area is illuminated by ultraviolet light.





PERINEAL INJURY

Bite Marks Bite marks may either by produced during excessive demonstration of love/enjoyment/passion where they usually present as an area of reddish-purple discoloura- tion showing tiny haemorrhagic dots with haphazard distribu- tion produced by suction coupled with pressure or the marks may be result of robust infliction where they are the result of strong apposition of teeth leaving an impact abrasion and occasionally laceration. In the former case, they may imply 'willing participation' in the act whereas in the latter case, it may imply infliction against resistance. Opinion of a forensic odontologist may be sought.

In the context of bite marks, examination of the lips of the victim also demands attention. It is inner surface, which is usu- ally involved with blows to the face or by the pressure of hand/ hands across the mouth to prevent screaming or by violent attempts at kissing the victim.

Under general examination, eyes also deserve observa- tion. The pupils and the reflex activity give an indication about intoxication or concussion following a blow or any other blunt force impact to the head. Redness and swelling of the eyelids and general suffusion of the conjunctivae may be consistent with history of prior crying. Petechial haemorrhages on the conjunctivae, eyelids and the skin of the face may be due to pressure on the throat during the act of the assault.

SPECIFIC EXAMINATION

Examination of the genital area should be carried out in good light with the patient in a comfortable position so as to allow full exposure of the genital area (Fig. 20.3B). The usual sched- ule to be followed may be as under:

Pubic Hair The pubic hair should be inspected; any matted hair, if present, should be cut away as close to the skin surface as possible and retained for laboratory examination. Entire pubic area should next be combed and any evidence available collected. For comparison purposes, some pubic hair should be pulled out so that the root characters are available for com- parison purposes. Hair often may be transferred between the parties by the contact necessary during the act.

The species of hair and the part of human body from where the hair had come can usually be determined by micro- scopic examination. The advent of Neutron Activation Analysis (NAA) has led to many claims of knowing individuality of the hair sample(s) but as yet it is not regarded as a method of positive identification.

Tops of Thighs, Vulva, and the Perineum These should next be examined and any area of injury or soiling be noted. Swabs from the introitus, perineum, and the anal margins should be taken before any digital contact has been made for examining the area. A brief account of injuries ordinarily expected at various age groups needs some description.

At the outset, it needs be remembered that there is great variation in the appearance of the external female genitalia, with age, sexual maturation, body size/shape, and other attend- ing factors depending upon the circumstances of each case. As a general rule, the younger the individual, the more prominent the tissue of the unoestrogenised genitalia and further, the more likelihood of these becoming contused, abraded, or lacerated. Injuries (or lack thereof) need be carefully recorded and docu- mented photographically.

In a child victim, sexual violation prompts skilled investi- gations. History in this context needs efficient documentation so as to have deductions appropriate to the victim's age. Major reason for paucity of diagnostic findings in such cases is the fact that children being reticent about reporting such conduct and in the event of reporting, frequent delays become instru- mental in letting the acute changes fade away. Since it is diffi- cult to visualise hymen in the children (because of its deep seated position), efforts need to be taken so as to record the findings effectively. (It may be necessary to apply either some local anaesthetic solution to the parts, or to administer general anaesthesia.) Additionally, vagina being very small, penetration of adult organ is usually prevented. As such, assaults on chil- dren mostly involve only fondling, simulated intercourse such as intercrural connection (i.e., penile friction between the inner thighs and external genitalia), or, oral or anal penetration. Hymen, therefore, is usually found intact and there may be redness plus tenderness of vulva. However, where there has been penetration, bruising and/or tears of anterior and poste- rior vaginal walls can occur. The hymen may be partially or wholly destroyed or may show bruising and/or lacerations.

In a prepubertal victim, vaginal penetration usually results in tearing of the hymen in the posterior 180°, i.e. between 3 and 9 o'clock position. These lacerations/tears may be associated with bruising or abrasions ventrally as well as to the posterior four- chette. The hymenal tears usually heal within 5 or 6 days and become shrunken and look like small tags of tissue after a week to 10 days. The labia may be red and inflamed. Usually some oedema of the vaginal introitus is present. Frank injury to the labia is not common, but some scratches/abrasions may be occasioned through scratching the part in case of poor hygiene of the area. Swelling and congestion of the mucosa at the introitus, the clitoris and the labia minora may also be caused by digital stimulation or masturbation. Minor tears may be seen in the regions of fourchette and fossa navicularis pro- duced by excessive stretching of the skin. Vaginal walls need careful scrutiny. There may be abrasions, bruising, lacerations neck including the adjoining facial area as a result of alleged 'smothering'. The victim, about 10–year-old female child, was taken by the alleged assailant (a known person to the family) who tried to perform sexual intercourse with the victim but however, failed to introduce the organ. He then attempted to widen/dilate the genital passage by introducing 'sugarcane pori'. To this, the victim cried helplessly. The alleged assailant becoming panicky, smothered the child to death (contributed by Dr. GS Mann, et al.) or any permutation and combination of these. Bruising of the vagina is seen as dark red areas against overall redness of the vaginal mucosa (within 24 hours, the colour becomes deep red or purple). It is more frequently seen on the anterior vaginal wall in the lower third, and on the posterior wall in the upper third. Bruising of this nature tends to substantiate penile pen- etration than the digital penetration. Frank lacerations can occur if there is gross disproportion between the penis and vagina, or in cases where some foreign bodies have been inserted into the vagina. Lacerations are usually seen in posterior fornix of the right side of the vault, and less frequently in the left side. In cases where there are no fresh injuries, vaginal examination needs to be conducted to assess (i) the laxity of the vaginal orifice, (ii) the length of the vagina into the posterior fornix, (iii) the number of fingers that can be introduced through the hymenal orifice and (iv) the areas and the degree of tenderness, etc. Such examination helps the examiner to assess elasticity of the hymen and to determine the degree of penetration that would be possible without its rupture.

In a postpubertal victim, oestrogenisation of the hymenal tissue provides some protection from the injury associated with intercourse and sexual assault. The oestrogenised hymen is elas- tic, and penetration can occur without leaving lacerations or dis- ruptions. The degree of any damage will depend upon the elasticity and/or pre-existing dilatation of the hymenal ring, disproportion between the penis and vagina and the amount of force used.

In a postmenopausal victim, injury to the genitalia is fre- quently sustained because the nonoestrogenised atrophic mucosa is relatively dry and friable, and therefore, gets easily trauma- tised. Further, as the elderly may develop bruising with less force than do normal healthy younger adults, trauma may be found with greater regularity (however, physical injuries must not be interpreted in a vacuum and their differentiation from changes occasioned through ageing and disease processes need be taken into consideration for ultimate interpretation). Frequent sexual intercourse and parturition usually destroys the hymen which is then represented by several small tags of tissue, called as carunculae hymeneals or myrtiformes.

HYMEN

One area of frequent confusion to medical investi- gators is normal variation in human morphology. The hymen is no exception (Lincoln C, Genital injury: is it significant? Med Sci Law 2001;41(3):206–16). The hymenal tissue undergoes distinct changes from the newborn period to the puberty and afterwards. In the newborn, it is thickened and redundant under the influence of maternal oestrogen, changing to nono- estrogenised state of 'scanty' hymen of childhood. At puberty, oestrogenisation of the hymenal tissue makes the tissue elastic and accommodative as detailed above. More commonly, it is an annular or ring shaped, moderately elastic membrane about 1 mm thick with a connective tissue core and stratified squa- mous epithelium on either surface. It is usually deficient ante- riorly and most pronounced posteriorly. It has a central or ventral opening that in due course provides outlet for the men- strual flow. Several distinct variants have been described:

- Annular—a circumferential ring of thin or thick tissue, perforated near the centre.

- Semilunar—this common variant has a crescentic shape with concavity upward.
- Septate—representing as a band of tissue running down the middle.
- Cribriform—multiple naturally occurring perforations through to the vaginal canal.
- Microperforate—showing large posterior component, with a tiny opening into the vaginal canal.
- Fimbriated—showing fringed edge.
- Vertical—with a vertical slit-like opening.
- Imperforate—absence of opening.

Studies have shown that notches or clefts are often found on hymenal edge/margin, and the examiner must be careful not to let the normal anatomical variants be a confounding error in the interpretation. Natural notches are usually sym- metrical, occur anteriorly, do not extend to the vaginal wall, and are covered with mucous membrane. Tears caused by sexual intercourse or by foreign body are usually situated pos- teriorly, or in the midline, and usually extend to the vaginal wall and are not covered with mucous membrane.

Rupture of hymen on first penetration is common but not inevitable because the thin elastic membrane is quite capable of stretching to accommodate penetration by erect adult penile organ. Furthermore, nonrupture may be on account of incomplete penetration or tough fleshy nature of the hymen or large hymeneal opening due to practice of masturbation or due to deeper placement of hymen as in young children. Smith and Fiddes report of finding an unruptured hymen in a woman who had been a prostitute for three months. Contrarily, there can be causes of rupture of hymen other than the intercourse, since masturbation, trauma (especially in athletes), mechanical dilatation, surgical operation, gynaecological examination, for- eign body insertion (sola pith being introduced into the vagina for rendering young girls fit for sexual intercourse—aptae viris), ulceration due to any cause, scratching of the parts due to irritation from lack of cleanliness, etc. may affect the condition of the hymen. During forcible penetration, evidence of rupture of hymen may be forthcoming but the character and extent of the injury will vary in different cases depending upon the nature of the hymen, disproportion between the male and female parts, the extent of penetration and the amount of force applied. Rupture of hymen is almost always associated with some degree of bleeding, the amount of which will depend upon the extent of the injury and vascularity of the area. If the quantity of blood found upon the girl's underclothing/clothing and at the place where the crime had allegedly been committed, appears to be greater than would reasonably have been expected from an injury to the hymen, one may be led to suspect that assailant might have received injury to his genitals too. Apart from such injury to the male, coitus may cause considerable bleeding where a small hymenal vessel has been incompletely torn. The severed edges do not unite but become rounded off in the process of healing, which may occur in 2–3 days if the tear is slight but more extensive tears may take a longer period to heal. It is not possible to date the injury of the hymen after it has completely healed. In women who are habituated in sexual intercourse and who have borne children, the remains of the hymen constitute what are known as caruncula myrtiformes, which are situ- ated around and close to the vaginal orifice presenting an appearance of small, different sized fleshy projections.

Above all, it is virtually impracticable to differentiate tears from digital penetration from those of penile pene- tration, though it is considered that tears due to digital pene- tration are often incomplete and not extending to the margins of the hymen but the penile tears due to limited penetration may also show similar findings. Frequently, there may only be abrasion or/and bruising of the hymen without rupture. Fingernail scratches may be seen, as well as general abrasions and redness or intradermal bruising from manual manipula- tion may be present. Extent of bruising, elasticity of the hymen, size of the hymenal orifice and the size of the penile organ (if the suspected assailant is also available for the exam- ination) should be taken into consideration for differential diagnosis.

From the above description regarding hymen and its rupture/nonrupture, it may be inferred that while recent rupture of hymen would suggest the introduction of an instru- ment of some kind and while loss of hymen does not neces- sarily indicate loss of virginity, its persistence does not unequivocally suggest existence of virginity (Table 20.1). To have some satisfactory evidence of virginity, various signs like intact hymen, a normal condition of fourchette plus pos- terior commissure and a narrow vagina with rugose walls must be considered conjointly. Depicting a wide variance in the extent and character of local injury in cases of sexual assaults, a case has been reported in Glaister's Medical Jurisprudence and Toxicology (10th ed.) where a girl of muscular build, aged about 16, alleged that forcible and complete intercourse had been performed on her by five men on ten occasions within 4 hours but no recent hymenal tear was demonstrable. In the same book, it has also been reported that in a series of 36 cases involving young females, only 16 showed evidence of recent rupture of hymen. The ages of the girls varied from 13 to 16 years.

Sexually Transmitted Diseases (STDs) The diseases for which the victim appears to be at risk may include (i) gon- orrhoea, (ii) chlamydial infection, (iii) syphilis, (iv) genital warts, (v) genital herpes, (vi) chancre and (vii) trichomoniasis. Hepatitis B and HIV infection may also be considered under prevailing scenario. To exclude gonorrhoea, chancroid, syphi- lis, etc., thin films to be made from the smears taken from low and high vaginal passage, gently dried and sent to microbiolo- gist in a sealed container with particulars of the case for fur- ther processing and evaluation. Blood sample should be taken to establish baseline and repeated after appropriate interval (depending on incubation period of each disease) to exclude the same. The STD can be attributed to the victim when (i) the accused is also suffering from the same disease, (ii) the disease appeared in the victim after its known period of incubation after the alleged sexual assault and (iii) the victim was not suffer- ing from the disease prior to the assault (incubation period of gonorrhoea is usually 2–8 days but may vary from 1 to 15 days; that of syphilis is 2–8 weeks, the average being 25 days; and that of chancroid varies from 3 weeks to 3 months).

Opinion

Rape is not a medical diagnosis, it is a legal provision enshrined under Section 375 of the Indian Penal Code. No doctor can be expected to opine as to the consent or nonconsent. All that can be expected from a doctor is the results of his findings and their interpretations. The doctor should make particular obser- vations about the following aspects:

- Any findings indicative of use of force by the assailant.
- Any findings indicative of use of alcohol or any stupefying drugs.
- Any evidence of previous sexual intercourse, i.e. the question of virginity or previous sexual experience may be raised under some circumstances.
- Time elapsed between the examination and the alleged assault.

Differentiating Points between Virginity and Defloration (True and False Virgin)

Virginity **May be defined as 'the state of being virgo intacta', i.e. a woman who has never had experience of sexual intercourse.**	**Defloration** **Refers to loss of virginity, i.e. a woman having had experience of sexual intercourse.**
Hymen is a membranous structure, varying in position, consistency, structure and shape. In children, it appears to be situated deeply because of the rotundity of the labia majora due to their excessive fat content. It barely admits tip of little finger in them. Shortly after puberty, it reaches the adult form and is situated at the orifice of vagina, partially closing it. In adults, when the edges of the hymenal orifice/opening are stretched and **it barely admits one finger, the presumption is in favour of virginity.**	**Usually ruptured. Exception being false virgin wherein hymen being thick, fleshy, or fibro-elastic, loose and edges undulated, it may remain intact in spite of repeated sexual intercourse.** **And, the hymenal orifice/opening may allow two fingers to pass through easily. In such cases, accessory signs of virginity (as outlined below in this table) need be considered to arrive at some satisfactory opinion as to whether one is dealing with the true virgin or false virgin.**
Vagina is a tubular organ about 9 cm long passing from the cervix of the uterus to the vestibule. Vaginal wall is composed of three layers: an inner mucosa, a middle muscularis and an outer fibrous layer. The mucosal layer is thrown into transverse **folds called vaginal rugae/rugosities. In a virgin, vagina is pinkish in colour, sensitive to touch, and its walls are approximated.**	**After repeated sexual intercourse, vagina lengthens into posterior fornix and the rugae/rugosities become less obvious so as to enable one to say that the vagina does or does not appear to** **be used to sexual intercourse (such changes are not usually produced with the regular use of tampons or digital**

Vaginal rugae are well-pronounced.	stimulation).
Labia minora are two thin folds of skin within the labia majora (i.e., they are covered by labia majora). Pink in colour and sensitive to touch.	Enlarged, partly pigmented and partly protrude out through the labia majoras.
Labia majora are thick, fleshy, and both side majoras are in close apposition covering the labia minora.	Less fleshy, slightly absorbed, both sides are not in full apposition exposing the labia minora.
Fourchette (lower or posterior meeting point of labia minoras)— intact and crescent shaped	May show healed tear
Posterior commissure (lower or posterior meeting point of labia majoras)—intact and crescent shaped	May show healed tear
Fossa navicularis (depression between the fourchette and the vaginal opening)—less conspicuous.	More conspicuous after repeated sexual intercourse.
Vestibule (the space between the labia minoras and above the vaginal opening)—narrow	Widen
Breasts—variable in size, firm, hemispherical with pinkish smaller areola and small nipples.	Variable in size, may be flabby or moderately pendulous, with wider areola and large and raised nipples.

Note: In the alleged rape and murder of two Shopian women, the team of doctors from AIIMS, New Delhi could reportedly rule out rape in the younger girl by observing intact hymen and the orifice/opening admitting tip of the little finger, vaginal wall being normal in appearance. Anterior and posterior commissures being normal. The team concludingly remarked (as gathered from the news reports): "there was nothing suggestive of penetration of penis or the like object through the hymenal orifice/opening".

The first three aspects have already been dealt with. The fourth needs some further elucidation. This is possible from the dating of various injuries present upon the victim and also from the findings present in and around the genitalia. In charges of rape, this aspect is of utmost importance in order to authenti- cate the victim's statement or to reveal discrepancies in her account. The various points in this concern may be as follows:

- Some engorgement of vaginal mucosa associated with swell- ing and redness of the introitus and labia minora may be suggestive of sexual contact but not conclusive of recent sexual intercourse.
- Pooling of seminal fluid in the vagina may speak of recent sexual intercourse but this pooling may rapidly drain out if an upright posture is adopted soon after ejaculation had taken place. Furthermore, there may be no pooling at all if a condom was worn or if ejaculation had taken place outside the vagina.
- In the living, the body reactions tend to clear the vagina of the foreign proteins. Motility may be maintained up to a couple of hours after the ejaculation into the vagina with the number of motile sperms gradually becoming less. Samples recovered from vagina may demonstrate identifiable sperms for as long as 48 hours and occasionally, even lon- ger. However, the persistence of motility is variable as it is influenced by a host of factors as enumerated below:

Factors attributable to the assailant:

- Alcoholism
- Drug addiction
- Diabetes

- Inflammation of the seminal vesicles
- Hot bath or hot sponging of the genital area prior to the act. (Temperature of the scrotum is usually 3–8° C lower than the body temperature. Any prior hot bath or sponging may therefore affect the motility of the sperms. The fond- ness for long hot baths had been blamed by the historians for the downfall of Roman Empire!)

FACTORS ATTRIBUTABLE TO THE VICTIM:

- Different phases of menstrual cycle have different effects on the motility of sperms, between 14 and 18 day of the cycle, motility lasts the longest in the female genital tract.
- Different areas of genital tract also have influence upon the motility of sperms. Sperms retain their motility much lon- ger in the cervix than in the vagina because the acidic pH of vagina may rapidly destroy the motility of sperms. Specimens obtained from the uterine cavity where the pH is alkaline may include living sperms even at the end of a fortnight after insemination.

In some instances, the accused may be azoospermic, namely:

- The very old
- The very young
- Those suffering from a variety of diseases involving epi- didymis, testes or seminal vesicles or some general diseases like tuberculosis, mumps, etc.
- Those who have undergone vasectomy
- Moreover, seminal fluid of a healthy man may be devoid of sperms if he has experienced numerous ejaculations over a relatively short span of time.

Therefore, in a case where the assailant is vasectomised, demonstration of the fluid to be of seminal origin requires demonstration of acid phosphatase enzyme. Prostatic secre- tion element of the semen contains rich percentage of acid

phosphatase than any other body fluid including vaginal fluid/ vaginal secretion (vaginal secretions usually contain small quantities of acid phosphatase of the order of 340 interna- tional units per litre). It rises to about 3000 international units in about 2–3 hours after the intercourse and gradually returns to normal in about 12–24 hours. Any level higher than 340 IU indicates seminal fluid. However, with the discovery of pros- tate specific antigen (P-30) and seminal vesicle specific antigen (MHS-5), which are specific to human semen, acid phospha- tase test is usually done as a screening test. P-30 is present in both normal and aspermic semen. Reportedly, it is detectable in vaginal fluid for a period of about 24 hours after the inter- course as compared to about 12 hours for acid phosphatase. When the fluid has been identified to be of the seminal origin, ultimate specificity (i.e., whether it belongs to the assailant or some other person) can be achieved through DNA testing.

RAPE TRAUMA SYNDROME

Sexual victimisation is associated with emotional, cognitive, and behavioural effects. These tend to be more chronic and severe than following other nonsexual violent crimes. The term 'rape trauma syndrome' was first described in 1970s by Burgess and Holstorm. Burgess et al. described two phases of this syndrome:

(i) An immediate or acute phase of disorganisation, characterised by emotional reactions of several kinds like acute tension together with feelings of guilt and humiliation.

(ii) A long-term or delayed phase of reorganisation during which the victim readjusts her life as far as possible. Presently, the syndrome is considered as a variant of 'post-traumatic stress disorder' (PTSD).

In the developed countries, Rape Crisis Centres have been established to provide counselling to the rape victims, and friends and relatives of the victim. These centres are largely staffed by volunteers, nonprofessional women (some of whom have been raped in the past), or who have been close to someone who was raped. Of late, the Apex Court of India has come to the rescue of victims of sexual assault and sexual harassment by holding that interim compensation may be awarded to a rape victim by a court of competent jurisdiction during the pendency of criminal trial. In a case from Kohima (1995), a lecturer who had married the victim (his student) and later refused to recognise her as his life partner was asked to pay interim compensation of | 1000 per month to the victim until her charges of rape, cheating, and other criminal offences were decided by the trial court.

ACCIDENTS FOLLOWING RAPE

Death may occur as a result of rape from shock due to fright and mental emotions occasioned in an effort to overpower the assailant, or due to excessive bleeding from genital and/or perineal injuries, especially among children. Injuries may cause delayed death from septic infection after several days or weeks.

Cases have been reported where death occurred from suffocation caused by covering the mouth and nostrils or by thrusting a piece of cloth down the throat to prevent the victim from crying for help. At times, the victim is first raped and then killed to destroy the evidence and also prevent identification of the assailant by the victim. On other occasions, it could be due to some misadventure (i.e., as a result of abnormal intercourse). The victim may die of choking especially at the moment of ejaculation during oral intercourse, or be choked by a plug of wool (or similar material) placed in the mouth to retain the seminal fluid. (A case has been reported wherein death had resulted from suffocation. A plug of cotton wool was recov- ered from the throat at the time of autopsy and was later found to have been contaminated by semen.)

EXAMINATION OF THE MAN SUSPECTED OF COMMITTING RAPE

In cases where the suspect is available for examination, he should preferably be examined by the same doctor who had examined the victim, as it would provide an opportunity for correlating the injuries found on the victim and physical fea- tures of the suspect. If this is not practicable, any doctor exam- ining the suspect should follow a set schedule that embraces all the essential points of examination and collection and preser- vation of samples. The pre-requisites for the examination of a suspect are same as those for the victim except that here the presence of a female attendant is not necessary.

GENERAL EXAMINATION

Height, weight, general built, routine examination of the systems, body surface from head to foot for any area of soiling, stains or injuries, etc. Presence of any typical abrasions consis- tent with production by fingernails or any bite marks should also be noted (Fig. 20.5A).

SPECIFIC EXAMINATION

This examination again may be carried out on some set schedule. Firstly, pubic hair may be observed for any matting, foreign hair, any other trace evidence, etc. Then, penile, scrotal and perineal regions should be inspected (Fig. 20.5B).

The findings upon these regions will more or less be dic- tated by the time interval between the alleged offence and the time of examination. When the suspect is examined within a few hours of the alleged offence or if he has not washed or bathed since the offence, the following useful findings may be appreciated:

The penis, especially the glans and the prepuce, may appear moist due to vaginal or seminal fluid. A swab should be taken and examined. To demonstrate the presence of vaginal fluid, the glans is soaked with moist blotting paper, which is then exposed to iodine vapours. Brown discolouration of the soaked part of the paper indicates presence of vaginal epithelium, as these cells contain glycogen that turns brown in the presence of iodine vapours.

Abrasions and/or bruises may be observed on the glans and prepuce and also on the frenulum. They may be inflicted by the victim during the struggle for self-protection or for preventing the act to be established or during forcible intro- duction of the organ into the vagina or due to disproportion between the size of the penis and the vaginal opening.

Swabs from the urethral orifice should be taken. Faecal soil- ing, blood and foreign hair are most likely to be trapped in the area of the coronal sulcus, particularly in the uncircumcised even if there has been an attempt to wash the genitals after the act.

If the suspect is not circumcised, the presence of smegma around the corona glandis is considered as suggestive of absence of sexual intercourse within the last 24 hours, since it gets rubbed off during the sexual act (smegma is a thick, cheesy secretion of sebaceous glands with a disagreeable odour, consisting of desquamated epithelial cells and smegma bacilli chiefly found beneath the prepuce). Nevertheless, the presence of smegma as proof against sexual intercourse need not be considered carrying any medicolegal value, as legally, mere penetration of the vulva is enough to constitute rape and therefore, it is unlikely that smegma will be rubbed off. Further, smegma accumulates if no bath is taken for 24 hours. Conversely, during customary daily bath, the prepuce is generally retracted for washing and any accumulated smegma gets washed away. It is well-known in the medical world that exam- ination of the smegma loses all importance after 24 hours of sexual intercourse (SP Kohli vs. Punjab and Haryana High Court AIR 1978SC1753, CrLJ 1804).

With the increasing use of condoms, one must look for a

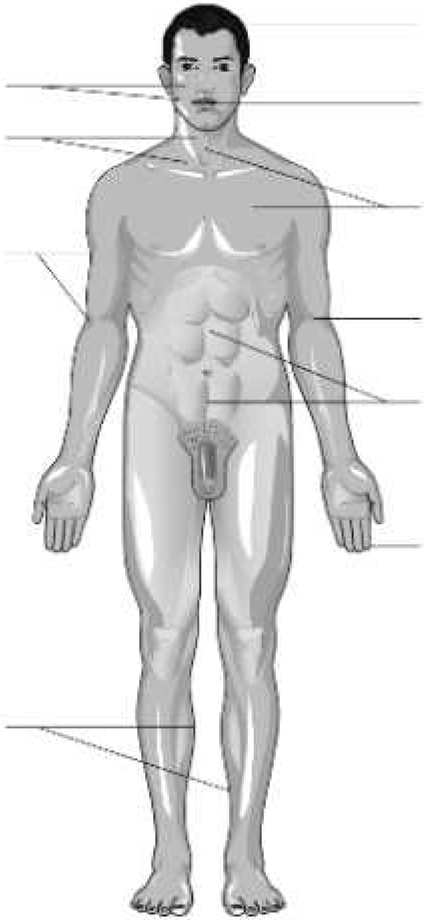
used condom. When available, blood stains and vaginal epithelial cells from the outer aspect of the condom and semen from the inner aspect may be obtained. Obviously, the most impor- tant identifying element is the documented presence of ejacu- late. DNA profiling has made the identification of the assailant possible so that the retrieval of spermatozoa is more critical than ever before. In a case, a used condom containing semen of the possible perpetrator was obtained from the deceased female's genitalia. Such a specimen needs be removed with great care, the end tied so as to retain the contained fluid.

The status of the accused may be examined to determine if there is anything to suggest that he is impotent. However, it has been submitted that potency being the usual and normal state in a man, it will always be presumed to be so, unless the contrary is proved by the accused through medical documenta- tion (see Annexure 5).

History Taking of Alleged Assailant

It also includes general and specific. Specific history here, of course, will be related to the questions regarding male. Explanation for any mark or injury upon the body must be sought.

Again, general observation of the individual should be maintained throughout the history taking and examination including his demeanour. Clothing must be assigned due importance as detailed earlier under the heading Examination of the Victim.



Blood (for toxicology and STD evaluation)

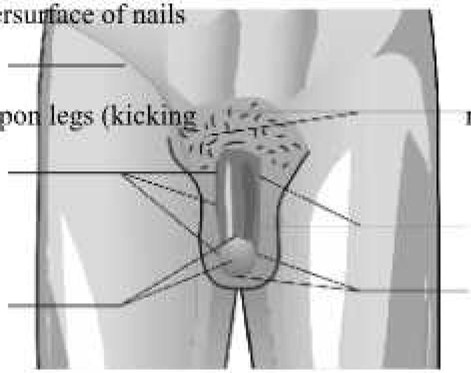
Swabs from areas suspected of having some staining, soiling, or carrying some trace evidence

Any tissue from the undersurface of nails

Any patterned bruising upon legs (kicking resistance)

B Signs of injury

Specimens



Vasectomy scar? (However, vasectomy does not preclude demonstration of the fluid to be of seminal origin)

Abrasions, bruising of glans, prepuce and/or frenulum, etc. (reminiscent of victim's efforts to prevent perpetrator's designs towards penetration) Swabs from glans and prepuce

Pubic hair combings to collect any foreign hair, fibre, or some other trace evidence

- Swabs from penile shaft
- Coronal sulcus, urethral swabs

IDENTIFICATION OF THE ALLEGED ASSAILANT

In the prosecution of a case of rape, the identification of the alleged assailant is a critical component. This may be gathered from the following:

- Evidence of vaginal epithelial cells upon the penis (if present).
- Fragments of skin or hair under the nails of the assailant transferred from the victim.
- Signs of injury on the general body surface and/or upon the

local area, particularly scratches and bite marks on the hands, arms and face of the assailant.

- The presence of seminal fluid in vagina may be tested for its compatibility with the semen of the assailant by group- ing the samples, similar phosphatase activity levels in the samples and the similar percentage of spermatozoa in the two samples may be indicative of common origin. However, a caution needs to be exercised in this regard because vari- ous chemicals may lead to erroneous results, either in a positive or negative direction. Ethanol and fluoride inhibit prostatic acid phosphatase. Many antiseptic solutions con- tain free phenols, which may contaminate the vagina because the victim's fear of impregnation and of contract- ing some disease results in rapid washing of the parts with some readily available solutions. These solutions may remove the seminal material or introduce factors that inter- fere with the detection of the constituents of seminal mate- rial. DNA profiling of the samples is the latest achievement towards positive identification.

OPINION

There is no single finding on examination of either the female or male that can point conclusively towards rape. It has aptly been said, 'Rape is an allegation, easily made, hard to prove and harder to disprove'. The opinion regarding the potency of the accused should be expressed in a negative form, i.e. 'from the examination, there is nothing to suggest that the individual is incapable of performing sexual inter- course', if he happens to be a healthy normal individual.

INCEST

This is an act of sexual intercourse by a man with a woman within a certain degree of blood relationship. Incestual practice is prohibited in most of the countries but not in India. In India, though it is not generally an accepted practice, in some parts, it is not only allowed but also promoted by compulsive marriage between the relatives.

From the ancient times, it has been recognised that there were genetic risks in births arising from the mating of close relations and from the Biblical period, lists of 'prohibited degrees' of relationships were declared. The extent of these lists varies from country to country and even between religious and secular codes in the same country. The commonest example is of a father indulging in sexual activities including intercourse with his daughter. Instances of brothers and sisters are less common and, at times, may be due to timid personalities.

A doctor's first duty is the welfare of the patient; therefore, he must evaluate the relative needs of the members of the family. Overriding all the considerations, he should promote the interest of the abused person.

INDECENT ASSAULT

Indecent assault generally means sex-linked misbehaviour towards a person of opposite sex or same sex. The desire may simply be to get sexual gratification but not necessarily aimed at intercourse. Often the acts are intended to insult a person or to embarrass the victim. This can mean many things, from an unproven rape to merely touching the buttocks in a crowded place, fondling of breasts, thighs, perineum, putting hand into the female's skirt or blouse, etc. Only a few have medicolegal aspects when some injuries having sexual attributes occur in the form of bite marks, abrasions, love bites, etc. The offence is punishable under Sections 351 and 354 of IPC.

After the August 1997 judgement of the Supreme Court in Vishakha case, guidelines for the prevention and redressal of sexual harassment of women at workplace were issued, which came to be known as Vishakha guidelines. In that light, a Bill has recently been introduced in the Parliament entitled, 'Protection of Women Against Sexual Harassment at Workplace Bill 2010'. According to this Bill, sexual harass- ment includes such unwelcome sexually determined behav- iour, whether (i) physical contact and/or advances, (ii) a demand or request for sexual favour(s), (iii) sexually coloured remarks and/or gestures, (iv) showing pornography and (v) any other unwelcome physical, verbal or non-verbal conduct of sexual nature. The Bill provides protection not only to women who are employed but also to any woman who enters the workplace as a client, customer, apprentice and daily wage worker or in ad hoc capacity. Students, research scholars in col- leges/universities and patients in hospitals have also been covered. Further, the Bill seeks to cover workplaces in the unorganised sectors too.

UNNATURAL SEXUAL OFFENCES

Section 377 IPC deals with unnatural carnal intercourse with any man, woman, or animal. The word 'carnal' is an ancient word which used to denote 'sexual' in the legal parlance. However, the word has been derived from Latin 'caro carnis' meaning 'of the body or flesh'. Therefore, this section, though generally understood to be applicable to penetration per annum, it also covers acts like putting the organ into the mouth of a human being (coitus per os), performing intercourse in the armpits (playing the bagpipes), submammary fissures or inter-crural folds, etc. The Section is wide enough to include a woman also, i.e. carnal intercourse by a woman with an animal is also covered under this Section (Section 47 of IPC defines 'animal' as denoting any living creature, other than a human being).

SODOMY

Sodomy means anal intercourse between two males (homo-sexual) or between a male and female (heterosexual). It used to be practised in the town of Sodom, from where it acquired its name. The Greeks of the Golden Age also practised it and therefore sometimes it is called Greek Love. It is also called Buggery.

In the United Kingdom, acts of anal intercourse are no longer criminal offences if they take place between the con- senting adult males (of and above the age of 21 years) and the act is carried out in private. As per Indian Law, both the active and passive partners are guilty of the offence, even if the act has been committed with consent and the consenting party is equally liable as an abettor.

The offence mostly involves two males. Sodomy is popu- larly referred to as paederasty when the passive agent is a child, who is known as catamite. A paedophile is an adult who frequently engages in sexual activities with children.

A homosexual component exists in everybody, but it varies quantitatively in different individuals and also varies at differ- ent epochs of life. The condition may be due to arrested devel- opment of mind. In hostels, prisons, military barracks, etc., this may be seen commonly where the boys or prisoners may act alternatively as passive agents for sexual gratification. There is a class of people in India known as eunuchs, whose main means of living is passive paederasty. They are therefore known as male prostitutes. Among them, there are two groups—the Hijrahs and the Zenanas. The hijrahs add to their tribes by recruiting boys and castrating them. On healing, the scar invaginates and their external genitals therefore look like those of females on a cursory observation. Being castrated before puberty, they develop feminine characters owing to loss of influence of male hormones. Consequently, they possess feminine voice, feminine type of distribution of fat and hair and develop some breasts. They dress like women, wear ornaments and adopt female tastes and habits. The zenanas live separately and their genitals are intact.

EXAMINATION OF THE PASSIVE AGENT

PRE-REQUISITES

(a) A requisition for the examination from an authorised person.

(b) Identification of the victim by the parent or guardian and noting of identification marks.

(c) Consent for the examination from the individual or parent or guardian as the case may be.

(d) Presence of a female attendant while examining the female passive agent.

HISTORY

General The general history includes the following:

- Details of past illness
- Surgical operations
- Any recent medications or alcoholic intake

- Bowel habits and any operation or instrumentation on bowel
- In case of female passive agents, details of childbirth or any instrumentation during delivery that may alter the normal anatomy of the anal verge and perineum.

Specific The specific history includes the following:

- Date, place and time of the alleged act
- Use of violence
- Use of any lubricant
- Any history of pain, bleeding from the anal canal
- Has the patient defecated since the alleged act
- Has there been any change of clothing
- Has the patient bathed or washed the anal area
- Clothing deserves a special mention. If not changed, they should be removed one by one by making the patient stand on a white sheet of paper so that any trace evidence, if available, may not be lost. Due precautions as stressed under the examination of the victim of rape should be practised in collection and packing of clothing for further laboratory examination. Particular attention should be paid to the crutch areas of under clothing for presence of seminal or blood stains or fecal/lubricant soiling.

EXAMINATION

General physical examination on the same lines as mentioned earlier.

Specific examination of the area in and around the anus and genitalia:

Firstly, pubic hair need attention. Any matted area, if pres- ent, should be cut as close to the skin as possible and sent for laboratory examination. Any other entangled foreign hair or trace evidence should be looked for.

Penis also invites examination because in many cases, oropenile contact is either preliminary to anal intercourse or is actually the entire extent of sexual contact. Swabs should be taken from the penile shaft and glans penis for the presence of salivary traces or any other material.

Perineum needs observation with special attention to the anal verge under good light and patient in knee-elbow position.

Before any digital examination is proceeded, swabs from the perineum, and verge and deeper regions of anus should be obtained.

Anal area: the appearance of anal verge must be noted carefully. Normally, the anal orifice is slit-like, running antero- posteriorly; surrounding skin shows marked natural folds due to the act of corrugator cutis ani muscle. In cases where anal intercourse has taken place, commonly there are changes in the normal anatomy, and the extent of such changes is dependent upon the following factors:

- Frequency of acts of anal intercourse
- Time interval between the last act of intercourse and the examination
- Age, built and the size of the orifice in a particular individual
- Degree of force applied during the act
- Size of the penile organ
- Use of lubricant

First ever intercourse tends to produce changes in the appearance of anal verge, which may vary from overt tearing of anal skin and underlying sphincter muscle or splitting of skin and production of anal fissure or to the mere abrasion/ bruising of the verge. Abrasions may be seen frequently that may be superficial or deep and present on any part of the cir- cumference of the anal verge. They can be produced by mod- erate frictional shearing of the penetrating penis but may also be caused by fingernails during the act of scratching due to poor hygiene of the area or rarely when the impact is upon this area. They may be extensive in cases where there is great dis- proportion between the anal orifice of the victim and the organ of the accused. Effective lubrication of the part will tend to reduce the production of these abrasions.

Bruising of the area, in and around the anus, may also be present in some cases.

Tearing of the sphincter is rare in case of adults, but can occur in children. Owing to the great contraction of the sphincter, the penis rarely penetrates deeper and consequently the tearing produced, if any, is usually triangular in nature hav- ing its base at the anus and sides extending vertically inwards into the rectum. Again lubrication and slow introduction of the organ may prevent these changes to appear.

Anal fissure, if present, are splits in the skin of anal verge and they may be restricted to the external skin only or may extend within the anal canal to the mucocutaneous junction. The situation of the anal fissure is dictated by the muscular support of the skin of the anal verge, and this tends to be the weakest at the posterior quadrant and consequently the fissure is commonly observed in that region. In case of women who have had children, the support is reduced anteriorly as well, and therefore anterior fissuring may also take place.

At the end comes the examination of anal canal and lower rectum with the help of proctoscope. Inner region should be looked for any injury, bleeding or seminal deposition or for deposition of any other material. Swabs may also be taken with the proctoscope in situation. If there is spasm of the sphincter, examination may be carried under anaesthesia.

SIGNS OF HABITUAL ANAL INTERCOURSE

The signs usually met in a passive agent habituated to the act of sodomy may be as follows:

- Shaving of the anal hair but not necessarily the pubic hair.
- Dilated and patulous condition of the anus, as normal folds at the anal verge tend to be lost so that the anal margins appear much smoother.
- Thickening of the skin at the anal margins that may extend into the anal canal up to the mucocutaneous junction.
- Scars of the healed fissures may also be seen.

- In extreme cases of habitual intercourse, the anus may be 'deep-seated' so that the anal area looks as though it is situ- ated in a funnel-shaped depression. But this may be absent in strong healthy individuals habituated to the act as passive agents, while it may be normal within some weak debilitated individuals or old women. The useful guide as to the patient's habituation to anal intercourse is lateral buttock traction test, in which the thumb is placed on the cheeks of the but- tocks on either side of the anus and gentle lateral traction is applied. In patients who are not accustomed to anal pene- tration (penile or instrumental or any other), the traction results in reflex constriction of the anal sphincter; the patients who are used to anal penetration react to the lateral traction by relaxation of the sphincter. But history of sur- gery or anal instrumentation should be excluded. Some natural disease should also be taken into account, if pres- ent. Presence or absence of gonorrhoeal discharge, chancre or condylomata should also be looked for. The same prin- ciples apply here as mentioned under examination of the victim of rape.

THE OPINION

It should be given on the same lines, i.e. interpretation of findings only. All the findings must be weighed together at the end, viz.

- Presence of semen/seminal stains in and/or around the anus.
- Soiling of the anal region with semen, faecal matter or any lubricant.
- Smearing of clothes with semen, blood, lubricants, mud or any other material.
- Injuries in and around the anus.
- Foreign hair or any other trace evidence in or around the anus.
- Changes in the general anatomy of the anal verge and the surrounding area.

However, it may be kept in mind that no sign may be evi- dent when the active agent has used adequate lubricant and has introduced the organ slowly into the anus without using undue force and the passive agent is a consenting party. Moreover, the acute signs of first ever penetration are usually short-lived and findings may get obliterated within about 24–48 hours. There- fore, the time interval between the alleged offence and the examination is a vital factor in appreciation of the findings.

BUCCAL COITUS (ORAL COITUS OR SIN OF GOMORRAH)

This offence is mentioned in the Bible. It used to be practised in the town of Gomorrah and hence the name 'sin of Gomorrah' is attributed to this practice. Oral coitus may be practised by both sexes. When the male organ is sucked by a female or another male, it is termed fellatio. When female sex organs including clitoris are sucked by a male or another female, it is called cunnilingus. Thus, it may be a heterosexual or homosexual practice. Either way it is punishable by law under Section 377 IPC as mentioned earlier.

There may not be any sign in the face or mouth of the pas- sive agent due to washing but signs of resistance in the form of minor injuries may be present on the face and elsewhere on the body. The penis of the accused may show abrasions caused by the teeth and may have stains of saliva. In the practice of fellatio, some danger to the victim to be choked is present.

HOMOSEXUALITY

The term 'homosexuality' denotes erotic thoughts and feelings is not unlawful and is not specifically covered under Section 377 IPC.

BESTIALITY

In bestiality, a lower animal is chosen for sexual intercourse, which may be practised either through the anus or vagina of the animal. Though it may be seen in both sexes, it is more common in males. She-goat or a hen may be chosen by a male and a pet dog by a female as these are easily available, relatively docile and convenient in size.

While bestiality may be due to sex starvation, the person is likely to be suffering from some mental aberration. In addition, the superstitious belief that venereal diseases are cured by sexual intercourse with a lower animal may lead to bestiality. The accused is generally a young person employed to look after the animals. While being alone with the animals in the fields, he is tempted to indulge in such a practice.

A male accused, on examination, may show his penis stained with mixture of his semen and the animal dung. Animal hair may be seen sticking to the penis or the surrounding area. In some cases, due to being kicked by the animal, abrasions, bruises and/or even lacerations may be present.

On examination of the animal, human semen may be seen in the vagina or the anus of the animal (or the cloaca in case of a hen). Human pubic hair may be present near the peri-anal area towards a person of the same sex as well as any associated sexual behaviour. The expression of homosexual behaviour varies with age and circumstances. Many people prefer to identify sexual orientation by using terms like lesbians and gay men. The terms 'lesbianism' and 'sapphism' have been derived from the island of Lesbos in the Aegean sea, where the practice of female homosexuality was being carried out by an exclusively female population ruled by Queen Sappho.

Psychosexual development of sex-type behaviours spans a broad mix of the elements that comprise 'masculinity' and 'femininity'. There is a continuum, with exclusively heterosexual people at one end and homosexual people at the other; between these extremes are the people who engage in varying degrees of both homosexual and heterosexual behaviour and relationships.

In case of men, homosexual physical intercourse includes oral genital contact, mutual masturbation, and less often anal intercourse. And in case of women, physical intercourse usu- ally includes caressing, breast stimulation, mutual masturbation and oral-genital contact (cunnilingus). Some women may practice full body contact with genital friction or pressure (tribad- ism), or use a vibrator or artificial phalluses (dildoes). Active and passive partners are usually exchanged, although one part- ner may habitually play as active and the other as passive part- ner. A preferentially active lesbian (who is most often a transvestite or transsexual) is known as a butch or dyke, while the usual passive agent is called a femme. In India, the practice

MEDICOLEGAL ASPECTS OF SEMEN

Semen is a human body fluid, stains of which are often involved in sexual offences like rape, sodomy, bestiality, attempted rape and sexual murder. Potency of the fluid carries value in civil cases like disputed paternity or nullity when the defence is impotence. Seminal stains are next in importance to blood stains, which are often found simultaneously on the personal garments/fabrics, etc., from the point of view of involvement and probative value.

Semen is a viscid, mucilagenous fluid with greyish-yellow colour and characteristic odour. It is a suspension of sperma- tozoa in a complex medium called the seminal plasma. The average volume of a single ejaculate ranges between 1.5 and ml. There are usually between 60 and 150 million sperms per millilitre of ejaculate, of which about 80% are motile at the time of ejaculation. The large number of sperms per ejaculate is necessary to overcome anatomical and chemical difficulties encountered by the sperm in its journey to the ovum in the oviduct. The sperms travel through chemically unfavourable vagina (pH-acidic) and pass through the cervix, uterus and ovi- duct in order to reach the ovum and fertilise it. Survival of the sperm depends upon sperm concentration, motility and rate of passage. The degree of motility may further be reported in terms of hypokinetic, normokinetic and hyperkinetic. The usual rate of speed is 1–4 mm per minute.

Thus, the bulk of the semen is seminal vesicle fluid, which is the last to be ejaculated and serves to wash the sperm out of the ejaculatory duct and urethra. The average pH of the com- bined semen is approximately 7.5, the alkaline prostatic fluid having neutralised the mild acidity of the other portions of the semen. The prostatic fluid gives the semen a milky appearance, while fluid from the seminal vesicles and from the mucous glands gives the semen a mucoid consistency. Also, the clotting enzyme of the prostatic fluid causes the fibrinogen of the seminal vesicle fluid to form a weak coagulum that holds the semen in the deeper regions of the vagina where the uterine cervix lies. The coagulum then dissolves during the next 15 to 30 minutes because of lysis by fibrinolysin formed from the prostatic profibrinolysin. In the early minutes after ejaculation, the sperm remain relatively immobile, possibly because of the viscosity of the coagulum. However, as the coagulum dis- solves, the sperm simultaneously become highly motile.

COMPOSITION OF HUMAN SEMEN

Colour: White, opalescent Specific gravity: 1.028 pH: 7.35–7.50	
Sperms: Average count about } From testes (contributes 100 million/ml volume)	about 10% of total
Fructose (1.5–6.5 mg/ml) Phosphorylcholine Ergothioneine Ascorbic acid Flavins Prostaglandins	From seminal vesicles (contribute about 60% of total volume)
Acid phosphatase Spermine Citric acid Cholesterol Phospholipids Fibrinolysin, fibrinogenase	From prostate (contribute about 30% of total volume)
Zinc Phosphate Bicarbonate	Buffers
Hyaluronidase Neuraminidase Zona lysins	Acrosomal enzymes

Although sperm can live for many weeks in the male genital ducts, once they are ejaculated in the semen their maximal life span is only 24 to 48 hours at body temperature. At lowered temperatures, however, semen may be stored for several weeks.

STRUCTURE OF SPERMATOZOA

The mature spermatozoon in the human measures about 60 μm in length and is divided for descriptive purposes into a head, neck and tail region (Fig. 20.6). The head has a flattened pyri- form shape and measures 8–10 μm approximately. The nucleus, which occupies major portion of the sperm head, has a large amount of chromatin comprising deoxy-ribonucleoproteins. Anteriorly, covering like a cap is the acrosome, which is a highly modified lysosome, derived from the Golgi apparatus during spermatogenesis. It consists of a membrane-bound sac of hydro- lytic enzymes and is completely enclosed within the plasma membrane of the sperm cell. The acrosome aids the sperm in penetrating the layers around the ovum.

Acrosomal contents and their functions:

- Hyaluronidase is a hydrolytic enzyme.

(i) It lyses the glycosaminoglycans in the extracellular matrix holding the cells of the corona radiata together. As the coronal cells become more loosely associated, sperm cells can propell themselves inward towards the zona pellucida.

(ii) Hyaluronidase may also be involved in breaking down the zona pellucida.

- Neuraminidase, also a hydrolytic enzyme, removes neur-aminic acid (sialic acid) from glycoproteins. In experimental studies, a neuraminidase-treated zona pellucida cannot be penetrated by sperm cells. Thus, the acrosomal neuramini- dase may aid in preventing more than one sperm from entering an ovum (polyspermy).

- Zona lysins are proteolytic enzymes that are capable of degrading the zona pellucida, perhaps easing the passage of sperm cells through to the ovum.

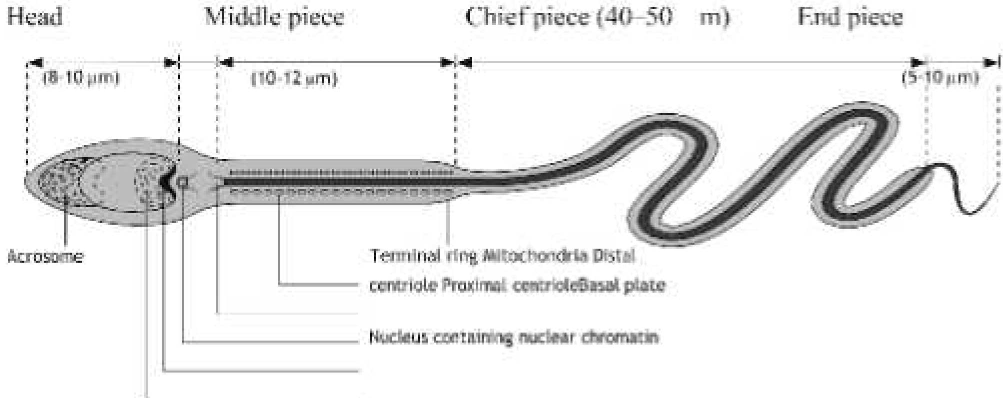
The neck is a short region containing the connecting piece composed of segmented columns and the proximal centriole. The tail measures about 50–60 µm in length and is com- posed of a middle piece, a principal piece and an end piece. The middle piece is about 10–12 µm in length. The core struc- ture is the axoneme, which is surrounded by outer dense fibres and more externally by a sheath of helically arranged mito- chondria. The principal piece is about 40–50 µm in length and is slightly narrower than the middle piece. The fibrous sheath, composed of two longitudinal columns and connecting ribs, is the characteristic component of this segment. The end piece is about 5–10 µm in length and contains only the axoneme and associated cytoplasm.

COLLECTION, PRESERVATION AND DESPATCH OF SPECIMENS

Materials/objects suspected of containing semen are usually sent to the Chemical Examiner of the State Government. Clothes stained with semen should be dried well before des- patch. Moisture will facilitate disintegration of spermatozoa through decomposition. If vaginal contents are to be exam- ined, the specimen should be obtained from the posterior fornix. A small amount of normal saline may be put into the posterior fornix before it is aspirated with a pipette. If a culture is required, the specimen should be obtained with sterile instruments. Several vaginal smears should be made at the same time on clean glass slides. The smears should be immersed immediately in a fixative that contains equal quantities of absolute alcohol and ether. Several vaginal swabs should also be taken and placed in clean test tubes. The swabs should be kept in a refrigerator until they can be examined for acid phosphatase. Suspected stains on pubic or perineal hair should be collected by clipping the hair. Dry stains on the skin are gently wiped with wet swabs, which are then air dried. Every item should be labelled sepa- rately before dispatch; the label should mention the particulars of the case, the site from where it is collected, and the date and time of collection.

SEMINAL IDENTIFICATION

Whether the material/stain is of seminal origin may be judged through preliminary scrutiny by physical and chemical examination.



Ultramicroscopic structure of human sperm.

PHYSICAL EXAMINATION

The naked eye appearance of seminal stains on the fabric depends upon the background on which it is located. Stains on white fabric appear yellow with borders appearing darker than the centre. On coloured or dirty fabrics, no colour may be appreciated. On nonabsorbent surface such as skin, leather, etc., the stain presents a scaly starchy appearance. On absor- bent surfaces such as cotton, silk or wool, the stain may be colourless or grey. When examined under ultraviolet light, sem- inal stains exhibit strong bluish-white fluorescence. Stains mixed with blood may not fluoresce. Fluorescence depends upon the choline of the semen. Substances such as food stains, vaginal secretions, urine, pus, etc. may also show fluorescence. Stains on artificial silk do not show fluorescence. The residues of modern detergents on clothes also fluoresce strongly.

CHEMICAL EXAMINATION

The rapid tests are Florence test (based on the exhibition of dark brown rhombic crystals of choline iodide, resembling haemin but are larger, arranged in clusters, rosettes or crosses, etc.) and Barberio test (showing yellow needle-shaped crystals of spermine picrate). Both these tests are simply suggestive of presence of some vegetable or animal substance. A negative test, however, reveals that the stain is not of seminal origin.

Another chemical test helping to establish seminal origin of the fluid is the demonstration of acid phosphatase enzyme in the fluid. However, presently it is being used as only screening test because of discovery of P-30 and MHS-5 secreted by prostate and seminal vesicle, respectively (as already discussed under the heading 'Rape'). It may be worth adding here that in the medicolegal context, factors affecting stability of this enzyme in the vaginal passage need to be kept in mind while interpreting results, viz.

(i) somato-sexual disorders (account for lower values than normal),

(ii) chronic prostatitis (leads to low levels of the enzyme in the semen),

(iii) amount of seminal fluid deposited into the vagina,

(iv) victim's activities (whether she has washed, douched, or done much walking, etc.) and

(v) vaginal environment (bacteria, hydrogen ion concentration, etc.).

CONFIRMATORY TESTS FOR SEMEN

Microscopic Examination

The morphology of intact spermatozoa of man is unique and distinguishable from that of animal spermatozoa. After the spermatozoa are damaged and broken up, this morphology is lost and not available for the detection of species origin. The microscopic detection of seminal stains based on morphology of spermatozoa thus offers an added advantage of their spe- cies origin. The extraordinary diversity of shape and structures encountered among the spermatozoa of different species prompted Wagner and Leuckart (1852) to state, "one may often safely venture to infer from the specific shape of these elements, the systemic position and the name of the animals investigated".

It serves as a confirmatory test for semen wherever the sperms are demonstrable, and obviously also valuable in deter- mining the potency. When one unbroken sperm is found, it is a proof of seminal fluid. In relation to determination of potency, sperm count and sperm motility should be taken care of. A potent fluid should normally contain not less than 60 million sperms per millilitre but counts within a wide range are consistent with potency. Complete absence of sperms (azoospermia) must not be assumed unless confirmed by an examination of at least three ejaculates.

Difficulties may arise when disconnected heads and tails are seen. Yeast, trichomonas, monilial spores, and isolated cell nuclei, etc. may simulate spermatozoa. A definite opinion in these cases can be given only by an expert. Spermatozoa usu- ally undergo disintegration within a few months of deposition. In exceptional cases, they may be seen even in very old stains. Gordon and Shapiro were able to identify complete spermato- zoa in a seminal stain 5 years after its deposition on a clean cotton material.

PROOF OF SEMEN

Prostate specific antigen (P-30) and seminal vesicle specific antigen (MHS-5) are specific to human semen and are pro- duced by epithelial cells of prostate and seminal vesicle, respec- tively. Antibodies specific to these antigens can be detected by various immunological tests like ELISA, immunodiffusion and agglutination-inhibition of human seminal plasma (HSP). These antigens have been reported to be present in the semen of aspermic persons as well.

DNA TESTING

Recent developments have now added the DNA technique to the armamentarium of forensic scientists. This is a remarkable advance in the forensic field, particularly in the sexual offences where the problems posed by admixture of semen and vaginal secretions can now be solved in substantial number of cases. Seminal fluid in the vagina of the victim of murder/rape can be matched against the blood DNA pattern of a suspect— there is no need to match semen against semen, as DNA from all sources in a given person must be identical. In sexual offences associated with homicide, as much material as can be obtained from the vagina should be collected either by pipette or by multiple swabs from different areas of vagina. These swabs should be frozen at –20° C if there is likely to be some delay in transmitting these to laboratory.

MEDICOLEGAL IMPORTANCE OF PREGNANCY

The medicolegal importance of pregnancy is manifold. A medical person may be requested to examine a woman to ascertain whether pregnancy exists or not under the following circumstances:

- A woman may plead pregnancy as a bar to hard labour or execution. If a woman sentenced to death is found to be pregnant, the High Court shall commute the sentence to imprisonment for life [CrPC

(Amendment) Act, 2008 (w.e.f. 31.12.2009)].

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ı A woman may advance pregnancy as an excuse to avoid attendance in a court of law as a witness. Pregnancy per se is not a sufficient excuse for not attending the court. She will be excused only when a physician certifies that delivery is imminent or that some serious complications may ensue if she were to attend the court.

- A woman may feign pregnancy and delivery after the death of her husband and produce a fictitious heir (suppositious child) to the estate that belonged to her husband. In such cases, i.e. the person who would have naturally succeeded thereto, may apply to the court for an enquiry to be made into the alleged pregnancy and delivery.

- Occasionally, it may be alleged that a woman living apart from her husband is pregnant. The allegation may be put forward in support of a suit for divorce. Sometimes, the woman defamed may be an unmarried female or a widow who seeks to clear her name.

- The question of pregnancy may be raised in criminal abortion. According to Sections 312 and 511, to cause or attempt to cause a woman 'quick with the child' to miscarry is a graver offence than if she is not 'quick with the child'. It is important to decide whether or not she was 'quick with the child' at the time when abortion was attempted or caused.

- A woman may claim to be pregnant and file a suit in a court of law for break of promise of marriage or for seduction.

- A woman may allege that she is pregnant in order to get greater compensation from a person or persons through whose culpable neglect her husband died.

- Pregnancy may well be a motive for the suicide or murder of an unmarried woman or widow.

- The question of whether a woman has given birth to a child recently or not, may be raised in an alleged case of infanti- cide and concealment of birth.

स At the time of marriage, if a woman is pregnant, marriage importance—more specifically in the early months—difficulties may be encountered.

DIAGNOSIS OF PREGNANCY

Although the diagnosis of pregnancy is not difficult in most cases, sometimes where a positive diagnosis is of utmost may be declared null and void.

- When the pregnancy is followed by death of the husband, the widow may claim a greater share in the ancestral property.
- Pregnancy beyond the scope of lawful wedlock generates many issues concerning the child.
- Working pregnant women are allowed additional leave facilities.

DIAGNOSIS

In medico legal cases, diagnosis of pregnancy must be based upon history, physical signs and laboratory investigations. One may prefer to categorise the various steps as presumptive, probable and positive instead of classifying them under three trimesters. Before examination, the doctor must obtain the consent of the woman in the presence of witnesses. Examina- tion without consent will lead to civil action for damages as well as criminal action for assault. The request of the members of the family or any other interested person does not give him the authority to proceed with the examination. It will be proper for a doctor to examine an arrested person even without consent when requested by a police officer not below the rank of Sub- inspector, provided there are reasonable grounds for believing that the examination of her person will afford evidence as to the commission of the offence (Section 53 of CrPC). When a female is to be examined under this Section, it shall be done only by or under the supervision of a female registered medical practitioner. If the woman is mentally defective or a minor, consent may be obtained from the parent or guardian or next of kin.

PRESUMPTIVE SIGNS OF PREGNANCY

AMENORRHOEA

Amenorrhoea may be the first warning symptom in normally menstruating women exposed to the probability of pregnancy. This is, however, not wholly reliable as amenorrhoea may result from chronic debilitating diseases, emotional stress and other factors. Moreover, cyclical bleeding can occur in the first 8–12 weeks of pregnancy either from a bicornuate uterus or uterus didelphys and even from a normal uterus prior to the fusion of the decidua vera and capsularis. Pathological lesions in the genital tract can also give rise to bleeding during pregnancy.

MORNING SICKNESS

In the early weeks, nausea and vomiting are common. 'Morning sickness' generally starts in about 4–6 weeks of pregnancy and may continue till about the 16th week. Usually, it is present in the early hours of the morning and shows signs of abatement as the day progresses. In some cases, however, sickness may continue throughout the day. Sometimes, nausea is more per- sistent than vomiting. In some cases, there may not be any morning sickness.

So long as it does not affect the general health, morning sickness is an ordinary physiological phenomenon associated with pregnancy. Occasionally, it may become a pathological symptom, when the nausea and vomiting become too exces- sive as to prevent the possibility of any nourishment being retained or even taken by the patient. This is called hypereme- sis gravidarum.

SALIVATION AND CHANGES IN DISPOSITION

Salivation is an early symptom and is pronounced in certain cases. The changes in disposition may be shown by a change in the temperament, resulting in the patient becoming irritable and capricious. She may evince a desire for articles of food quite at variance with her ordinary preferences. These have been termed the longings or pica of pregnancy; they are not of diagnostic value, as they are purely subjective and may occur in various neurotic conditions as well.

IRRITABILITY OF THE BLADDER

Frequency of micturition is sometimes complained of, and is due to the pressure exerted on the bladder by the growing uterus. As the uterus increases in size and becomes an abdomi- nal organ, this pressure is relieved and the symptoms gradually disappear.

CHANGES IN THE SKIN

Pigmentation is one of the characteristic changes that take place in pregnancy. This is more marked on the forehead and cheeks in the form of dark brown patches, more noticeable in those who are fair skinned. Pigmentation and striae may also be seen on the breasts and over the abdominal wall. A linear pig- mented area stretching from the umbilicus to the symphysis pubis is of deeper colour and is known as the linea nigra.

The abdominal wall distends as the pregnancy advances, and grows thinner, especially around the umbilicus. The skin over the abdomen shows depressed lines, pinkish or slightly bluish in appearance. These lines are called the striae gravi- darum. They are curved, irregular, arranged more or less concentrically, sometimes radially, around the umbilicus, grad- ually becoming broader and deeper near Poupart ligament. They may also be found over the thighs on the anterior aspect, sometimes on the posterior aspect as far as the knees, as well as under the breasts. These lines are caused by the rupture of the subcuticular elastic fibres, and after delivery they heal, leav- ing pearly white or silvery bright lines, now known as linea albicantes.

CHANGES IN THE BREASTS

Changes in the breasts are marked, particularly in primigravi- dae. There is a general enlargement with prominence of the veins and increased pigmentation, forming the characteristic primary and secondary areolae. The nipples also become more prominent, erectile and turgescent. Montgomery's follicles appear first on the primary areolae and later on the secondary areolae. The secondary areolae develop from the 20th week onwards, while the other changes generally take place during the first trimester—from the fourth to the 12th week of pregnancy. Presence of little fluid in the breast can usually be detected from the 12th week onwards by gently squeezing the breast in the direction of the nipple. The fluid is clear and contains some colostrum corpuscles.

In multiparae, the changes in the breasts are not of much diagnostic value because pregnancy may take place in a lactat- ing woman, while pigmentation of the areola and the milky secretion in the breasts may persist after a previous pregnancy. While the absence of these signs does not prove the nonexis- tence of pregnancy, their presence cannot help one to a posi- tive conclusion unless supplemented by other signs.

BLUISH DISCOLOURATION OF THE VAGINA

This sign is generally detected between the fourth and 8th weeks of pregnancy. The discolouration increases in intensity up to the 16th week, when it has perhaps reached its maximum. It persists throughout pregnancy. The vulva and the vaginal mucous membranes, consequent upon the congestion of the blood vessels, present a violet or light blue tint, and later a pur- plish or deep blue tint. This sign was first described by Jacquemier, and later emphasised by Chadwick, and is there- fore known as Jacquemier sign or Chadwick sign.

QUICKENING

An important symptom that may be felt during the second tri- mester is quickening. The active foetal movements are gener- ally felt by the mother first at the end of the 16th week; the term 'quickening' is applied to the first recognition. The move- ments become more vigorous and may sometimes be painful. They may cease entirely in some cases although the foetus con- tinues to be alive. Their sudden and complete cessation, how- ever, is suggestive of death of the foetus in utero.

Quickening is important from the medicolegal point of view in the sense that when a condemned woman pleads preg- nancy as a bar to hard labour or execution, the court may postpone the execution of the sentence of death or commute it to life imprisonment. The usual certificate required from a doctor in such a case is—whether the woman is 'quick with the child' or not. Also in cases of criminal abortion upon a woman who is 'quick with the child', punishment is enhanced.

PROBABLE SIGNS OF PREGNANCY

HEGAR SIGN

Softening and compressibility of the isthmus or lower uterine segment constitutes Hegar sign. This is of great value and has been observed from about the 6th or 8th week to the 12th week of pregnancy. This sign is more difficult to recognise in mul- tiparae than in primiparae.

BRAXTON HICKS SIGN

Intermittent uterine contractions are known as Braxton Hicks sign, and it is found irrespective of whether foetus is alive or dead. It may be detected by palpation as early as in the 16th week. These contractions, as a rule, occur throughout preg- nancy at fairly long intervals and last for a few seconds. They may be easily elicited by keeping the hand in full contact with the abdominal wall over the uterus, when the gradual relaxation and contraction of the uterine musculature will be felt. Similar contractions are sometimes noticed in cases of haematometra and occasionally with soft myomas.

BALLOTTEMENT

Internal and external ballottements are objective signs of preg- nancy, which can be elicited during the fourth or fifth month of pregnancy. Ballottement tests may be performed by external means as well as internal means. Accordingly, the tests are termed as internal ballottement test and external ballottement test. In external ballottement test, grip of two fingers is applied over the lower part of uterus, the woman being in semi-inclined position. As the foetus takes lowest position inside the uterus in this posture of woman, it is closer to the fingers. By exerting thrust with the help of the fingers, the foe- tus can be made to move up in the amniotic fluid. It may some- times be elicited in cases of fibroids or ovarian tumours associated with ascites. It is difficult to be elicited when the abdomen wall is thick and fatty. After a while, the foetus reset- tles again in the lower part of the uterus. In internal ballotte- ment, the test is performed by pressing two fingers on the sides of the fornix and imparting a force for the upward move-ment of the foetus, which also resettles at the lower part of the uterus after a while. This test gives satisfactory positive result by the fourth or fifth month of pregnancy when the quantity of amniotic fluid is comparatively more and the foetus can thus be made to move freely. After fifth/sixth month, difficulty may be faced in eliciting these tests due to proportionate decrease in the quantity of amniotic fluid in comparison with the size of the foetus. This may not be demonstrable in condi- tions associated with a deficiency of the liquor amnii, where the foetus is not presenting by the cephalic pole.

UTERINE CHANGES

The uterus is perhaps the most important organ to undergo remarkable changes due to pregnancy, which are more easily appreciable in the early months as compared to later months.

UTERINE SOUFFLE

With increase in the size of uterus and the foetus inside, the circulation of blood in uterus is also increased. This increase in circulation causes flow of more amount of blood inside the uterus through the uterine vessels; thus, when the lateral aspects of fundus is auscultated, murmur is heard, which syn- chronises with the mother's pulse beat.

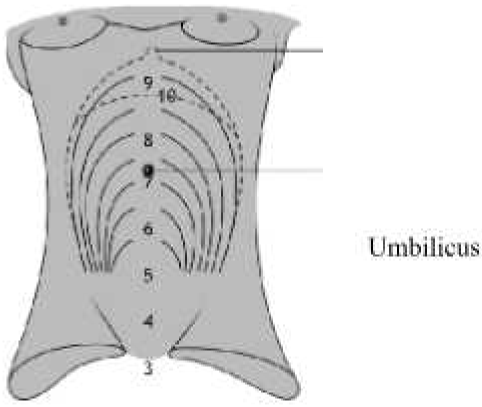
It becomes appreciable from the end of the fourth month. This type of sound may also be heard with the help of a stethoscope, when there is increased blood supply in the uterus due to any reason like a new growth inside the uterus. Uterine souffle must not be confused with foetal heart sound, which is more rapid in its rate and does not synchronise with mother's pulse.

ENLARGEMENT OF UTERUS

Under normal conditions, the uterus enlarges uniformly and its height is proportionate to the period of pregnancy.

The anteverted fundus of pregnant uterus becomes just palpable at the symphysis at about 10 weeks. By the 12th week, it is palpable above the symphysis; it is halfway between the symphysis and umbilicus at 16 weeks and at the level of the umbilicus at 20 weeks (Fig. 20.7). The fundus then rises one 4th of the way to the xiphisternum each month until the ninth, when at term it sinks to the level it occupied at the 8th month but there is a falling forward of the fundus. Determining the duration of pregnancy by this method cannot be accurate because of the inconsistency of the location of the umbilicus, thickness of the abdominal wall, the amount of liquor amnii, the size of the foetus and the possibility of multiple pregnancy. Despite these, at times the estimate is fairly accurate.

The height of the uterus is usually smaller when compared to the period of amenorrhoea in cases of ectopic gestation, retroverted gravid uterus, intrauterine death of the foetus and oligohydramnios. On the other hand, it is larger in vesicular mole, hydramnios, multiple pregnancy, and concealed acciden- tal haemorrhage and in tumours complicating pregnancy.



Relative height of the fundus at the various lunar months of pregnancy.

PREGNANCY TESTS

The need for more rapid and accurate diagnosis of pregnancy soon after conception has become more urgent keeping in view the liberalisation of the abortion law, as pregnancy termi- nations carried out soon after conception carry little or no risk. None of the physical signs and symptoms at so early a period of pregnancy can definitely confirm it; hence, the need for laboratory procedures.

LABORATORY TESTS

- Bioassay
- Immunoassay
- Haemagglutination inhibition test (Pregnosticon) or flocculation inhibition of hCG-coated particles (Gravin- dex test)
- Radioimmunoassay (RIA)
- ELISA test

BIOASSAY

The bioassay techniques that have been employed in the past to detect hCG in the urine of pregnant women are not routinely employed now.

Immunoassay Human chorionic gonadotrophin (hCG) has both (alpha and beta) subunits. Antigen–antibody reactions are utilised to detect its presence in the serum and urine. The tests using hCG antibodies for alpha subunits are not specific. Cross-reaction with luteinising hormone occurs as the alpha subunit is identical for both. However, antibodies raised against the beta subunits of hCG are highly specific and do not cross react with luteinising hormone. RBC or latex particles coated with hCG are used as the indicator to detect antigen–antibody reaction. Levels of 1.5–3 IU/ml of hCG can be detected.

- The principle of haemagglutination inhibition of erythro- cytes or prevention of flocculation of hCG-coated latex particles is employed. There are two basic categories of immunoassays—the tube test and the slide test.

▪Tube test: For carrying out the test, a small quantity of urine (5–8 ml) is filtered. About 0.1 ml of the urine is pipetted into the ampoule provided with the Pregnosti- con kit, and 0.4 ml of distilled water is added. The ampoule is shaken for 1 minute and placed in the test rack. The test rack holding the ampoules is left to stand for 2 hours without disturbing it in any way. Then the result of the test can be read off.

▪Slide test: Gravindex and Pregnosticon slide tests are the ones in vogue. They substitute latex particles sensitised with hCG for the red blood cells used in most of the tube tests. A drop of the woman's urine is mixed with antibody on a slide, and latex particles are added. Results are read in 1–3 minutes. Agglutination indicates absence of hCG required to neutralise the antibody, suggestive of nonpregnancy. Lack of agglutination indicates that the level of urinary hCG is high enough, on which one may assume pregnancy.

The tube tests are more sensitive than the slide tests, as the tube tests are capable of diagnosing pregnancy as early as in 4–7 days following a missed period. They are, however, more reliable beginning the 2nd week after a missed period.

Because of the limited sensitivity in detecting early pregnancy, immunoassays are associated with a high inci- dence of false negatives. It is always advisable, under the circumstances of a negative test, to repeat it a week later.

- In radioimmunoassays, iodo-hCG (I125) is used as the radio-ligand for antibodies raised against hCG. The RIA is dependent on the displacement of the radioligand by non- radiolabelled hCG in the biological fluid. The 'free' and 'bound' iodo-hCG are separated. Radioactivity of the bound form is measured, and from a standard chart, the hCG value is obtained.

ELISA Test The enzyme-linked immunosorbent assay (ELISA) is based on a principle similar to that of radioimmu- noassay, i.e. competitive inhibition of a labelled hormone to its antibody by an unlabelled hormone. The label in RIA is radio- active, while that in ELISA is a plastic or certain inert particle or enzyme-end point. Clear blue colour means positive, colourless means negative.

POSITIVE SIGNS OF PREGNANCY

Palpation of the Foetal Parts

About the middle of pregnancy, the foetus is generally increased to a size when it can be recognised by abdominal palpation. As pregnancy progresses, this sign is of great value, not only in detecting pregnancy but also in ascertaining the various posi- tions of the foetus in utero.

AUSCULTATORY SIGNS

Auscultation over the abdomen during pregnancy is useful to elicit various sounds, some of which are of great importance in the positive diagnosis of pregnancy.

The foetal heart sounds can be heard from about the 17th week to 20th week of pregnancy using Pinard's fetoscope. This is the only sign of pregnancy that by itself and in the absence of all others is perfectly reliable for the diagnosis of pregnancy. The point of greatest intensity of the foetal heart sounds will vary with the position of the child in utero. Ordinarily, the foetal heart beats 120–160 times a minute.

It is possible to hear foetal heart sounds using the ultra- sound Doppler technique. The ultrasound wave reflected by the moving blood flow undergoes a shift in pregnancy, the echo of which is detected by the receiving crystal, adjacent to the transmitting crystal. This method to detect foetal heart sounds becomes useful by the 10th week.

Echocardiography can be used to detect the foetal heart movement as early as in 48 days after the last menstrual period.

RADIOLOGICAL DIAGNOSIS

The foetal skeleton can be made out in a good radiograph as early as in 16–18 weeks and, when seen, is conclusive evidence of pregnancy. Radiography is not of use prior to 16 weeks. When the abdominal wall is thick or when there is hydramnios or multiple pregnancy, the foetal skeleton may not be seen clearly. Realisation of the hazards of radiation in pregnancy has, however, made the obstetrician restrict its use consider- ably, especially in early pregnancy.

ULTRASONOGRAPHY Ultrasonography by the pulse-echo sonar method is now being widely applied for diagnostic purposes in obstetrics. The gesta- tional sac is detected as a well-defined white ring by the 6th week. Foetal echo within the sac appears by the commencement of the seventh week. Foetal heart reaction can be detected by the end of the 7th week. In 8–14 weeks, the crown rump length of the embryo allows accurate estimation of gestational age. Sonog- raphy allows early identification of dead embryo when the ges- tation sac appears ill-defined with absent foetal echo. The earliest identification of multiple pregnancy is possible by this technique. Also, successful recognition of a vesicular mole, the placental site, foetal anomalies and, subsequently, hydramnios and the assessment of foetal growth are possible with this method with- out submitting the patient to the risks of radiation.

MEDICOLEGAL IMPLICATIONS OF DURATION OF PREGNANCY

It is not possible to fix the actual date of conception even when the exact date of fruitful coitus is known, because the union of spermatozoon and ovum occurs at a variable time after coitus. In some it may occur within a few hours, while in others after a few days. The spermatozoon may retain its motil- ity in the vagina up to a couple of hours, though it can be pres- ent as long as 2–3 days after intercourse. The spermatozoa may retain their motility in the cervical canal and uterus for 5–7 days, but the power to fertilise is usually retained for not more than 48 hours. The ovum can survive in a fertilisable form only for about 24 hours and probably only for 8–12 hours after it leaves the ovary. The time taken by spermatozoa to travel from the vagina to the tubes is 6–24 hours, but may be as short as 1–2 hour. Ovulation usually takes place 2 weeks before the onset of the next menstrual cycle. However, pregnancy may occur on any day of the cycle and even during menstruation. Therefore, it is impossible to fix the time of conception accu- rately. At most, the examiner can calculate 280 days from the first day of the last menstrual period and the date so obtained will be somewhere in the middle of the last 2 weeks of pregnancy. The time of fixation of pregnancy is further complicated by the fact that the pregnancy may occur when menstrual flow is suppressed because of other causes. On the other hand, men- ses have been known to continue in spite of pregnancy.

Generally speaking, the duration of pregnancy is 280 days in a woman with a 28-day menstrual cycle, but it may last only for 240 days or extend to 300 days or more depending on the duration of the menstrual cycle. In India, England, USA and elsewhere, the law does not lay down any limit for the duration of pregnancy. In the case of Gaskill vs. Gaskill, the Lord Chancellor accepted 331 days as the period of gestation. In another case, Lord Simonds of the House of Lords did not accept 360 days as the period of gestation and came to the conclusion that the woman had committed adultery and the child was not that of the husband. It is clear therefore that each case will be dealt with on its own merit.

Children born at or after 210 days of intrauterine life are viable, but those born after 180 days may also be viable and capable of separate existence. The size of the child assumes importance while considering protracted or shortened preg- nancies. As a rule, the longer the period of gestation, the larger the infant. It is by no means unusual to find relatively larger infants in short period of gestation as in diabetic mothers and comparatively smaller infants in protracted pregnancy when there is, for example, multiple pregnancy and malnutrition in the mother.

DIFFERENTIAL DIAGNOSIS OF PREGNANCY

PSEUDOCYESIS (FALSE OR SPURIOUS PREGNANCY)

This condition may occur in women who have an intense desire to become pregnant. Most frequently, it is observed in a woman who is approaching the menopause, when her menstrual flow has become scanty or has ceased for a time. A deposit of fat takes place in the anterior abdominal wall and omentum, and the intestines become distended with flatus. In such cases several of the doubtful signs and symptoms of pregnancy may be pres- ent, e.g. menstruation may cease, the mammary sign of gestation may appear and the abdomen may become progressively prom- inent. The patient may imagine that she feels foetal movements; striae may appear both on the abdomen and breasts. The diag- nosis of this condition is not difficult, but the physician should be on guard in assessing any statements the patient may offer in regard to her condition. Ultrasound is useful in such cases; needless to say, the biological test will invariably be negative.

SUPERFOETATION AND SUPERFECUNDATION

Superfoetation means the fertilisation of an ovum from a subsequent ovulation in a woman who is already pregnant, and the consequence is the birth of two children at the same time, one of whom may be mature and the other immature. They may however be born at full term, one few weeks ahead of the other. The condition, though not impossible, is difficult to prove. Pregnancy does not close the cervical or tubal orifices immediately. The ovulation usually stops with the onset of preg- nancy, but should it occur after the onset of pregnancy as ovula- tion may take place particularly during first trimester of pregnancy until the decidua vera comes into apposition with decidua reflexa and the decidual cavity gets obliterated, fertilisation of the newly released ovum may take place following coitus.

Superfecundation means multiple pregnancy resulting from the fertilisation of two or more ova liberated in the same menstrual cycle by spermatozoa introduced during successive acts of coitus. The condition is possible but difficult to prove since both fertilised ova develop as twins and go to full term at about the same period. If the mother has had sexual relation with two men of different race and two children are born at term, having different racial characters, it is substantial indica- tion of superfecundation.

SURROGATE MOTHERHOOD

A surrogate mother is one who is hired to bear a child whom she turns over at birth to her employer. The surrogate mother, therefore, has no genetic contribution to make. In spite of the fact that the surrogate mother makes the much larger contribu- tion towards the birth of the baby, the baby is considered ille- gitimate, if the mother is not the legal wife of the man. Some agencies advocate that the surrogate must be married and be a mother of at least one healthy child who should be medically as well as psychologically fit. She should not indulge in cigarettes, alcohol or any other drug during pregnancy and must agree to give up her rights after the baby is born. Her husband must also pass tests. The agency arranges the contract, life insurance for the surrogate's family (if she happens to die during pregnancy or childbirth) and life insurance or a 'will' for the child, should the (contracting) couple die before the child is born.

Surrogate may be compelled to terminate pregnancy if so wished by the contracting couple. There have been instances where the contracting individual has specified the sex of the baby as well and refused to take the baby, if it was not normal and filed a suit against the surrogate alleging that she had bro- ken the contract. A New Jersey court opined that the time difference between producing semen and producing a child is enough to destroy the analogy. What surrogates sell is not their labour but their body itself, and every act that they perform may be under the scrutiny of the contracting couple.

The surrogacy may be employed in a variety of events.

For instance:

- A couple (Mr. and Mrs. A) cannot have a child because Mrs. A is unable to receive the fertilised ovum into her womb and nourish it there due to a malformation of the womb or as a consequence of a disease. They, therefore, resort to extrac- tion of Mrs. A's ovum to be fertilised by Mr. A's sperm in the laboratory. She has, therefore, played an important role in the production of this baby. The resultant embryo is implanted into the womb of another woman (Ms. B) who carried the foetus to full term on the understanding that on birth, she will hand over the baby to Mr. and Mrs. A; Ms. B is surrogate mother.

- Another form of surrogacy leads to even greater problems. Mrs. A does not have viable eggs in her ovaries. Ms. B is therefore artificially inseminated, using Mr. A's sperms. In this case, Mrs. A has played virtually no role and Ms. B is the genetic mother as well as the surrogate mother (by agreement).

Surrogacy has become controversial from the time it involved money. It involves lawyers, contracts and highly paid go-betweens and anonymous payers too. That is why surro- gacy is sometimes called 'baby selling' and surrogates as 'whores'. It may be viewed as a mode of exploiting women for the benefit of men who ensure that the baby has their genes. The rights of the contracting father are considered as para- mount. The contracting couple adopts the baby soon after its birth so that they become legal parents of the child. Unlike attached. Placental abruption resulting from maternal trauma usually manifests within minutes to a few hours of the injury. Where the abruption is delayed, one needs to consider non- traumatic aetiologies such as maternal hypertension, cigarette smoking, cocaine abuse and prior abruption or still birth, etc. The criteria suggestive of the probable causative relationship between a traumatic event and a subsequent abortion have been reported as including (i) the traumatic event was followed by a process that led ultimately to abortion; (ii) the foetus and placenta were studied pathologically and found to have been normal; (iii) the appearance of the foetus and placenta were compatible with the stage of gestation at which the traumatic event occurred; and (iv) absence of factors that are known to cause abortion, such as uterine abnormalities, chronic infec- tion in the mother and a history of exposure to abortifacients or a physical attempt to induce abortion, etc.

CHILD ABUSE TRAUMA AND PREGNANCY

Pregnancy is accompanied by unique physiologic changes geared towards accommodating and delivering the growing foetus. In majority of cases, the body is able to adapt to these changes. However, severe life-threatening complications may arise at occasions, leading to death of the mother (maternal mortality is defined as the death of a woman during pregnancy or up to 5 months after delivery). Two of the most common complications presenting as sudden and unexpected maternal death are embolic in nature—(i) pulmonary artery thrombo-embolism and (ii) amniotic fluid embolism.

The pregnant uterus by acting as a hydraulic shock absorber for forces directed at the anterior abdominal wall and dissipating them in its elasticity provides protection for the remainder of the abdominal organs. Furthermore, at least until 12th to 13th gestational week or so, the foetus is situated low within the mother's bony pelvis, providing an added element of protection from direct impact injury. Traumatic uterine rupture needs be differentiated from nontraumatic rupture. In the former, uterus is often ruptured in the fundic region. It is theorised that during blunt force impact, amniotic fluid will distribute pressure relatively equally in all directions and the rupture, if it occurs, will be at the weakest point, which is most commonly at the fundus. In the latter, rupture preferen- tially occurs in the regions of already weak uterine wall (such as presence of scar). Risk factors for nontraumatic /therapy- related uterine rupture may include prior caesarean section delivery, increased gestational age, and the use of uterotonic drugs such as oxytocin and prostaglandin and obstetric inter- ventions like forceps delivery or breech extractions, prolonged labor with cephalopelvic disproportion, etc. The placenta, in contrast to the uterine wall, is nonelastic and cannot contract or expand to the same extent as the uterine wall to which it is

United Nations Convention on the Rights of the Child sets out basic rights and standards for judging the welfare of children, including the maltreatment. It encompasses both the maltreatment of children within family settings and that occurring through group processes and social forces. Countries vary in their approach to the problem of child maltreatment. In the United States, if any professional entertains any suspicion as to the maltreatment of the child, he is required by law to report the things to the local child welfare agency (mandatory report- ing). In countries like Belgium and Holland, maltreatment cases are dealt with confidentially through health and social workers. The United Kingdom lies between these extremes. In India, any doctor who has reason to suspect about the mal- treatment of the child is required to report the matter to the police. The Juvenile Justice (Care and Protection of Children) Act, 2015 provides for taking special measures towards the care and protection of children.

HISTORICAL BACKGROUND

In the Eastern culture, cases of child abuse are rare because the children are considered as the gifts of God. However, instances of ill-treatment of young children who work as domestic ser- vants are not uncommon. Though assault and murder of children is well-known in every country, the battered child syndrome is different from the usual homicide. The syndrome was first mentioned in 1946 when an American Radiologist, Caffey, wrote a paper in a radiological journal drawing atten- tion to the peculiar association of subdural haemorrhages with fractured long bones. Initially, it was thought to be related to increased fragility of bones. About a decade later, he wrote a second paper in which he proposed that parental abuse might be the cause of the lesion. From that time onwards, an avalanche of articles led to the present awareness of the problem. The problem has variously been known as child abuse syndrome/battered baby syndrome/shaken baby syndrome/ nonaccidental injury in childhood, etc. The children afflicted are usually young, usually less than 4 or 5 years of age. On the whole, child abuse is a matter of Clinical Forensic Medicine as abusers seldom intend to kill their victims. Deaths are, in a way, accidental, but may sometimes be processed under charges of 'culpable homicide not amounting to murder' or 'death due to rash or negligent act' depending upon the circumstances.

POINTS FOR SUSPICION

The patterns of injury are fairly constant and mainly comprise bruises and fractures. The classic feature is repetition of inju- ries. Major suspecting points may include:

- delayed reporting of injuries,
- injuries not corresponding to those that would be antici- pated from the explanation given,
- injuries may be of recent origin and/or different ages, and
- sudden death in case of fatality.

TYPES OF ABUSE

Many types of abuse can be encountered and there may be overlapping to varying extent. Physical abuse has been explained as physical assault to a child by any person having custody, care or charge of that child. Methods may include hit- ting, throwing, inducing burns or scalds, biting, poisoning, suf- focating and drowning [Meadow, R (1997). ABC of Child Abuse (3rd Ed.)]. Some rare conditions may also be pointed out here:

- Munchausen syndrome by proxy—when a parent or carer feigns an impression or produces a state of ill health in a child, it is labelled as factitious illness by proxy or Munchausen syndrome by proxy. Common features of presentation include factitious epilepsy, nonaccidental poi- soning or multisystem disorders. Fabrication may result in harm to the child or have an impact on child's physical and emotional development.

- Gentle homicide—this term may be used when the child is killed through asphyxia, specifically 'smothering', which may be carried out with a pillow or bed clothes. Occasionally, the perpetrator may press the face of the child against his chest, or hands may be used to clamp the nose and mouth of the child. Diagnosis can be approached by taking into account the circumstances and detailed autopsy findings. Sexual abuse has been explained as sexual activities that involve a child and an adult, or a significantly older child [Finkelhor D. (1994) Current information on the scope and nature of child sexual abuse]. It may be in the form of contact sexual activities or noncontact sexual activities. The former may include penile, digital or object penetration and nonpenetra- tive acts like touching or kissing of sexual parts of the body of the child or making the child touch sexual parts of the abuser's body. The latter may include exhibitionism or encouraging the children to have sex together. Child neglect refers to the under-provision of the child's basic needs, both physical and psychological. It may occur through parents or through institutions, i.e. in orphanages, nurseries, educational establishments, etc. Various types of neglect may be present:

▪Physical neglect—principally involving lack of provi- sion of the child's basic physical requirements like food, shelter, clothing, etc., and also includes failure to protect the child from physical harm or danger.

▪Emotional neglect—involving inattention to the child's emotional needs, i.e. failure to give due love and affection.

▪Medical care neglect—involving failure to provide the necessary medical/surgical treatment (including immunisations).

▪Educational neglect—comprising inattention towards the education of the child.

RANGE OF INJURIES

The most common mode of death is the head injury. Next in frequency is the injury of some abdominal organ/viscus, and the remaining account for some small percentage. Many of the injuries might not have themselves been fatal, but recognition of their mode of production will go a long way in distinguish- ing an accident from deliberate maltreatment. In this context, the words of forensic pathologists, Johnson, Cameron and Camps act as guiding force—"The skin and bones tell a story which the child is either too young or too frightened to tell". The following types of injuries may help in strengthening the diagnosis of abuse/maltreatment (Fig. 20.8).

Bruising (of recent origin and/or of different ages showing variance with the history) may be encountered as given below:

- Around the limbs, especially the wrist and forearms, upper arms, thighs and ankles, etc., because these places form convenient sites for the grip.

- On the buttocks due to hand smacks or beating with a strap or some similar object. Presence of bruising on the inner side of thighs may indicate possible sexual interference.

- Face, cheeks and mouth often may be bruised due to slap-ping. Forehead and ears are the other sites in this region.

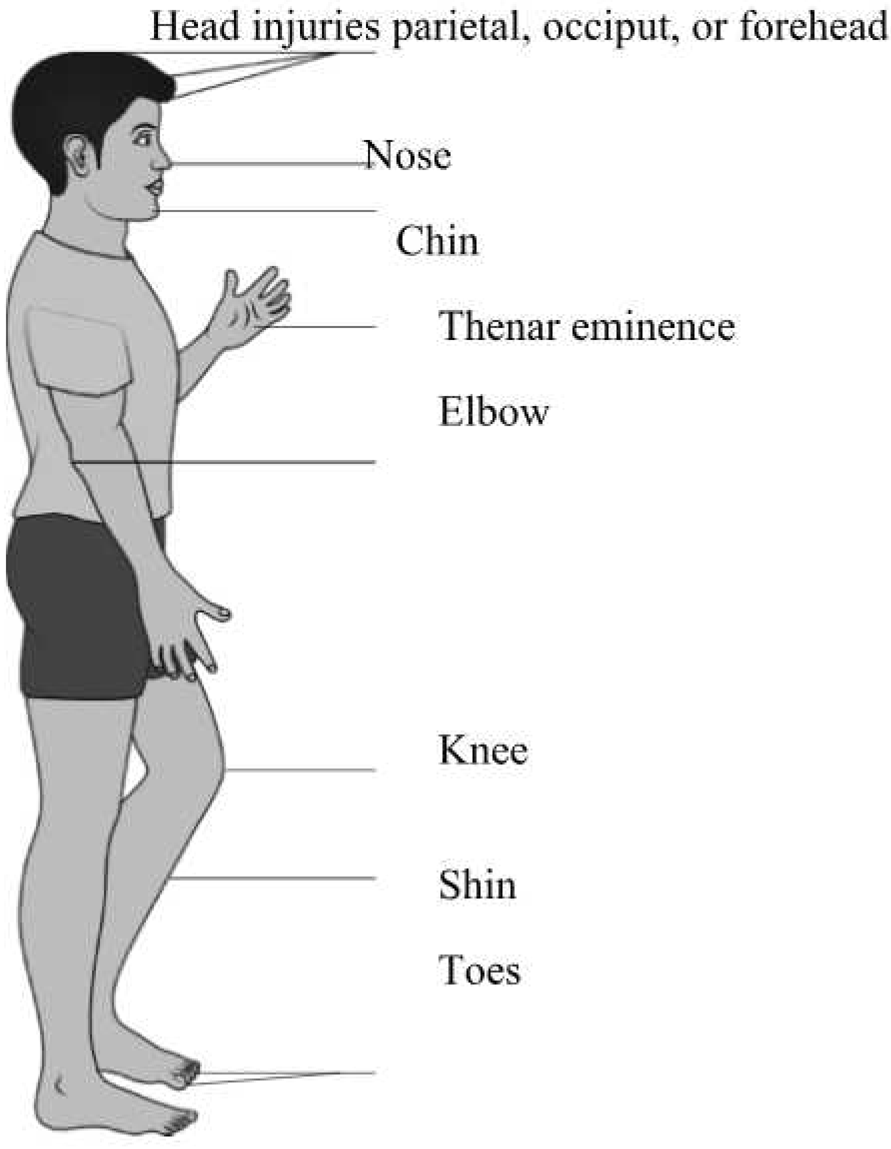
- Scalp bruising is better appreciated through palpation and is often a part of the deeper head injury. More often, it will be localised and inconsistent with a simple fall.

- Chest, abdomen and neck may show bruising resulting from finger pressure (usually in the form of small discoid lesion, once called as 'six penny bruises' from the size of the coinage in Great Britain).

Skeletal damage (of recent origin and/or different ages demonstrating variance with the history) is often encountered.

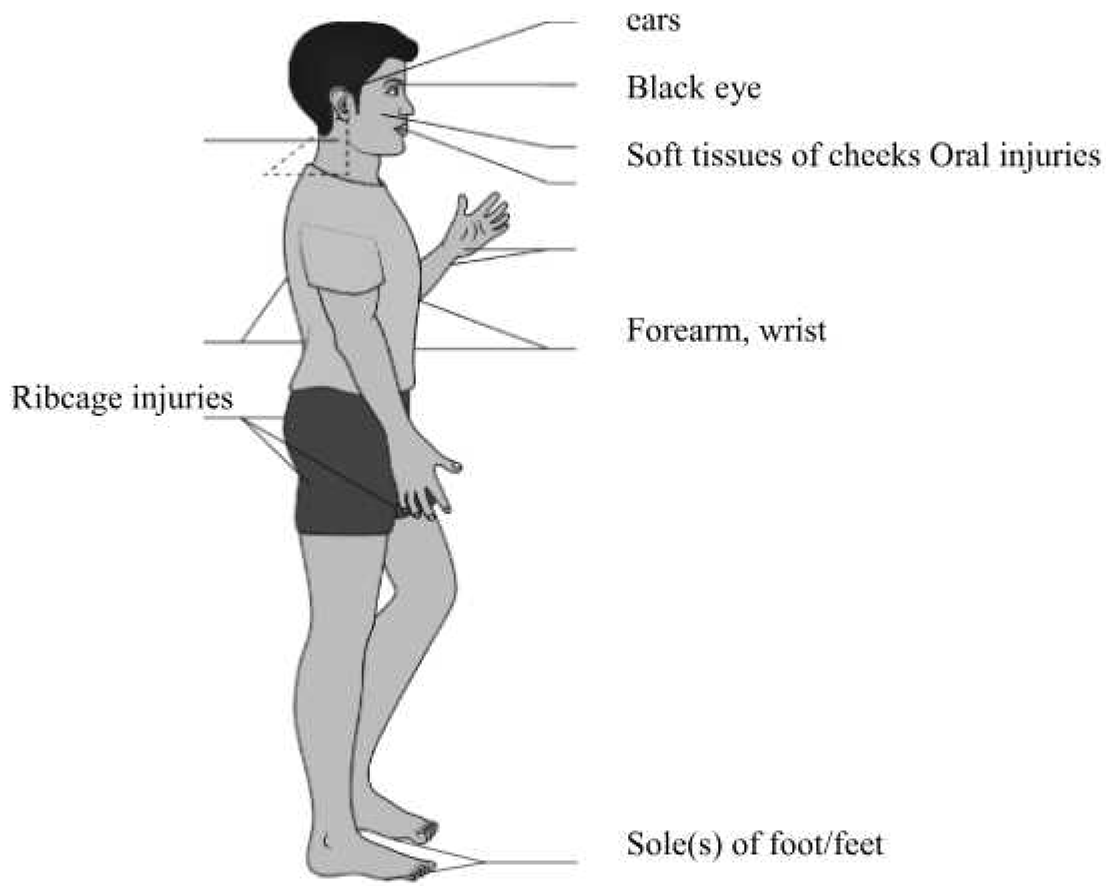
A

Typical sites for accidental injuries.



B

Typical sites for nonaccidental injuries.



Concerns are raised when encountering:

- Injuries with particular pattern
- Injuries to the soft tissues
- Incompatibility with the explanation
- Delay in presentation
- Injuries of different ages

Diagnosis largely depends upon radiology. Common types of fractures encountered in such situations are as under:

- Skull fractures, with or without intracranial haemorrhage, usually subdural, have been reported. At autopsy, any haem- orrhage needs detailed description relating to site, amount, colour and adhesiveness. Careful differentiation between coup and contrecoup lesions will help to determine if the injury resulted from a moving object striking a fixed head or a moving head striking a fixed object. Harwood-Nash et al. found that out of 4465 childhood head injuries, 1187 had skull fractures and subdural haemorrhage was twice in incidence in the nonfracture cases. The commonest site being the occipitoparietal area. The differentiation that whether the fracture has occurred from accidental fall or from deliberate impact is warranted. Notwithstanding the flexibility, it has been reported that the infant skull gets fractured with application of much less mechanical force than would be needed to fracture a mature skull. However, brain injury is not a necessary accompaniment of the frac- ture of skull and it is impossible to forecast the conse- quences following any fall, though of minor magnitude.

The pattern of fracturing is somewhat peculiar because

of the presence of open sutures and fontanelles in the chil- dren. Fracture lines tend to end at sutures. However, if the fracture crosses sutural line, there is usually a lateral dis- placement so that the two limbs of the fracture are not in line, the so-called 'side-stepping'. (Sutural 'diastasis' [separa- tion] may occur with or without fractures, the loosely knit skull plates being easily displaced by distortion of the cal- varium.) Another common fracture that may be resulted from a blow or a fall on the side or top of the head is in the form of a horizontally placed fissured fracture running backwards from the frontoparietal suture, often turning down towards the base of the skull. In the event of an impact on the vertex of the skull, such fractures may occur bilaterally due to cracks occurring along the lines of the maximum stress.

- Fractures of the extremities are often caused by indirect force, i.e. the bone damage being produced by stress from abnormal angulation, torsion or traction, rather than from a direct impact upon the bone. Swinging the child by the writs or ankles, dragging them by arm or violent shaking using limbs as the 'grasping/griping sites' are the usual mechanisms. Swinging, wrenching or twisting can lead to avulsion of metaphysis. Chipping of the edges of the metaphyses or epiphyses may also occur. Periosteum being loosely attached to the bone can get easily lifted during shearing or traction effects.

- Chest cage injures, in general, are not usually of acciden-

tal origin in children. Involvement of several consecutive ribs on one or both sides is often encountered in child abuse. Damage may be fresh or old demonstrating different radiological appearances. (Nobbing fractures is the term used to denote fractures occurring due to the assailant/ abuser holding the child with hands and shaking it violently or squeezing from side to side, thus fracturing ribs on both sides close to the spine, giving a nobbing appearance. Such fractures may be produced due to rib being levered against the transverse process to the extent that breakage occurs. They are much more appreciable after a week or two, when callus gets formed.) Rib fractures in the axillary line may be the result of anteroposterior pressure, rather than side-to-side squeezing. Fractures on other sites are usually the result of direct impact such as fist blow or kick.

Damage to the internal organs is almost always confined to the abdominal viscera. Forcible impact on the lower chest or the abdominal wall is responsible for such injuries. An excuse that the child fell or tripped upon some protruding obstruction might be forwarded by the parents. It is a matter of fact and interpretation as to whether the injuries are compatible with the explanation given or not. The central tissues/organs are the main sufferers. Liver is the frequent sufferer, the most common lesion being a laceration, which may be superficial or deep seated involving one or both lobes depending upon the manner of impact. Other common sufferers are (i) second part of the duodenum that crosses mid-line and is liable to be 'sandwiched' between the compressed anterior abdominal wall and the promontory of the lumbar spine and (ii) jejunum that may or may not be accompanied by laceration of the mesen- tery. Simpson records a case of a child wherein the external evidence of injury was confined only to some trivial bruises of the face. However, autopsy revealed 17 fractured ribs and liver plus spleen floated out through the incision made down the trunk. The mother, at first denied such violence, but later admitted losing her temper and sweeping the child by the legs against the bed rail.

Thermal injuries may sometimes be encountered. These may be scalds or dry burns. Scalds are usually produced by dipping the child in hot fluid. The term 'punished child' is sometimes used in this context when the child is dipped in hot water as a punish- ment for having become soiled. The distribution of burns is self- explanatory. (As the child is lowered into water, he involuntarily flexes his legs. The knees are brought up against the abdomen and lower legs folding back against the thighs. The child is then lowered into water up to his waist. Because of such attitude, there is often sparing of the skin in the inguinal region and popliteal fossae.) Dry burns may be produced in a variety of ways. A particular type of burn may be a 'cigarette burn'. Such burns are most often seen over the parts not normally covered by clothing. The mark may be rounded or bizarre in appear- ance. Fresh cigarette burns are red/reddish. On healing, they become pinkish and later have a silvery sheen on the surface.

CHAPTER-19

MEDICAL NEGLIGENCE

Negligence has two meanings in law of torts:

(1) Negligence as a mode of committing certain torts as, e.g., negligently or carelessly committing trespass, nuisance or defamation. In this context, it denotes the mental element.

(2) Negligence is considered as a separate tort. It means a conduct that creates a risk of causing damage, rather than a state of mind.

It is in the second sense that it has been discussed here. The term 'malpractice' refers to any professional misconduct that encompasses an unreasonable lack of skill in professional behaviour. The term 'medical negligence' is usually preferred to 'medical malpractice', which is charged with emotional bag- gage. Negligence was defined by Baron Alderson in Blyth vs. Birmingham Waterworks Co as 'the omission to do some- thing that a reasonable man guided by those considerations that ordinarily regulate the conduct of human affairs, ... would do, or doing something that a prudent and reasonable man would not do.'

It was suggested that medical negligence was an example of negligence at large, but the more modern view is likely to be that expressed by Lord Denning in Hatcher vs. Black and others. He declined to liken the case against a hospital to a motor car accident or an accident in a factory: 'On the road or in a factory there ought not to be any accidents if everyone used proper care. But in a hospital, when a person was ill and came in for treatment, no matter what care was used there was always a risk, and it would be wrong and bad law to say that simply because a mishap occurred the hospital and doctors were liable. Indeed it would be disastrous to the community. It would mean that a doctor examining a patient or a surgeon operating at the table, instead of getting on with his work, would be forever looking over his shoulder to see if someone was coming up with a dagger (i.e., an action for negligence). There are risks inherent in most forms of medical treatment. All that one can ask is that he should keep these risks to the minimum. If he has done this, no injury which occurs, how- ever serious, is actionable.'

ELEMENTS OF NEGLIGENCE

All manner of interventions can be used in clinical work, some of which may be novel, strange or even bizarre, but none of them represents negligence unless the patient (plaintiff) can show the presence of following four elements by a preponder- ance of the evidence, i.e. they are more likely to be present than not. The four elements can be summarised as four Ds of negli- gence, namely: Duty, Dereliction, Direct causation and Damage.

DUTY

The concept of duty adapts itself to the changing circumstances even as the law itself, as stated by Lord Macmillan, "categories of negligence are never closed". It is, therefore, difficult to express it as a general proposition but, broadly, duty means a standard of behaviour imposing some restrictions on one's con- duct. It implies a legal duty rather than a moral one. A duty is created where there is an offer to treat/care, i.e. 'therapeutic intent' forms the key issue that is instrumental in establishing doctor–patient relationship. This relationship may be formed extremely easily and by no means depends upon any formal acceptance of a patient by a doctor. Even in an emergency, once a doctor approaches an ill or injured person with the intention of assisting him, then a valid duty of care is set up. This is not- withstanding the fact that the patient may be unconscious and quite unaware of the doctor's presence. In the United States, some States brought in legislation to limit actions for negligence arising out of casual treatment at the scene of accidents, as the number of such actions had become so frequent that the doc- tors became extremely reluctant to render aid in emergencies.

It is important to appreciate that the negligent advice is just as actionable as negligent treatment. It must be something more than casual advice; there must be some evidence of assumption of responsibility, e.g. the payment of fee. Where a doctor examines a patient for some purpose other than pro- viding advice and treatment, no doctor–patient relationship is established and thus no duty of care exists. A doctor conduct- ing a medicolegal examination for any purpose (such as insur- ance, determination of disability, etc.) is not there in his capacity as a 'healer' and no duty of care arises. In such circum- stances, there is obviously a duty not to inflict any damage upon the patient. If the doctor happens to inflict an injury, say, while attempting to draw a blood sample in such cases, the patient has a right of action. In such cases, a duty, however, exists between the doctor and the authority employing him to provide an accurate report and any incompetence, in this con- text, would be a breach of contract, not a tort.

Duty Depends Upon Reasonable Foreseeability of Injury

Whether the defendant owes a duty to the plaintiff or not depends upon reasonable foreseeability of injury to the plain- tiff. To decide culpability, we have to determine what a reason- able man would have foreseen and thus form an idea of how he would have behaved under the circumstances. Explaining the standard of foresight of the reasonable man Lord Macmillan observed:

'The standard of foresight of the reasonable man is, in one sense, an impersonal test. It eliminates the personal equation and is independent of the idiosyncrasies of the particular person whose conduct is in question. Some persons are by nature unduly timorous and imagine every path beset with lions. Others, of more robust temperament, fail to foresee or nonchalantly disregard even the most obvious dangers. The reasonable man is presumed to be free both from over-apprehension and from over-confidence. But it is still left to the judge to decide what, in the circumstances of a particular case, the reasonable man would have had in contemplation, and what, accordingly, the party sought to be made liable, ought to have foreseen'. Here there is room for diversity of views. What to one judge may seem far fetched may seem to another both natural and probable.

In emergency situations (accidents, disasters, etc.) where healthcare professionals attend victims at the place of occur- rence, they have to work in extremely adverse and hazardous conditions. Standard of care expected under such circum- stances may not be that as expected otherwise. Further, under such situations, prioritisation of the victims may be done on the concept of 'necessity'. The position was pointed out by Mason and McCall Smith (1999), "A doctor working in an emergency, with inadequate facilities and under great pressure, will not be expected by the courts to achieve the same results as a doctor who is working in ideal conditions". This was alluded to by Mustill J in Wilsher, where he said, "If a person was forced by an emergency to do too many things at once, then the fact that he does one of them incorrectly 'should not be taken lightly as negligence'." Further, in such situations (and otherwise too, in the present scenario), the victim/patient is usually treated by a team of healthcare professionals to a varying degree. Though the need for inexperienced doctors (interns, house surgeons, etc.) to learn through training and experience is well-recognised, yet junior doctors can meet the standard of care by seeking help when they feel that things are becoming overly complicated. An action in negligence will obviously succeed if help is not sought and a deficient stan- dard of care is provided.

DERELICTION

Negligence belongs to the part of civil law known as 'negligent torts' (a tort is a civil wrong) that may be styled as 'sins of omission', i.e. the plaintiff alleges that the doctor neglected to do something or left something out, which is ordinarily a part of the proper care. This points out to the central issue of 'stan- dard of care' required to prove negligence. But how is that standard established and how does the court become aware of it? The first question is usually answered by the case laws (previous judgements of the courts) or the law on the books. Such a standard is usually set by the 'peer view', i.e. what a 'sub- stantial minority' of respectable doctors skilled in the same speciality would have done under similar circumstances if they had been in the place of the defendant at that time. The latter question, i.e. how the judges (medical laypersons) are sup- posed to know what constitutes average practice, especially in terms of technical aspects of clinical work. This invites the role of 'expert witness' who is called by the court to help the jury to sort out the issue of liability based upon reasoning, background and scientific debate.

A much hyped Heart Care Hospital came under a sharp focus with the Consumer Disputes Redressal Forum holding the hospital guilty of unfair trade practices along with negligence. The forum observed, "There is no document to suggest whether the complainant or his family members were told by the hospital that angioplasty on other two vessels, which were blocked was not conducted. There are two consent letters but in none of these letters this fact is mentioned. It appears that the fact regarding the blockage of other two vessels of the patient was being con- cealed from him and his family. It must have been concealed so that the patient does not come to know that a part of the job has been completed and treatment of other two vessels is to be done for which the patient may come again after 4–6 months." The hospital was told to pay | 2 lakh as compensation and was also directed to refund | 2.27 lakh charged as fee.

MISTAKEN DIAGNOSIS

An erroneous diagnosis is negligent only if it implies an absence of due care or skill. Failure to adopt generally approved meth- ods of diagnosis or treatment in the appropriate circumstances is a perilous course. Thus, the omission of X-ray examination in circumstances where a fracture or dislocation was suspected or ought to have been suspected may be sufficient to establish lack of reasonable care.

However, it should be noted that as the medical practice evolves, the criteria of 'accepted practice' changes. For example, it is no longer felt obligatory to go in for X-ray of the skull in cases of head injuries, both on the grounds of unnecessary expense, harmful radiation and doubtful efficacy. It is clinical and especially the neurological examination that is more important. Usually, the regimen of treatment would be the same whether or not the X-ray reveals a fracture. The practice of invariably X-raying the cases of head injuries has, probably, arisen from fears of medicolegal consequences rather than from clinical necessity. Notwithstanding all this, the radiological examination of a patient following any sort of traumatic injury has become so much of a routine that it is likely that there would be a danger of a finding of negligence if no radiological examination was sought, particularly when the history was suggestive of possibility of some fracture or dislocation or presence of a foreign body in a wound.

A doctor may find himself/herself negligent if a wrong solu- tion has been injected by mistake or oversight. He may inject the fluid into an artery instead of vein or use solution intended to be used as intramuscular as intravenous. In a case, a nurse misread the instructions of the doctor and gave the child an intravenous injection of chloroquine instead of chloromycetine, which resulted in cardiac arrest. Delay in resuscitation left the child in a vegetative state and compensation to the tune of | 12.5 lakhs was awarded to the minor child taking into account the cost of equipments and the recurring expenses for the rest of the life of the minor child and | 5 lakhs to the parents of the minor child for the mental agony and the life-long care and attention that they have to bestow on the minor child [Harjot Ahluwalia (minor) through parents vs. M/s Spring Meadows Hospital and others].

DIRECT CAUSATION

The third element in liability requires that the damage, alleged to have resulted, should bear a direct 'cause and effect' relation- ship to the negligence of the doctor. A common concomitant of the causation factor is the legal concept of the 'but-for' test,

i.e. 'But for that negligence, would the harm have occurred?' would not have occurred. In contrast, a doctor's delay in the diagnosis of a highly aggressive malignant neoplasm might not necessarily affect the patient's chance of survival.

DAMAGE SUFFERED BY THE PATIENT

This is an injury or disability suffered by the patient and must be distinguished from 'damages' which are the financial com- pensations awarded to the successful plaintiff. The purpose of awarding damages in a tort action is to ensure that a person who has suffered damage (injury/harm) is made 'whole' or is returned to the previous condition that existed before the injury. Because it is generally not possible to alleviate the effects of an injury resulting from medical negligence, public policy necessitates redressal through financial compensation to the plaintiff. Two types of compensatory damages have generally been recognised: General damages being awarded for non-economic losses like pain, sufferings, mental anguish, grief and other related complaints. Special damages include past and future medical, surgical, hospital and other related costs, past and future loss of income, expenses for the cremation in case of death and unusual consequences of the alleged injury such as where there is aggravation of a pre-existing state of disease. Punitive or exemplary damages may occasionally be awarded in addition to those that are intended to set an example for the future or to punish the egregious behaviour of the defendant. Unfortunately, relatives/attendants of the deceased often equate the duty of care with that of 'recovery' or 'successful outcome' in the case (especially in surgery). In such like cases, conduction of autopsy by a board of doctors (including expert from the concerned specialty) is an ideal procedure. Photographic and videographic recording of the procedure may be carried out where felt necessary. Additional investiga- tions including histopathological and toxicological studies need to be considered as a part of work-up. Expressing opinion invites caution and the same should be logical and appropri- ately worded. The autopsy surgeon carries ultimate responsi- bility to determine the cause of death and therefore, must not accept dogmatic or unsubstantiated findings/answers from the consultant(s). However, he/she must always remain open to healthy discussion in considering/discussing a range of possi- bilities. It needs be remembered that it is neither the job nor a correct practice to summarily comment upon the aspect of negligence in the postmortem report or in some other report because pronouncing the aspect of negligence is in the purview of the Honourable Court.

In that determination, causal contributions by the plaintiff 's actions or failure to act, pre-existing or adventitious conditions and possible opportunities for follow-up remedial action, etc. may be explored. A typical example may be a case where there occurs an intestinal perforation resulting from abscess forma- tion due to some retained instrument by a surgeon in the abdominal cavity.

PROOF OF NEGLIGENCE

The standard of proof in civil actions, which include virtually all cases of medical negligence, is the 'balance of probabilities'. This is unlike the burden of proof in criminal trials where the jury must be satisfied of the guilt, 'beyond reasonable doubt'.Ordinarily, the task of proving negligence rests upon the plaintiff and it follows therefore that in medical cases it is for the patient or his relatives to establish his claim and not for the doc- tor to show that he acted with due care and skill. There are, however, certain cases, when the plaintiff need not prove that and the inference of presumption of negligence is drawn from the facts of the case, according to the maxim, 'res ipsa loquitur'. An example of the application of maxim was in the case of Cassidy vs. Ministry of Health. The plaintiff was operated upon for a Dupuytren contracture of the third and fourth fingers of his left hand. After the operation the patient's left hand and forearm were bandaged to a splint, which was kept in place for 14 days. During this period, he complained of pain in his hand but apart from the administration of sedatives no other action was taken. When the bandage was removed, it was discovered that all his four fingers of the hand were stiff and that the hand was to all intents and purposes useless. The Ministry denied negli- gence and liability for the surgeon under whose care the patient had been admitted. In the court of first instance, judgement was given for the Ministry on the ground that the patient had failed to establish negligence on the part of the surgeon or of any other member of the hospital staff. The patient appealed. The Court of Appeal held that the mere proof of the facts would cause a reasonable layman to draw the inference that the injury could have been caused only by want of care on the part of the hospital staff and that it was sufficient to call for an explanation from the defendant. The appeal was successful and the plaintiff was awarded damages.

Essentials of 'Res Ipsa Loquitur'

(i) Nature of injury or damage, suggested by common knowledge or inferred from expert evidence, that without negligence, it does not occur.

(ii) The defendant must be in exclusive control of the instrumentation or circumstances. The error in such cases is so obvious that the defendant has to establish his innocence.

(iii) The plaintiff must not contribute to his own injury or damage.

REBUTTAL OF PRESUMPTION OF NEGLIGENCE

The rule of *res ipsa loquitur* only shifts the burden of proof and instead of the plaintiff proving negligence on the part of the defendant, the defendant is required to disprove it. If the defendant is able to prove that what apparently seems to be negligence was due to some factors beyond the control of the defendant, he can escape liability. To rebut the presumption of negligence, it has also got to be proved that to ward off the evil consequences of such events, necessary preventive measures had been adopted. The maxim of *res ipsa loquitur* applies when the only infer- ence from the facts is that the damage could not have occurred but for the defendant's negligence. When the damage incurred is capable of two or more explanations, such a presumption may not be applicable.

SOME INSTANCES OF 'RES IPSA LOQUITUR'

Retention of Swabs, Packs, Instruments, Drains, etc.

Leaving a foreign body during an operation is the most deplorable accident. Many surgeons in conservation will reveal having removed foreign bodies, but seldom report the same. Such an accident of leaving a foreign body in the operation area may be seen in any area irrespective of specialty. Less than 10% have been reported to have been left to the upper abdomen where gallbladder surgery predominates and the gynaecologists appear to be the greatest offenders. The coils of intestines carry the notorious habit of crowding into the operative field thereby leading to certain unexpected situations. Under such circum- stances, attention may be directed towards saving life while ignoring the less essential. Admittedly, the present day operation is an organised team effort, and the mishap of leaving a foreign body during surgery may have origin in any source, ultimately affecting the surgeon's reputation.

It is logical to think that surgeon and his assistant(s) are burdened with so much technical responsibility that it is not possible for them to give individual attention to sponges and instruments. This may be best left to the scrub nurse who may also be assisted by the floating member of the operating room staff. It is, how- ever, essential that the surgeon and his assistant(s) must also confirm that nothing is left inside the abdomen by visually and manually examining the interior, particularly the recesses.

In cases, where the loss of sponge or any other material/ instrument is detected while the patient is still in the operation theatre or in the adjoining recovery room, it may be safer to re- open under the same anaesthesia. It becomes simply an extension of the operative work necessitated by the complication. However, if the patient has come out of the anaesthesia, no further step may be taken without fresh consent and information to his rela- tives. Here, the troubled surgeon must act in the best interests of the patient thinking that it would decidedly be to his advantage. Courts have stressed that the surgeon must himself deter- mine that no sponge/instrument has been left behind. Frequently, the surgeon, because of the critical condition of the patient, is unable to make proper search without endanger- ing the life of the patient. Under such situations the courts generally feel that the surgeon should take/show due care in retrieving all the sponges or instruments before he/she asks the nurse for the count. Defences against the charge of negligence may include:

- Difference in type of sponge found and the sponge used in the operation. It is for this reason that the law demands its preservation under seal and presentation to the court.
- Possibility of sponge having been left in another operation.
- Absence of causal relationship between leaving the sponge and the injury.
- In abortion cases, the patient may conceal the information of earlier attempts at abortion and may blame the surgeon for a retained foreign body after attempt at abortion, if she happens to have had an abdominal operation before.

Operation on the Wrong Patient or on the Wrong Part of a Patient

The range of possible mistakes is wide, ranging from an operation on the wrong digit to an operation on the wrong patient, sometimes on the wrong side or on the wrong limb.

Administration of the Wrong Substance

The allegation that a wrong substance has been administered is normally unanswerable, but it is not always easy to determine the responsibility. A recurring error may be the administration of a substance of a right kind but in the wrong strength. Such cases also stress that it is not enough for the doctor to rely on the nursing staff. The doctor should preferably see the bottle or ampoule from which the solution has been taken and also verify the label. In the event that some dispensing error might have been there, it is imperative that the remaining solution and the stock bottle or ampoule are set aside for appropriate tests.

CONTRIBUTORY NEGLIGENCE

If the plaintiff by his own want of care contributes to the damage caused by the negligent or wrongful act of the defendant, he is considered to be guilty of contributory negligence.

This is a defence in which the defendant has to prove that the plaintiff failed to take reasonable care of his own safety and that was a contributory factor to the harm ultimately suffered by the plaintiff. If A, going on the wrong side of the road, is hit by a vehicle coming from the opposite side and driven rashly by B, A can be met with the defence of contributory negligence on his part. In the medical practice, it may occur when the patient tampers with his dressings and induces infection or removes a plaster cast or bandage or more commonly ignores instructions to return for further treatment or follow-up, etc.

VICARIOUS LIABILITY

Physicians usually employ or supervise other less qualified health team members. They, therefore, owe their patients the duty in assigning supervision to the nurses or subordinate staff properly. The duty may create vicarious liability, whereby one person may be liable for the wrongful acts or omissions of another. There are several legal doctrines in this context.

The simplest such doctrine is known as 'respondeat supe- rior' (let the master answer) and states that an employer is lia- ble for the negligence of his or her employees. For example, if a doctor's office nurse injects a drug into a patient's sciatic nerve, causing injury, that patient may sue the physician for the nurse's negligence. Similarly, the interns, house surgeons/resi- dents, etc. who work under the guidance of superiors will not be answerable to any negligent act committed by them during training. Further, their liability may also be vicariously imputed to the hospital as an employer. In the words of Lord Denning, "Whenever they accept a patient for treatment, they must use reasonable care and skill to cure him of his ailment. The hospital authorities cannot, of course, do it themselves; they have no ears to listen through a stethoscope and no hands to hold the surgeon's knife. They must do it through the staff, which they employ. And if their staff is negligent in giving treatment they are just as liable for that negligence as is anyone else who employs others to do his duties for him ... once they undertake the task, they come under a duty to use care in the doing of it and that is so whether they do it for reward or not." Doctors may also be vicariously liable under other legal doctrine for the negligence of hospital employees they super- vise. For example, surgeons have been sued for errors and omissions by operating room personnel, under the 'captain of the ship' doctrine. This doctrine holds a surgeon liable based on the legal action that he or she exercises absolute control much like the captain of a ship at sea who is responsible for all the wrong perpetrated by the crew. The captain of the ship doctrine has been largely replaced by the 'borrowed servant' doctrine. Under this doctrine, a surgeon may be held respon- sible for the negligence of a nurse or any subordinate doctor, committed under direct control and supervision of the sur- geon. Further, an employee may serve more than one employer. In such cases, the lending employer temporarily surrenders control over his worker and the borrowing employer tempo- rarily takes over the control and thereby becomes responsible for all the acts committed under his or her direct supervision and control. Both the employer and the employee may be sued by the patient because the employee alone may be financially not so sound as to pay the entire damages. Usually, liability is fixed upon those who are actually at fault and those whose control over the negligent worker/employee is demonstrable.

LIABILITY FOR INJURY TO THE THIRD PARTIES

All doctors have a duty to warn patients about the aspects of their medical condition and/or treatment that could injure/ harm others, e.g. the doctor of a epileptic patient may be liable for injury to the non-patient if the injury has indirectly been caused by the negligent treatment or failure to advise the patient of the risks of engaging in dangerous activities. Although there may not exist doctor–patient relationship with the third party victim, yet the doctor may be held liable for ordinary negligence under the concept of 'reasonable fore- seeability', i.e. the injury to the non-patient was a foreseeable consequence of the patient's condition, which imposed on the doctor a duty to avoid injury to the foreseeable victims.

MEDICAL PRODUCT LIABILITY

Pharmaceuticals may be treated differently from other manufactured products. This different treatment may be partly due to the factor involving interaction that occurs between the body of the patient and the chemical compound of the drug. Frequently, the response of the drug depends upon the indi- vidual's physiology than on the product design.

The concept of strict liability eliminates the need to prove negligence for an injury caused by a defective product. Some commentators consider that the rules of strict liability should be applied to the drugs, while others think that a limited form of strict liability with less stringent rules be applied to drugs. Still others do not differentiate between drugs and other manufactured products. Multiple policy considerations govern the rules for appli- cability of strict liability in torts, namely: compensation or appor- tioning of the loss amongst all the consumers of the product, deterrence, encouraging useful conduct by both the parties to an action, protecting consumer expectations and improving the allocation of resources, etc. Injury or death of the patient may result from unexpected by-product of faulty, defective or neg- ligently designed medical/surgical instrument or inadequate instructions. The manufacturer becomes responsible provided it is shown that he departed from the usual standards of care and skill with respect to design, assemblage, package, failure to test and inspect for defects or failure to warn. If the instru- ment functioned satisfactorily in previous operations or for several previous years in the hospital's possession, it is a proof that it was not defective at the time of supplying. Later, if the instrument develops a defect through ordinary and gradual wear and tear, or if the physician or the hospital misused the manufacturer's medical products, the hospital or physician owner is liable for the failure to inspect, test and get such defects repaired.

In the development of concept of defectiveness of a drug, the most appropriate approach seems to be the 'risk/utility' test. This may be taken as a balancing test between the risk of danger associated with a product and the utility of the product to the consumer. The emphasis here is on the safety of the product rather than on the reasonable or unreasonable action of the manufacturer. The supplier of any product, including the manufacturer, is under a duty to use reasonable care to warn adequately about the risks associated with the use of its product(s). This duty extends to the risks about which the manufacturer knows and those about which, through reason- able care, should have known. However, a manufacturer is not responsible for unforeseeable or unknown dangers he is unable to discover with reasonable care. Drug manufacturer's duty to warn includes a warning to the physicians of the risks that are likely to ensue in the normal use. The doctor may be consid- ered as the 'learned intermediate person' and as such, the duty of the manufacturer to warn ends here in most of the cases and it is then the duty of the doctor to warn the patient. However, in cases where the manufacturer knows that the product will reach the public without individualised medical intervention, the drug manufacturer is duty-bound to warn the public at large. For example, in the case of immunisations where the individual is given the standardised dose of the vac- cine, birth-control pills and certain drugs of common use with ample advertisements on the television.

Adequacy of warning may also be material in determining the liability. Adequacy of warning is achieved, if it is obviously displayed giving fair appraisal of the extent of the danger and properly instructing about the manner of use of the product.

Medical/sales representatives occupy a position differ- ent from those of other salespersons. Their potential misrep- resentation of the product may lead to cause harm to the ultimate consumer. These persons, acting as a link between the manufacturer and the doctor, are the most common transmit- ters of the information concerning the pharmaceuticals. They are frequently torn between a desire to increase the sale and a duty to inform the doctor about the possible side effects and contraindications of the drug. Even though the oral commu- nications of these representatives are difficult to monitor, the manufacturer and the drug companies may be held liable for improper over-promotion of safety by representatives.

The manufacturer, the seller or anyone in the chain of sales may be sued by the buyer or any other ultimate user of the product who has suffered injury/harm/damage through the use of the product. If the injury/harm/damage was related in someway to the warning, evidence will be required as to the physical and chemical properties/qualities of the drug neces- sitating displaying of adequate warning.

CRIMINALISATION OF NEGLIGENCE

Negligence in civil and criminal context carries some distin- guishing features. There can be no civil action for negligence if the negligent act or omission has not been attended by an injury to any person, whereas bare negligence involving the risk of injury is punishable criminally though nobody is actually hurt by it. Further, in a civil action, the injured party has an option to sue specific person or those falling in the chain of events, whereas in an action for criminal liability, every person is responsible for his own act, there must be some personal act. And above all, in determining liability in civil cases, the out- come rests upon balance of probabilities, i.e. was it more likely than not that the condition was caused by negligence rather than some complication of disease, whereas in determining criminal liability, the standard of proof is 'beyond reasonable doubt'.

Differentiating Features between Civil and Criminal Negligence

Civil negligence	Criminal negligence
Lack of reasonable care and skill in the professional behaviour.	Gross carelessness and scant regard for patient's welfare.
A dispute between two parties in their individual capacity.	A case between the State and the accused doctor.
The injured party has an option to sue specific person or thosefalling in the chain of events.	Every person is responsible for his own act. And, there must besome personal act.
There can be no civil action for negligence if the negligent actor omission has not been attended by an injury/harm/damage tothe patient.	Bare negligence involving the risk of injury is punishablecriminally, though nobody is actually hurt.
Contributory negligence can be cited as a defence.	Contributory negligence does not constitute defence.
The standard of proof rests upon the balance of probabilities, i.e. was it more likely than not that the condition/damage/harm was caused by negligence rather than by some complication.	The standard of proof requires establishment of guilt 'beyondreasonable doubt'.
Accused doctor is liable to pay damages.	Accused doctor is punishable with imprisonment or fine orboth as per provisions of the IPC.

Note: Certain patterns of conduct may be more likely considered to equate a culpable state of mind with criminal negligence.

Examples may include

(i) disregarding past experience (i.e., the defendant doctor had sufficient knowledge of the problem based on his previous experience to have known that the problem would cause danger, but the doctor ignored the danger);

(ii) *(ii)* failing to limit harm/damage in a timely manner (i.e., despite occurrence of initial negligence, exercising/not exercising due steps to limit the harm becomes the decisive issue) and

(iii) *(iii)* appearance of improper motive (i.e., practicing in defiance of restrictions, or practicing in a manner that suggests more interest in financial gains than patient's well-being).

CONSUMER PROTECTION ACT AND MEDICAL NEGLIGENCE

Headlines proclaiming that a historic judgement of the Supreme Court permits doctors to be sued for medical negligence led to hysterical outbursts from doctors. The apprehensions that it will lead to huge increase in the medical expenditure on account of the insurance charges as well as tremendous increase in the defen- sive medicine and that there will be no safeguards against frivolous and vexatious complaints are largely unfounded. An analytical study of tort litigation in India during the period from 1975 to 1985 made by Professor Galanter reveals that a total number of 416 tort cases were decided by High Courts and Supreme Court, as reported in *All India Reporter*; out of which, 360 cases were related to 'Motor Vehicles Act', and cases related to medical practice were only three in number, because people in India are less litigation oriented as compared to those in England or USA. The judgement has neither invented liability of doctors nor modified the notion. It has simply laid down that doctors provide a service and are accountable under the Act. It has provided a speedier and inexpensive mode of adjudication through the 'Consumer Dispute Redressal Fora' (Table 23.2). On balance, however, patients should be net gainers, as most people will happily pay a bit more for steps that may save their lives or limbs. The law, probably, does not want to permit the medical profession to play demi-God but wants to instill some fear in the minds of cavalier doctors.

The Apex Court in its latest judgement (Martin F D'Souza vs. Mohd Ishfaq; decided on 17.02.2009) has again emphasised that the guidelines conveyed in Jacob Mathew case be observed strictly and warned the police officials not to arrest or harass doctors unless there is a prima facie case of medical negligence. A couple of excerpts from the judgement conveying significant breather to the medical profession are being penned down:

- We, therefore, direct that whenever a complaint is received against a doctor or hospital by Consumer Fora (whether District, State or National) or by the Criminal Court then before issuing notice to the doctor or hospital against whom the complaint was made, the Consumer Forum or Criminal Court should first refer the matter to a competent doctor or committee of doctors, specialised in the field relating to which the medical negligence is attributed, and only after that doctor or committee reports that there is a prima facie case of medi- cal negligence notice should be issued to the concerned doc-tor/hospital. This is necessary to avoid harassment to doctors who may not be ultimately found to be negligent.

- The Courts and Consumer Fora are not experts in medical science, and must not substitute their own views over that of specialists. It is true that the medical profession has, to an extent, become commercialised and there are many doctors who depart from their Hippocratic Oath for their selfish ends of making money. However, the entire medical frater- nity cannot be blamed or branded as lacking in integrity or competence just because of some bad apples.

CHAPTER-20

CONSENT TO AND REFUSAL OF TREATMENT

Every human being of adult years and sound mind has a right to deter- mine what shall be done with his own body, and a surgeon who performs an operation without patient's consent commits an assault for which he is liable in damages".

With these words Judge Cardozo in 1914 expressed a patient's right to autonomy in medical decision making. One who consents to being 'touched' cannot later complain that he or she has been battered, even though the touching may have caused actual harm.

Consent plays an important role in the criminal law in the sense that it has the effect of exonerating or extenuating a with cases where the act is done in good faith and for the benefit of the child or insane person, by or by consent of guardian or person empowered to give consent for that purpose on behalf of the child or the insane. Section 92 deals with cases of emergency. Under this Section, consent may be absolutely dispensed with when the circumstances are such as to render consent impossible or when, in case of person incapable of assenting, there is not one at hand whose consent can be substitute.

The concept is primitive one and is based upon the Roman maxim 'volenti non-fit injuria', i.e. he who consents cannot complain of it. The concept was also to be seen in the ruling of the Judge Cardozo in context with the famous amusement ride case: "One who takes part in such sport accepts the dangers so far that they are obvious and necessary just as a fencer accepts the risks of a thrust by his antagonist or a spectator at a ball game the chance of contact with the ball" [Murphy vs. Steeplechase Amusement Co; 250, NY; 479, 482(1929)].

Consent may be defined as the concurrence of 'wills', and its chief essential constituent is the consciousness or knowledge of the act consented to ('will' implies the faculty by which a rational mind makes choice of its ends of action, and directs the energies in carrying out its determinations). Section 90 of IPC instead of giving positive definition of the word 'consent' defines it in the negative terms. This Section explains that if the consent is obtained by coercion (under fear of injury), undue influence, fraud, misrepresentation or misconception of fact, the consent gets vitiated. Further, the Section goes on to say that the consent given by a person who by reason of unsoundness of mind, intoxication, or immaturity of age (i.e., a child under 12 years of age) is incapable of understanding the nature and consequences of the act to which he consents is not valid in the eyes of the law. Sections 87 and 88 of IPC speak of exemption of liability when the harm is caused by an act done in good faith and for the benefit of the consenting individual. Section 89 of IPC deals.

TYPES OF CONSENT

The consent may either be implied or express. An implied consent is a consent which is not written, i.e., its existence is not expressly asserted, but nonetheless, it is legally effective. It is pro- vided by the demeanour of the patient and is by far the most common variety of consent in both general and hospital practice. It implies consent to medical examination in a general sense but not to procedures more complex than inspection, palpation, and auscultation. Some medical procedures in which implied consent is readily apparent include an emergency, a comatose patient requiring immediate treatment, a mentally incompetent patient requiring treatment when a legal guardian is unavailable, an intoxicated patient lacking capacity to reasoning and any patient allowing treatment to proceed without objection. Typical situation may be cited when the patient proffers the arm for the venepuncture. Legal problems may not normally arise from a simple venepuncture. However, the issue may get complicated when the repeated attempts are being made, the initial being unsuccessful. Admitted that there is never any intention to harm, it is nevertheless possible that such unskilled attempts may be regarded by the courts amounting to 'recklessness' denoting want of care and breach of duty imposed by law. An express consent is one, the terms of which are stated in distinct and explicit language. It may be oral or written. For the majority of relatively minor examinations or therapeutic proce- dures, oral consent is employed but this should preferably be obtained in the presence of a disinterested party and not a per- son closely associated with the patient whose later testimony may be biased. Disinterested witness in a hospital practice could be any literate paramedical staff, e.g. a nurse, a pharma- cist, etc. Oral consent, where properly witnessed, is as valid as written consent, but the latter has the advantage of easy proof and permanent form.

DOCTRINE OF EXTENTION AND PROPORTIONALITY

When a patient consents to medical therapy or for the performance of a procedure or a surgical operation, the scope of the consent is limited to whatever parameters were expressed before the medical intervention. Nevertheless, in appropriate circum- stances an extension of the scope of the consent would be permissible to save the life of the patient. The doctrine of proportionality advocates that artificial life support (in the form of respirator, intravenous fluids, or nasogastric feeding, etc.) needs to be maintained as long as it constitutes propor- tionate treatment, i.e. the treatment that has at least a reason- able chance of providing benefit to the patient that outweigh the burden attendant upon the treatment.

A classical example of the application of this doctrine may be seen in the case of Samira Kohli vs. Dr. Prabha Manchanda & Another (decided by the Apex Court on 16.01.08). Facts, in brief, were as follows:

On 09.05.1995, the appellant, an unmarried woman aged about 44 years, visited the clinic of the respondents for her complaint of prolonged menstrual bleeding for 9 days. After examination and ultrasound report, the respondent had a dis- cussion with the appellant and advised her to come on the next day for making an affirmative diagnosis.

On 10.05.1995, the appellant was admitted for diagnostic and operative laparoscopy. The 'consent form' for surgery filled by Dr. Lata Rangan (respondent's assistant) described the procedure to be undergone by the appellant as "Diagnostic and operative laparoscopy. Laparotomy may be needed".

On 10.05.1995, the appellant was put under general anaes- thesia and subjected to laparoscopic examination. The appellant left the respondent's clinic on 15.05.1995 without settling the bill. Consequently, the respondent lodged a complaint with the police alleging nonclearance of bill by the appellant. However, appellant also lodged a complaint against the respondent on 31.05.1995 alleging negligence and unau- thorised removal of her reproductive organs.

The litigation was dragged through various strata of Consumer Courts and finally, National Consumer Disputes Redressal Commission decided in favour of the doctor. However, the Apex Court setting aside 'the order' of the Commission decided the appeal in favour of the patient on the basis of inadequate consent for surgery. Some relevant contents from the judgement are being reproduced:

- Consent given only for a diagnostic procedure cannot be considered as consent for therapeutic treatment. Consent given for a specific treatment procedure will not be valid for conducting some other treatment procedure. The fact that the unauthorised additional surgery is beneficial to the patient, or that it would save considerable time and expense to the patient, or would relieve the patient from pain and suffering in future, are not grounds of defence in an action in tort for negligence or assault and battery. The only exception to this rule is where the additional procedure though unau- thorised is necessary in order to save the life or preserve the health of the patient, and it would be unreasonable to delay such unauthorised procedure until patient regains conscious- ness and takes a decision.

- There can be a common consent for diagnostic and operative procedures where they are contemplated. There can also be a common consent for a particular surgical procedure and an additional or further procedure in the event of doctor/ surgeon having anticipated the possible need for the same.

- Highlighting the components of informed consent, the Apex Court observed that it should include (*i*) disclosing nature, purpose and procedure of treatment with its benefits and effects; (*ii*) alternatives (if any available); (*iii*) an outline of the substantial risks; and (*iv*) adverse consequences of refusing treatment. "But there is no need to explain remote or theoretical risks involved in the process or in its refusal, so as to frighten a patient either into refusing the necessary treatment or undergoing a fanciful or unnecessary treatment", the court stressed.

DOCTRINE OF INFORMED CONSENT

The term 'informed consent' was first used in 1957 by a California Appellate Court in Salgo vs. Lenand Stanford, Jr., University Board of Trustees case. In this case, the patient consented to an aortogram without being advised, allegedly, of the risk posed by the use of contrast medium. The patient suffered damage and filed a suit against the doctor. The court asserted, "A physician violates his duty to the patient and subjects himself to liability if he withholds any fact that is necessary to form the basis of an intelligent consent by the patient to the proposed treat- ment." Since that pronouncement, the doctrine of 'informed consent' has evolved largely through case law and the following elements are generally considered to meet the standard of an adequate dissemination of information:

- A doctor should explain to his patient the nature of the procedure, treatment or disease.
- The patient should be informed about the expectation of the recommended treatment and the likelihood of success.
- The patient should know what reasonable alternatives are available and what the probable outcome would be in the absence of treatment.
- The patient should be informed about the particular known inherent risks that are material to the informed decision.
- Of considerable importance, however, is the necessity to convey to the patient the doctor's readiness to listen and to discuss anything the patient may fear as a risk, a side effect, or a concern about the proposed treatment. Informed con- sent is an ongoing process, a two-person conversation extending over time, rather than a form signed once and for all, never again to be discussed.

ABILITY TO CONSENT

A patient giving consent must be of adult years and capable of comprehending the information provided by the doctor during the dialogue and making a decision concerning the course of treatment. The patients lacking mental capacity to give informed consent require a surrogate, usually a close family member or guardian to give substitute consent. The substitute consent must be obtained through the same process of dialogue that the doctor would have had with patient if he or she were competent. In some situations, where there exists difference of opinion among the family members regarding a patient's care or if family members are distant emotionally or geographically, formal legal proceedings may be advisable to determine who can give con- sent for the incompetent patient.

EXCEPTIONS TO MEDICAL DISCLOSURE

Who is responsible for obtaining the patient's informed consent? The duty falls upon the patient's attending doctor at the time in question, as it is obvious that a doctor is in the best position to decide what information should be disclosed for the patient to make an informed choice, notwithstanding the fact that courts do not provide practical standards of disclo- sure. The nurse or the other provider may only supplement or complement the doctor's specific information with general information regarding the patient's condition. A substitute doctor covering for the patient's original doctor has an inde- pendent obligation to inform the patient of the risks, benefits and alternatives to the part of the treatment that he/she is to administer.

HOSPITAL'S ROLE

A question that may creep, particularly for those practising in a hospital setting, is—Does the hospital has a responsibility to ensure that the patient received adequate disclosure? Under the theory of 'respondeat superior', an employer-hospital could be held jointly liable with an employee-doctor whose failure to obtain informed consent can be shown to have caused injury and damage to a patient. A hospital policy must govern the procedure by which consents are obtained and any deviation from such a policy may be admissible evidence. Hospital liability informed consent. The patient may reject disclosure out of a desire to remain ignorant or the patient may have already had a similar medical experience.

EVEDENTRY PROOF OF ADEQUATE DISCLOSURE

"Document it. If you haven't documented it, you didn't do it." I agree with Dr. Mark E Battista's premise that failure to document usually reflects negatively on the part of the doctor. Moreover, fighting in the patient's medical record is often a key factor that a plaintiff 's attorney looks for before undertaking the case. Written documentation of the informed consent is of prime importance for both the parties should litigation later arises. The weight to be accorded to such documentary evidence versus a mere oral consent is a question for the trier of the fact. However, a written consent form signed by the patient often provides strong documentary evidence, which usually forms a rebuttable presumption that valid consent was obtained. It may be necessary to establish the time, location, the persons present and the content of the document, etc.

The imbalance of authority and specific knowledge between the doctor and the patient dictates that society must expect the doctor to pay the highest duty of fidelity and honesty to his patient. In the legal parlance, it has been termed as 'fiduciary relationship' (i.e., relationship of trust and confidence between the doctor and patient). Doctor's over-riding consideration should remain towards his patient, while also remaining aware of his duty towards colleagues and the community at large. Failure of empathy and communication often act as precipitating factors for negligence suits. When something has gone wrong, the doctor should show readiness to assure every step to readdress patient's medical and related problems. Falsification of records to hush up the things, 'scratching out' the records to mend the same or insert- ing addenda between other notes is readily identifiable. Such modi- fications/alterations raise suspicion rather than lending support.

SECTION 53, 53A AND 164A OF CrPC IN RELATION TO CONSENT

SECTION 53: EXAMINATION OF ACCUSED BY MEDICAL PRACTITIONER AT THE REQUEST OF POLICE OFFICER

- When a person is arrested on charge of committing an offence of such a nature and alleged to have been committed under such circumstances that there are reasonable grounds for believing that an examination of his person will afford evidence as to the commission of an offence, it shall be lawful for a registered medical practitioner, acting at the request of a police officer not below the rank of sub-inspector, and for any person acting in good faith in his aid and under his direction, to make such an examination of the person arrested as is reasonably necessary in order to ascertain the facts that may afford such evidence, and to use such force as is reason- ably necessary for that purpose.

- Whenever the person of a female is to be examined under this Section, the examination shall be made only by or under the supervision of a female registered medical practitioner.

[Explanation: In this Section and in Sections 53A and 54, 'examination' shall include the examination of blood, blood stains, semen, swabs in case of sexual offences, sputum and sweat, hair samples and fingernail clippings by the use of mod- ern and scientific techniques including DNA profiling and such other tests that the registered medical practitioner thinks necessary in a particular case; 'registered medical practitioner' means a medical practitioner who possess any medical qualifi- cation as defined in clause (h) of Section 2 of the Indian Medical Council Act, 1956 (102 of 1956) and whose name has been entered in a State Medical Register.]

SECTION 53A: MEDICAL EXAMINATION OF ACCUSED OF RAPE

- When a person is arrested on charge of committing rape or an attempt to commit rape and there are reasonable grounds for believing that an examination of his person will afford evidence as to the commission of such offence, it shall be lawful for a registered medical practitioner employed in a hospital run by the Government or by a local authority and in the absence of such a practitioner within the radius of 16 km from the place where the offence has been commit- ted by any other registered medical practitioner, acting at the request of a police officer not below the rank of a sub- inspector, and for any person acting in good faith in his aid and under his direction, to make such an examination of the arrested person and to use such force as is reasonably necessary for that purpose.

- The registered medical practitioner conducting such exami-

nation shall, without delay, examine such person and prepare a report of his examination giving the following particulars, namely: the name and address of the accused and of the person by whom he was brought; the age of the accused; the marks of injury, if any, on the person of the accused; the description of material taken from the person of the accused for DNA profiling; and other material particulars in reasonable detail.

- The report shall state precisely the reasons for each conclusion arrived at.
- The exact time of commencement and completion of the examination shall also be noted in the report.
- The registered medical practitioner shall, without delay, forward the report of the investigating officer, who shall forward it to the Magistrate referred to in Section 173 as part 1 of the documents referred to in clause (a) of sub-section of that Section.

SECTION 164A: MEDICAL EXAMINATION OF THE VICTIM OF RAPE

- Where during the stage when an offence of committing rape or attempt to commit rape is under investigation, it is proposed to get the person of the woman with whom rape is alleged or attempted to have been committed or attempted examined by a medical expert; such examination shall be conducted by a registered medical practitioner employed in a hospital run by the Government or a local authority and in the absence of such a practitioner, by any other registered medical practitioner, with the consent of such woman or of a person competent to give such consent on her behalf and such woman shall be sent to such regis- tered medical practitioner within 24 hours from the time of receiving the information relating to the commission of such offence.
- The registered medical practitioner to whom such woman is sent shall, without delay, examine her and prepare a report of his examination giving the following particulars:
  - the name and address of the woman and of the person by whom she was brought;
  - the age of the woman;
  - the description of material taken from the person of the woman for DNA profiling;
  - marks of injury, if any, on the person of the woman;
  - general mental condition of the woman; and
  - other material particulars in reasonable detail.

- The report shall state precisely the reasons for each conclusion arrived at.
- The report shall specifically record that the consent of the woman or of the person competent to give such consent on her behalf of such examination had been obtained.
- The exact time of commencement and completion of the examination shall also be noted in the report.
- The registered medical practitioner shall, without delay, forward the report to the investigation officer who shall forward it to the Magistrate referred to in Section 173 as part of the documents referred to in clause (a) of sub-section (5) of that Section.
- Nothing in this Section shall be construed as rendering any examination lawful without the consent of the woman or of any person competent to give such consent on her behalf.

EUTHANASIA

The word 'euthanasia' is a Greek word, which means easy (or gentle) death. It is a practice of granting a painless death to persons suffering from painful and incurable illness or from incapacitating physical disorder. The various forms may be as shown in Table.

Considerations for Euthanasia

Term	Essential features
Voluntary active euthanasia	Intentionally administering medications or other interventions to cause the patient's death at the patient's explicit request and with full informed consent
Involuntary active euthanasia	Intentionally administering medications or other interventions to cause the patient's death when patient was competent but without the patient's explicit request and/or full informed consent; e.g. patientmay not have been asked
Nonvoluntary active euthanasia	Intentionally administering medications or other interventions to cause the patient's death when patient was incompetent and mentally incapable of explicitly requesting it; e.g., patientmight have been in coma
Terminating life-sustaining treatment (passive euthanasia)	Withholding or withdrawing life-sustaining medical treatments from the patient to let him or her die
Indirect euthanasia	Administering narcotics or other medications to relieve pain with incidental consequence of causingsufficient respiratory depression toresult in patient's death
Physician-assisted suicide	A physician providing medications or other interventions to a patient with understanding that the patient intendsto use them to commit suicide

AID IN DYING, DOCTOR-ASSISTED SUICIDE AND EUTHANASIA

A doctor's compassionate considerations to pass orders for turning off the respirator in a respiratory dependent patient or for withholding needed medication or not administering hydration and nutrition in patients who suffer excruciating, agonising, slow and very painful deaths may be regarded as some examples of 'letting the patient die' or 'aid in dying'. Here, the doctor is playing his role, though on compassionate grounds but with the approval of the patient or the immediate next family member, to the course of treatment or nontreatment. Another example of 'aid in dying' with the doctor's involvement is the 'terminal sedation'. This method of 'doctor-aided dying' includes the administration of large doses of morphine and similar medica- tion that has a dual effect of relieving pain and hastening death of terminally ill patient. Such forms of aid in are not to kill or hasten death but rather to relieve the intractable pain and suf- fering of the terminally ill patient. Consent, as written earlier, is provided by the patient or the surrogate decision maker (where the patient is incapable of expressing consent). Even the 'advanced medical directives' or the so-called 'living wills' (laws to say in advance that one does not want to be kept alive by artificial means, when there is no hope) have also been recognised. On the other hand, if the patient requests the very same treatment with its known dual effect and the doctor knowingly provides the medication so that the patient can end his/her life, it is considered as doctor-assisted suicide. Here, the intent of the patient to end life prematurely by unnatural means is communicated to the doctor, which introduces a criminal element and, therefore, not recommended/advocated. In 'doctor-assisted suicide', the doctor provides the patient with medical know-how (i.e. discussing painless and effective medical means of committing suicide) enabling the patient to end his/her life. Finally, where a doctor or any healthcare pro- vider provides a medical treatment intended to cause death of a terminally ill patient without that patient's or a family mem- ber's consent may be charged with murder or culpable homi- cide. The doctor will be committing voluntary active euthanasia wherein the doctor causes the death of a competent patient. Criminal law exists to protect the public interest as opposed to the private interests.

This becomes all the more relevant while looking at the judgement of the Supreme Court, declaring: 'Right to die' not included in the 'Right to life'. The operative part of the judge- ment is produced below: "When a man commits suicide, he has to undertake certain positive overt acts and the genesis of those acts cannot be traced to, or be included within the protection of the 'right to life' under Article 21. The significant aspect of 'sanctity of life' is also not to be overlooked. Article 21 is a provision guaranteeing protection of life and personal liberty and by no stretch of imagi- nation can imply 'extinction of life'. Whatever may be the phi- losophy of permitting a person to extinguish his life by committing suicide, we find difficult to construe Article 21 to include within it the 'right to die' as a part of the fundamental right guaran- teed therein. 'Right to life' is a natural right embodied in Article 21, but suicide is an unnatural termination or extinction of life and therefore incompatible and inconsistent with the concept of 'right to life'. With respect and in all humility, we find no similarity in the nature of the other rights, such as the right to 'freedom of speech', etc., to provide a comparable basis to hold that the 'right to life' also includes the 'right to die'.

CHAPTER-21

MEDICO LEGAL IN NUTSHELL

General Forensic Medicine

Personal Identification

Medicolegal Autopsy

Thanatology

Injuries and its medical legal aspects

Asphyxial Death

Medico legal expects of sexual offences

GENERAL FORENSIC MEDICINE

Forensic Medicine has been defined as the branch of medical discipline dealing with the application of knowledge of principles and practices in regard to the medical and paramedical sciences in relevance to the purpose of administration of law implying to justice.

Inquest- An enquiry to investigate the case of death, especially in case of sudden, suspicious and unnatural death.

- Types of inquest
    - Police Inquest
    - Magistrate Inquest
        - Executive Magistrate Inquest
        - Judicial Magistrate Inquest

Police Inquest	Executive Magistrate Inquest	Judicial Magistrate Inquest
• Conducted u/s 174 CrPc by police • Information is given to executive magistrate of the area • All the cases are being done expect those handled by the magistrate • Examination of witness is done u/s 175 CrPc • Exhumation Cannot be ordered enquiry of investigation Regarded has inferior • Examination of Viscera can be requested but not ordered	• Conducted u/s 176(1) CrPC by executive magistrate • Case of exhumation and death of a woman occurred within 7 days of marriage • Examination of witness is done u/s 176(1) CrPC • Exhumation can be ordered and the quality of investigation regarded as superior • Examination of Viscera can be ordered	• Conducted u/s 176(1) CrPC by judicial magistrate • Cases of conditional death, death of person in police firing. • Examination of witness is done u/s 176(1A) CrPC • exhumation can be ordered and the quality of investigation regarded as best • Examination of Viscera can be ordered

Subpoena-writ directive to be issued in original and duplicate by the Presiding Officer of the court compelling the presence of the witness before the court of law under penalty on a specific given date and time, with the purpose of produce evidence. Non-compliance of the same punishable u/s 174 CrCP and can be issued warrant of arrest u/s 87CrCP.

Evidence- Any probative material or species of proof that can be presented at the time of trial in order to induce belief in the court of law.

- Types –
  - Recording to acquisition direct and indirect evidences
  - According to presentation, oral and documentary

According to presentation in court

Evidence

Direct evidence can be either of them

Documentary evidence

Oral evidence

Medical certificates

Medicolegal reports

Dying declaration

Dying deposition

Exceptions to oral evidence

- Of ill health
- Of death
- Of insanity
- Of age
- Of Sex
- Pensioned disabilities

- Injury report
- Post mortem report
- Sexual assault report
- Report on abortion, recent delivery
- Report on anaesthetic death

- Statement, written or verbal, made by dying person (presumed that will speak nothing but the truth) as to the cause of circumstances bearing material facts relating who to his/her impending unnatural death.

- Statement of a dying person, recorded on oath, before magistrate and accused or his council, stating the condition which resulted in his dying circumstances.

DyingDeclaration recorded by anyone

•oath not administered

•presence of accused or lawyer not necessary
•cross examination not done
•mere recording of statement
•documentary evidence
•if victim survives, loses value
•less of legal value
•prevalent in India

Dying Deposition recorded by judge or judicial magistrate

•oath administered
•presence of accused or lawyer necessary
•cross examination done
•court by the bedside
•oral evidence
•if victim suntives, retains value
•much of legal value
not prevalent in India

6 A's of Professional Misconduct

6 A's of Professional Misconduct

- Association - with unqualified persons
- Advertising
- Adultery
- Abortion
- Addiction
- Alcohol

Professional Negligence	
Offence when willful negligence or utter disregard for care and attention Duty towards patient Damage to the patient always present Trial done by civil or criminal court Punishment of imprisonment or fine or both Appeal done in higher court	Offence when code of medical ethics being Professional Misconduct Punishment of warning or erasure of name violated Appeal done to state or central government No such duty necessary Damage need not be present Trial done by medical councils from medical register

Medical Practice & Pena/ Provisions

U/S 74 /PC Non —attendance in obedience to summons from court

U/S 118 [PC Concealing design to commit offence punishable with death or imprisonment for

life

U/S 175 /PC Omission to produce document to public servant legally bound to produce it

U/S 176 /PC Omission to give notice or information to public servant legally bound to give it u/s 177 [PC Furnishing false information

U/S 178/PC Refusing oath or affirmation when duly required to public servant to make it u/s 179 [PC Refusing to answer public servant authorized to question

U/S 182 /PC False information with intent to cause public servant to use his lawful power to the injury of another person u/s 191 [PC Giving false evidence u/s 192 /PC Fabricating false evidence u/s 193 [PC Punishment for false evidence a/s 194 [PC Giving or fabricating false evidence with intent to procure conviction of capital offence

u/s 195 [PC Giving or fabricating false evidence with intent to procure conviction of offence punishable with imprisonment for life or for certain period

u/s 197 /PC Issuing or signing false certificate

201 /PC Causing disappearance of evidence of offence or giving false information to screen offenders u/s 202 /PC Intentional omission to give information of offence by person bound to inform

I-O/S 203 [PC Giving false information respecting an offence committed

204 /PC Destruction of document to prevent its production in court as evidence u/s 269 /PC Negligent act likely to spread infection of disease dangerous to life u/s 270 /pc Malignant act likely to spread infection of disease dangerous to life u/s39 Crpc Any person aware of commission of offence punishable under IPC shall forthwith the information to nearest magistrate or police officer of such commission

u/s 160CrPC Police officer has the power to summon any witness (including doctor) to police station for recording a statement s 161 CrPC Police has power to examine witness s162 CMC Oral statements made to police and recorded should not be signed. Legal protection to medical professionals provided by u/s 88 to 93 I

PERSONAL IDENTIFICATION

Identity Establishment

Race
Religion and caste
Age
Sex
Height and Weight
General configuration and Stature
Congenital pecularities
Dactylography
Anthropometry
Acquired and personal pecularities
Photographs & Illuminations
EV method of identification
Superimposition test
DNA Fingerprinting

Race — can be identified through a. clothings, b. complexion, c. eyes, d. hair, e. teeth, f. feet, g. tattoo marks, h. social status-habits-trade, i. cephalic index, j. skeleton

Traits	**Caucasian**	**Mongloids**	**Negroids**
Skin	Fair	Fair/black/brown	Black
Scalp hairs	Thin, blackish brown or reddish brown	Thick, black, straight	Curly, wooly short
Iris	Grey or blue	Black	Black
Skull	Round	Square	Narrow & elongated
Forehead	Raised	Inclined	Small & compressed
Orbit	Triangular	High up & round	Low down & square
Nasal aperture	Elongated & narrow	Rounded & flat	Broad & wide
Face	Proportionately small	Proportionately large & flat with prominent malar bones	Malar bones prominent, jaws projecting and teeth set oblique
Palate	Triangular	Rounded	Rectangular
Upper limbs	Normal	Comparatively small	Proportionately long
Lower limbs	Normal	Comparatively small	Proportionately long
Lumbar vertebrae	Anterior exceeds posterior by 5.6mm	Posterior exceeds anterior by 5.8mm	Curve is straight
Cephalic index	75-79.9	80 & above	70 — 74.9
Height Index	71	75	72
Nasal Index	46	50	55

Sex — can be identified through study of a. generic sex, b. hormonal sex, c. anatomical sex, d. gonadal sex, e. psychological sex. Anatomical Sex can be distinguished using distinct features of a. skull, b. pelvis, c. Mandible, d. Sternum, e. Thorax & Ribs, f. Sacrum, g. Femur, h. Humerus, i. Radius & Ulna.

Traits	Male	Female
A. skull		
General	Larger, heavier, more massive	Smaller, light, less massive
Architecture	Rugged	Smooth
Walls	Thicker	Thinner
Surface	Rough	Smooth
Muscular ridge	More marked	Less marked
Capacity	1500 -1550 mL	1350 -1400 ml
Forehead	Steeper, less rounded	Vertical, fuller, rounder
Glabella	More prominent	Small or absent
Frontonasal junction	Distinct angulation	Smooth curve
Orbits	Relatively smaller, square, set lower on face, round margins	Relatively larger, rounded, set higher on face, sharp margins
Supraorbital ridges	Prominent	Less prominent or absent
Zygomatic arch	Heavier and more prominent, laterally arched	Lighter and less prominent, more compressed
Nasal aperture	Higher and narrower	Lower and broader
Frontal eminences	Small	Large
Parietal eminences	Small	Large
Frontal sinuses	More developed	Less developed
Maxillary sinuses	Larger	Smaller
Occipital protuberance	Very prominent	Less prominent
Mastoid process	Large, blunt, M type	Small, pointed, F type
Digastric groove	Deeper	Shallower
Occipital condyles	Larger	Smaller
Palate	Larger, broader, U shaped	Smaller, narrower, Parabolic
Foramina	Larger	Narrower
Foramen magnum	Larger and oblong	Smaller and rounder
Teeth	Larger	Smaller
B. PELVIS		
Bony framework	Massive, more erect, muscular markings more, rougher, stands higher	Less massive, less erect, muscular markings less, smoother
Bones	Tough, thick, heavy	More delicate, thin, light
General shape	Deep funnel	Flat bowl
Ilium	Curve reaches higher level, more prominent, less vertical, distance between crests more, curves less marked	Curves reaches lower level, less prominent, more vertical, distance between crests less, curve more marked

Preauricular sulcus	Not prominent, narrow, shallow	More frequent, broad, deep
Acetabulum	Large, directed laterally	Small, directed anterolaterally
Obturator Foramen	Large, oval, base upwards	Small, triangular, apex forwards
Greater sciatic notch	Smaller, narrower, deeper	Larger, wider, shallower

Embryo (2nd week-3rd month of gestation

Ovum (fertilization-2nd week of gestation

Child (1 yr – 12 yrs)

Foetus (3rd month of gestation – born)

Infant (born- 1 yr age

Adolescent (12 yrs – 18 yrs)

Young adult (18 yrs- 40 yrs)

Middle aged (40 yrs- 60 yrs

Old Aged (60 yrs – death)

Intra-uterine Age Assessment-

Lunar Month of IUL	Features
End of 1st month	- Greyish white mass of conception - 1cm long - 5gms approx.. weight - Limb buds formation process begins - 2 dark spots indicates the eyes - Mouth is indicated by cleft.
End of 2nd month	- 4cm long - 10gms weight approx.. - Limbs, mouth and nose are demarcable by now. - Sex indistinct - Placenta starts forming
End of 3rd month	- 9cms long - 30gms weight - Head separates by neck - Mouth is closed by lips - Heart divided into chambers - Sex organs appears

	- Limbs develops with fingers and toes - Nails start appearing
End of 4th month	- 16cm length - 100 to 120 gms weight - Sex distinct - Convolutions of brain begins - Skull partly ossified - Fine downy lanugo hairs. - Meconium found in duodenum
End of 5th month	- 25cms in length - 450gms in weight - Nails are distinct - Thin hair over scalp - Skin covered with vernix caseosa - Meconium found in beginning of large intestine
End of 6th month	- 30cms in length - 1kg weight - Skin, red and wrinkled, covered with vernix caseosa - Nails become thicker - Testicles lie close kidneys
End of 7th month	- 35cm in length - 1.5kg weight - Eyelids are open - Skin dusky red covered with thick layered vernix caseosa - Nails distinct - Meconium found in in entire large intestine
End of 8th month	- 40cm in length - 2kgt weight - Scalp hair dense - Skin rosy red with soft lanugo hairs covered all over except face - Cerebral convolutions well developed. - Left testicle descends into scrotum
End of 9th month	-45cm in length - 2.5kg weight - Downy hairs disappears on body except shoulders - Testicles descends into scrotum - Vernix caseosa found in flexures of joints, armpits, folds of neck. - Meconium found in end of large intestine
End of 10th month	- Full term fetus - 45 to 50cm length - 3 to 4kgs in weight - 3 to 5 cms of scalp hair length

	- Lanugo hairs present over shoulders only - Face shows no wrinkles - Testicles in scrotum; vulva closed with labia majorae covering up the labia minorae - Meconium found in rectum

Lunar Month of IUL Important Ossification Centers
- 1.5 month ⟶ Clavicle - 2nd month ⟶ Lower jaw - 3rd month ⟶ Ishium, upper sacral segmens - 4th month ⟶ Ear ossicles, mid sacral segmens - 5th month ⟶ Oscalcis - 6th month ⟶ Manubrium sterni and bodies of sternum - 7th month ⟶ Talus and 1st segment of sternum - 8th month ⟶ Last sacral vertebra, last segment of sternum - 9th month ⟶ lower end of femur - 10th month ⟶ lower end of femur, cuboid, upper end of tibia

Extra-uterine Age Assessment-

Bones	Age of Appearances	Age of Fusion
Head of humerus	1 year	18 years
Lower end humerus	5-7 years	16 years
Lower end of radius	2 years	19 years
Upper end of radius	5 years	16 years
Lower end of ulna	6 years	19 years
Upper end of ulna	9 years	16 years
Head of femur	1 year	17 years
Lower end of femur	9 months IUL	18 years
Upper end of tibia	0 years (at birth)	18 years
Lower end of tibia	1 year	17 years
Lower end of fibula	1 year	17 years
Upper end of fibula	4 years	18 years
Hyoid greater cornu	10 months IUL	40-60 years
Hyoid lesser cornu	16 years	20-30 years
Manubrium Sterni	5 months IUL	60-70 years
1st sternebrae	5 months IUL	25 years
2nd sternebrae	7 months IUL	20 years
3rd sternebrae	7 months IUL	15 years
4th sternebrae	10 months IUL	40 years

Xiphoid process	3 years	
Clavicle (primary center)	5th – 6th week of IUL	45th day
Clavicle (medial end)	15 years	22 years
Coracoid years	1 year	15
Subcoracoid	16 years	17 years
Acromion years	16 years	20
Hamate	3months	
Triquetral	3 years	
Triquetral	3 years	
Lunate years	4 years	18
Scaphoid	4-5 years	
Trapezium	4-5 years	
Trapezoid	4-5 years	
Pisiform	9-12 years	
Iliac crest and pubis	14 years	20 years
Ischium years	16 years	20
Acetabulum	13 years	15 years

Symphysis Pubis –

- *Below 20 years – even appearance of surface with layer of compact bone*
- *Between 20 to 25 years – markedly ridged and irregular*
- *Between 25 to 35 years – ridges disappears*
- *Between 35 to 45 years – articular surface looks smooth and oval*
- *Between 45 to 50 years – narrow beaded rim develops in and around the margin of articular surface*
- *Above 50 years – erosion with breaking down of ventral margin marks the presence in varying degree*

Skull –

- *Anterior fontanelle closure – 0.5 year*
- *Closure of Metopic suture – 2 to 4 years*
- *Closure of sagittal surface – 25 to 40 years*
- *Closure of coronal surface – 25 to 30 years – to – 40 to 45 years*
- *Closure of lambdoid suture – 30 years to 50 or 55 years*
- *Closure of spheno-temporal, occipito-mastoid, parieto-mastoid, spheno-parietal suture – 50 years to 70 to 80 years*

AcrusSenillis –

- *Opaque zone around periphery of cornea – 40 years*

➢ *Completes and circularize – 60 years*

Medicolegal Importance of Age bars –

IUL{	• age of viability – 180 to 210 days
6-7 months{	• 1st milk tooth erupts
2 years	• all milk teeth erupts
6 years	• 1st permanent molar tooth erupts
< 7 years{	• not to be held criminally
10 years	• age of abduction considered
12 years{	• half indian railway ticket for travel
<14 years{	• Cannot be employed
14 years	• Child and can be employed
15 years	• youth offenders to refamatory school
16 years{	• age of consent for sexual intercourse
18 years{	• minimum age for sending youthful offender to Borstals
	• Marriageable age for females • age of consent for all kinds
21 years{	• Attainment of majority • age of marriage for males

MEDICOLEGAL AUTOPSY

Autopsy is the special type of examination of a dead body, examining all the body cavities.

External Examination

- For unknown body, not any congenital or acquired peculiarity
- Full body photograph must be taken
- Before removing the clothing, they must be examined for –
  - Burns
  - Buttons
  - Color
  - Design
  - Disarrangements
  - Stains
  - Tears
  - Type of garment
  - Wetness
  - Wrinkles
  - Ornaments
- Record height, weight, age and sex
- General features
- Record the state of Post mortem Stiffening
- State of natural orifices
- Hands for trace evidence
- Color and state of skin, eyes and nose
- Examine skull for external injury
- Examine neck for fingertip or bruise or scratch evidence
- Check for Post mortem Staining

Internal Examination

- as a rule of thumb, open skull first.
- Then examine neck through incision given
- Explore thoracic cavity
- Finally explore the abdominal cavity.

Incision

- *I – shaped*
  - Under the chin from midline to the pubic symphysis, sparing the umbilicus
- *Y – shaped*
  - From two mastoid process, meets at xiphisternum, then proceeds as I shaped incision
- *Modified Y – shaped*
  - From below both anterior axilliary folds, goes below breasts, meets at the xiphoid process and extends as the I shaped incision

- *T – shaped*
    - Straight incision from suprasternal notch till pubic symphysis, with incision horizontally extended towards acromion processes

Methods to remove organ

- *Virchow's method*
    - Organs removed one by one separately
- *Rokitansky's method*
    - In situ dissection
- *Letulle's method*
    - All organs from tongue to prostrate, removed en masse in single block
- *Ghan's method*
    - Cervico-thoracic removed separately with abdominal organs removed separately and pelvic organs separately

Examination of brain – for obvious signs of disease, cerebal vessels, cortical contusions &hemorrhages, ruptured berry aneurysms, cerebal infarctions.

Examination of Heart – for adhesions, aneurysms, flaccidity, focal hyperemia, pericarditis, rupture, and weight.

Examination of lungs – cut lungs by far as possible to retain large bronchial stump.

Examination of Stomach – for nature of food, digestion state, smell, color, character, presence of foreign and suspicious matter.

Examination of Liver – examine bile, and bile duct, with hepatic artery and portal vein with the lymph nodes.

Examination of Kidneys – for thrombi, emboli and atherosclerosis and congenital malformations, note the smoothness or granularity of the surface.

Examination of blood – for fluidity of flood, and distinction between ante mortem clots and post mortem clots.

Collections of Specimen –

Anal swab
- In case of anal intercourse
- for spermatozoa test

Bile
- Determination of poison
- pass needle into lumen through gall bladder and aspirate to collect

Bite marks
- for DNA analysis by mucosal cells
- swabs with saline moistened cotton swab, dry and preserve

Blood
- for toxicological examination
- best to collect from peripheral vessel to avoid post mortem diffusion, 10ml

Bone marrow
- For diatoms
- In case of drowning cases

Bone marrow
- For toxicological examination
- by lumber puncture

Cyst fluid
- for echinococcus hooklets
- collect from hydatid cyst

Ferces
- for protozoa and helminths
- 10gms from rectum

Urine
- for toxicology
- catheritization of urethra

vaginal swabs
- in case of saxual assault
- for spermatozoa test

- for toxicology
- insert syringe in eyeball and collect all (1-5 ml.)

Preservatives –

Saturated salt solution	• most common except corrossives
Rectified spirit	• in all cases except acetic acid alcohol, chloral hydrate, chloroform, ether, formaldehyde, formic acid, kerosene, paraldehyde, phenolic acid, phosphorus
Blood preservatives	• sodium fluoride and potassium oxalate • in case of alcohol, use sodium azide
Urin Preservatives	• saturated saline or rectified spirit of thymol or sodium benzoate or conc HCl

Post Mortem Report

PMR – Introductory Part	
▪ Name of the deceased ▪ Age of the deceased ▪ Sex of the deceased ▪ Weight the deceased ▪ Height of the deceased ▪ Residence of the deceased	▪ Place from where body was brought ▪ Date and time of examination of body ▪ Mention of authority ordering the examination
PMR – Examination part - External	
▪ Examination of clothes ▪ Examination of stains ▪ Soiling material ▪ Cut marks, tears, stab marks, loss of buttons, etc. ▪ Identity ▪ State of eyes, mouth, natural orifices, nails, hairs, etc.	▪ Rigor mortis ▪ Post mortem lividity ▪ Signs of decomposition ▪ Skin and body surface features ▪ Odour ▪ Documentation of injuries ▪ External genitals
PMR - Examination Part – Internal	

▪ **Cranial cavity** ▪ **Thoracic cavity** ▪ **Abdominal cavity** ▪ **Dissection of spinal cord (when indicated)** ▪ **Dissection of extremities (when indicated)**	▪ **Cavity Examined for any injury, disease, pathological lesion or collection of blood/fluid** ▪ **Organs examined for any injury, disease or pathological lesion** ▪ **Weight, size, shape, surface, consistency, cut surface, color of the organs are noted**
PMR – Conclusion part	
▪ Time since death ▪ Cause of death ▪ Manner of death	

I.P.C. Section 46 defines Death

- Death of a human being unless the contrary appears from the context.

Medicolegal Definition

- Death is a permanent and irreversible cessation of tripod of life.

Rule of thumb, says that within 20 second of cardiac arrest, breathing stops, and heart stops within 20 minutes by stoppage of breathing and brain dies within 3 minute of stoppage of the other two.

Tests for stoppage of circulation –

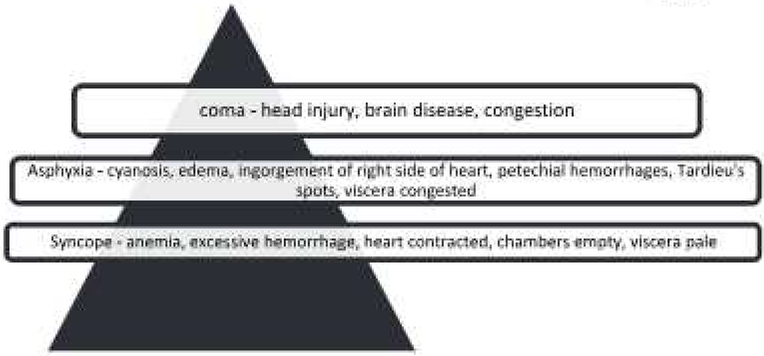
- Magnus test
- Icard's test
- Diaphanous test
- Fingernail test

Tests for stoppage of respiration -

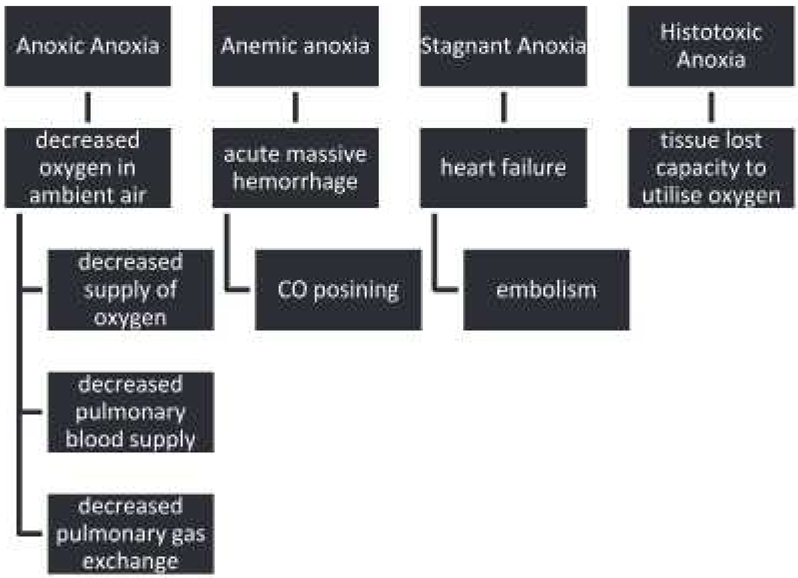
- Winslow's test
- Mirror test
- Feather test

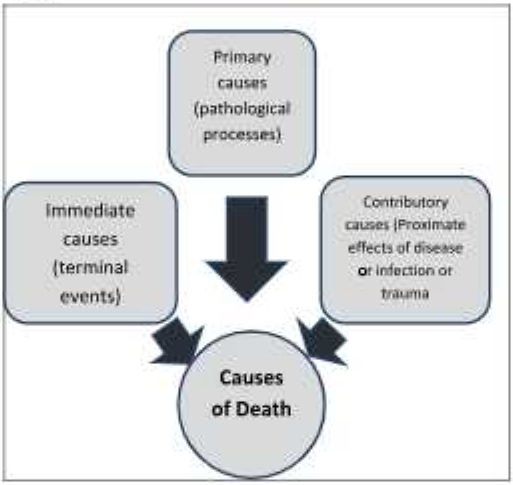
Harvard criteria for brain death-

- Unreceptivity and Unresponsivity
- No movements of breathing
- No reflexes
- Flat EEG
- All these to be repeated after 24 hours



Bichat's mode of death –

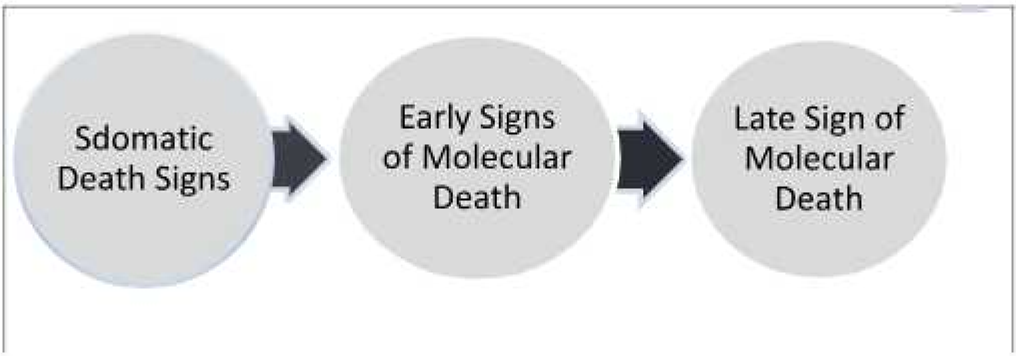




Death Trance/ Suspended Animation
Absence of Apparent sign of death, associated with state of insensibility and loss of voluntary power. Occurs in drowned person, vagal inhibitory response, narcosis, electrocution, sunstroke, surgical shock, apnoic new born. Yoga practitioners are the volunteer to the death like trance.

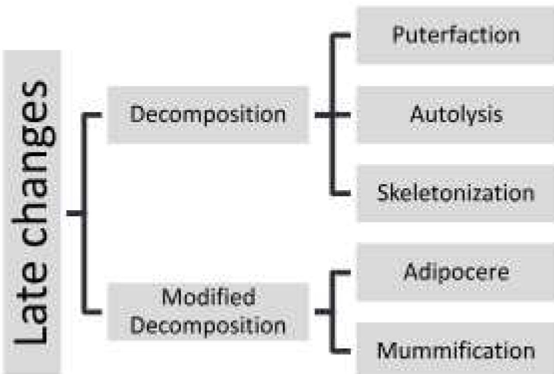
Signs of Death -

- Immediate changes
- Early changes
- Late Changes



• Cessation of circulation • Cessation of respiration • Insensibility	• Algore Mortis • Skin Changes • Eye Changes • Livor Mortis • Chemical Changes of body fluids • Rigor Mortis	• Putrefction • Adipocere Formation • Mummification

Signs of Death	Post Mortem Changes
Early Signs	▪ Facial pallor ▪ Loss of elasticity ▪ Primary relaxation ▪ Contact pallor ▪ Ocular changes ▪ Cadaveric lividity of post mortem lividity or livor mortis ▪ Algor mortis or cooling of body ▪ Cadaveric rigidity of rigor mortis ▪ Secondary relaxation
Late Signs	



Post Mortem Changes	Features
Facial pallor	▪ Due to stoppage of circulation, blood drains from the capillaries. ▪ Face becomes pale. ▪ But in asphyxia, it becomes congested and cyanotic, due to compression over neck, obstruction of vernous return.
Primary Relaxation	▪ Muscle Flaccidity ▪ Muscle tone is lost

	▪ Chest wall flattens ▪ Muscular tissue is still alive ▪ Chemical reaction still alkaline ▪ Response to electrical stimuli
Contract Pallor	▪ Body part in contact with ground or so, becomes flat. ▪ Blood vessels from these areas are pressed out. ▪ Medicolegal Importance –Position of body in which it stayed for some significant amount of time after death can be evaluated.
Algor Mortis	▪ Cooling of the body ▪ 1-3 hours, cooling rate is low. ▪ Next 6-9 hours , outer core well established and inner core cools rapidly ▪ Next 15-20 hours, body approaches surrounding temperature. ▪ Medicolegal Importance –Sign of death & Time since death can be estimated
Liver Mortis	▪ Commence within half an hour of death. ▪ Appearance starts by 2 hours. ▪ Fixation occurs by 6-8 hours. ▪ Medicolegal Importance –Reliable sign of death; Time since death; Body position; Manner of death (asphyxia death)
Rigor Mortis	▪ Cadaveric Rigidity ▪ Commence within 1-2 hours ▪ Appearance within 3-4 hours ▪ Fixation within 12-18 hours ▪ Passes off within 18-24 hours ▪ Medicolegal Importance –Reliable sign of death; Time since death; Position of body; Indicates molecular death

Color of PM lividity significance

- Normal- bluish or reddish purple
- HCN poisoning – Cherry Red or Pinkish
- CO poisoning – Pinkish
- Posphorus or K-chlorate/-nitrate/-aniline – Dark brown

- Sulphuric acid- Greenish blue
- Cold exposure – bright red
- Drwoning death – red

Autolysis

- Self destruction of body tissues by enzymes.
- Process early and rapid in tissue rich in hydrolytic enzymes, pancreas and gastric mucosa.
- Immediate in tissue like heart, liver and kidney.
- Delayed in fibrous tissues like uterus and skeletal muscles.
- Skin slippage or Degloving of skin
- Hair and nails are loosened
- Gastromalacia
- Oesophagomalacia

Putrefaction

- Change in color – hemolysis of RBC imparts greenish discoloration
- Liberation of gases – causes bloating of features, disintegrates post mortem lividity, post-mortem purging.
- Liquefaction of tissues – organs are converted into thick semi fluid matter.
- Post mortem blisters.
- Post mortem Marbling.
- Maggots – voracious eaters

Organs putrefying early in Sequence

Brain → Trachea and Larynx → Stomach and Intestine → Spleen → Liver

Organs putrefying late in Sequence

Esophagus → Diaphragm → Heart → Lungs → Kidney → Urinary Bladder → Uterus → Prostate

TIME SINCE DEATH

Within 1 hour	•general muscular flaccidity •muscles react to electrical stimuli
Within 2 hour	•body cool •post mortem lividity starts developing in patches
Within 3-6 hour	•Tache Noire appears •Rigor Mortis
Within 6-12 hour	•hypostasis well marked •Rigor Mortis maintained •greenish discoloration appearance at the right iliac fossa
Between 12-24 hours	•Rigor mortis starts to disappear from face, neck, amd upper limb •Greenish discoloration at right iliac fossa well marked
Between 24-48 hours	•Rigor Mortis disappeared •Marbling of skin associated with blister formation occurs
Between 48-72 hours	•P. M. staining may shift due to pressure developed by putrefactive gas •Putrefaction seen over body
Between 3-5 Days	•Brain liquefies •Nails, lips, and teeth become loose and may fall off •Abdomen and thorax bursts open
Between 5-10 Days	•Collequative necrosis result, in soft tissue getting changed into black pultaceous mass separating from bony attachments. •body ends exposed
Between 10 days to 1-2 month	•all soft tissue including cartilages fallen off •only bare sleleton left, skeletonisation completed.

FORENSIC ENTOMOLOGY

Study of insects and their life cycle that are infesting the dead bodies are known as forensic entomology

Medicolegal Importance –

- Manner of death
- Cause of death
- Movement of cadaver from one side to other
- Postmortem interval
- Place of disposal

Flis lay Eggs	1st Instar larva	2nd Instar larva	3rd Instar larva	Larva to Pupa	Pupa to adult
Summers- within minutes	Summers- 8 hours	Summer- 1 day	Summer- 3 days	Summer - 5 days	Summer - 7 days
Winters within hours	Winter - 1 day	Winter - 4 days	winter - 6 days	Winter - 8 days	Winter - 10 days

INJURIES AND ITS MEDICOLEGAL ASPECTS

I.P.C. section 44 defines injury.

- any harm whatever illegally caused to any person, in body mind, reputation or property

Medicolegal definition –

- any lesion of the body, external or internal caused by violence, with or without breach of continuity of skin.

Classification of Injuries –

MEDICAL	MECHANICAL	THERMAL	PHYSICAL	CHEMICAL	EXPLOSIONS
MEDICOLEGAL	SUICIDAL	HOMICIDAL	ACCIDENTAL		
LEGAL	SIMPLE	GRIEVOUS			

Simple Injury	Grievous Injury
• Abrasion • Contusion • Lacerated wound • Incised wound • Stab or punctured wound • Gun shot wound • Blast injuries • Burn injuries • Electrical injury	• Emasculation • Permanent privation of sight of either or both eye • Permanent privation of hearing of either or both ear • Privation of any member or joint • Permanent impairment or loss of any joint of member. • Fracture or dislocation of any bone or tooth • Permanent disfiguration of head or face Injuries causing severe bodily pain for 20 days or more, when person is unable to follow his ordinary pursuits.

Abrasion – kind of mechanical injury which results from denudation of the epithelial layers of the skin.

- ➢ Types of Abrasion
  - ○ Scratch
  - ○ Graze
  - ○ Pressure Abrasion
  - ○ Impact Abrasion
  - ○ Atypical abrasion
- ➢ Age of Abrasion

- ➢ **Medicolegal Importance**
  - ✓ They lie at the precise point of impact by the blunt force.
  - ✓ They may be external sign of an internal injury severe in nature.
  - ✓ Nature of injury and manner of causation are suggestive.
  - ✓ Patterned abrasion or Impact abrasion connects the crime with the cause.
  - ✓ Situation and direction are suggestive or circumstances and nature of crime.

Contusion – Infiltration of extravassated blood into the tissue space from the rupture of the capillaries of subcutaneous and subepithelial tissues, by the blunt force application over the area.

- ➢ Age of Contusion
- ➢ Medicologal Importance
  - Multiple bruises may cause death from internal hemorrhage leading to shock and death.
  - Bruises may indicate to the severe internal complications underlying.
  - Accidental bruise present with foreign body matters indicate the manner of causation and are often associated with laceration, fractures and dislocations
  - Homocidal bruise are usually in regard to the sexual assault and criminal assaults, such as hard blund weapon blow, fist blow, throtting, etc. they are associated with other injuries and noticed over nay part of the body correlating with the time of infliction and its age.
  - Suicidal bruises are very rare, cause it is painful to self-inflict it.

R	• 24 hours, look Reddish
V	
I	• next 2 days, from 1st to 3rd day, indigo or bluish black coloration
B	
G	• next 2 days, from 4th to 6th looks greenish
Y	• next 2 days, from 7th to 9th day, yellowish coloration of skin
O	• next 2 days, 10th to 12th, skin color restored

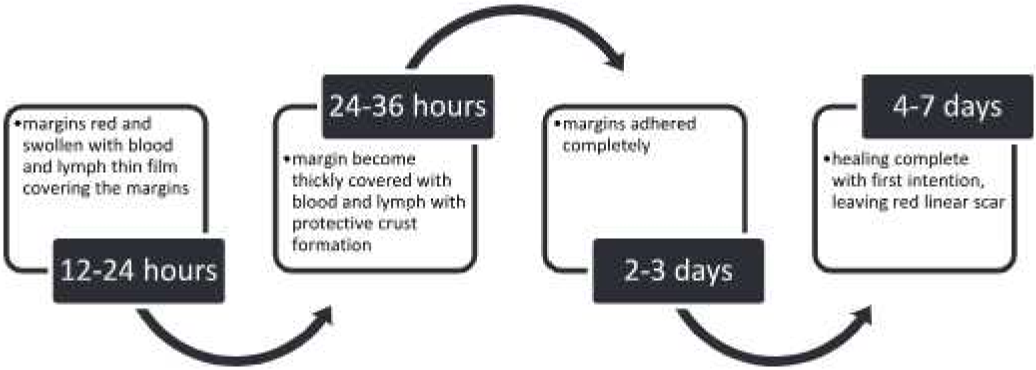
Lacerated Wound- The injury to the skin and deeper tissues causing them to torn apart by application of blunt force.

- ➢ Types of Lacerated wound
  - Split Laceration
  - Stretch Laceration
  - Avulsion Laceration
  - Tearing Laceration
  - Cut Laceration
  - Internal Organ Laceration
- ➢ Medicolegal Important
  - Caused by blunt force injury
  - Some inference can be drawn about the causative agent by the shape and character of the fracture.

- Oblique impact shows the direction of the force.
- Homocidal Laceration usually over vertex until unless exceptionally proven. Defence wounds are characteristic.
- Suicidal Laceration are rare.
- Accidental laceration found over the same of accidental infliction and mostly over exposed surface of the body.

Incised Wound – Body tissue when struck or pressed against sharp linear or pointed edges of the weapon with profuse bleed and fine margin

➢ Age of Incised Wound



➢ Medicolegal importance
- ✓ Gives idea about the nature of weapon used.
- ✓ Tailing of the wound estimates the direction of the wound and the relative position of the victim with the assailant.
- ✓ Hesitate and multiple cuts shows the suicidal act when over accesible part and indicates self hand usage with respect of angle and direction. Cadaveric spasm supports the light sharp weapon enclosed and support the suicidal act.
- ✓ Defence Wounds accomplish homicidal act with the presence at the extremities and the fatal nature. Defence wounds are caused in due time to prevent from the weapon attack and usually done by the upper limb but can be of any kind due to reflex protection. These will be absent in those who are unconscious and limbs engaged or attacked suspiciously from unseen angle of the victim.
- ✓ Accidental incised wounds are caused by fall onto sharp weapon, or the weapon may fall over. These are slight, linear and slicing in nature and usually not fatal.

Stabs Or Perforating Or Punctured Wound – Injuries whose depth are greatest in dimensions. *Punctured Wounds* are produced by pointed weapons. Fatality is associated only when inflicted over vital organs. *Penetrating wounds* are those punctured wounds which penetrate any natural body cavity. *Perforating Wounds* are those which perforate the body tissue through and through with an entry as well as an exit. Entrance wound will be bigger than the exit wound due to the tapering of the weapon and rocking of the attack

➢ Medicolegal Importance

✓ The shape gives an idea about the type of the weapon used.

✓ Direction and dimension relates the position of the victim with the assailant.

✓ Depth of injury ascertain the force of pentration with the mens rea establishment.

✓ Age of injury estimates the time of infliction.

✓ Nature of injury is also inferred by deep study of the injury.

✓ The circumstantial evidence may conclude the reconstruction of the act.

Firearm injuries –

Rifled Weapon

- Long barreled
  - Rifles, Military rifles, sporting rifles, 0.22 rifles, Target rifles
- Short Barelled
  - Revolvers, Automatic pistols, Machine Guns, Stengun

Smooth Bored Weapon

- Single barrel shotgun
- double barrel shotgun
- Repeating or self loading shotgun
- Slide action shotgun
- Bolt action shotgun
- Semi automatic shotgun
- Automatic shotgun

Slug firing Weapon

- Air pistol
- Air gun
- Air rifles

when bullet strikes right angle

- to long bone, it bores a hole through and through
- a small bone, splinters

when bullet strikes at an angle

- comminuted fracture is observed
- splinter fracture may act as secondary missile worsening damage

when bullets strikes oblique

- oval shaped entry wound observed
- excess bevell at exit wound

when bullet strikes chest

- it may get deflected by the ribs and recochet under skin which may come out along line of entry
- it may be lodged into plural cavity or may even enter abdomen

when bullet strikes scalp and skull

- it may delect when hit obliquely, and may come out against the line of fire
- direct hit will cause entry wound of same size of bullet with clean cut hole
- exit wound will be larger bevelled - determines line of fire
- line of fire in occipental region accounts for more fatality than the frontal region
- glance strikes causes gutter lacerated injury

At short range, entry wound is atypically larger

- due to trial wobbling of bullet at the moment living the muzzle end
- when strikes at the end of its flight where the gyroscopic effect on bullet deminishes and it wobbles before it tumbles
- also in case of swan off barrel
- also when the bullet is smaller than the barrel
- stud guns injury

Wound of Entry	Wound of Exit
Usually smaller than the projectile due to elasticity of skin except in near and contact shot	Certainly larger than the projectile except point black ranges
Margins are inverted and irregular but clean in high velocity	Margin are everted and irregular with tear
Abraded and grease collar present with underneath bruise	Abraded and grease collar always absent
In close range, tattoing, singeing, blackening and burning are characteristically present	No such characteristic findings
At surface bone clean cut is observed	Bone at exit wound looks like excavated hole due to beveling
Fibres microscopically be observed to be driven inside	Fibres macroscopically be observed to be driven outside

Bleeding is less	Bleeding is more evident
No fat protrusion	Fat may protrude out
Soft tissue around looks cherry red due to carbon monoxide in contact shot	No such feature
Metal ring or lead ring observed	Absence of metal or lead ring
More metallic particles presence evident	Less metallic particles presence evident

Detection of Gunshot Residues –

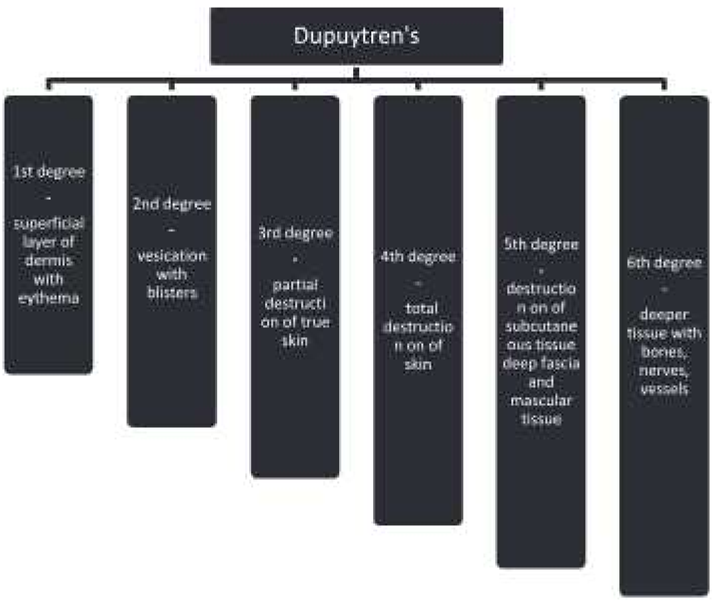
- *Dermal Nitrate Test*
- *Neutron Activation Analysis*
- *Flameless atomic absorption spectrophotometry*
- *Harrison and Gilory test*

Thermal Injuries –

- **Burns** – An injury produced by application of the dry heat, such as flame, radiant heat or heated solid substance. It is restricted to local effect of dry heat.
    - *Heated solid or molten metal* – applied momentarily producing blister with erythema
    - *Flames* –Produces vesication usually with soft tissues and skin severely burnt alongwith singeing of hair and blackening of the skin.
    - *Due to radiation* – mild erythema to local dermatitis with hairs shed off and pigmentation with telangiectasis.
    - *Corrosive agents* – no blisters, through manifested locally. No singeing, no red line of demarcation. Eschars are formed which are soft, moist and slough out easily.
    - *Electricity and lightening* –contact burn, spark burns and flash burn.

Willson's

- Epidermal
- Dermo – Epidermal
- Deep



Evan's

- 1st degree or superficial burn – epidermis only
- 2nd degree or partial thickness burn- dermis and epidermis
- 3rd degree or full thickness burn – whole of skin

➢ **Rule of Nine**

Adults	Children
• **9% - head [7%] and neck [2%]** • **9% - each upper limb [arm 4, forearm 3 and hand 2]** • **9% - front of each lower limb** • **9% - back of each lower limb** • **9% - front of chest** • **9% - Back of chest** • **9% - front of abdomen** • **9% - Back of abdomen** • **1% - perineum**	• **13% - head and neck** • **9.5% - each upper limb** • **13% - front of chest and abdomen** • **13% - Back of chest and abdomen** • **18% - each lower limb** • **1% - external genitalia** • **5% - buttocks**

➢ **Age of Burns**

12-24 hrs	• Exudates from burns begins to dry
24-48 hrs	• Dry brown crust formed
2-3 days	• on infection, pus will be formed • But not before 36 hours
1 week	• superficial sloughs Separate
Fortnight or more	• Deep slough Separate
More the 2 weeks	• Red granulation tissu covering up burn surface when present indicates more then 2 weeks

➢ Manner of Burn Injury
- suicidal burns – common in females.
- accidental burns – common in women and children.
- Homicidal burns – rare.

- Self inflicted burns - superficial burns may be inflicted over accessible parts of body.

- Scalds – an injury produced by application of liquid or farms steam.
  - Degree of scalds –
    - 1st degree – erythema by vasoparalysis
    - 2nd Degree – vesication due to increased capillary permeability
    - 3rd Degree – dermal necrosis

Feature	Dry Heat	Moist heat	Chemical Burn
Cause	Flame of heated solid body	Liquid below 60 degree Celsius or steam	Chemicals
Site	At or above site of contact	At or below the site of contact	At or below the site of contact
Edges	Deep burns may fade into more superficial burns, so sharply defined edges may not be present	Sharply defined edges usually present	Same as in moist heat
Splashing and Trickling	Absent	Present	Present
Skin	Dry wrinkled, charred	Sodden and bleached	Destroyed
Vesicles	At the circumference of burnt area	Over the burnt area	Seen with specific chemicals only
Red line	Present	Present	Absent
Color	Black	Bleached	Distinctive
Charring	Present	Absent	May be present
Singeing	Present	Absent	Absent
Ulceration	Absent	Absent	Present
Healing	Donotforminsuperficial burn in deep burn, thick and contracted scar forms	Thin and less contracted scar	Thick and contracted scar forms
Clothes	Burnt	Wet and not burnt	Show edema

ASPHYXIAL DEATH

Anoxia	Stagnant Anoxia	Anemic Anoxia	Histotoxic Anoxia
• Lack of oxygen availability	• imperfect oxygenation in tissue	• reduced oxygen carrying capacity of blood	• interference with tissue oxidation

Features –

- ➢ **Tardieu's Spot**
- ➢ **Cyanosis**
- ➢ **Increased capillary permeability**
- ➢ **Dilatation of heart**
- ➢ **Persistent fluidity of blood**

Phases —

- ➢ **First phase - Dyspnoeic phase**
- ➢ **Second phase - Convulsive phase**
- ➢ **Third phase - Apnoeic phase**

Violent Asphyxial Deaths	**Caused by compression of wind pipe**	**Hanging**
		Strangulation
	Caused by submersion of mouth and nostrils under fluid	**Drowning**
	Caused by exclusion of air from lungs by anything other than constriction at neck, and drowning	**Suffocation**
	Caused by compression, above mechanical and/ or mechanical fixation of chest usually (may be chest and abdomen)	**Traumatic Asphyxia**

Hanging-

- Typical Hanging — neck vessels become occluded to maximum
- Complete Hanging — constriction by weight of the body
- Partial Hanging — constriction by weight of head by noose ligation
- Judicial Hanging —judicial degree followed, head jerked against body weight dislocation
- Lynching — informal public execution by mob

Differences	Antemortem Hanging	Postmortem Suspension
Ligature Mark	Oblique, non continuous	circular
Knot	Single, simple, one side	More than one knot
Ecchymosis	Well marked on either sides	Usually absent
PM staining	Noticed above ligature Mark and dependent-parts	Noticed over dependent part
Parchmentization	Brown parchmentization	Not well marked
Sub cutaneous tissues under ligature	White hard and glistening	Bruised, muscle ruptured
Cyanosis	Deep and pronounced	Less deep or even absent
Face	Congested	Absence sign of hanging
Neck	Stretched and elongated	None
Tongue	Usually protruded	No Change
Saliva	Dry mark of saliva	Absent
Involuntary Discharge	Not common	very common instrangulation or suffocation
Evidence of Injuries	Self inflicted injuries	Fatal injuries present
Point of suspension	Antemortem self suspension	Nature and type of ligature

Strangulation	
➢ By Ligature ➢ By manual pressure on neck ➢ By compressing throat with foot, Knee, elbow or some such other thing ➢ Bansdola ➢ Mugging ➢ Palmer Strangulation ➢ Garroting ➢ Thagi-way	➢ Throttling ➢ Smothering ➢ Overlying ➢ Gagging ➢ Choking ➢ Café Coronary ➢ Inhalation of Irrespirable Gases ➢ Traumatic Asphyxia ➢ Burking

Differences	Sucidal Hanging	Strangulation
Age	More common in adolescent, young or elderly adults	No age limits
Ligature Mark	Oblique, non-continuous	Circular, complete
Knot	Single knot	More then one knot
Suicidal Note	Usually present	Usually absent
Place of occurrence	In doors	Anywhere
Point of Suspension	Accessible	Inaccessible
Injuries	Self inflicting	Injury for rapid death of unconsciousness
Signs of Struggle	Absent	Always present
Hyoid Fracture	Unusual	Uncommon with injury to thyroid cartilage
Involuntary Discharge	Feces and urin less common, seminal fluid more	Feces and urine more common and seminal fluid less common
Poisons	presence of irritants	Circumstantial evidence

Drowning –

- Wet drowning – water inhalation, lungs get water logged, air entry prevented.
- Dry drowning – obstructive asphyxia caused by laryngeal spasm induced by small amount of water entering larynx.
- Secondary Drowning – predisposing cause but ultimate cause of death.
- Cold water Drowning – sudden cardiac arrest or vagal inhibition, Immersion syndrome.
- Shallow water Drowning – When small puddle of water leads to drowning sufficient to submerge mouth and nostrils.

Criteria	**Freshwater Drowning**	**Seawater Drowning**
Size and weight	Ballooned but light	Balloned, very distended
Color	Pale pink	Purplish or bluish
Consistency	More emphysematous	Less emphysematous
Pleural effusions	Generally absent	Generally present
Shape after removal from body	Retained, do not collapse	Tend to flatten out
Sectioning	Releases froth, crepitus heard	Greater quantity of froth
Greater extent of injury to lung	Lesser	Greater
General circulation of blood	Hemodilution	Hemoconcentration
Cause of death	Ventricular fibrillation, hypoxia of hear muscels, cerebral hypoxia	Pulmonary edema, electrolyte imbalance

<u>Ante mortem Drowning</u>

Presence of fine shaving lather froth over mouth and nostrils	Coarse bubbles but no froth
Presence of vegetarian in clenched hands	Not noticed
Presence of algae, mud in trachea and lower bronchial tubes, also in stomach and intestines	Not present
Lungs, ballooned up, bulky	Lungs collapsed and decomposed usually

Difference of chloride and Magnesium content of blood in chamber of heart	Not characteristic
Marks of violence if present	Inconsistent
Presence of water in mid ear with retracted genitals, cutis anserina, wahserwoman hands, wet clothings, mud evidence	Water never present in mid ear unless due to tympanic membrane perforation

MEDICOLEGAL ASPECT OF SEXUAL OFFENCES

Sexual Offence Proper	Unnatural Sex Offences	Saxual Preversions
• Rape • Incest	• Sodomy • Tribadism • Bestiality • Buccal Coitus	• Sadism • Masochism • Fetichism • Transvestism • Exhibitionism • Voyeurism • Necrophilia, etc.

Rape [Sec. 375 I.P.C.] – unlawful sexual intercourse (Carnal knowledge) by man

With his wife aged below 15 years

With any other women under the age of 18 years with or without her consent

With any other women above that age, against her will, without her consent

Even through her consent but as that consent having been obtained by some and lawful means, become invalid

Firstly: Against her will.

- Secondly: Without her consent
- Thirdly: With her consent when consent obtained by putting her or any one she is interested for fear of death or hurt
- Fourthly: With her consent when the man knows he is not her husband and that her consent is given that he is another man to whom she is or believes herself to be lawfully married.
- Fifthly: With her consent when at the time of giving the consent by reason of unsoundness of mind or intoxication or administration by him personally or through another of any stupefying or unwhole some substance, as a result she is unable to understand the nature and consequence of the act to which she gives consent
- Sixthly: With or without her consent when she is of age.

CHAPTER-22

ANNEXURES

Instruction for the Medical Officers conducting Medico-legal examination for Victim/Accused of Sexual Abuse

(Refer to the Guidelines and Protocols, Medico legal care for survivors/victims of sexual violence issued by the MoHFW, http:/mohfw.nic.in/showfile.php?lid=2737)

The examining doctor should carefully read the Guidelines for responding to survivors of sexual violence issued by the MoHFW, and should be well aware of the comprehensive care tobe provided.

1. Informed consent: Doctors shall inform the person being examined about the nature and purpose of examination and in case of child to the child parent/guardian/person in whom the child reposes trust. This information should include:
   a. The medico-legal examination is to assist the investigation, arrest and prosecution of those who commited the sexual offence. This may involve an examination of the mouth, breasts, vagina, anus and rectum.
   b. To assist investigation, forensic evidence may be collected with the consent of the survivor. This may include removing and isolating clothing, scalp hair, foreign substances from the body, saliva, pubic hair, samples taken from the vagina, anus, rectum, mouth and collecting a blood sample.
   c. The survivor or in case of child, the parent/guardian/person in whom the child reposes trusts, has the right to refuse either a medico-legal examination or collection of evidence or both, but that refusal will not be used to deny treatment to survivor after sexual violence.
   d. As per the law, the hospital/examining doctor is required to inform the police about the sexual offence.

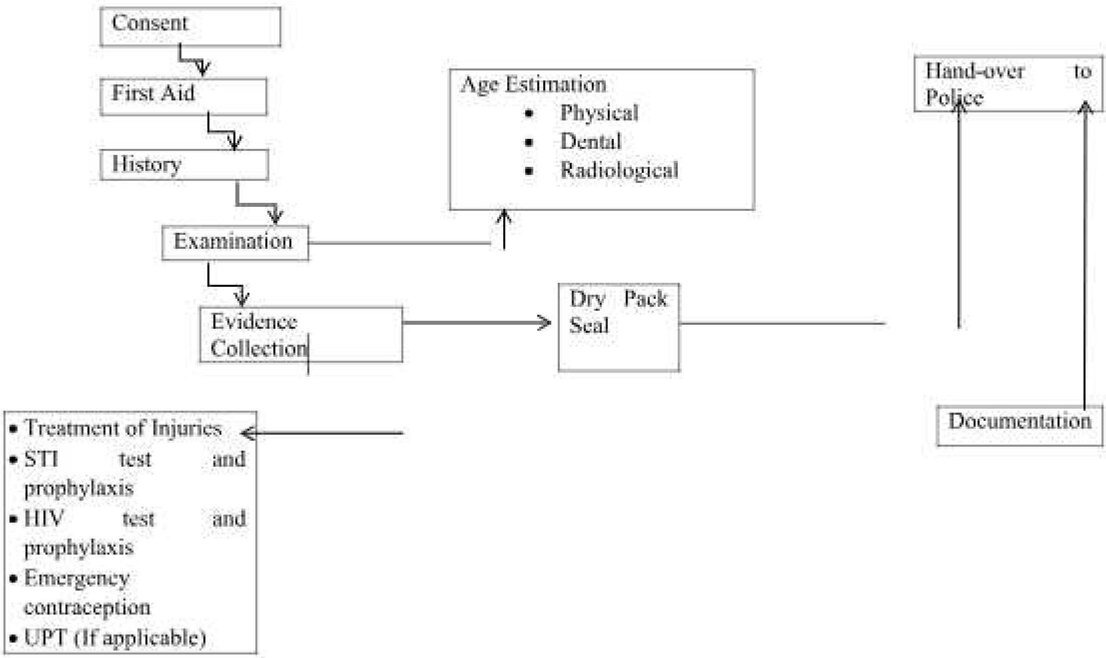
However, if the survivor does not wish to participate in the police investigation, it will not result in denial of treatment for sexual violence. Informed refusal will be documented in such cases.

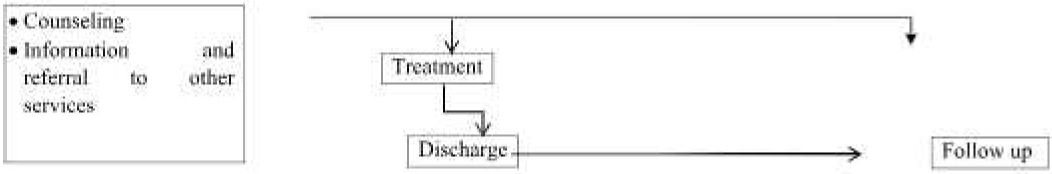
2. Per vaginum examination, commonly referred to by lay persons as 'two-finger test' , must not be conducted for establishing an incident of sexual violence and no comment on the size of habituation to sexual intercourse should be made as it has no bearing on a case of sexual violence. No comment on shape, size, and/or elasticity of the anal opening or about previous sexual experience or habituation to anal intercourse should be made.
3. Injury documentation: Examine the body parts for sexual violence related findings (such as injuries, bleeding, swelling, tenderness, discharge). This includes both micro mucosal injuries which may heal within short period to that of severe injuries which would take longer to heal. Please refer to section VI Point 17 of the guidelines.
   - Injuries must be recorded with details – size, site, shape, colour.
   - If a past history of sexual violence is reported, then recorded relevant findings. Sexual violence is largely perpetrated against females, but it can also be perpetrated against males, transgender and intersex persons.

4. The nature of forensic evidence collected will be determined by three main factors- nature of sexual violence, time lapsed between incident of sexual violence and examination and whether survivors has bathed or washed herself. Please refer to Section VI Point 21 of Guidelines.

5. **Opinion:** The issue of whether an incident of rape/sexual assault occurred is a legal issue and not a medical diagnosis. Consequently, doctors should not, on the basis of the medical examination conclude whether rape/sexual assault had occurred or not. Only findings in relation to medical findings should be recorded in the medical report.
   - Drafting of provisional opinion should be done immediately after examination of the survivor on the basis of history and findings of detailed clinical examination of the survivor.
   - It should be always kept in mind that normal examination findings neither refute nor sexual violence. Hence circumstantial/other evidence may please be taken into consideration.
   - Absence of injuries may be due to:
     i. Inablity of survivor to offter resistance to the assailant because of intoxication or threats
     ii. Delay in reporting for examination

The following are the components of a comprehensive health care response to sexual violence and must be carried out in all cases:




• Counseling
• Information and referral to other services
Treatment
Discharge
Follow up

CONFIDENTIAL

ANNEXURE-1

MEDICO-LEGAL EXAMINATION REPORT OF SEXUAL VIOLENCE

1. Name of the health facility…………………OPD No. ……………………IPD No. ....
2. Name…………………………D/o or S/o (where know)……………………………………………
3. Address……………………………………………………………………………………………… …………………………
4. Age (as reported)……………………………….Date of Birth (if Known)………………………………
5. Sex(M/F/Others)………………………………………………………………………………… ……………………..
6. Date and Time of arrival in the hospital…………………………………………………………………..
7. Date and Time of commencement of examination…………………………………………………
8. Brought by…………………………………………………………….(Name & signatures)
9. MLC No………………………………………………………….Police Station………………………………………
10. Whether conscious, oriented in time, place and person……………………………………………..
11. Any physical/intellectual/psychosocial disability…………………………………………………...
   (Interpreters or special educators will be needed where the survivor has special needs such as hearing/speech disability, language barriers, intellectual or psychsocial disability.)
12. Informed Consent/refusal
   I………………………………………D/o or S/o……………………………hereby give my consent for:

a) Medical examination for treatment Yes/No
b) Medico legal examination Yes/No
c) Sample collection for clinical & forensic examination Yes/No

I also understand that as per law the hospital is required to inform police and this has been duly explained to me.

I want the information to be revealed to the police Yes/No

I have understood the purpose and the procedure of the examination including the risk and benefit, explained to me by the examining doctor. My right to refuse the examination at any stage and the consequence of such refusal, including that my medical treatment will not be affected by my refusal, has also been explained and may be recorded. Contents of the above have been explained to in…………………………language with the help of a special educator/interpreter/support person (circle as appropriate)…………………………………………………………………………………… ……………………........If special educator/interpreter/support person has helped, then his/her name and signature………………………..

Name & signature of survivor or parent/guardian/person in whom the child reposes trust in case of child (<12>yrs)

……………………………………………………

……………………………………………………

……………………………………………………

With date, time & place

Name & signature/thumb impression of witness

……………………………………………………

……………………………………………………

……………………………………………………

With Date, time & place

13. Marks of identification (Any scar/mole)

(1)…………………………………….. **Left Thumb impression of patient**

(2)……………………………………..

14. Relevant Medical/Surgical history

Onset of menarche (in case of girls) Yes/No Age of onset……………………………………..
Menstrual history – Cycle length and duration…………………..Last menstrual period…………..
Menstrual at the time of incident – Yes/No
Menstruation at the time of examination – Yes/No
Was the survivor pregnant at time of incident – Yes/No
If yes duration of pregnancy………………….weeks
Contraception use: Yes/No If yes – method used:………………………………………
Vaccination status – Tetanus (vaccinated/not vaccinated),

Hepatitis B (vaccinated/not vaccinated)

15 A.History of Sexual Violence

(i) Date of incident/s being reported………………   (ii)Time of incident/s…………………………….(iii) Location/s…………………………………………   (iv)Estimated duration : 1-7 days……..1 week to 2 months……………………………………..   2-6 months…………………> 6 months………………………………………………………………   Episode: One……………..Multiple……………….Chronic (>6 months) ……..Unknown……….   (v) Number of Assailant(s) ……………….   Name/s (if known)……………………………………………………………..………………   (vi) Sex of assailant(s) …………………………………………………………………………..   (vii) Approx. age of assailant(s) ………………………………………………………………   (viii) If known to the survivor - relationship with the survivor…………………………………   (ix) Description of incident in the words of the narrator: Narrator of the incident: survivor/informant (specify name and relation to survivor)

15 B. Type of physical violence (If any, describe):

Hit with (Hand, fist, blunt object, sharp object)	Burned with
Biting	Kicking
Pinching	Pulling Hair
Violent shaking	Banging head

Dragging Any other:

15 C.

i. Emotional abuse or violence (if any) (insulting, cursing, belittling, terrorizing)…………………
ii. Use of restraints (if any)……………………………………………………………………………………….
iii. Used or threatened the use of weapon(s) or objects (if any)……………………………………………
iv. Verbal threats (for example threats of killing or hurting survivor or any other person in whom the survivor is interested; use of photographs for blackmailing etc.) (If any):………
v. Luring (sweets, chocolates, money, job) (if any): …………………………………………………………………..

vi. Any other: ……

15.D.

i. Any H/o drug/alcohol intoxication: ………………………………………………………………………………..

ii. Whether sleeping or unconscious at the time of the incident: …………………………………………………

15.E. If survivor has left any marks of injury on assailant/s, enter details: ……………………………..

15.F. Details regarding sexual violence:

Was penetration by penis, fingers or object or other body parts (Write Y=Yes, N=No, DNK=Don't Know) Mention and describe body part/s and/or object/s used for penetration

	Penetration				**Emission of Semen**	
Orifice of Victim	By Penis	By body part of self or assailant or third part (finger, tongue or any other)	By Object	Yes	No	Don't know

Genitalia (Vagina and/or urethra)						
Anus						
Mouth						

Details regarding sexual violence	**Yes(Y)/ No (N)/ Don't Know (DNK)**
Oral sex performed by assailant on survivor	
Forced Masturbation of self by survivor	
Masturbation or Assailant by Survivor	
Forced Manipulation of genitals of assailant by survivor	
Exhibitionism (perpetrator displaying genitals)	
Did ejaculation occur outside body orifice (vagina/anus/urethra/mouth)? (if yes, describe where on the body)	
Kissing, licking or sucking any part of survivor's body (if yes, describe)	
Touching/Fondling (if yes, describe)	
Condom used* (if yes status of condom)	
Lubricant used* (if yes, describe kind of lubricant used)	
Whether object was used (if yes, describe)	
Any other forms of sexual violence (elaborate)	

***Explain what condom and lubricant is to the survivor**

Post incident has the survivor	**Yes (Y)/ No (N)/ Don't know (DNK)**	**Remarks**
Changed clothes		
Changed undergarments		
Cleaned/washed clothes		
Cleaned/washed undergarments		
Bathed		
Douched		
Passed urine		
Passed stools		
Rinsing of mouth/Brushing/Vomiting		

Time since incident……

H/o vaginal/anal/oral bleeding/discharge prior to the incident of sexual violence…………………….

H/o vaginal/anal/oral bleeding/discharge since to the incident of sexual violence……………………

H/o painful urination/painful defecation/fissures/abdominal pain/pain in genitals or any other part since the incident of sexual violence…………………………………………………………………………………….

16. General Physical Examination

Is this the first examination Yes/No

ii.Pulse………….per-minute BP ………..mm of Hg

iii.Temp…………….^{0}F Resp. Rate……………….per-minute

iv. Pupils ………

v.Any observation in terms of general physical wellbeing of the survivor…………………………………..

17. Examination for injuries on the body (if any)

The pattern of injuries sustained during an incident of sexual violence may show considerable variation. This may range from complete absence of injuries (more frequently) to grievous injuries (very rare).

(Look for bruises, physical torture injuries, nail abrasions, teeth bite marks, cuts, lacerations, fracture, tenderness, any other injury, boils, lesions, discharge specially on the scalp, face, neck, shoulders, breasts, wrists, forearms, medial aspect of upper arms, thighs and buttocks) Note the Injury type, site, size, shape, colour, swelling signs of healing simple/grievous, dimensions.)

Injuries on the body (if any)	**Details**
Scalp examination for areas of tenderness (if hair pulled out/dragged by hair)	
Facial bone injury: orbital blackening, tenderness	
Petechial haemorrage in eyes or other places	
Lips and Buccal Mucosa/ Gums	
Behind the ears	
Ear drum	
Neck, Shoulders and Breast	
Upper limb	
Inner aspect of upper arms	
Inner aspect of thighs	
Lower limb, Buttocks	
Other, please specify	

18. Local examination of genital parts/other orifices:

A. External Genitalia: Record findings and state NA where not applicable.

Body parts to be examined	**Findings**
Urethral meatus & vestibule	

Labia majora	
Labia minora	
Fourchette&Introitus	
Hymen (findings only if relevant for example: fresh tears, bleeding, edema etc. to be documented)	
External Urethral Meatus	
Penis	
Scrotum	
Testes	
Clitoropenis*	
Labioscrotum*	
Perineum	
Any Other	

*Relevant in case of transgender only

B. Per/Vaginum/Per Speculum examination (Should not be done unless required for detection of injuries or for medical treatment).

P/S findings (if performed) ………………………………………………………………………………………………..

P/V findings (if performed) ………………………………………………………………………………………………..

Record reasons of performing P/S or P/V examination ……………………………………………………………..

C. Anus and Rectum (encircle the relevant)

Bleeding/tear/discharge/edema/tenderness

D. Oral Cavity – (encircle the relevant)

Bleeding/discharge/tear/oedema/tenderness

19. Systemic examination:

Central Nervous System: ……………………………………………………………………………………

Cardio Vascular System: ……………………………………………………………………………………..

Respiratory System: ………………………………………………………………………………………………

Chest :………
………………………

Abdomen: ____

20. Sample Collection/Investigation for hospital laboratory/Clinical laboratory

i. Blood for HIV, VDRL, HbsAg

ii. Urine Test for pregnancy

iii. Ultrasound for pregnancy /internal injury (if required)

iv. X-ray for Injury (if required)

21. Sample collection for Central/ State Forensic Science Laboratory

i. Debris collection paper

ii. Clothing evidence where available – (to be packed in separate paper bags after air drying)

List and Details of Clothing worn by the survivor at time of sexual violence

iii. Body evidence samples as appropriate (duly labeled and packed separately)

Body evidence samples	Collected/Non collected	Reason for not collecting
Swabs from Stains on the body (blood, semen, foreign materials, others)		
Scalps hair (10-15 strands)		

Head hair combing		
Nail scrapins (both hands separately)		
Nail clippings (both hands separately)		
Oral swab		
Blood for grouping, testing drug/alcohol intoxication (plain vial)		
Blood for alcohol levels (Sodium fluoride vial)		
Blood for DNA analysis (EDTA vial)		
Urine (drug testing)		
Any other (tampon/sanitary napkin/condom/object)		

iv. Genital and Anal evidence (Each sample to be packed, sealed and labeled separately to be placed in a bag)

* Swab sticks for collecting samples should be moistened with distilled water provided.

Body evidence samples	**Collected/Non Collected**	**Reason for not collecting**
Matted pubic hair		
Pubic hair combing (mention if shaved)		
Two Vulval swabs (for semen examination and DNA testing)		
Two Vaginal swabs (for semen examination and DNA testing)		
Two Anal swabs (for semen examination and DNA testing)		
Vaginal smear (air-dried) for semen examination		
Vaginal washing		
Urethral swab		

Swab from glans of penis/clitoropenis		

* Samples to be preserved as directed till handed over to police along with duly attested sample seal.

22. Provisional medical opinion

I have examined (name of survivor)……………………….M/F/Other…………………………………………

D/o of S/o (where known)…………………………………….Aged…………………..years/months/days reporting……………………………………………………………………………….(type of sexual violence and circumstances)……………………………………………………., days/hours after the incident, after having(bathed/douched etc)……………………………..

My findings are as follows: ……………………………………………………………………………………………………

………

………

………………………………………………………………………

i. Samples collected (for FSL), awaiting reports

ii. Samples collectd (for hospital laboratory)

iii. Clinical findings

iv. Additional observations (if any)

23. Treatment prescribed:

Treatment	Yes	No	Type and comments
STI prevention treatment			
Emergency contraception			
Wound treatment			
Tetanus prophylaxis			
Hepatitis B vaccination			
Post exposure prophylaxis for HIV			
Counselling			
Other			

24. Date and time of completion of examination

………………………………………………………………………………………

This report contains ……………………….number of seats and……………………..number of envelopes.

Signature of Examining Doctor

Name of Examining Doctor

Place: Seal

25. Final Opinion (After receiving Lab reports)

Findings in support of the above opinion, taking into account the history, clinical examination findings and Laboratory reports of ……………………………bearing identification marks described above, …………………………………………….hours/days after the incident of sexual violence, I am of the opinion that

Signature of Examining Doctor

Name of Examining Doctor

Place: Seal

COPY OF THE ENTIRE MEDICAL REPORT MUST BE GIVEN TO THE SURVIVOR/VICTIM FREE OF COST IMMEDIATELY

ANNEXURE-2

MAN POWER OF POST MORTEM EXAMINATION

Autopsy Surgeon/Autopsy Officer

- Medical officer- Having degree of M.D. (F.M.T.) or Diploma in Jurisprudence
- Forensic pharmacist- D- Pharma with Forensic Medicine
- Ward boy - High School
- Cleaner/Mortuary Assistant – 8th passed

Duty – 12 hours/day

INFRASTRUCTURE –

1- Mortuary block
2- Number-2 (one in autopsy block, one open mortuary)
3- Distance from the department

Size- 400 sq. Mt. (autopsy block)

90sq. Mt. (open mortuary) 10x9m outside of autopsy block

4- Lighting – natural light with provisions for electric lights and working portable shadowless lamp is having 1000 watt/300 flux of luminious on table.
5- Number of autopsy tables available – 2
6- Exhaust arrangements
7- Water supply, drainage, washing arrangement and disposal of waste.
8- Fly proofing

Electric fly catcher has also been installed

9- Other facilities available in main mortuary block

- Washing area of medical officers(bathroom)
- Record room with internet connection
- Viscera room
- Reception area
- For relatives of the deceased
  - Waiting area
  - Facility for cold drinking water
  - Toilet facilities

10- As per the updated requirements of Medical council of India for assessment of Postgraduate course in Forensic Medicine (2016-17) the details of open mortuary are as under:

- Size- 90sq. mt.
- Location – in campus, adjacent to main mortuary block
- Ventilation
- Lighting – natural light (translucent sheet on ceiling) and artificial source available
- Fly proofing

11- Mortuary attendant room – a room for on duty mortuary attendant is designated near the main entrance towards the mortuary.

ANNEXURE-3

MLR No.: ____________

PROFORMA FOR AGE CERTIFICATION

DDR/FIR No.:________________Dated______________U/S ____________PS________________ Name:______________S/O, W/O, D/O _________________________ Sex: ____

Date, place and time of examination: ____

Consent: I,_________________________________S/O, D/O, W/O ______________________________ my/my ward's_________________________________medicolegal examination including relevant investigations, the nature and consequences of which have been explained to me in the language that I understand. I certify that I have not/my ward has not been examined before for the said purpose.

Signature:

Identification marks:

Examinee In presence of (if needed)

1. ____

2. ____

Brief history (including alleged age): ____

____

____

Menstrual history (in case of females): ____

General physical examination:

- Vital signs:
- Mental status: Conscious/co-operative/oriented to time and place
- Height:
- Weight:
- Hair:
  - Moustache
  - Beard
  - Axillary hair
  - Pubic hair
  - Body hair
- Voice: High pitched/low pitched
- Genital examination:
  - Development

- Deformity (if any)
  - Congenital
  - Acquired
- Breast examination (in females):
- Relevant systemic examination:

Dental examination:

	2	
/	1	/
8		S
	2	
/	1	/
8		S

✓ Present X Missing

\# Present and fractured S Space for 3rd molar

Radiological examination:

X-ray plate no.	Part X-rayed	Findings

OPINION: Based on the general physical, dental and radiological examination, the estimated age of the person is between

_________________________ and______________________years.

Date:_____________ Place: __

Signature of the Doctor (with name and designation)

ANNEXURE-4

PROFORMA FOR MEDICOLEGAL EXAMINATION

of Injuries

MLR No.: ____________

DDR/FIR No.:________________Dated______________U/S_
____________PS_______________ Name:________________________________
Occupation:____
____
Examined in presence of (in case of female victims): ________________________

my/my ward's___________________________________medicolegal examination including relevant investigations, the nature and consequences of which have been explained to me in the language that I understand. I certify that I have not/my ward has not been examined before for the said purpose.

Signature:

Examinee In presence of (if needed)

Identification marks:

1. ____
2. ____

Brief history:

General physical examination:

1. Vital signs: ____________
2. Build: ____________
3. Weight: ____________
4. Height: ____________

Relevant systemic examination/referral:

Examination of the injuries:

Sr. no.	Type of injury	Location of injury	Dimensionsof injury	Weapon	Duration since infliction/ sustenance	Nature of injury (simple/grievous dangerous)	Referral / investigation (s), etc.

Note: The above information must include (*i*) type, situation and number, (*ii*) size, shape, depth and direction, (*iii*) condition of edges/margins, ends and floor, (*iv*) foreign body/material adherent or embedded (like metal, glass, hair, dirt, etc.), (*v*) extent of haemorrhage (if recordable), (*iv*) evidence of age of the wound (duration since infliction/sustenance). In case of firearm wounds, additional features like presence of abrasion collar and deposition of firearm residue (with nature and extent of distribution).

Date:_____________ Place: __

Signature of the Doctor(with name and designation)

Note: It is prudent to conduct photography wherever warranted.

ANNEXURE-5

PROFORMA FOR EXAMINATION OF A VICTIM OF SEXUAL ASSAULT

MLR No.: ______________

DDR/FIR No.:________________Dated_______________U/S________

____________PS__________ Name:____________________S/O, W/O, D/O _____

Age:_____________________Years Sex:________________Marital status: ________ Address:_______________________________________

Occupation:____

Requested by: ____

Brought by: ____

Date, place and time of examination: _____________________________

Examined in presence of ____________________________________

Consent: I,_____________________________S/O, D/O, W/O ____________

R/O____, give my free and voluntary consent for my/my ward's___________________________________medicolegal examination including relevant investigations, the nature and consequences of which have been explained to me in the language that I understand. I certify that I have not/my ward has not been examined before for the said purpose.

Signature:

Examinee In presence of

Identification marks:

1. ____

2. ____

Brief history

a. History of the incident (in verbatim, in detail):
(with date, time and place of the alleged offence and names if known of the alleged offender/s)

b. Posture acquired during the act (i.e., whether standing, lying, sitting):

c. Whether the victim was menstruating at that time (menarche, LMP, etc.)

d. Use of any contraceptive: ______

e. Whether in senses or intoxicated:

f. Whether struggled/cried for help:

g. Did she experience pain during the act:

h. Was there any emission of semen:

i. Did the assailant wear the condom/use lubricant:

j. Post-coital complaints of pain/discomfort while walking:

k. Did she change the clothes after the incident?

l. Whether passed urine/stool/took bath since the alleged assault:
m. Whether suffering from any general/emotional disease and whether on some medication:
n. History of any past or present STDs:
o. Is she pregnant? If yes, the duration of pregnancy:
p. H/o previous pregnancy(ies), abortion(s) or delivery(ies), etc.

General physical examination:

- Height:
- Weight:
- Build:
- Mental status:
- Vital signs:
- Secondary sexual characters:
- Gait:
- Dental status:

Examination of the clothing:

(Look for tears/hair/foreign material/blood stains/seminal discharge/any other evidence)

Extragenital examination:

(Look for presence of abrasions/bruises/lacerations/stains/foreign body, especially over the face, breasts, back and inner aspectsof thighs)

Genital examination:

- Pubic hair: Present/Absent Matted/Non-matted
- Length of pubic hair:
- Vulva (labia majora/minora):
- Fourchette and posterior commissure:
- Hymen: Intact/Torn (if torn, position/size, Fresh/old)
- Discharge if any:
- Digital examination (to be done after taking appropriate swabs):
  - Easy/painful
  - Areas of vaginal tenderness
  - Laxity of vaginal orifice
  - Elongation of posterior vaginal fornix
  - Signs of pregnancy (if any)
- Speculum examination: location of injuries on the vaginal wall, cervix, appearance of the cervical os, etc.
- Any other finding:

Samples for laboratory investigation:

1. Clothing (carrying some stain or other evidence)
2. Loose hairs/foreign material over the clothes
3. Matted pubic hair

4. Loose pubic hair
5. Nail scrapings/clippings
6. Swabs from over the breasts/cheeks/inguinal region/any other bite area
7. Vaginal swabs (ant., post., lateral fornices)
8. Vaginal aspirate from the posterior fornix
9. Urethral swab for venereal disease
10. Blood for grouping, toxicology or any other investigation
11. Urine for toxicology (if available)

Above marked samples has/have been labelled, sealed and handed over to Police ___________ B. No.____________ of___________ Police station.

OPINION:

Date:_____________ Place: __

Signature of the Doctor (with name and designation)

Note: It is prudent to conduct photography wherever warranted.

ANNEXURE-6

PROFORMA FOR EXAMINATION OF AN ACCUSED OF SEXUAL OFFENCE

MLR No.: _______________
DDR/FIR No.:_______________Dated_____________U/S____________________PS
____
Name:____S/O _____________________________________
____
Brought by: ____
Date, place and time of examination: ____
Consent: I,_________________________________S/O, D/O, W/O _____________________________
my/my ward's____medicolegal examination including relevant investigations, the nature and consequences of which have been explained to me in the language that I understand. I certify that I have not/my ward has not been examined before for the said purpose.

Signature:

Identification marks:

Examinee In presence of (if needed)
1.____
2. ____

Brief history:

- History of the incident (in verbatim, in detail):(with date, time and place)
- Whether passed urine/stool/took bath since the alleged assault:
- Whether changed the clothes after the incident:
- History of any past or present STDs:

General physical examination:

- Height:
- Weight:
- Build:
- Mental status:
- Vital signs:
- Secondary sex characters:
- Dental status:

Examination of the clothing:

(Look for and give accurate description of tears/hair/foreign material/blood stains/seminal discharge/any other evidence on theclothes of the person)

Extragenital examination:

(Look for presence of abrasions/bruises/lacerations/stains/foreign body especially over the face, arms, inguinal region, etc.)

Genital examination:

- Pubic hair: Present/Absent

Matted/Non-matted

- Penis:

General development

Injuries and their distribution (if any):

Smegma	Present/Absent
Prepuce	Circumcised/Retractile/Nonretractile
Frenulum	Intact/Torn
Discharge from the urethra	Present/AbsentAny other evidence of STD

Samples for laboratory investigation:

1. Clothing (carrying some stain or other evidence)
2. Loose hair/Foreign material over the clothes
3. Matted pubic hair
4. Loose pubic hair
5. Nail scrapings/clippings
6. Swabs from buccal mucosa
7. Penile swab
8. Urethral swab
9. Blood for grouping, toxicology and any other investigation

Above marked samples has/have been labelled, sealed and handed over to Police______________________
B. No._____________of___________Police station.

OPINION:

Date:_____________ Place: __

Signature of the Doctor (with name and designation)

Note: It is prudent to conduct photography wherever warranted.

ANNEXURE-7

PENAL PROVISIONS APPLICABLE TOMEDICAL PERSONS

IPC	Context
118	**Sections 118, 119 and 120 all contemplate the concealment of a design for commission of an offence by persons other than the accused. Under Section 107, such concealment constitutes an abetment. CrPC creates an obligation for the public(including doctors) in respect of several offences of serious nature (Section 39 and 40) to give information to the police.**
174	**Nonattendance in obedience to an order from the public servant (a doctor receiving summons from the court or from someother authority is duty bound to appear for such court or authority). Refusal or intentional omission to attend is punishable.**
175	**Omission to produce documents or electronic record to the court or public servant.**
176	**Intentional omission to give notice or information to public servant. It covers situations like information about commissionof an offence, its prevention, or apprehension of an offender, etc.**
177	**Section 160 of CrPC reserves the right of police to require attendance of witnesses, and Section 161 deals with examinationof a witness by the police through investigational interrogation (including those of doctors). Furnishing false information is punishable.**
178	**Refusing oath or affirmation when duly required by the public servant to make it.**
179	**Refusing to answer public servant authorised to question.**
180	**Refusing to sign the statement.**
181	**False statement on oath or affirmation to public servant or person authorised to administer an oath or affirmation.**
191	**Deals with false evidence and is based upon recognition of decline of moral values and erosion of sanctity of oath.**
192	**Fabricating false evidence. The wording of this Section is so general as to cover any species of crime that consists in theendeavour to injure another by supplying false data.**
193	**Punishment for giving or fabricating false evidence in judicial proceeding or in any other case.**
197	**Issuing or signing a certificate knowing or believing that the certificate is false has been put on the same footing as theoffence of giving false evidence.**
198	**Using or attempting to use a certificate knowing or believing it to be false in some material point.**
201	**Causing disappearance of evidence of offence, or giving false information to screen the offender.**

202	Intentional omission to give information of an offence to the magistrate or the police by person knowing or having reasonto believe that the offence has been committed.
203	Giving false information respecting an offence committed.
204	Destruction of document or electronic record to prevent its production as evidence.
304A	Covers cases wherein a person causes death of another by such acts as are rash or negligent but there is no intention to cause death and no knowledge that the act will cause death (Under English Law, such cases are termed as manslaughter by negligence).
336–338	Rash or negligent acts that endanger human life, or the personal safety of others, are punishable under Section 336 even though no harm follows and are additionally punishable under 337 and 338 if they cause hurt or grievous hurt, respectively. The word 'rashly' means something more than mere inadvertence or inattentiveness. It implies an indifferenceto obvious consequences and to the rights of others.

ANNEXURE-8

PENAL PROVISIONS AFFORDING PROTECTION TO MEDICAL PERSONS

IPC	Context
87	Protects a person who causes injury to another person above 18 years of age by doing an act not intended or known to be likely to cause death or grievous hurt. It appears to proceed upon the maxim *volenti non fit injuria*, i.e. he whoconsents, suffers no injury.
88	Sanctions the infliction of any harm if the act by which it is caused is done in good faith and for the benefit of the person consenting to the act. Hence, a surgeon performing an operation for the benefit of the consenting person does not standliable if it entails any harm to that person.
89	Empowers the guardian of a child under 12 years of age or an insane person to consent to the infliction of any harm to the child or the insane person provided the act by which the harm is caused is done in good faith and for the benefit ofthe child or insane person.
90	Instead of giving positive definition of 'consent', this Section defines it in negative terms. It goes to explain that a consentis not a free consent in the law and is no answer to a charge of crime, if it has been procured by putting a man under the fear of an injury, coercion, or under a misconception of fact, or the consent is given by a person who by reason of unsoundness of mind or intoxication or immaturity of age (a child under 12 years of age) is incapable of understandingthe nature and consequences of the act to which the consent was accorded.
91	Excludes acts that are offences independently of harm caused. For example, causing a miscarriage is an offence independently of any harm that it may cause or be intended to cause to the woman. Consent of the woman or herguardian to the causing of such miscarriage does not justify the act.
92	Consent may be dispensed with when the circumstances are such as to render consent impossible or when, in the caseof person incapable of assenting, there is no one at hand whose consent can be substituted. This Section sanctions emergency action taken by a medical man on his own initiative acting in good faith in the interest of the individuals.
93	No communication made in good faith for the benefit of the person is an offence by reason of any harm to the person towhom it is made. A doctor communicating to the patient about his/her serious condition sending some feeling of shock to the patient may not be considered to commit any offence. However, ethics may be questionable.

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