Reference Manual
on
Autopsy Examination

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Preface

These guidelines were developed to improve the standards of the autopsies conducted in District Hospitals of Nepal. The guidelines are intended to assist specially the trainees in deciding how to perform certain postmortem examinations, and to avoid pitfalls. The postmortem examination has a continuing vital role in the basic study of disease processes, therapeutic response and complications, research, education, genetic counselling, and in audit of medical practice in addition to its elementary role in determining a cause of death.

These guidelines are recommended best practices and the applicability it in a specific case is balanced by the state of the body, information known at the time of the postmortem examination, and professional judgment. This document will be revised in the future as forensic pathology evolves and new facilities are available.

General objectives

I. To provide assistance and support to the trainees.
   - To decide on the best practices applicable to a particular case.
   - To minimize non-reviewable errors at autopsy.
   - To help ensure that autopsy findings, are documented adequately using uniform procedures.

II. To ensure appropriate samples are collected at autopsy.

III. To ensure appropriate ancillary testing is performed after autopsy.

History

The word ‘necropsy’ was used for description of investigation of dead, which was later, changed to ‘autopsy’. Postmortem examination without any ambiguity is used in Britain, which lacks precision on the extent of how extensive the examination is done. In some areas of world, the bodies are disposed without any examinations as per laws of land.

It is believed that investigation of dead bodies was introduced earlier than judicial system by the enthusiast medical knowledge seekers following the principle of “dead teach the living”. Evidence of forensic dissection dates back to thirteenth century at University of Bologna by William of Saliceto as mentioned in his book “Surgery” about a case he examined in 1275. In sixteenth century, various codes developed in Europe like the Bamberg code in 1507, Caroline Code in 1532 and Theserian code in 1769, which added more principles producing modern day medico-legal investigation of the dead. Hospital or clinical autopsy added values to it where modern concept of pathogenesis of disease and cellular pathology were introduced by Carl von Rokitansky and Rudolf Virchow respectively. With adoption of judicial system, the modern day autopsy was given its shape and is emphasized in most countries of the world to detect and investigate unnatural and sudden deaths.

In Nepal however, autopsy was believed to be initiated in Bir Hospital but no evidence as to who performed it for the first time has been traced. It continued to be the center for death investigation, until 2047BS when it moved to Institute of Medicine, Tribhuvan University. Besides Tribhuvan University, BP Koirala Institute of Health Sciences is the only other medical institution performing autopsy on routine basis. The load of autopsies being carried out all over the nation is borne by fresh medical graduates of the country following training on medico-legal investigation of death for a period of 1 to 2 months at local health centers.

With an aim to train these graduates, present guideline in an initiative taken by Medico-legal Society of Nepal (MeLeSoN) and Nepal Government (Health ministry and Nepal Health Research Council).

Legal aspect of autopsy in Nepal

Muluki Ain, 2020 B.S.

Chapter 10 Jyan Sambandhi ko Mahal

Number 1. Nobody can kill, order to kill or attempt to kill any person except if it is permitted by law.

Number 2. If a person dies due to suicide or homicide, any witness and next to kin should provide information to responsible person of community, concerned member of Village Development Committee (VDC) or Municipality and Police Office. After receiving such information, the responsible person must follow following procedures:

a) Perform preliminary investigation (Muchulka) and secure the scene and body until police arrives at the scene.

b) If it is case of homicide, try to find the suspect, arrest the suspect and handover to police.

c) The document (Muchulka) prepared should be handed over to police and police should perform further inquiry and deed of dead body examination.

d) The body should be examined and post-mortem report should be obtained by doctor of the nearby hospital and by chief of the dispensary if hospital and/or doctor is not available.

Number 3. In case of suicide, homicide, or suspicious death, the investigator should observe from distance and note whether there is scene disturbances, dragging marks, any other objects present at the scene.

The relevant objects or material should be lifted and keep secure until disposal of the body. The scene should be described with all boundaries and the condition of the body should be described in detail and sketched while preparing the document of preliminary investigation.

a) If there are injuries in the body, document location, measurement with length, breadth and depth, number of injuries, any contusions, lacerations, imprint injuries, any breakage of body part, grievous injuries, abrasions of different types and any puncture or penetration.

b) In death due to hanging, ligature material should be taken to office and following details should be noted.

- Whether pupils are dilated or brownish lips.
- Protruded eyeballs or not.
- Tongue protruded and between lips or not.
- Whether there is discharge of saliva, mucoid discharge, blood, feces, semen etc. from mouth, nose, anus and other orifices.
- Whether the ligature mark on skin is harder or not.
- Hands clenched or not, hands and feet touch the ground or not.

c) In case of body found in water – ponds, lakes, river, canal. following details should be examined:
   - Whether abdomen is distended and wrinkled palm skin or not while taking body out from water.
   - Whether blood smears present the site of recovery and over the face of body or not.
   - Whether there are injuries on the head, neck and trunk of the body and blood smears or not.
   - Hands are open or closed and if anything is clenched in the fist
   - Body should be kept in prone position and pressure should be applied over back to look to detect water is present in stomach or not.
   - Whether penis is shrunken and with smaller size or not.
   - Whether there are abrasions in hand fingers or not.
   - Whether mud is present in the female genitalia or not.

d) In case of snakebite, following details should be examined.
   - Whether there is swelling on the area of bite and the hairs are easily plucked or not.
   - Whether there is history of severe pain at the site, frothing from mouth, flexion of digits, difficulty to open eyes, yellowish or bluish face and thin blood not quickly clotted or not.
   - Whether the person was drowsy and could not walk or not.

e) In case of poisoning following details should be examined.

- Whether there is history of smaller eyes with constricted pupils and dilated after death, sleepy and unconsciousness before death, excessive sweating, dry mouth or not.
- Whether there is history of severe dryness of mouth and throat, flushed face, sleepy, disoriented, dilated pupils, slurred speech and frequently unconsciousness or not.
- Whether there is history of diarrhea vomiting, burning pain abdomen, thrust, swollen like face, tachycardia, weakness and unconscious before death or not.
- Whether there is history of shock, burning mouth and throat while taking food and muscle cramps or not before death.

Number 4. After completion of examination of the body, police personnel shall sign a letter for cremation of the body. The body shall not be cremated or thrown away or decayed without obtaining such a letter.

- One who does not issue a letter to permit cremation of body or one who cremates the body without receiving the letter – Fine of Ten Rupees.
- If person cremates, or causes to be cremated, the body for the purpose of concealing fact, prior to examination of the body – Imprisonment for Six months, in addition to punishment pursuant to other laws.

Number 5. Any act or action without malice or intention to commit murder, and the act would not result in death but someone dies as a consequence of such an act or action, it shall be deemed accidental homicide *(Bhabitabya)*.

Number 6. Punishment for accidental homicide shall be as follows:

- Accidental homicide with a weapon – Fine up to Three Hundred Rupees
- Accidental homicide due to negligence or recklessness – Fine of up to Five Hundred Rupees or Imprisonment not exceeding Two years or both
- Person engaged in taking care of or educating beats that person or any other act for the benefit of the deceased – Fine of up to Fifty Rupees
- Accidental homicide after beating the deceased – Fine of up to Five Hundred Rupees or imprisonment not exceeding Two years or both
- Accidental homicide due to any other act – Fine up to Two Hundred Rupees

Number 7. Death shall not be deemed a murder, if person dies under following circumstances:

- In defense, to protect one's life
- Except in theft of food, vegetables or fruits, to defend one's property
- To defend government property

Number 8. If a person hurts another person, thereby causing fracture or breaking of any body part, with intention to kill, and such victim dies before it is cured anytime later, such a perpetrator shall be considered to be a murderer.

Number 9. If somebody dies within 21 days of an assault with intention to kill, within three days if by forms of application of other excessive force except injury and within seven days by poisoning, the death shall amount to murder.

Number 10. Except in cases where accidental homicide is proved, if any person hits/beats in the sensitive part of body (*Sandhi or Kuthaun*) by his/her hand, such act will be deemed murder if death occurs, suffering from the pain,

- within Seven days
- Within Five days, in the case of using excessive force
- Within Twenty One days of suffering from infection of the wound or without recovering from it
- If someone dies after such dates, it shall be dealt with as Hurt/Battery.

Number 11. Any hurt causing victim unable to move around or work, following which somebody else cause hurt or commits a crime, and such a person dies within 21 days, the death was caused by the person caused pain subsequently.

- The person, who caused hurt earlier with the intention of murder, shall be punished for Five to Twelve years. (Number 15)
- If it was done without intention to cause death, it shall be dealt with as Hurt/Battery.

Number 12. Victim recovered and was able to move around or work, somebody else cause hurt or commits a crime, and such a person dies within 21 days, the death was not caused by the person caused pain earlier.

- The person, who caused hurt earlier with the intention of murder, shall be punished for Five to Twelve years. (Number 15)

- If it was done without intention to cause death, it shall be dealt with as Hurt/Battery.

Number 13. A person who directly uses his or her hands with an intention to separate the person dispute shall not be liable to any punishment

- Use of dangerous weapon with or without edge – all are liable for Imprisonment for life, along with confiscation of entire property.
- Use of poison – Imprisonment for life, along with confiscation of the entire property.
- Cause or instigate other to administer poison – Imprisonment for life.
- Principal murderer (person causing the injury that caused death) - Imprisonment for life, along with confiscation of entire property.
- All involved in the commission of crime –Imprisonment for life.
- A person who catches the victim and creates conducive environment (Sanjog) to kill – Imprisonment for life.

Number 14. Person using stick, stone, kick or fist person, without intention to kill, without any malice (*Ibi*), without hiding in a secret place (clandestinely), with an immediate provocation, without using any serious/hazardous weapons or poison, and victim dies within the date due to hurt or pain inflicted – Imprisonment for Ten years.

Number 15. Person opens fires, throws bomb or cuts with serious weapon, or commits any act to kill another person, to the extent possible, even if victim does not die, all persons involved in commission of the offense – Imprisonment for Five to Twelve years.

Number 18. Person who abandons a baby born alive – Imprisonment for Four years

- If baby is found dead, the person who abandoned shall be murderer.

Number 20. A case shall not be registered if it is not filed

- within Twenty years, if complaint shows that it is a case of murder and the investigation does not identify any accused
- Within Two years if the complaint does not mention it as a murder case.

Number 21. Autopsy should be performed with documentation of real findings like injuries, scars and other lesions, which are present on the body accurately. If the findings are deliberately documented in distorted form, will be punishable with fine of 500/- Rupees.

Number 28. If any person procures abortion or knowingly commits the activities which are likely to cause abortion, with intention, s/he will be punished as follow:

- Below 12 weeks of gestation: one year imprisonment
- 12 – 25 weeks of gestation: three years imprisonment.
- Above 25 weeks of gestation: five years imprisonment.

Number 28. A. Nobody should procure abortion with coercion, threat and undue application of any activities to a pregnant woman. It will be punishable as follow, if committed:

- Below 12 weeks of gestation: one year imprisonment
- 12 – 25 weeks of gestation: three years imprisonment.
- Above 25 weeks of gestation: five years imprisonment.

Number 28. B. Abortion can be performed by authorized health professional, under condition prescribed by Government in following conditions:

- Abortion within 12 weeks of gestation with consent from pregnant mother.
- Abortion within 18 weeks, with consent from pregnant mother, if pregnancy is a result of rape or incest.
- If the pregnancy is likely to endanger the life of woman or cause serious injury to her physical or mental health and if there is evidence to support that the child would suffer from severe physical and mental anomaly, certified by authentic medical Specialist, with consent from the mother.

Number 28. C. Sex identification of embryo is prohibited by law.

- If it is done will be punished with 3-6 months of imprisonment.

Number 28. D. Abortion after sex identification – Imprisonment for 6 months to 2 years.

Number 29. If a person commits an act to a pregnant woman with some anger or malice (Rishibi) and such an act results in abortion

Number 32. If a person commits the offence referred to in Number 29

a) with the knowledge that the woman is pregnant
   - Imprisonment for Three months if fetus is up to Twenty Five weeks
   - Imprisonment for Six months if fetus is more than Twenty Five weeks

b) without the knowledge that the woman is pregnant
   - Fine up to Five Hundred Rupees if fetus is up to Twenty Five weeks
   - Fine up to One Thousand Rupees if fetus is more than Twenty Five weeks

Number 33. A case of abortion shall not be registered if not filed within Three months

Government Cases Act 2049

Section 11 (1) Post-Mortem Examination (Autopsy): If there is death within the jurisdiction of police office and death is related or suspicious of any homicide or suicide or accident, at least Deputy Inspector of Police must visit the place immediately and prepare a document (Muchulka) about scene and dead body with photographic record including following points :

a) The detail to identify the deceased
b) Detail on place and position of the body
c) Detail on injuries, if any with place, number, length, breadth and depth of the injury
d) Any possible weapon or objects possibly to cause death and findings on the body
e) Any feature on the body which is supportive to find cause of death
f) Others relevant information

Section 11 (3) Police officer should send the body for autopsy to governmental Medical Officer on the expenses of government

Section 11 (4) If the body is decomposed, it is not necessary to send the body for autopsy to hospital, and police office should document the same in Muchulka

Section 11 (5) The police officer should handover the body to relatives with a disposal letter after autopsy. If there is nobody to receive the body, the police officer should dispose the body on government expenses as per Police Act section 22 (a).

Section 12 **Examination of blood, semen etc.**: If there are reasons for procuring evidences by the examination of blood, semen, any part of body investigating police officer can request government medical officer or laboratory. For female suspect, a female examiner or a female on the guidance of a male examiner should perform examination.

Section 13 **Obtaining Expert Opinion:** If investing officer feels the need to obtain the opinion from an expert, he/she can take expert opinion on any matter related with criminal case.

Government Cases Regulation 2055

Section 6 Inquest and autopsy:

a. The investigating police officer should prepare a deed of examination of dead body (*Muchulka*).

b. The investigating officer may not send the body for autopsy if there are no evidences of criminal and suspicious death and should prepare *Muchulka* accordingly

Section 7. Report of Autopsy:

a. After completion of autopsy, the government doctor must prepare the report and submit the report within 24 hours, excluding travel time.

b. It is duty of concerned hospital or health post to send report within 24 hours when police sends for injury examination or other condition of a concerned person during the course of investigation.

Section 8. Expenses

Police officer should provide necessary amount needed for transportation of the body from scene to hospital.

Police Act 2012

Number 22. A. About unidentified body:

If any unidentified body is found, police should identify and handover to relatives in natural death.

If body is unidentified or unclaimed, police can provide the body to Medical Institutes if they need for teaching learning activities. If Medical institutes do not want the body, police through Village Development Committee or Municipality or Social Organizations should finally dispose the body.

However, in case of death due to homicide, suicide, accident or other suspicious circumstances, body can be disposed as under this provision only after completion of investigation and post-mortem examination.

Safety during autopsy

Special operational procedures for safety of health personnel working inside the autopsy room must be maintained. Although it was believed that autopsy should be carried out in broad daylight, the theory held true during times where electric lighting system was not well developed. These days, a properly ventilated and well-illuminated room can serve the purpose very well. Ample running water and proper drainage system, aided by waste management, is essential for a clean mortuary. The autopsy room should be located at a reasonable distance from hospital, to avoid contamination and exposure of infective materials and odor. Use of UV lamps after working hours and weekly fumigation is recommended.

Separate working area is needed for high-risk cases to avoid exposure to all members. Unauthorized personnel should not be allowed in. All personnel should be immunized for tetanus, tuberculosis, hepatitis B, etc. and educated about hazards and preventive measures, self-safety and safety of others. First aid tool kit is should be kept at standby, in case of any mishaps like cuts, pricks, etc. A periodic medical checkup is necessary to all individuals working in and around mortuary. Logistics like caps, gloves, googles suits, gowns, apron, boots, arm sleeves, etc. must be abundantly present and replaced periodically by new ones.

Soiling floor, walls and instruments with rough handling of bodies resulting in splashes of fluids and water, and should be minimized to the extent possible. In case of cuts and pricks, contamination must be avoided and bleeding hastened to assist disinfection, by washing under clean running water. Splashes to eyes must be treated by washing eyes with cold running water immediately. Any accidents inside autopsy room must be documented and screening of the victim must be done regularly. Instruments dipped in Lysol (1:40 solution) for 2 hours can be considered safe to use although autoclaving is ideally recommended.

Plastic apron, hair cap, gumboots, gloves and facemask, as well as liquid soap, running water are essential in any autopsy room.

Steps to keep autopsy instruments clean:

1. Use forceps to gather all instruments in a perforated tray.
2. Wash instruments under running water and try removing all stains.
3. Put instruments in soap solution and clean with ordinary brush for persistent stains.
4. Wash in running water repeatedly.
5. Put instruments in cidex (Lysol) solution tray.

Autopsy Biosafety:

Keeping in mind the era of global immigration and bioterrorism, awareness of possibility of epidemics cannot be ruled out. Experience of forensic experts working with diseases like SARS, bird flu, swine flu, Ebola, corona virus, hanta viruses, etc. have heightened the amount to biosafety required to perform medico-legal autopsy.

General preview

Every occupation has exposure in medical field and so does autopsy practices. Invective agents like bacteria, virus, fungi, helminths, parasites and prions are the threats mortuary individuals are exposed to and at the risk of developing contagious diseases. These infective materials are introduced through pricks, cuts, inhalations, ingestion or passage through pre-existing wounds.

Cuts and puncture wounds should be irrigated immediately with soap and running water. In case conjunctival splashes occur, the eyes should be washed immediately. Injured employees should go to the emergency department. Any individual with open wounds or dermatitis should not assist in autopsy procedures, or in case the open wound must be completely covered with waterproof barrier

General Rules

Simple rules practiced in mortuary can help reduce the risk of transmission. Initially before starting an autopsy, a board/notice must be kept outside the mortuary written ‘hazard’ in big letters to avoid unauthorized entry. Autopsy suit must be well ventilated and nylon suits are preferred since they do not absorb fluid. Only well trained staffs must handle the body and instruments. One of the well-trained staff must be kept aside and clean to record the findings and help with logistics. The risk of splashes, spills, droplets, or aerosols are reduced to maximum level. Following completion of autopsy, every instrument, suit and even paper in which recording was done needs to be replaced with a new one. It is suggested to use disposable logistics for cases even doubtful of hindering biosafety setting of a mortuary.

Basic Logistics:

Personal protective equipment (PPE) is required to establish minimum level of biosafety includes double sets of gloves, gowns, scrub suits, plastic aprons and sleeves, N95 masks, googles or face shields, shoe covers and gumboots confined to non-contaminated areas. Cut-resistant and puncture-resistant hand protection (plastic or steel gloves) is also available but recommended for high-risk procedures.

Approaching sharp instruments:

The frequency of injuries sustained during autopsy procedures can be reduced using simple practices. Most injuries to mortuary staffs are due to sharp and pointed objects hence use of such instruments should employ extra care. Needle pricks are common and its use and disposal should be methodically governed.

Use of blunt tip scissors and curved scissors instead of scalpel to eviscerate abdominal and thoracic organs can reduce the risk of injuries. Using forceps to hold tissues rather than free/opposite hand and use of knitted or steel cut-resistant gloves can provide extra protection. Use of towel to cover cut jagged ends of ribs can prevent scrape injuries. Sponge can be used to steady the organ while making slices. Large toothed forceps or clamps can be used to assisting in suturing at the end of the autopsy. Instruments used for infective cases should be cleaned in an enzymatic cleaner or detergent, then rinsed and soaked in 2% aqueous glutaraldehyde or 1:10 solution of bleach for at least 10 minutes to disinfect them.

Bone dust and aerosols:

Aerosols are commonly formed while sawing the bones; this can be reduced by moistening the bone before sawing. Besides that, systems like HEPA (high efficiency particulate air filtering) vacuum the dust and prevent it from being released.

Soft tissues extracted for analysis:

The fixation of tissue for histopathological analysis require at least 10 time the volume of 10% formalin (containing 3.7% formaldehyde) than the tissue volume. Mycobacterium are not killed by this fixation and require 10% formalin in 50% ethyl alcohol. The time required also varies depending on the volume of tissue.

Keeping laundry, instruments and workstation decontaminated:

In case of routine decontamination, all instruments should be dipped or detergent solution for at least 10 minutes then rinsed with water and decontaminated with disinfectant such as 5.25% sodium hypochlorite (1:10 solution of household bleach in water) for another 10 minutes. Glutaraldehyde does not damage aluminum and steel. One should rinse work surfaces with hot water followed by a 1:10 solution of bleach. Floors in the autopsy work area should be cleaned with a detergent solution, decontaminated, and rinsed with water. Ultraviolet light provides a secondary source for decontaminating room surfaces and air. Any wet clothing, towels, or other reusable laundry should be placed into leak-proof biohazard bags before transport.

Remains

Following completion of autopsy, all the fluid collections must be absorbed by sponge and the dead bodies must be sutured in the best way possible to avoid cosmetic defects. The body must be first washed with detergent solution then snit-septic solution (household bleach 1:10).The body should then be rinsed with water and placed in a disposable leak-proof plastic body bag. In case the dead body is assumed infectious, hazard label must be pasted for safety of everyone handling the body before last rights are performed. This should be included in death certificate too. Usually this is indicated on the death certificate as well. Fluid accumulations should be carefully removed by aspiration or blotting.

Management of waste and Human Tissue collected for analysis

Any tissues to be stored for analysis purposes should be kept in a sterile, wide mouthed and air tight plastic container. The contained must be sealed adequately and transported in an opaque plastic bag. Disposable wastes must be double bagged, secured and stored in metal or plastic canisters/containers. Any spills must be cleaned with disposable towels and contaminated area should be cleaned with detergent then household bleach (1:10. Finally, the decontaminated area should be wiped dry.

After removing gloves, one should wash his or her hands with soap and water and/or immediately and thoroughly any time following contamination.

Vaccines

Everyone working in mortuary must be vaccinated against Hepatitis B and tetanus.

Other Biohazard encountered during Autopsy:

Formaldehyde

Exposure to liquid or vapors of formaldehyde can cause various symptoms and diseases including headache, oto-rhinological irritation, throat irritation, chronic cough, wheezing, shortness of breath, pharyngitis, asthma, chronic airway obstruction, pharyngitis, menstrual, sexual and reproductive disorders, although the incidence is high, the severity in most cases are usually low.

Radioactivity

At times, mortuary workers may come across death following receipt of radioactive substance, introduced either for diagnostic or therapeutic purpose. Probability of coming across collection and proper disposal of radioactive fluid or tissue also can also be rare entity. In such condition, specialist consultation about the amount of activity remaining in the body, source, fluid or tissue should be estimated based on half-life of the isotope. Only if the remaining amount is less than 5mCi, normal safety procedures are helpful, exception to which is therapy with insoluble isotopes where activity is maximum. In case the residual activity is more than 5mCi, the team must perform the autopsy in limited short period to prevent individual exposure. Lead suits may be helpful in case the radioactivity is too high. The fluid in the body must be carefully drained.

Autopsy preparation

It was in 1991, the General Assembly of the United Nations endorsed the MODEL Autopsy Protocol of United Nations. Although the methods, procedures and technologies of autopsy varies from land to land, the motive has always remained the same - to administer justice by investigation of dead body.

Types of autopsy

There are two main types of autopsy:

1. **Pathological or Hospital autopsy**

   This is the type in which, following consent of relatives, medical personnel perform an examination with aim to answer the extent of disease, its significance in transmission to offspring and to understand the nature of disease proper for research and academic purposes. In many countries and jurisdiction, this type of autopsy is not held with a belief that if the disease remains unknown to attending physician, the case should be reported as medico-legal.

2. **Medico-Legal or Forensic Autopsy:**

   This type is performed on request of legal authorities who are responsible for investigation of sudden, suspicious and unnatural deaths. This legal authority in Nepal is the police, who conduct the death investigation. For death investigation and postmortem examination, the permission of the relatives is not required. In many jurisdictions the medico-legal autopsy is often further subdivided into: those held on apparently non-criminal deaths, such as accidents, suicides, deaths from sudden natural causes, or associated with medical and surgical treatment, industrial deaths, and so on

   The truly forensic autopsy held on suspicious or frankly criminal deaths, usually at the investigation of the police. The type of pathologist that deals with these categories also varies from place to place but, as the systems are so diverse, there is little point in discussing the details. What is much more important is that whichever pathologist tackles each type of case; he or she should be trained and experienced in that particular field.

Preparation for a forensic autopsy:

The routine autopsy procedure is usually uniform for all cases but the associated procedural cautions are required for each individual case, which will be discussed further in this guideline. The objectives of all autopsy procedure should be able to answer following questions:

The objectives of an autopsy:

Who? To make a positive identification of the body.

What? To determine the cause of death (in the newborn, whether live birth occurred).

How? To determine the mode of dying and (when?) time of death if possible

It is also vital to demonstrate all external and internal conditions, describe and measure any external and internal injuries, obtain samples for analysis and evidence, provide a written report, offer expert testimony, and, restore the body to the best possible cosmetic condition, before release to the relatives.

Pre-requisites:

Certain preliminary context should be fulfilled before carrying out any autopsy procedures, which are listed as:

Consent and Authority:

Any medico-legal autopsy should be carried out following a request made by death investigating authoritative body, which satisfies the forensic expert. In Nepal, police leads any death investigation. No consent is required from family members to carry out autopsy procedure. As an unofficial and humanitarian formality, it is best to inform the family members about commencement of procedure. It is best to make one of the family member identify the deceased to avoid exchange of bodies or other mistakes during handing over. If the authorization is not clear, it is best to clarify it with investigating officers.

Personnel permitted to witness autopsy:

The family members must be informed of place and time of autopsy but their attendance in autopsy room should be refused. Somehow, attendance of a doctor from family members or accused side and defense lawyers can witness the autopsy given that the report

documents their presence. Mortuary in-charge can refuse performing autopsy given that unwanted attendance, if forcefully attempted.

A second autopsy may be requested if the findings of the first autopsy are not accepted by any party. This usually takes place at a later date, after the accused has been charged and granted legal representation, but sometimes the second pathologist will attend the original autopsy. The investigating police and/or their technical team can witness medico-legal autopsies in criminal or suspicious cases.

Trainees, interns and medical students who wish to observe autopsy for academic purposes should allowed only upon the wish of the officer examining the case. In cases of hospital death, presence of the treating doctor is allowed and encouraged, provided it is not a case of alleged medical negligence against him/her, since it is expected that he/she has the best knowledge of the medical history. However, in all cases, the number of attendees witnessing the autopsy should be minimized, as there might be risk of loss of confidentiality, overcrowding of mortuary, mismanagement and high probability of contamination of evidence. The hazards of autopsy should be explained to any one attending mortuary for the first time and awareness must be created about PPEs during autopsy.

No casual observers must be allowed, not even police personnel or lawyers not involved in that particular case. Media should not have access to autopsy room and no one except the designated personnel should be allowed to take photographs and videos. Names of all individual witness a particular autopsy must be mentioned in the postmortem report.

Scene of Death Examination:

It is advisable for forensic examiner to visit crime scenes whenever he/she thinks is required. Such cases usually are homicide, suspected homicide and obscure cases. In context of Nepal, forensic examiners tend to visit scene of crime whenever police need help understanding the circumstances in better way or in case the examiner thinks some additional value to the cause and manner of death would be added by visiting crime scene. It is not advisable to visit crime scene alone and he/ she should be guided to the scene by investigating police officer.

- Swabs and containers for blood and body fluids
- Formalin jars for histological samples
- Plastic bags, envelopes, paper, spare pen and pencil

- Body charts for recording external injuries
- Waterproof apron and rubber gloves, Hand lens, electric torch, mini-tape recorder
- Thermometer, syringes, sterile swabs
- Dissection set, including handsaw (if autopsy is to be performed at a remote location)
- Cutting needles and twine for body closure, digital camera with flash

Department of Forensic Medicine, Maharajgunj, Kathmandu has been managing to visit the scene of death based on a roster designed, in every case of suspicious death once information is received from the Nepal police. The main objective of the doctor to visit crime scene is to access the environment, circumstances, position and condition of the body when found dead. The examiner visiting crime scene should have a list of things ready to visit a crime scene, some of which are given below:

Where no professionals for evidence collection are available, the pathologist must try to collect trace evidence himself by remaining within the limits of his expertise. The medical personnel should accept the instructions of police officers in relation to the approach to the body. Photographs must be takes as much as possible. In case of blood pool or splashes present in crime scene, a detailed photograph of each area where such are present should be photographed for the patterns to be studied and analyzed later. Photograph of dead body should be taken in relation to its position of surrounding fixed objects.

Skin can be felt for accessing temperature, eyes, limbs, head and neck region can be viewed whenever suspected of any lesion. Rigor mortis, livor mortis and algor mortis can be examined to correlate with the changes during autopsy. While doing so, if scene of crime officers require any samples at this stage, it must be allowed. Without disturbing the evidential values, the body can also be moved to look at the sides and undersurface with caution. There is no any routine as such which tells us what to do first, since each case is unique in its own way. The only aim should be not to disturb the scene for collection of evidence by scientists and SOCOs and not to create an artifact, which can make the entire case go valueless in court of law, reasoned to defect in sample collection.

Crime scene and time since death:

The investigating officers are first to reach the scene of death, followed by medical experts. The time of death in most of these, cases are most sought query by police officer and family members when the occurrence of incidence is not known.

Any methods used to calculate time since death has to been considered just an estimate and medical experts should best avoid answering the exact time calculated by whatsoever means. An estimate of time of death can always be wrong and non-scientific; hence, it is always advisable to answer such queries with caution. Any unofficial information can be given to investigating bodies to move forward with the case, but documenting the time as definite can create problems if proved wrong later.

Based on changes seen after death, like cooling of the body temperature, rigor mortis and hypostasis present during investigation of scene of death, on can give a range of time period which may again vary due to various factors like built of the victim, clothing, variation in temperature with time and micro environment, abundance of body fat, etc. The insertion of a thermometer into the body orifices during scene investigation, as mentioned some textbooks, is controversial and can result in creating artifact.

The body should be cautiously kept in a body bag and zip closed, or wrap in plastic sheet, with edges secured. The function of a pathologist at any scene of suspicious death is to observe the circumstance in which death occurred, preserve fragile evidence, supervise the removal of the body and offer an opinion, based on experience, about the nature of death only where this can reasonably be done. The pathologist is a part of a team of specialists, and the multi-disciplinary approach requires cooperation and coordination.

Property, clothing and identification

Clothing and property associated with dead bodies play a vital role not only in identification process but also for interpretation of injuries like direction of force, severity and pattern of injury, trace evidences like gunpowder in case of firearm related injuries, and also gives an idea on type of weapon used. In many cases, there will be no opportunity to examine the clothed body in the mortuary especially if the death has occurred in hospital settings where bodies arrive to mortuary covered in hospital sheets. The pathologist should seek for clothing worn by victim at the time of incident whenever possible. Requests must be made to the hospital that the clothing removed for treatment should not be destroyed but should be stored as evidence and sent along with the body to the mortuary.

The mortuary members should have first-hand knowledge about importance of clothing and properties in investigation of death and a system must be established within mortuary to retain and store clothing and properties of the deceased. During autopsy the contents present inside pockets of the deceased like ID cards, documents, keys, ornaments,

etc. should be noted in a log and informed to police about the same, as some of these items might help solving the last part of the puzzle.

Death due to trauma, injuries to bodies should be analyzed based on tears and stains on the clothes as well. Samples like blood, saliva and seminal fluids can be of vital importance to forensic laboratory and forensic doctors might be the first one to notice them. In cases related to firearm deaths, gunpowder residues might be found on the clothing. In traffic fatalities, tearing of the clothes, grease marks, road dirt, broken lamp or windscreen glass, and even metallic or paint fragments from the vehicle may all assist in reconstructing the event and in identifying the unknown vehicle in a hit and run cases. Other objects associated with the body that may be helpful include medicines, which may assist in determining the nature of the disease from which the deceased had suffered, for example, atenolol, insulin.

In some suicides, empty drug or poison containers may be with the body. Other helpful artefacts include such items as hearing aids, syringes, external pacemakers and inhalers. The clothing must be removed carefully and, especially in criminal or suspicious cases, the pathologist should supervise and assist the mortuary technician, especially as some technicians are not always aware of the importance of clothing in the reconstruction of events.

It is best to remove clothing by pulling over the head and limbs, unless this might interfere with any injuries or stains. If rigor is intense or if there is blood on the face or hands, it may be advisable to cut off some or all of the clothing. This should be done after consultation with the forensic scientists, if they are present, so that the cuts will be made where they will least interfere with later laboratory examination. In any event, cuts should avoid passing through pre-existing damage or staining of the garments. Each item of the clothing should be placed separately into a paper bag.

Identification for autopsy:

Under this heading, word identification is confined to formal recognition of identified body to be autopsied shall be discussed. Identification of unknown dead individuals is different forensic exercise as a whole. Before any dissections is started, it must be ensured by pathologists that the deceased under investigation is the right person who is identified by some responsible individual in his/her compos mentis.

These individuals usually are relatives, friends or family after viewing the face of the deceased. Cases with facial structures beyond recognition, e.g.: crush injury to head, burn injuries and decomposition, is when identification is made by clothing, ornaments or documents carried by victim at the time of death. Such cases can sometimes lead to misidentification and proper care must be given to confirm identity of the person.

Once the identification is confirmed, a tag is to be tied around deceased fingers or toes with a serial number assigned. The confidentiality of the deceased should be respected. In case the autopsy surgeon is not satisfied with identification process, he should never start autopsy and police must be called back to clear the objections put forward.

The pathologist must record in his autopsy report the date, time and particulars of the person identifying the body to him, so that 'continuity of evidence' is ensured for legal purposes, which cannot successfully be challenged by the defense at a subsequent trial.

History-taking and Autopsy:

History taking is an essential part in clinical practice and even more vital in death investigation, but the reliability of case on history should not always be done in medico-legal cases. History in autopsy cases are usually incomplete, translucent and confusing. To make it worse, sometimes one case may present with two or more totally different histories and at times perpetrator might be giving the history favorable on his/her side and also provide misleading information. It is advisable to listen to all, keep all histories in mind at the same time never be biased in your personal opinion based on history provided.

Some pathologists in the past have suggested that the autopsy must be performed blindly without knowledge of history; however, this is controversial as some cases may be diagnosed only after examination of the scene of death. Sometimes, approaching other experts may be the best way of obtaining information. In situations where cause of death could not be established, the pathologist can do no more than enter his most reasoned choice or, with honesty, state that the cause is undetermined.

Precautions regarding potential infective conditions

Many forensic cases require examination of drug abusers and persons with promiscuous sexual behavior, greatly increasing the exposure of autopsy personnel. One school of thought maintains that all autopsies should be carried out with total precautions against all infective risks, as the infective load may not be pre-determined in all cases.

However, this is almost impossible to achieve and also does not help the problem of infected material being sent to other laboratories.

A more commonly practiced protocol is to carry out pre-testing for HIV and hepatitis in all autopsy cases. The results can often be obtained early enough, in a few hours; to assist in determining the level of protection required or even if the autopsy is to be withheld, due to unjustifiable risks.

A positive result should ensure that the autopsy is carried out with precautions, additional protection as well as decreased accessibility to non-essential personnel. In addition, infective material that are sent to laboratories should be labelled as such. Hepatitis is more of a risk than HIV infection. The infective period for corpses infected with HIV is variable, Cao et al. recovered infectious virus from liquid blood held at room temperature for 2 months. Virus in high concentrations have been found to remain viable for as long as 3 weeks. Bankowski et al. found 51 per cent of virus survived in plasma and monocyte from cadavers up to 21 hours after death. Other series found survival in corpses from 18 hours to 11 days after death. Virus has been recovered from the spleen up to 14 days after death. Refrigeration seems to make little difference to viability. Douceron *et al*. (1993) obtained viable virus up to 16 days after death in refrigerated bodies.

Other infections, such as tuberculosis, hepatitis viruses, anthrax, plague, Creutzfeldt–Jakob, etc., pose the major risk to autopsy personnel and any other individuals handling body and body fluids after death.

Appearance of the body after death

Once death occurs, all cells of the body will die and cessation of normal metabolic functions occurs. These changes can be seen biochemically, resulting from autolysis of cells. Finally, these changes can be visible to naked eyes, which a doctor must be able to interpret as to give time since death. The appearance of the body after death reflects changes, but the reliability and accuracy of these changes to estimate post mortem interval is doubtful.

Early Post-Mortem Interval

Immediate changes after death

Following stoppage of heart, lungs and brain, cells use anoxic pathways until their metabolic reserve is exhausted and will slowly begin to die. Loss of brain activity results in absent reflexes hence stopping the breathing process. Corneal reflex ceases and pupil become non-reactive to light. Retinal vessels when viewed under ophthalmoscope will show fragmentation of blood inside retinal vessels; called *trucking* or *shunting* of retinal vessels. Intraocular pressure drops resulting in flaccid eyeball appearance. Absence of blood pressure results in pale conjunctiva, skin and mucous membrane.

In case of asphyxia deaths or congestive conditions, face and lips may discolored red or blue. Rigor mortis in small muscles around hair follicles will result in prominence of hair and beard after death, which is usually misunderstood as growth after death. Loss of muscle tone during the period of primary flaccidity may result in voiding of urinary bladder or emission of semen, which should be considered as artifact rather than ante-mortem phenomenon or otherwise. Regurgitated food particles found in airways should be examined carefully as they may be found in significant number of autopsy. Cause of death should be given as chocking or aspiration only following microscopic examination of peripheral airway terminals.

Rigor mortis

Lack of oxygen following death will result in temperature dependent physiochemical change in muscles. Due to this lack, energy cannot be retrieved from glycogen through glucose using oxidative phosphorylation, which results in cessation of adenosine tri-phosphate (ATP) production. Secondary anoxic process then takes over for some time giving lactic acid as by product. Cell cytoplasm becomes increasingly acidic. Low ATP and high

acidity causes actin and myosin filaments to bind together and form a gel, giving rise to stiffness in muscles. Shortening does not occur unless the muscle is under tension. Hence in conditions where muscles are acidic (heavy exercise, electrocution, epileptic seizures) rigor mortis develops faster. In people with extremes of ages or in emaciation, rigor mortis is hard to detect due to low muscle mass.

Rigor mortis develops uniformly throughout the body but generally detectable in smaller group of muscles like those around eyelids, jaws and finger. It advances down to the body from head to legs as muscles are larger are we move downward in our body. Using this movements time since death is estimated or rather guessed. No accurate PMI can be derived as rigor is influenced by various factors.

Another factors affecting rigor mortis is temperature. Cooler the temperature, process of rigor is delayed. One should have an idea of microenvironment around the body at the scene of death before estimating time since death. Rigor mortis is seen following stage of primary flaccidity, which may last for 1-2 hours after death. It is believed that it takes 12 hours of rigor to be complete, it stays in body for next 12 hours and starts disappearing in head to toe pattern once decomposition is initiated. These numbers are very unreliable since factors like diurnal variation in temperature, body mass, age, clothing, etc. plays vital role in rigor mortis.

It is best to test for rigor across a joint using very gentle pressure from one or two fingers only; the aim is to detect the presence and extent of the stiffness, not to ‘break’ it. If rigor is broken by applying too much force, those muscle groups cannot reliably be tested again.

Cadaveric rigidity

Cadaveric rigidity is stiffness of muscles with immediate onset. This stiffness unlike rigor mortis does not pass through the stage of primary flaccidity, hence occurs immediately after death. Deceased may present with items held tightly in his palms resulting from sudden stiffness of voluntary muscles. It is believed that cadaveric spasm occurs in individuals who are at high level of emotional or physical stress during death. Although the exact mechanism of causation of cadaveric spasm is not known, many hypothesis on neurogenic phenomena have been put forward.

Post-mortem lividity

Following loss of heart function, circulation ceases. In addition, relaxation of muscle tone causes the vascular bed to allow movement of fluid within blood vessels along the line of gravity. These fluids move along blood vessels and settle down at dependent parts of the body, which can be visually manifested as livor mortis, post mortem hypostasis or lividity. Currents occur between warmer and colder areas of the body resulting in redistribution of drugs and chemicals after death. Filling of dependent blood vessels occurs too. The passive settling of red blood cells under the influence of gravity to blood vessels in the lowest areas of the body is of forensic interest. This results in a pink or bluish color to these lowest areas, which is called post-mortem hypostasis or lividity. Hypostasis is not always seen in a body and it may be absent in the young, the old and the clinically anemic or in those who have died from severe hemorrhages. It can be masked in individuals with dark skin colors, jaundice or some dermatological conditions.

Compression of skin in contact with a firm surface can prevents collection of blood in these dependent parts as a result of which partial pallor can be seen within the areas of lividity. This can also be caused by pressure of clothes or any objects in contact with dead body and the condition is known as contact flattening.

Hypostasis can help pathologist get idea about position(s) of body at the time of death. The distribution of the hypostasis must be examined meticulously to understand position at death, as it may sometimes be misleading if the position of the body has been changed after death. A good example is of a dead body being flown in running river. A body suspended during hanging shall develop hypostasis over distal aspect of upper and lower extremity giving feature of ‘gloves and stockings’ whereas body facing downwards shall get face and conjunctiva congested which can sometimes attribute to misleading condition mimicking asphyxia deaths.

In cases where a person is dead for long period of time (usually more than 6-12 hours), blood collected inside the capillaries may clot and hypostasis present would not blanch on applying pressure over adjacent body surface. Whenever any confusion arise in ascertaining whether the discolored area is contusion or hypostasis, one must give a small incision on the surface and pour running water over the cut area. In case the lesion is contusion, the clot would not wash off unlike in hypostasis.

The color of hypostasis and its extent also bears forensic significance. It may be seen as dark red to blue in cases of deaths due to asphyxia. Some indicators of blood color can be drawn in cases of poisoning too. Cherry red hypostasis is an indication of carbon monoxide poisoning, brick red of cyanide poisoning and septic deaths due to Clostridium Perfringes results in bronze hypostasis. Pinkish hypostasis is seen in bodies preserved in cold temperatures and in individuals dying from hypothermia. Hypostasis to appear is so variable that it has no reliable role in determining the time of death.

No decisions on cause of death should be made on assumptions based on color of the hypostasis. All we can derive from hypostasis is whether the body has been moved after death, that too in case where the blood inside the vessels are not fixed and clotted.

Algor mortis

According to Newton's law of cooling, exchange of heat occurs from warmer object to colder objects until both objects between which heat is exchanged are at equilibrium of temperature. Cooling of dead body also follows the same principle but with less uniformity.

Since human body is not a uniform structure, its temperature will not fall evenly. Each body part has its own unique environment due to which there is variation in axillary, oral and rectal temperature in human even when taken at same time. Hence, each body will lie in its own unique environment and each body will cool at a different speed, depending upon the many factors surrounding it. Estimation of time since death based on body temperature shall again be an assumption only.

Factor effecting the cooling of body after death:

- Posture of the body: extended or curled into a fetal position
- Clothing: type of material, position on the body – or lack of it
- Obesity : fat is a good insulator and emaciation :lack of muscle bulk allows a body to cool faster
- Environmental temperature: day, night, winds, rain, humidity, mass of the body, surface area
- Body temperature at the time of death, site of reading of body temperature

Late postmortem changes:

Along with increase in time since death, the body undergoes changes due to autolysis or progressive decomposition.

Decomposition/putrefaction

All living organisms including human beings are reduced from complex chemical composition to a simpler form after death. During this process, every living being becomes a part of food chain or chemical digestion by autolytic enzymes produced by lysosomes present within one's own cell.

Casper's dictum states that if all other factors are equal, then, when there is free access of air, a body decompose twice as fast than if immersed in water and eight times faster than if buried in earth. Temperatures are usually lower on water than those on land. Initial phases of this decomposition process is of forensic significance as its can result causation of artefacts mimicking injuries or pathological lesions/conditions which may be misleading to untrained investigating officers. Due to scavenging by insects, rodents, birds, fishes and predatory animals, various postmortem injuries may be caused in the body which if not properly differentiated can make investigation process go haywire. Liquefaction of soft tissues and adipose, purging, discoloration of skin intro green, brown and black can be wrongly interpreted when examined by untrained eyes.

First visible sign of decomposition is greenish discoloration seen over right iliac region of anterior abdominal wall. Gut bacteria enter and when hemoglobin comes in contact with methane and hydrogen sulphide excreted by bacteria, it gives rise to a complex sulph-meth-hemoglobin. This complex is responsible for producing the greenish hue. Since, caecum lies closest to the anterior abdominal wall; this greenish hue is seen first over right iliac region. Bacteria then enter the blood stream and spread throughout the body, resulting in linear branching patterns of discoloration along the lines of veins called 'marbling of veins'.

This greenish discoloration over time will get generalized throughout the body. At the same time, blisters containing reddish brown fluids will begin to appear at multiple places. The entire body will swell as a result of putrefactive gases produced. Eyeballs will start protruding out and rectal or uterine prolapsed, as a result of pressure built inside the body. Postmortem delivery of dead infant is not uncommon following decomposition of dead body of lade pregnant during life, which must again be understood properly by people working in

crime scene to avoid misleading investigation towards infanticide, death during deliver, sexual abuse and perversions. Face, abdomen, genitals, breast start bloating. Hairs become loose and fall apart. Blood stained frothy fluid will ‘purge’ out from nose and mouth. With advancement in decomposition, tissues will start to liquefy and fall apart. Last tissue to liquefy would be prostrate and uterus due to presence of fibrous tissues likes tendons and ligaments. Finally, skeletonisation occurs in a variable period of time and no one can actually guess how much time one would take to be completely skeletonized. This is because there are so many environmental and biological factors involved in this process, which do not follow exact time formula of minutes, hours, days and months.

Adipocere

Adipocere is a chemical change in the body fat, which is hydrolyzed to a waxy compound not unlike soap. This process is most commonly seen in bodies found in wet conditions (i.e. submerged in water or buried in wet ground) but this is not always the case and some bodies from dry vaults have been found to have adipocere formation.

In the early stages of formation, adipocere is a pale, rancid, greasy semi-fluid material with a most unpleasant smell. As the hydrolysis progresses, the material becomes more brittle and whiter and, when fully formed, adipocere is a grey, firm, waxy compound that maintains the shape of the body. The speed with which adipocere can develop is variable; it would usually be expected to take weeks or months, but it is reported to have occurred in as little as 3 weeks. All three stages of adipocere formation can coexist and they can also be found with areas of mummification and putrefaction if the conditions are correct.

Mummification

Drying or desiccation of dead bodies after death is known as mummification of the dead body. Certain conditions are required for body to undergo the process of mummification. A dead body lying in middle of desert is a good example of condition favorable to undergo this process. Dry conditions with breeze flowing over the body will evaporate the body fluid and transport it to distant places. Mummified bodies are dry and leathery in consistency. The advantage that mummification has over decomposition process is that the external features are preserved to certain amount. Facial recognition can be possible in many cases. Thin individuals usually are more liable to undergo mummification in the above-mentioned environment or microenvironment as their body will cool and desiccate quickly amounting to less water reserve.

Skeletonisation

The process of skeletonisation depends on many factors, including the climatic, biological, anthropological and environmental factors surrounding the body. It occurs rapidly in a body present on the surface of the ground than in buried. Tendons, ligaments, hairs and nails can somehow be identifiable even after skeletonisation has occurred. It is expected that it takes around 5 years for bones to be completely free of soft tissue. Cartilages will decompose into a greasy material covering the articulating surfaces which when sawed would release smoke and smell of brunt organic matters.

Identification from bones are discussed in guidelines made for forensic anthropology. Besides that, examination of the bone marrow space may reveal residual organic material that can sometimes be suitable for DNA analysis. Examination of the cut surface of a long bone under UV light may assist in dating, as there are changes in the pattern of fluorescence over time. Dating bones, as with all post-mortem dating, is fraught with difficulty. Carbon-14 dating is believed to be of no use in this short time-scale, but examination of the bones for levels of strontium-90, which was released into the atmosphere in high levels only after the detonation of the nuclear bombs, may differentiate bones from before and after 1940’s.

External examination

Most important of all is external examination of the dead body as most of the evidence related to death is present above the surfaces that can help in investigation. Proper and meticulous external examination can provide the investigator with baseline information which when corroborated can give bigger picture of the deceased,

Without impatience, a forensic expert must spend quantitative amount of time for careful examination of the body surface applying general principle. Procedural baseline, which can be carried and adjusted depending on types of case, is given as follows:

Following identification of deceased, clothes are examined first. Any stains, contents, tears or cuts must be noted. In case of unidentified bodies, labels and size of the cloth can be recorded for identification purposes. Apparent age of the individual is recorded to be compared with legal documents later. Changes in skin elasticity, discoloring of hair, senile hyperkeratosis, tooth loss, arthritic changes and arcus senilis are some factors that determine age group of an individual.

Built of the patient is accessed by measuring length of the body. The length should be measured in centimeters or inch, from top of the head to heel. Undertakers measure length from head to toe to estimate size of the coffin required, hence it is called undertaker's height. Body weight is measured in kilograms and should never be estimated to assess his/ her nutritional status, leanness, dehydration, edema, emaciation or obesity.

State of cleanliness like personal hygiene is accessed by examining hair and beard lengths, state of nails and presence of fecal or urinary soiling. Parasitic infestations if any should be noted. Any dried stains must be identified and recorded mentioning the location. Skin color should be noted and must not be confused with color change due to hypostasis, congestion or generalized contusions. Any deformities of the physique of the deceased must be noted as well.

For identification purpose, marks of identification like moles, birthmarks, etc. should not be missed. Acquired marks like tattoos, scars, fracture resulting in deformity, circumcision, scars of hesitation cuts over forearms, amputation etc. must be recorded. Any artefacts created on the body due to of therapeutic endeavors must be differentiated and all other signs of treatment must be clarified through documentation.

Vomitus, froth or blood if present at nose, ears or mouth must be recorded and accessed after cleaning to find source. Purging of fluid must be recorded after distinguishing it from bleeding. Vaginal discharge, presence of sanitary pads and tampons must be noted in case of female deceased. Ejaculation of semen after death is a postmortem phenomenon and can be found regularly in variety of cases without any significance. It should not be related to sexual activity before death.

Degree of rigor mortis developed over the body must be accessed by flexing all major joints of hands and legs. Hands should be carefully examined to document injuries like defense wounds or marks of electrocution. Suicide notes held tightly in hands and gone unnoticed at crime scene to be found later during autopsy cannot be ruled out. In case a fist cannot be opened, a cut over flexor tendons of wrist can help open it.

Recording injuries is prime element in forensic cases. The injuries must be carefully examined and conveniently recorded in body diagram. Stage of healing must also be examined and documented. Initially the wound must be identified and further differentiated into abrasions, contusions, lacerations, incised wounds, stab wounds, burns etc. The shape and size of the injury must be noted. Condition of margins, borders, and base should be explained wherever necessary. The injury must then be located with orientation to axis of the body and position it in reference to surface anatomical landmarks. It may be helpful to understand the stage of wound healing by mentioning color of the injury.

In case of burn injuries, which are widespread, 'Rule of Nine' should be applied. Injuries over the head are crucial part of external examination. Due to cushioning effect of scalp hair, especially in females, the injuries like contusions usually tend to hide. It is best to shave the scalp hair and examine the injury. This will provide clear picture of the wound along with margins and depth. Any artefacts created during shaving must be identified to differentiate from ante-mortem injury.

Careful examination of eyes to look for petechial hemorrhages, condition of conjunctiva and sclera is a must. Petechiae should also be sought behind the ears and in the skin of the face, especially around the mouth, chin and forehead. Size of pupil is useful in cases related to poisoning. Any defect like cataract, vitreous hemorrhage etc. in lens should be noted.

Examination of mouth cavity may reveal false teeth, foreign bodies, remnant of ingested drugs, bitten tongue or in case of child abuse injuries to frenulum of lips and gums.

Erosion or corrosion of mucous membrane of oral cavity may be suggestive of recent ingestion of irritants or poisons.

Any bleeding from nose, mouth and ears could be seen in cases of injuries to head. Frothy blood tinged fluid is seen in deaths due to drowning and in pulmonary edema. Leakage of CSF should be accessed in case injury is located in deeper parts of ears and nose.

Finally, external genitalia is examined. Examination of male genitalia is done to access any disease condition or injuries whereas examination of female genitalia is of greater forensic value. Routine examination of the male genitals includes general inspection of the penis, glans and scrotum, with palpation of the testes. Circumcision should be noted. Examination of anus can reveal injuries in case of sodomized victim and confuse the examiner equally owing to flaccidity of anal sphincter after death. One should not come to a diagnosis of sexual abuse without other corroborative evidence such as fresh mucosal tears (rule out sever constipation) or swabs positive for semen.

Examination of the vulva and vagina is made should be done regularly to exclude sexual interference or any diseased condition. A detailed examination is carried out in case of death following sexual abuse.

Internal examination

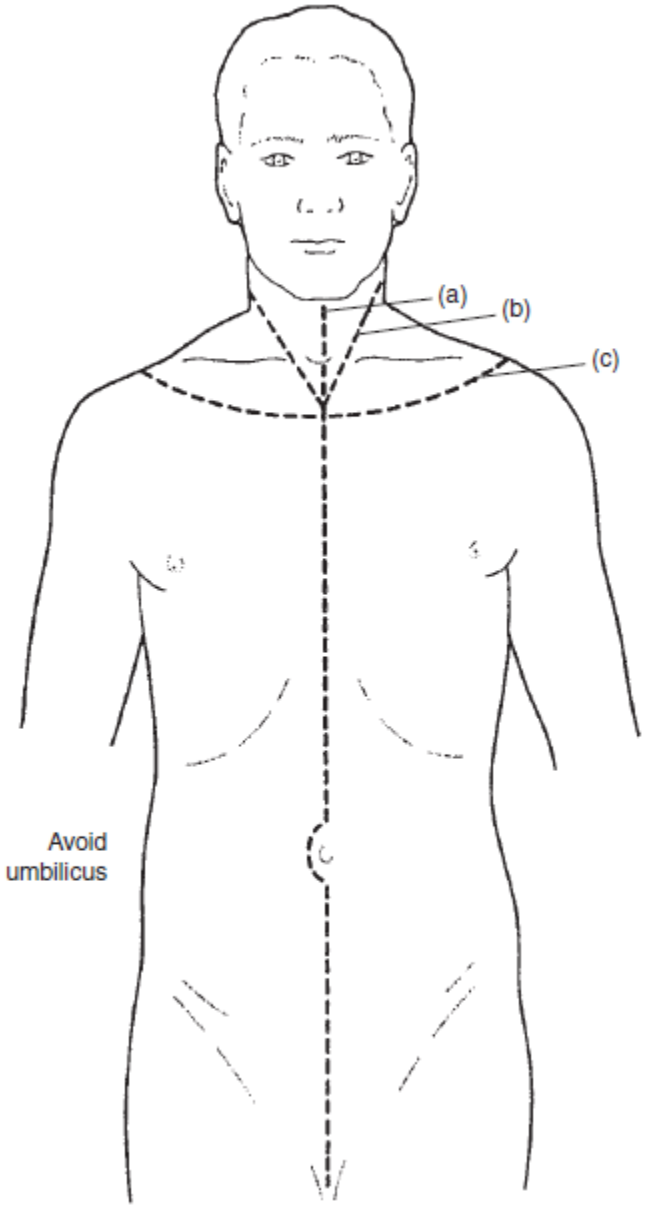
Removal of internal organs:

Following external examination, the person involved in examining the dead body must make sure all the safety measures are followed including use of PPEs. All the instruments must be sharp and uncontaminated.

A primary shallow incision is initiated at base of the chin along anterior midline. The scalpel is then cruised over the neck making sure the depth is not more, in which case, there might be injuries to underlying neck structure. The incision is then continued over the thorax where sternum prevents injuries to underlying structures, but extra case must be taken while one passes scalpel along the abdomen.

Only a light cut should be made, just sufficient to cut through skin and adipose layer exposing parietal peritoneum. A small puncture is made in the peritoneum and forefinger and middle finger of one hand is inserted through the hole to lift it. A scissor or knife is inserted and cut along anterior midline, guided by inserted fingers. This procedure can prevent puncturing the intestines and causing artefacts, fluid leakage and bad odor.

Incision given to access skull is called coronal incision and it extends from above one mastoid to another passing through top of the head. It is better to keep the incision posteriorly to make stitching less visible, where hair is abundant. Hair should be wet, combed and parted, to avoid severing, and following stitching, can be combed back to hide the stitch marks. Umbilical area must be spared while making initial incision over the abdomen, for cosmetic purpose as it becomes difficult to stitch later in which case there are chances of leakage of materials through it.



Incisions – a) Midline 'I' b) Modified 'Y' (Bloodless dissection of neck) c) 'Y' – sub-clavicular

Body cavities:

To expose body cavities, there are two ways of proceeding. Firstly, once the initial incision is given from base of chin to symphysis pubis, the skin and fat layers can be strapped off exposing the underlying muscles. The origin of each muscle is then given a cut on its lateral end and reflected medially. Another way is to reflect skin, adipose and muscle all together, laterally exposing the underlying rib cage and abdominal cavity.

Removing the neck structures:

To remove the neck structures, a 10-12 cm high wooden/metallic block is placed under shoulders of cadaver, which allows head to fall back, extending the neck. A stout knife is passed under skin of upper neck until floor of mouth is reached. This knife is then run around inside of mandible and tongue is freed. Tissues at back and sides of pharynx are then divided and cut is given through tonsillar area. Tongue is grasped by fingers passed behind mental symphysis and drawn down. Remaining laryngeal tissues are divided laterally freeing the neck structures and carotids. In case of any suspicious injuries to the neck structures, it should be removed in the end following removal of organs from all three body cavities, viz. abdominal, thoracic and cranial cavities.

Thoracic cavity:

Articulating surfaces of sternoclavicular joints can be located by moving shoulder tip on either side. Once they are located, a cartilage knife is introduced vertically and laterally to disarticulate the joints. In elderly, the joint might be ankylosed where handsaw and shears might be helpful. Once the joints are separated, a stout knife is penetrated through second intercostal space and dragged downwards along para sternal line, medial to costo-chondral junction till diaphragm is reached. The sternum and medial rib segments are free now. This section is lifted and dissected away from the mediastinum, keeping the knife close to the bone to avoid puncturing the pericardium. The degree of inflation of the lungs should is assessed at this point to note for any asymmetry of inflation and complete or partial collapse, emphysema, over distension.

In case pneumothorax is suspected, the chest wall can be punctured following collection of water between fold of reflected tissues and chest wall along mid axillary line to note for presence of bubbles to confirm the presence. Marked tension pneumothorax would release hiss of escaping air when tip of knife penetrates parietal pleura. Both these findings would be negative in case there is a patent communication between parietal pleura and bronchioles.

If pleural adhesion is present, careful removal with help of curved scissors can be helpful in evisceration process. Any effusions or collection of blood should be noted mentioning their color, amount and smell if any by inserting a sponge, soaking it and removal squeezing it in a measurable vessel. Utter care must be applied in cases where ribs fracture may have occurred, as the fractured piece of rib may act as a sharp pointed object.

Abdominal cavity, pelvic cavity and their removal en-masse:

Now that the chest organs are free, diaphragm is incised. Non-operating hand should pull liver and spleen medially, stretching the left leaf of the diaphragm, while curved scissors are used to cut towards the costal margins, posteriorly under the organ then through cruciate ligaments and caudally behind the kidney. The cut then curves up over the psoas muscles, ending at pelvic brim. Same procedure is done on the opposite side by shifting the position of dissector to opposite side of the table. The chest organs along with neck structures are then lifted and gently pulled forward towards the feet of the deceased. If any resistance is offered by the block being removed, careful cutting of cruciate ligaments must be re-done. Iliac vessels and ureters are last to cut through and the whole mass of viscera is then taken away to dissection bench where cleaning under running water is available.

Inspection of abdominal cavity for ascites, fecal fluid, pus or blood is done. Loops of bowel are inspected for anomalies like infarction, perforation and distension. Infarction must be distinguished from hypostasis. Posterior part of bowel is examined for retroperitoneal hemorrhage due to ruptured aorta or aneurysms.

The testes are pushed upward through inguinal canal widened by blunt dissection. Ovaries in females are incised and tubes are examined. Uterus is sliced along midline from fundus to cervix and any mass or product of conception, if doubtful, must be subjected to histopathological analysis.

In women, the ovaries and tubes are mobilized forwards and the knife passed around the wall of the pelvic bowl, then in front of and below the bladder. In cases where sexual assault or abortion is suspected, a special technique is required.

Body fluid samples:

Blood and other fluids are necessary for analysis in toxicological, biochemical, microbiological and serological investigation. It is not advisable to use residual blood collected in cavities for analysis and considerable care must be applied in sampling. Although heart blood was considered ideal for analysis, now the modern concept suggests that peripheral blood from femoral or subclavian veins must be collected, best before autopsy is started.

Aspirating 20ml of blood by puncturing femoral veins by a needle or syringe before dissection is the method of choice, especially if only external examination is to be performed.

Subclavian or external iliac veins can be used in case the body has been eviscerated. Similarly, if large amount of blood is needed for analysis, a cut across iliac veins at brim of pelvis and holding container into the pelvis can accumulate significant amount before evisceration is performed.

Other option is internal jugular vein which when cut copious amount of blood can be obtained and collection is easily done in a container held by hand. When the skin is dissected off the neck, the internal jugular vein is exposed, especially if a sternomastoid muscle is divided and pulled aside. When cut, a copious flow of blood is usually obtained, that can be collected directly into a container.

Urine is collected by catheter before autopsy or suprapubic puncture with a syringe and long needle during autopsy. It is obtained after the abdomen is opened, but before the organs are removed. Extra care should be taken not to contaminate the urine with blood.

Vitreous humor can be aspirated with a hypodermic needle attached to a 5 ml syringe. It is inserted into the outer canthus of the eyeball after pulling the eyelid aside so that when released it covers the puncture mark.

The needle must be directed towards the center of the globe to avoid aspirating material and both eyes should be used, as they often differ somewhat in their chemical composition. Collapsed eyeball following removal of vitreous, it is be re-inflated with water with aim to improve the cosmetic appearance.

Cerebrospinal fluid may be obtained by passing a needle into the theca between the lumbar spines. An alternate to this is by performing a cisterna puncture through the atlanto-occipital membrane. Any attempt to obtain clear cerebrospinal fluid from the interior of the skull after removal of the brain is not recommended owing to false positive results it may provide.

Removal of the brain:

Scalp is incised along coronal plane from one point behind any of the two ears to correspond other side. Underlying deep scalp tissues are peeled off by traction assisted by freeing with help of knife. In cases where injury to head is present, scalp must be reflected to nape of the neck. Face is peeled back from jawline or downwards from forehead without perforating it to examine facial injuries. It is not practiced that often owing to restoration hassles and cosmetic flaws.

On exposure of skull vault, hand or electric saw is used to cut through outer table of skull angled on both sides from forehead and occipito-parietal area. Careful sawing is necessary to avoid artefacts mimicking head injuries. A chisel and hammer can be used to remove skullcap ensuring intact dura mater.

The dura mater is then cut circumferentially. Falx Cerebri is separated with help of blunt ends scissors passing between the Falx and cutting at the extreme of depth possible. Frontal region of the brain is reflected carefully, and cranial nerves, optic chiasma and pituitary stalk are separated with help of scalpel. Each side of Tentorium Cerebri is cut along the line of petrous part of temporal bone to lateral wall of skull. Scalpel can be used further to foramen magnum and transect the spinal cord at a furthermost reachable point.

By gently sliding the hand below the brain, it is rotated backwards for removal removing any adhered dura still attached. Floor of the skull is now examined after stripping the dura with strong forceps to reveal basal fractures, if present. Petrous part of temporal bone can be sawed to look for any hemorrhages in middle ear.

With a chisel and hammer, dorsum sellae is fractured along its upper anterior surface. Diaphragm of the Sella can be grasped with forceps and scissors used to cut around its margins. Upward traction raises the pituitary gland from its fossa, allowing a scalpel or fine scissors to transect the inferior connections for removal.

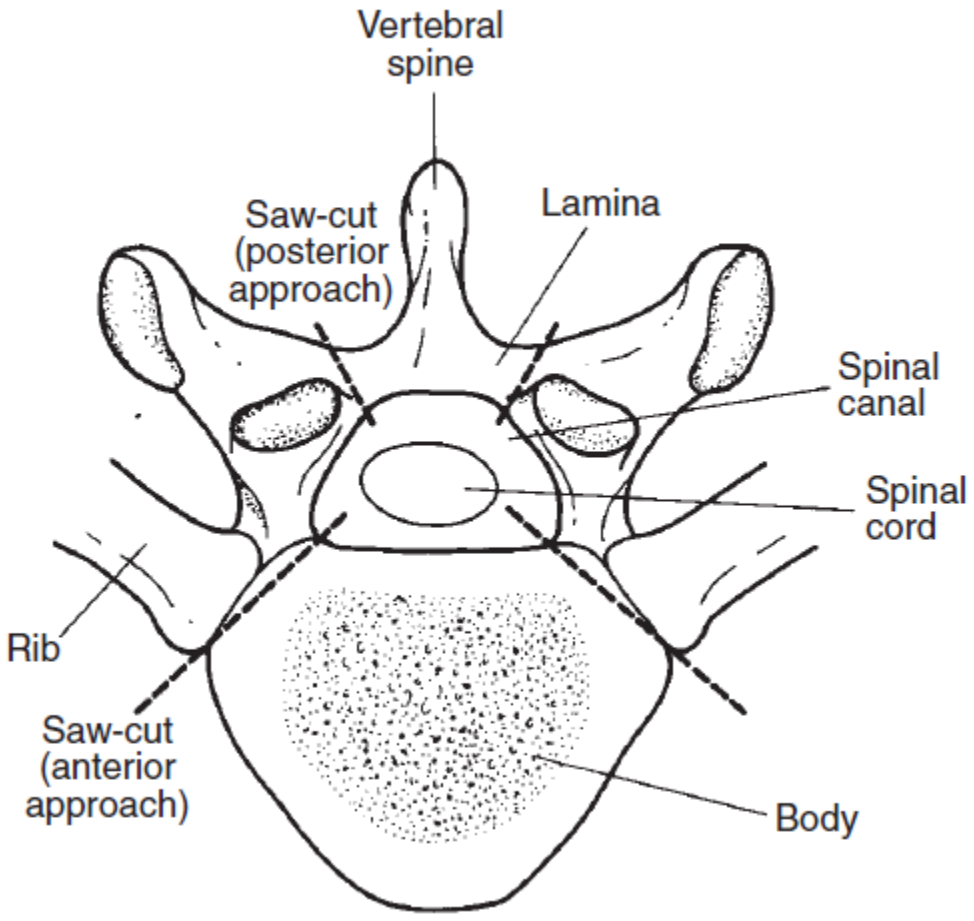
Removal/examination of spinal cord:

Examination of spinal cord is not indicated unless injuries or anomalies exists. In conditions where damage to vertebral column is suspected, one should never hesitate in examining the spinal cord. Two approaches are used to access spinal canal – anterior approach and posterior approach.

Most widely used is the posterior approach. A midline incision from occiput to lumbar region is given. Para-spinal muscles are reflected with underlying sub-cutaneous tissue. Parallel saw cuts are made with oscillating saw down the length of the spine, dividing right and left laminae and giving access to spinal canal. Caution must be applied not to cut deep as spinal dura may be perforated. The cuts must be as laterally placed as possible, to allow cord to be removed with ease.

In anterior approach, the vertebral bodies are removed by sawing through pedicles laterally. Heads of the ribs usually makes this procedure difficult and rarely used one. The only advantage is that the body need not be turned over and invasion is minimal.

Once the canal is exposed by either approach, dura is examined for any anomalies or infections. Nerve roots are then detached from dural attachments and dura is carefully opened with foreceps and scissors to examine the cord. It is then peeled out from the canal, below to upwards. It is examined following formalin fixation before cutting and samples taken for histopathology. Following removal of cord, the canal is examined for any protrusion of disc, fracture or dislocation.



Cut lines on the vertebra to expose spinal column

Examination and dissection of individual organs

Examination of viscera:

The thoracic and abdominal viscera should be laid at proper height, under good illumination, in such a way that the tongue faces the pathologist and the aorta upwards. The same sequence of examination should be carried out in all variety of the case, which if done routinely nothing is missed.

Neck:

Tongue is examined for any injuries, congestion or diseases. Slicing of tongue may reveal deep-seated hemorrhages occurring usually in cases like hanging, chocking and strangulations. In case of suspected chocking, glottis is examined. Hyoid bones and thyroid cartilage should be palpated to check for any fractures, usually the horns and cornua.

Esophagus is opened with blunt end scissors to avoid artifact over mucosa of esophagus until cardiac sphincter is reached. Any foreign object found must be recorded for future analysis. Thyroid must be sliced and examined. Scissors are then entered through larynx into the trachea up to the carina. Any objects found here must be correlated with possible chocking. Regurgitation phenomena following death must be kept in mind and surrounding contusions must be noted if present in lumen of trachea.

Examination of lungs:

Any adhesions noted during removal of lungs must be corroborated with surface patches, emphysema and petechiae. Lungs are separated at hilum with the help of brain knife. During this procedure, if any visible embolism is present needs to be retrieved for analysis. To demonstrate saddle embolus, some pathologists advice to open the pulmonary trunk and right ventricle before removing the lungs.

The lungs are then weighed before cutting. Both lungs are placed with hilum facing dissection table. Upper surface is held by non-operating hand and is cut along sagittal plane from apex to base with brain knife held parallel to the board. This cut surfaces can be opened like a book and examined for any tumor, masses, infarction, pneumonic changes, trauma, etc. Small bronchioles must be assessed for thickening and blockage. Small pulmonary vessels must be examined for embolus and thrombus.

Examination of heart and great vessels:

The heart is placed in such a way that the lower end now faces the pathologist. Scissors are used to cut apart aorta from heart at the level or aortic arch outside the reflection of pericardium. The inferior vena cava is opened from its lower end into the liver. The pericardium is inspected externally for patches of adhesions, collection of fluid and blood tamponade and opened with scissors. The delivered heart is then inspected externally for pericarditis, adhesions, infarct or aneurysms. In infants, thymus must be examined by slicing it. The general size of the heart must be noted, but it is weighed only after all the clots are removed following completion of dissection. Valve patency is checked and inspected.

Inflow outflow technique of dissection is the convenient and widely used technique for dissection of heart. A blunt end scissor or stout knife is passed through right atrium into right ventricle and drawn out laterally to expose right upper and lower chambers. The whole of the right side of heart is now open and displayed. It should be washed out and the endocardium and valve examined.

A similar procedure is repeated on left side of the heart but fingers are introduced down through the mitral valve to estimate its size and detect any stenosis before dissection on this side begins. The whole heart is now exposed and washed to be weighed. After weighing, the endocardium and valves are examined.

Coronary ostia are examined and from left coronary trunk are cut serially at the gap of 3mm, followed by cuts over left circumflex and the right coronary. It must be continued until the lumens of the coronaries are no longer visible.

In case there is a gritty feeling during cut section, it must be understood that the vessel is calcified. Once the coronary arteries have been examined, the myocardium is given a ‘sandwich’ cut through the thickness of the left ventricle. Before this, thickness of both ventricles should be measured. Any area of discoloration or fibrosis in this wall must be sectioned and subjected for histopathological analysis.

Examination of the abdominal organs:

Dissection up to cardiac sphincter has been discussed above. Stomach is now ligated at its pyloric sphincter with a help of twine and entire block is separated from intestines. It is then placed in a container to be weighed. The content of stomach, color and its odor must be recorded. Greater curvature is opened with the help of scissors and contents allowed to pour into a container, which can later be discarded or analyzed, based on its significance.

Gall bladder is palpated for its patency and content and bile can be collected for analysis of drugs like opium derivatives. Adrenals are separated and examined. If kidney is lifted against weight of liver, adrenals can be located between liver and kidney. The pancreas lies under the stomach and should be cut lengthwise, from the curve of the duodenum to its tail, lying against the splenic hilum. The kidneys are exposed by incising their capsules. The kidneys can usually be peeled out of their capsules unless they are adherent. It is not usual to open the whole length of the intestines during autopsy unless indicated.

Examination of the brain:

After removal of the brain, it is weighed first. It is then up to the forensic examiner whether to examine it immediately or following fixation of the brain. In cases of neurological significance, it is always advisable to fix the brain in formalin and dissect it several weeks later. Advantage fixation has over normal brain is that the consistency becomes more firm hence thinner sections can be made for naked eye as well as histopathological examination.

Majority of the cases however need no fixation, if the lesions are apparently visible on external examination. In case where brain is softened due to ischemia or infarction, it is advisable to fix the brain. While dissecting the wet brain if the examiner thinks the brain needs to be fixed, it is suggested to immediately stop the dissection and submerge the slices and remaining brain in formalin buffer. Subarachnoid hemorrhage if present should be recorded and then fixed.

Be it wet or fixed dissection, the procedure for examination of brain remains the same. Surface examination for symmetry of cerebrum and/or any contusions or herniation is the first thing examiner should do. Hippocampal herniation from tentorial aperture, flattening of gyri and filling of sulci is suggestive of cerebral edema. Uncal herniation can be differentiated as discolored lesion due to infarction. However, cerebral tonsil coning through foramen magnum can be confused with anatomical pouting. Discoloration due to infarction can be helpful in such cases to identify cerebral tonsil herniation. Meningeal examination to look for sub arachnoid, sub-dural or extra-dural hemorrhage is an important lesion not to be missed. Cerebral blood vessels like circle or Willis is examined to seek for any aneurysms. Fluctuant masses under cerebral cortex can be palpated to examine internal hemorrhages, cystic tumors and abscesses.

Initial cut is made through peduncles of cerebrum by brain knife, which separates cerebrum from cerebellum and brain stem. Cerebellum is then examined for substantia nigra

and aqueduct. Cerebellum are cut vertically to display fourth ventricle and dentate. Pons and medulla are sectioned transversely. Along the coronal plane, cerebral hemispheres are cut in serial sections each measuring about 1 cm thick in a single sweep.

How to fix the brain in formalin?

Ten percent buffered 5 to 8 liters formalin is taken in a wide mouth container to allow the brain to be submerged completely. Brain is removed leaving falx and parasagittal bridging veins intact. The brain is then suspended from the falx, in upright position.

Alternative method:

A thread of metallic clip is used to hold basilar artery and tie to support across mouth of container leaving vertex clear from the bottom. It must be understood that weight of the brain increases by up to 8 % after fixation in formalin.

Types of postmortem examination

There are various methods that can be implemented for systemic dissection. These methods vary with dissection sequences and procedures but the aim remains the same. The forensic examiner can adapt to any of the procedures described below as per requirement of the case and diagnosis of the disease.

Until date, many techniques have been developed for postmortem examination. Most common ones include Virchow, Ghon, Letulle and Rokitansky procedure. However, Rokitansky procedure characterizing in situ dissection without removal of any organs to exterior have failed to convince medical examiners over time and is less routinely done.

Virchow method is used by examiners when removal of organ one by one is desired. Disadvantage of this method is that a clear picture of inter-organ relationship is lost. For example removal of kidneys alone and examining it may not be helpful to understand pathology involving ureters and bladder. Ghon method removes thoracic, abdominal and genitourinary organs in block whereas Letulle's method removes all the organs from tongue to rectum in a single mass (en-masse).

As an examiner, one should be prepared to modify any standard autopsy technique to best demonstrate the pathologic changes and important pathologic relationships. Regardless of the method of dissection, well-maintained instruments can make the work less tedious. A list of instruments useful in postmortem procedures is presented in the box (next page).

Instruments and equipment useful for postmortem examinations

- Organ knife 10 inches or 15 inches
- Scalpel knife holder and no. 22 disposable blades
- Forceps, teeth, 10 inches
- Forceps, teeth, 6 inches
- Forceps, serrated tips, 6 inches
- Forceps, Adson, teeth
- Forceps, Adson, serrated tips
- Forceps, straight and curved, 8 inches
- Mosquito forceps, straight and curved, 5 inches
- Scissors, , straight, 9 inches
- Scissors, curved, 9 inches
- Scissors, straight round point 5.5 inches
- Scissors, curved round point 5.5 inches
- Enterotome (intestinal) scissors, 8 inches
- Wire cutters
- Rib shears
- Probe, 1 mm thickness
- Postmortem hammer
- Millet and chisel
- Self-oscillating (Stryker) saw
- Small ruler
- Meter stick
- Plastic-coated measuring tape
- Postmortem needles

Letulle method

Removal of Organs

After the initial examination of organs and cavities, abdominal contents are removed. Carotid arteries are identified. Scissors or scalpel is used to transect laryngeal pharynx above the level of epiglottis through thyro-hyoid membrane. Esophagus is transected as well. Larynx is reflected inferiorly and carotids are cut. Removal of tongue is done by cutting posterior of rami of hyoid bone and through neck oral cavity is reached and tongue is grasped. Tip of the tongue is flipped posteriorly into the neck and anterior attachments are cut free. Pleural and connective tissue is freed from any adhesions. Right and left leaves of diaphragm are cut along their lateral and posterior surfaces and the cut is extended through psoas muscle excluding vertebral column.

For pelvic region, bladder and prostrate are separated from pelvic wall by retracting them with non-operating hand. Rectum is separated from coccyx by extending the plane of dissection posteriorly and transected at the level of proximal urethra. Rectum is cut less than 2cm above the anorectal junction. Pelvic organ is now reflected upwards and outwards exposing the iliac vessels bilaterally. Connective tissue attachments are now removed and organ block is removed.

Neck is lifted and thoracic organs are reflected detaching the posterior attachments and adhesions if any. Apply inferior and upwards traction cutting any attachments like diaphragmatic and abdominal wall.

Examination of body cavities:

Following removal of thoracic and abdominal mass, body cavities and walls are inspected for the last time. Testes are removed by entering the scrotal sac from inguinal canal which is previously enlarged by blunt dissection. Pushing and lifting the tested and spermatic cord upwards towards pelvic brim and cut testes free.

Separation of individual organs:

Once the organs are removed, they are placed on a dissecting board. Inferior venacava is opened at the level of diaphragm, sparing right renal artery. From distal aortic arch, descending aorta is reached to examine the intimal surface. Any atheromatous plaques or aneurysms encountered must be recorded. Esophagus is opened next along its posterior

aspect and examined to seek for any fistulas, variceal bleeding points or mucosal and sub mucosal variances. On exposing the bed of adrenals below hemi-diaphragm, glands are palpated to identify adrenals. Dissect away the supra-renal fat above superior pole of kidneys. Adrenals are then removed carefully and weighed. Right adrenal is pyramidal in shape and left is semi-lunar. Neck and thoracic organs are now separated from abdominal block by cutting between inferior aspect of pericardium and superior surface of diaphragm.

Neck and Thoracic Organs Examination:

Transect the lungs at the level of carina of both bronchii near the hilum. Weigh lungs and inspect the surface. Pulmonary parenchyma is palpated to look for any mass or areas of consolidation as seen in cases of chronic lung diseases like pneumonia, tuberculosis, etc.

Many pathologists examine the lungs fresh although fixation can be done. The method of McCulloch and Rutty is best for examination of fresh lungs. For slicing lungs, a sharp long knife is essential. After slicing the lungs longitudinally, lung parenchyma is examined for consolidation and scarring. Large airways and blood vessels are examined for presence of thrombi or emboli.

Heart

After careful removal of pericardium, the surface of the heart is examined, with the coronaries cut in cross sections at 2-3mm interval. Heart is slices at 1cm interval in short axis at apex and continued until the inferior margin of atrio-ventricular groove. The remaining portions of atrium and ventricular chambers are opened. Presence of any artificial valves should be recorded. Heart is weighed after removal of vessels and postmortem clots.

Examination of Abdominal Organs

Stomach and Intestines

Anterior aspect of organ block is exposed to dissect diaphragm away from esophagus and liver. Omental fat is removed from greater curvature of stomach and with a use of Enterotome stomach is opened along its greater curvature from pylorus to cardiac sphincter. The cut is continued through duodenum to expose ampulla of Vater and duodenal mucosa. It is advisable to leave the head of the pancreas intact.

Pancreas

Remove adherent fat surrounding pancreas and weigh it. Serial transverse sections are made along it long axis to examine pancreatic parenchyma. Several cut sections are made through head of pancreas allowing examination of pancreatic parenchyma and Wirsung and Santorini ducts.

Liver and biliary tree

On rotating the liver posteriorly, the inferior surface can be accessed. Mild compression on gall bladder will extrude bile from ampulla. Through common bile duct, with a help of fine scissors, retrograde opening into hepatic duct, cystic duct and gallbladder can be made. Another way is to open the gall bladder and extend incision through the duct. Any calculi retrieved should be collected for biochemical analysis.

Removal of adherent diaphragm and lesser omentum can give clear picture of liver surface. It must be weighed before dissection. It can be cut in parasagittal, coronal and horizontal planes to examine the underlying consistency and fatty changes.

Spleen

Remove the spleen at its hilum, inspect its capsular surface, and weigh it. Many pathologists make multiple slices of the spleen along its short axis. We prefer to make sections along the long axis of the spleen either parallel or perpendicular to the plane of hilum. With any method, make sufficient sections to inspect the parenchyma fully. Note whether the follicles are visible, and examine the condition of connective tissue trabeculae.

Examination of the Genitourinary Organs

Identification of ureters is done by inspecting them running along each side of midline through fat and fascia. Average luminal circumference is measured and opened along its long axis to look for any abnormality until bladder is reached.

Kidneys are removed by blunt dissection around renal capsule and perinephric fat. Weigh the kidneys after removing adherent perinephric fat. A longitudinal section is then cut along the lateral plane of both kidneys, which exposes pelvis, calyces and cortico-medullary junction. Collect calculi if present. Strip off the capsule and examine the surface of cortex for any lesions.

Examination of Testis

Right testes can be differentiated from left by viewing lateral aspects of both. Any attached spermatic cord is detached by cutting through it. Testes are weighed and cut along the sagittal plane to examine the parenchyma. Pull the portion of cut surface to seminiferous tubules, which if they do not strip off in post-pubertal males is indication of testicular atrophy.

Examination of female genitor-urinary tract:

In females, the procedure is slightly different, owing to anatomical variation in both sexes. Rectum is opened through posterior midline and removed from pelvic region. Scissors are introduced into urethra and opened along its long axis until bladder is reached. Bladder is separated from its attachments. Fallopian tubes and ovaries are examined and dimension of ovaries are measured. Fallopian tubes are opened longitudinally and serial cross sections are made. Ovaries are cut lengthwise exposing parenchyma for inspection. Proximal vaginal canal is opened along its lateral surfaces to note epithelial surface. Cervix is examined and width of os is measured. Uterus is opened along its lateral aspect to measure dimension of cavity and thickness of endometrium.

Examination of male and female genitalia:

Genitalia are not always removed as a part of routine examination. In special circumstances like sexual assault or gross pathology in this region, extensive dissection is required. Abdominal incision is extended to the base of penis. Mid portion of pubic arch is removed with help of saw and entire genital block is removed along with bladder, prostrate and rectum. In females, the abdominal incision is extended up to labia majora. Pubic arch is removed with saw and elliptical incision id made around external genitalia and anus and the block containing vagina, uterus, bladder and rectum is removed in a single block for examination.

Individual organ removal (the Virchow Method)

In this procedure, the individual organs are removed sequentially and dissected immediately after removal. This technique is effective for normal or diffusely diseased organs but has disadvantages, as relationships between organs are lost due destructive nature of structure during evisceration. This method has been developed over the years to avoid adverse situations to attend details while inspecting organs in situ. The procedure begins with examination through the peritoneal, pleural, and then pericardial cavities, which are cut, opened and inspected, with the organs separated and removed from those areas.

First, the abdominal wall is inspected, and then the cavity and finally the fluid is removed, measured and documented. The abdominal organs are inspected and palpated before being dissected from its anatomical position. It is suggested that gastrointestinal tract starting from appendix is inspected first, along with mesenteric lymph nodes. Next spleen, liver, kidneys and finally pelvic organs are examined. The pancreas can be examined by separating attachment of greater omentum between stomach and transverse colon.

The thoracic cavity is examined after removing the sternal plate. At first, the pleural cavities are inspected thoroughly and any collection, if present, measured. If chest wall is adherent with fibrous band it should be documented before being separated by blunt dissection.

The anterior mediastinal soft tissue is examined next. In adults, thymus is atrophic and any gross pathological changes needs to be documented. Pericardium is inspected before being cut open. Any collection of fluid, blood or clots from the pericardial sac is collected and measured.

Thoracic Organs:

After examination of all cavities and collection of blood for further investigation, as required, the heart is removed by lifting the apex and severing from attached large vessels namely, inferior vena cava, superior vena cava, pulmonary veins, pulmonary arteries and finally aorta. The heart is freed for further detail examination.

If pulmonary thromboembolism is suspected, the pulmonary artery should be dissected initially, by cutting with scissors just above the origin from right ventricle.

Next, the lungs are freed from hilar attachments by lifting forward and outward, out of pleural cavity, holding the root by the non-cutting hand and cut is made through primary bronchus, vessels and pleura.

Neck Organs:

Neck structure can be dissected in situ or can be removed similar to en-bloc evisceration. The soft tissue over the neck attachments are dissected and freed from the lateral and posterior aspects of the upper esophagus and trachea. During in situ dissection, the posterior wall of the pharynx is dissected, next to the uvula, to examine pharynx. The tonsils are incised and esophagus is cut open from the posterior wall of trachea to inspect mucosal surface of trachea as well as esophagus. The Thyroid gland can be dissected by giving longitudinal incisions over the lateral aspects of thyroid gland.

Abdominal Organs:

Before dissection of individual organs from abdominal cavity, all organs are inspected in situ, removed and all collections measured. Presence of diffuse adhesions of peritoneal structures makes it better to eviscerate en-bloc.

The order of removal of abdominal organs depends on the pathological condition and preference of dissector. It is more convenient to remove normal organ first and leave pathological organs, which may require careful dissection. As a routine, spleen is removed first, and then followed by gastrointestinal tract, liver, pancreas, kidneys and adrenal glands with ureters. Finally, the aorta is dissected in situ.

Spleen is removed by gentle manipulation to avoid tearing of its capsule. It is lifted from the abdominal cavity and cut from its hilar structures. The gastrointestinal tract is inspected from the stomach to the rectum, including the mesentery and lymph node. The gastro-intestinal tract should be dissected after complete separation from abdominal cavity and cut open in a sink. First, the duodenum is mobilized around second to third part and cut with scissors. The flow of bile through Ampulla of Vater is assessed by squeezing the gall bladder. Once the free flow of bile has been established, gastrointestinal tract starting from sigmoid colon is removed. The colon is pulled forward so that the mesocolon can be released from its attachment. The sigmoid colon is then pulled medially and mesentery incised. This incision is extended inferiorly as far as possible to reach the rectum before moving proximal. Care must be taken at splenic flexure if the spleen has not been removed. The transverse

colon is detached from the stomach by tearing its attachment to the hepatic flexure, ascending colon, caecum and around the appendix. From Terminal ileum, a cut is made through the mesentery, close to the small bowel and extended proximally to reach the duodenum. Once the entire intestinal tract has been freed, the rectum is released by cutting as low as possible, after massaging all of the intestinal contents back into the sigmoid.

To remove the liver, hepatic hilar structures are divided, by stretching the hepatoduodenal ligament. The hepatic artery, followed by the common bile duct and portal vein are cut. The distal portion of esophagus is ligated to prevent spillage of stomach contents, and transected to mobilize the liver.

Next, the liver is pushed forward by passing the left hand between the right lobe of the liver and the diaphragm. The liver is grasped by placing the thumb under the lower anterior border and insert the remaining fingers into the long incision for grip. The liver is lifted and released after cutting hepatoduodenal ligament. Hepatogastric ligament, inferior vena cava, falciform ligament, coronary ligaments, soft tissue between the liver and right kidney, avoiding any damages to adrenal glands. Liver is removed from the abdominal cavity and dissected on a cutting board.

The pancreas is dissected from its attachment by lifting the stomach and cutting all the soft tissue around the pancreas. Stomach along with a portion of duodenum is removed by cutting proximal to the ligation over the esophagus.

Now only the genitourinary tract and large abdominal vessels are left in the abdominal cavity. The kidneys and adrenal glands are removed together or separately. The thoracic aorta is cut in situ, along its ventral surface into the iliac arteries. Renal arteries are cut open on both sides from the aorta.

Kidneys and adrenal glands are located by palpation, then with use of forceps and scissors adrenal gland is separated from the upper pole of kidney. Peri-renal fat is removed from by blunt dissection. Then the kidneys are lifted anteriorly to expose the ureters, which are cut along their course to the bladder.

The Virchow (individual organ) technique is summarized as

- Inspect the abdominal and pleural cavities.
- Open the pericardium and remove the heart. Remove the left and then the right lungs. Assess the pharynx, esophagus, trachea, parathyroid glands, and thyroid gland.

- Remove the spleen. Assess biliary tract patency. Remove the intestines. Open the stomach. Remove the liver. Remove the pancreas. Shell out the left and right kidneys and adrenal glands. Trace the ureters.
- Dissect the pelvic structures.
- Inspect and open the large arteries and veins.

Special circumstances

Detection of air emboli

Death as result of intravenous infusions, childbirth, operative procedures, or any instrumental injuries to the chest and neck should be examined for presence of air embolism over the heart. The most effective method of demonstrating air embolism is to take X-ray of chest before evisceration. Air embolism in heart and great vessels can also be demonstrated in old conservative methods where radiographic facilities are limited.

The large neck veins are left intact before the heart is dissected in situ, to avoid confusion with air introduced during evisceration. After removal of sternal plate, the anterior aspect of pericardium is incised longitudinally and cut ends held with forceps. Any bulging of right atrium and ventricle and air bubbles in epicardial veins should be recorded. Then water is pour into the pericardial space to completely fill it. Once it is covered with water completely, an incision is given over right atrium and right ventricle and closely observe for any air bubbles that escape. Finally, large bore needle with syringe is filled with water and introduced through the incision over the right ventricle and syringe chamber is inspected for presence of air bubbles. If air bubbles are seen then the inferior vena cava is clamped and abdominal cavity is filled with water, attempt to localize the source of the embolism if possible.

This whole procedure is only reliable if the postmortem examination is performed immediately after death of the person. As the time of death advances, the chance of gaseous collection within the cardiac chamber due to bacterial decomposition increases dramatically.

Detection of pneumothorax

Pneumothorax is the most overlooked condition during autopsy procedures. It can occur due to traumatic chest injuries or be spontaneous, as result of rupture of emphysematous bullae. Pneumothorax can be demonstrated by taking simple plain X-ray. Alternatively, it can be demonstrated during autopsy examination before evisceration.

The skin and subcutaneous tissue are first reflected from the chest wall taking precaution not to puncture the intercostal soft tissue and penetrate the pleural space. When skin is completely reflected to the level of mid-axillary line, water is poured into the angle between subcutaneous tissue and chest wall. Intercostal tissue below the water line are punctured with the tip of a blade. If pneumothorax was present, air bubbles will be released from the puncture site. If this method is not followed properly, the pneumothorax may be

easily over looked.

Investigations:

Recent advances have led to development of a wide variety of investigations. These include biochemistry, histology and immunohistochemistry, toxicology, as well as other physical investigations including tool mark examination, odontology, entomology, botany etc. As a result, a wide range of samples may need to be collected taken during examination of the body. The nature of investigation naturally depends upon the nature of the death, the type of autopsy and most importantly, the availability of the resources and technology.

Toxicology

"All substances are poisons; the dose differentiates a poison from a medicine"

– Paracelsus (1493-1541).

Toxicology is the study of poison, specifically, the science that deals with properties, action, toxicity, fatal dose, detection and estimation as well as interpretation of the toxicological analysis and treatment of poisoning.

Forensic toxicology deals with medico-legal aspects of harmful effects of substances on humans. It involves the study and practice of analytical toxicology to the purposes of the law. It involves not just the detection and estimation of a drug, poison or substance, but also the interpretation of these findings. The toxicological investigations would include detecting the presence of extraneous chemicals, poisons as well as drugs of abuse or estimation of concentration of chemicals, drugs and substances intrinsically present in tissue.

This requires the collection of specimen during the autopsy examination. The specimen that needs to be collected depends on the type of toxin, the route of administration, site of metabolism as well as the method of excretion. In general, the routine samples that are collected in most autopsy cases include blood, urine, stomach contents, liver and kidney, cerebrospinal fluid, bile.

The samples should be collected in clean containers. The sample containers need to be airtight, transparent and sterile. The containers should have a wide-mouth to facilitate filling and emptying of samples. The samples should be accompanied with a form informing the laboratory of details of the deceased, brief history, analyses required. Where indicated, biological samples should indicate the known status of infective conditions, including hepatitis or HIV infection.

Sample collection

The methods, site, amount, preservatives used for sample collection depend on the nature of poison as well as nature of investigation whether toxological, biochemical, microbiological or histopathological.

Body Fluids:

1. Blood:

Blood is usually collected from peripheral veins – Femoral, Jugular or subclavian – as central blood – heart, aorta, venacava – has the chances of contamination by passive diffusion of poison from stomach in ingested poisons. Blood should never be obtained from body cavities, –Hemothorax, hemoperitonium – after evisceration.

Blood is ideally obtained at the beginning of autopsy by venipuncture from either femoral or subclavian veins. It can also be collected after incising the jugular or subclavian veins. It is recommended that at least 30 ml of blood be collected, with 10 ml without preservatives, 10 ml with sodium fluoride, 10mg per ml of blood, and 10 ml in EDTA.

2. Bile:

Bile can be collected after opening the abdominal cavity and puncturing the gall bladder with syringe, or by incising the gall bladder. It can be useful in analyses for opiates, which are concentrated by the liver and excreted into the gallbladder.

3. Urine:

At autopsy, it can be collected after opening the cavity and opening the bladder or with the help of syringe by puncturing the bladder. Around 30ml urine is collected.

Urine was once preferred for post-mortem screening as analysis is easy because of lack of binding proteins that hinder extraction. In addition, many drugs are excreted in the urine and provide suitable samples for examination in chronic poisoning. Acute poisoning deaths however, do not have time to excrete the drug before its effects cause death.

4. Vitreous Humor:

Vitreous humor is second only to blood in value for toxicological analysis. Vitreous level reflects drug concentrations in blood approximately 1-2 hours before death and so can be extrapolated for appropriate distribution rations to calculate the blood concentrations. The difficulty in using vitreous humor arising from the increased sensitivity required for analytical techniques as compared to blood and urine analysis. Vitreous humor should be

analyzed in cases with positive blood alcohol to estimate the blood levels 1-2 hours prior to death. Vitreous analysis for electrolytes, sodium, chloride, urea nitrogen, and creatinine can also be used to estimate the time since death.

Studies on other body fluids including synovial, peritoneal fluid and pleural fluid can help determine their suitability for analysis.

Solid Organs:

1. Stomach:

Stomach should be collected by ligating the cardiac and pyloric ends before removal. The exterior of the stomach should be washed clean of blood and other contamination before opening to examine the contents. The greater curvature is opened with large scissors, with a pan or jar held underneath to collect the contents. The content is examined and then poured into a wide-mouth, transparent glass container.

The stomach is then examined for congestion, edema, erosion, ulcer and presence of tablets or capsules etc. The stomach and its contents should be preserved in saturated solution of sodium chloride.

2. Part of liver:

Liver is the primary site of metabolism for majority of drugs in the body. The Right lobe is preferably collected, due to possibility of passive diffusion of ingested poison from stomach to the left lobe, resulting in false high level of poison in the liver. The amount of liver required depends on the lab. In our context, an estimated 200-300gm of liver is to be collected. Liver is also preserved in saturated solution of sodium chloride.

3. Half of each kidney:

Kidney is the primary site of excretion for most drugs. Halves of both kidneys should be collected due to the possibility of pre-existing unilateral renal failure resulting in negative results if only the affected kidney is collected. Kidneys are also preserved in saturated solution of sodium chloride.

4. Loops of intestine:

While not routinely collected in our context, the proximal 30cm of small intestine is recommended for collection, if the deceased survived for more than a few hours as the ingested poison would have moved to the small intestine by peristalsis. Small intestine is also preserved in saturated solution of sodium chloride.

5. Large intestine:

The large intestine is seldom collected. However, some authors have described the importance of collection of large intestines in heavy metal poisoning. Large intestine is also preserved in saturated solution of sodium chloride.

6. Muscles:

Muscle tissue is relatively well preserved especially the deeper muscles of the thigh, as compared to blood, vitreous or even urine. The solid organs, liver and kidneys also tend to decompose rapidly. In addition, the drug concentrations in the muscles are a better representation of blood concentrations than the levels in the liver or kidneys. Muscles would also be preserved in suspected intra-dermal injected poisons. Muscles should also be preserved in saturated sodium chloride solution.

7. Skin

In cases of insect or snakebites, the skin surrounding the fang marks should be preserved for histopathology and immunology studies. Forensic Science Lab does not carry out these tests; hence, local arrangements with microbiology department may need to be made. Skin around injection sites can also be preserved for toxicological analysis. A control sample of skin one cm in diameter should also be collected.

8. Hair:

Hair tends to collect drugs in significant concentrations and provide valuable information regarding the duration of exposure. Once deposited, drugs and their metabolites are stable indefinitely. In addition, very little effort is required for collection of hair.

Hair should be cleanly plucked, along with the roots, in a tuft of at least 10-12 hairs and tied at one end so that root end can be easily identified. It is then air-dried and sealed in a paper envelope. It is important to remember that hair can give erroneously high levels due to external contamination.

Analysis of drug concentrations in hair can be an important defense against allegations of medical negligence by investigating patient non-compliance. They are especially helpful in decomposed bodies when other solid organs are too decomposed to yield any reliable results.

Hair is used routinely for analysis of chronic heavy metal poisoning, drugs of abuse like cocaine, heroin, amphetamines, as well as marijuana. Recent studies have been developed tests to recognize chronic heavy drinking few months before death.

Preservatives:

Though many samples for analysis are best sent in their original state, others require additives to prevent changes in the concentrations as well as to maintain them in optimum condition. Tissue can usually be refrigerated for 1-2 days, but long-term storage requires significantly lower temperatures. In warm conditions, yeasts and other alcohol-producing flora can ferment the sugars present in the tissue and produce significant quantities of alcohol.

1. Sodium Fluoride:

Body fluids are generally preserved in sodium fluoride in the ratio of 1:10 i.e. 10mg of sodium fluoride for every ml of blood. Sodium fluoride inhibits glucose utilization by microbes and prevents their growth and multiplication and can preserve body fluids at room temperature for up to 3 months.

2. Saturated solution of Sodium Chloride:

Saturate solution of Sodium Chloride is concocted by dissolving sodium chloride in water until a precipitate is formed. This saturated solution is hypertonic, causing dehydration of the all tissue, including any microorganisms present.

Documentation

The samples should be collected in suitable containers or envelopes and should be sealed. The samples should be labeled, including information about the registration number, personal details (age, sex, occupation, symptoms and medical history), Time of death and collection of sample, the sample that has been collected, the investigation that is being requested as well as the preservatives used. In out context, a summary of the autopsy report or the report itself is required to be dispatched with the samples to assist the laboratory, In addition, a chain of custody should be maintained to guard against any disputes about the reliability of the samples.

While chemical analysis is necessary for the detection and estimation of drugs, it is important to realize that toxicology is not just the detection of drugs and the estimation of the concentration in blood, but also pertains to the effects of the drug on the body including assessment of the symptomatology and eventual toxicity.

While blood concentration levels should exceed the fatal dose, this is also dependent on various factors like age, sex, weight of the deceased as well as presence of any pre-

existing conditions or disease. The cause of death can only be determined by examining the physiology and pathology and so should only be decided by a medical doctor with training in Forensic Toxicology.

Role of x-ray in forensic toxicology:

X-ray can be useful in detecting heavy metals build up in tissue, since they are radio-opaque, and can be detected on x-ray. However, the diagnostic value of this has not been confirmed due to its non-specificity and diagnosis should be confirmed by toxicological analysis.

Microbiology

Clinical autopsies frequently require samples for culture to investigate bacteriology, virology and rarely mycology. This is rarely required in forensic autopsies. Swabs can be immersed in a transport medium to facilitate the growth of the organism during transportation and samples collected from multiple sites. Lung and brains samples are commonly collected for virology studies.

Blood is best collected, with sterile needle and syringe, from a large vessel, such as the femoral vein, before starting the autopsy. Blood may also be collected from freshly opened heart chamber using a sterile swab.

In all cases, cultures need to be performed soon after death, to decrease contamination. The determination of significant growth in the culture requires specialised training and is best left to a doctor with specialist training in forensic microbiology.

Histology

Histopathological examination of tissue is an integral part of all autopsies to rule out occult natural disease. While this is not possible in all cases in resource-scarce context, histopathology may be extremely relevant and perhaps irreplaceable, for estimating the progress of myocardial infarction, the estimation of time since injury as well as in profound disease. It is recommended to retain samples of liver, spleen, kidney, heart, lung, thyroid, adrenal, pancreas, muscle and brain in all cases where the cause of death cannot be determined and when resources permit.

The tissues are sampled by taking relatively large pieces at autopsy, which are later trimmed. The tissue is placed in a large volume of buffered formol–saline and allowed to fix

for at least several days. The volume of fixative should be at least six times the total volume of tissue. Tissue should not be squeezed into a tight container, barely leaving any space for formalin, resulting in half-fixed and perhaps half-dried or decomposed tissue.

Specialized techniques including histochemistry, fluorescent microscopy and immunohistochemistry are used especially in the investigation of sudden death but a discussion is beyond the scope of this guideline.

Autopsy examination of fetus and infants

Postmortem examination of fetus, infant or young child should be performed with a special approach, different from that of adult. The presence of anatomical malformations or developmental variation should be assessed and dissection should preserve the anatomic relationships of the anomalies.

Thus, the organs are usually dissected en-bloc. Doctors who perform postmortem examination on fetuses and infants, therefore, should have a good working knowledge of normal anatomy, to identify the abnormalities and preserve the anatomic relationship until a consultation can be obtained.

Facilities and equipment

The facilities and equipment needed to perform fetal autopsy should be adequate from adult autopsy and minimum requirements are:

- Camera for photographic documentation
- Scale with case serial number
- Good source of light
- Standard weighing scale and measuring tapes
- Sterile swabs sticks
- Sharp cutting blade, scissors, plain and toothed forceps, etc.
- Facility of portable X-ray machine in certain cases

Postmortem examination

Different measurements and observation are used to document either normal anatomy or various pathologic conditions. For a good practice, postmortem examination should always be documented with photographs. The external features routinely photographed include ffrontal views of entire body, close ups of the face and side of head, as well as any other unusual features. Photographs provide an accurate record, not only for academic purpose but also for the occasional case in which re-evaluation of the external features is needed. In addition to pictures, abnormal features should be documented through measurements of structures that can be compared with reference standards. For this reason, these autopsies require additional representation using a tape measure.

Maceration (organ softening due to decomposition) is a confounding problem in fetuses that have been retained in-utero following death. The degree of autolysis is variable depending upon intra-uterine conditions. Careful examinations of gross and microscopic changes help to estimate the time of death. Despite deformation due to maceration, many malformations can be distinguished upon careful inspection.

External examination

All the relevant measurements of fetal head circumference, chest circumference at the level of nipple, abdominal circumference at level of umbilicus, length of fetus (such as crown-rump, crown-heel and foot) and total weight of body should be documented. Any congenital anomalies and marks of treatment should also be recorded.

Examination of head and neck:

Distribution and quality of hair over the head and rest of the body should be documented, as should the distribution of vernice casceosa over the neck and skin fold of arm and thighs. The size of the fontanelles should be measured. Any soft tissue swelling over the scalp (caput succedaneum) should be describe. The eye, palpebral fissures should be examined, whether it can be opened, the size of pupils, color of iris and sclera. The size, shape and position of nose as well as patency of choana should be examined. Oral cavity should be examined by digital palpation for detection of any abnormalities. The size, shape and position of pinna as well as the patency of external auditory meatus should be documented. The position of trachea and size of thyroid gland, features of congenital anomalies, like anencephaly, cleft palates, choanal atresia, etc. should be described in detail. Any injuries that may have taken place during the delivery procedure should be documented.

Examination over chest and abdomen:

The size and shape of the chest and abdomen including any abnormalities and symmetry, position of nipple, distribution of subcutaneous fat over chest and abdomen should be documented. Abdomen should be palpated for any mass, including enlarged lymph nodes, liver and spleen.

Position and patency of meatus in male genitalia should be examined and scrotum palpated for presence of testes and any other masses. In females, the position of the meatus and configuration and relative size of the labia and clitoris should be examined. Anal orifice should be inspected for position, patency and anomalies, like absence or atresia. Limbs should be examined for symmetry and muscle bulk.

INTERNAL EXAMINATION:

In internal examination, all three cavities are opened, similar to adult autopsy. To open the chest and abdominal cavities, 'I' – incision is given, starting from symphysis mentii to pubic symphysis at mid-line and by passing left or right few centimeters at the level of umbilicus.

The skin, subcutaneous tissues and muscles are reflected off the chest and abdomen. Inspect abdominal cavity for any collection (fluid, blood etc.) or adhesion. Collections are measured in a calibrated jar or at the very least estimated, if calibrated jar is not available.

Before opening chest plate, if pneumothorax is suspected, the entire body is placed in a basin or big container and the whole body immersed in water to observe for any escape of air from thoracic incisions, through the intercostal space. The chest plate is removed by cutting cartilaginous part of the rib cage at the costo-chondral junctions.

Chest cavity:

The chest cavity is inspected for any collection, adhesion and anomalies. The origin and relative positions of the great arteries as they arise from the heart should be noted.

Abdominal cavity:

The orientation and position of the abdominal organs should be inspected in situ. In fetuses and young infants, the liver is relatively large, extending well across the midline. Position of the right hepatic lobe should be in the right upper quadrant. Examine the location of spleen over left upper quadrant just lateral to the stomach.

The caecum and appendix are fixed to the posterior peritoneal wall in the right lower quadrant by the end of second trimester. Position of both kidneys and adrenal glands should be noted on each side after coils of intestines have been reflected. The gonads should be located and in females, the shape and position of the uterus between the bladder and rectum ascertained.

For premature males, intra-abdominal testes should be removed before evisceration. The umbilical arteries can be identified coursing along either side of the bladder. When the positions of the organs have been determined, the organs can be eviscerated in anatomically related groups (Ghon method) or all together en-bloc (Letulle method). The entire block from tongue to rectum can be removed, as in adults.

Procedure:

Both the thoracic and abdominal organs are removed in single block by detaching from its posterior attachments. The large veins and arteries of the neck should then be carefully dissected and identified, starting from the heart. These vessels should not be cut until all have been identified.

Before thoracic organs are removed, thymus should be carefully dissected from the pericardium, by elevating the thymus from the mediastinum. Before cutting any major vessels, the pericardial sac is cut opened and trimmed of free parietal pericardium.

A block is placed underneath the shoulder blades, causing hyperextension of the neck, and easing the release of tongue and dissection of neck structures. The tongue is released from the oral cavity by cutting in U-shape fashion from its attachment over the mandible. By holding tip of tongue, it is pulled outwards and downwards and released from its posterior attachment by cutting with a sharp blade. Then the large arteries and veins should be carefully dissected. The complete thoracic structure can be pull down to the level of diaphragm.

The remaining abdominal organs should be removed by cutting on both sides of the diaphragm, and moving coils of intestine to one side and posterior peritoneal attachment is released. The entire bloc can be removed after separating from the level of rectum and anal canal.

Separation of the organ blocks

After the entire block has been eviscerated (using the Letulle method), the dorsal or posterior aspects of the block are examined by cleaning with clear running water. The descending aorta is lifted, transected, and opened vertically until its terminal branches along the posterior wall. Next, the diaphragm is reflected and separated to remove adrenal glands from the upper pole of kidneys.

The whole block is turned over to examine the ventral or anterior aspect. The procedure is slightly different from dissection in adults. The heart and lungs are separated from rest of the block by cutting along the inferior vena cava, esophagus, descending aorta at the level of diaphragm. This approach maintains the relationship of pulmonary arteries, ductus arteriosus and arch of aorta to the heart as well as of the esophagus with trachea.

The coils of small intestines are separated from its mesenteric attachments at ligament of Treitz up to the upper segment of rectum. Both ends of stomach (esophageal end and pyloric end) are either clamped or ligated before its separation. The whole length of intestine is examined for any malformations.

The patency of the biliary tree can be assessed by manually expressing bile from the gall bladder. Gall bladder is examined after separation from the liver. The liver is separated from diaphragm. The Spleen is separated from the hilum and removed.

The remaining block consists of the part of esophagus, stomach, duodenum and pancreas. The pancreas is removed from the stomach bed and dissected. In males, the testes are examined by removing them through the inguinal canal. In female, the uterus with ovaries are dissected from pelvic floor for examination.

Dissection of organs after evisceration

While preferable to examine the heart and lungs following overnight perfusion with formalin, social and cultural norms dictate quick release of the body and fixation of organs may not be feasible.

Dissection of The thoracic Block:

The esophagus is cut open from posterior aspect and the trachea and larynx from anterior aspect thus preserving any tracheo- esophageal anomalies. The lungs are separated from its hilum.

Dissection of the heart:

There are various methods of dissecting the heart to study the pathological lesions. For academic purposes, the best method is to open the heart chamber along the lines of normal flow of blood.

First, the right atrium is opened by a separate long axis incision infero-laterally to avoid the orifice of the inferior vena cava. This allows for inspection of the ostium of the coronary sinus and the oval fossa and the tricuspid valve. The patency of the connection between the atrium and right ventricle should be examined by use of a probe or finger.

The ventricle is opened by continuing the atrial incision through the atrioventricular valve and into the ventricle along the inferior aspect, parallel to the interventricular groove to the apex. Then the patency of pulmonary valve is examined using a probe, and the out flow tract is opened by continuing the same incision from the apex into the main pulmonary artery.

On the inferior aspect of the heart, the left atrium is incised in Y- shape fashion to show the connection of the pulmonary veins with the left atrial cavity and to expose the mitral valve. After the patency of mitral valve is accessed, the incision should be carried along the inferior surface through the valve and the left ventricle to the apex, parallel to the interventricular septum. The incision is continued along the septum over the anterior aspect of left ventricle by using anterior descending coronary artery as a landmark.

For histologic examination, one section from each side of the heart, including atrium, ventricle, atrioventricular valve, and coronary artery, should be taken along the inferior incisions; papillary muscle sections from the right and left ventricles may also be collected. In cases with cardiac defects, the heart is kept together with the lungs en bloc and sections for histology taken judiciously to preserve the educational value of the gross specimen.

Dissection of lungs:

Until the proper anatomical relationship between heart and lungs has been established, the lungs should not be separated from the heart. After complete examination of the size, shape, color and volume of the both lungs, each lungs is dissected and weighed.

Dissection of abdominal organs:

The separated liver and spleen should be sliced along the long axis, parallel to their inferior surfaces. This preserves the major vessels in liver and hilum in spleen. Umbilical vein, portal sinus and venous duct (ductus venosus) that are present over the inferior surface of the liver should be opened longitudinally. The contents of the stomach should be retained for evidence of chorio-amnionitis, in infants older than 1 day of age.

The Pancreas is also dissected along the longitudinal plane. The capsules of kidneys are stripped to preserve generative glomeruli, and each kidney is dissected completely half so that the cortico-medullary area and renal pelvis are clearly visible. The ureters should be opened in order to examine the patency or probing can be done. The urinary bladder should be cut open to examine for any anomalies. The testes should be dissected.

In fetus or neonates, sternum should be cut with a heavy knife at mid-line to expose ossification centers. Similarly, lower end of femur and upper end of tibia as well as calcaneus, talus and cuboid bone are also cut to examine for appearance of ossification centers.

Dissection of Brain and spinal cord

The procedure for removal of brain from its cavity in fetus and infants similar to that of adult autopsy, however, precaution should be taken while cutting the skull vault, if the superior sagittal sinus need to be preserved to examine for thrombosis.

A coronal incision is given over the scalp starting from one end of mastoid process to the other. The two halves of the scalp are reflected forwards and backwards, to expose the skull vault. Any caput or hemorrhage can be noted during the scalp reflection. As the skull bone is thin in fetus, a sharp knife or heavy scissors can be used to cut open the skull.

In order to preserve the superior sagittal venous sinus and falx, it is better to cut about 0.5cm on either side of the midline suture and the occipito-parietal sutures. This can be done by using a scalpel for the initial incision and extended using scissors. The coronal suture is cut across, and the frontal bone cut on each side to form two bony flaps. These two bone flaps can then be reflected downwards, with the dura matter attached, to allow examination of the surface of the cerebral hemispheres. Any subdural or subarachnoid hemorrhage can be noted and the extent of the subarachnoid space assessed.

The brain is mobilized to examine the falx Cerebri, tentorium, vein of Galen, and cerebrum. The anterior end of the falx is incised and dissected backward and removed. The superior sagittal sinus can now be opened with scissors and examined for thrombus. Now brain can be removed in the same way as in adults; however, it is complicated by the fragility of the brain, particularly in a perinatal and/or macerated body.

The frontal lobes should be lifted away from the base of the skull and the optic nerves transected. Then internal carotid arteries, the pituitary, and the oculomotor nerves are transected on both sides. The temporal lobes should be eased away from the base of the skull and the tentoria cerebelli incised on both sides, either with scissors or scalpel. This will further separate the brain from the base of skull, exposing the brain stem. The medulla oblongata, the cranial nerves, and the vertebral arteries should be cut with a scalpel, as distally as is possible.

Brain is removed by holding the occipital lobes with the left hand and gentle traction of brain stem with fingers of right hand. The remaining dural venous sinuses should then be incised with a scalpel and examined for thrombus. An initial examination of the brain should be made to assess the maturity of the gyri and to identify edema and /or herniation.

Cerebral hemisphere is separated from cerebellum and brain stem is separated from cerebellum by cutting cerebellar peduncle. Serial coronal section (1 cm thick) of cerebral hemisphere is dissected with the help of brain knife by placing convexities downwards on cutting board, starting from the frontal lobe and ending with the occipital lobe. In the same way, cerebellum and brain stem are also cut in the coronal plane.

Examination of the placenta

Examination of the placenta is a vital part of any fetal or perinatal post mortem. In any case of stillbirth, prematurity, or Intra Uterine Growth Retard, a sample of membranes and parenchyma can be taken, using a sterile scalpel and forceps for bacteriology, if infection is suspected.

The cord length and site of insertion should be described. Examine for ruptures, varices, numbers of vessels and true knots. The fetal membrane is examined for meconium staining and discoloration for signs of infection. Point of rupture of sac and size should be noted. The maternal cotyledons should be examined for their completeness. The membranes and cord should be separated and placental disc measured and weighed. Any blood clot received with placenta should be measured.

The placental disc is sliced at approximately 1 cm intervals. Any focal lesions, such as hematoma, infraction, thrombosis should be measured and noted. Sections of cord, membranes, and placental parenchyma should be taken for histology examination, in addition to any lesions identified macroscopically. In multiple pregnancy-associated placenta, the dividing membranes should be carefully examined to assess the number of chorionic and amniotic membranes.

Autopsy examination of pregnancy related death:

Most of the deaths associated with pregnancy are not related with medico-legal investigation, these are most often associated with complication of childbirth, pre-existing medical condition of mother and termination of pregnancy. In later scenarios death investigation plays crucial role to find mechanism and cause of death.

For better understanding of the cause of death in pregnancy and after delivery, complete postmortem examination should be carried out, with histological and other essential ancillary investigation as well. A study reveals that, about 26 million legal and 20 million illegal abortions are performed annually throughout the world. The most common direct causes of maternal deaths include:

- Thrombosis and thromboembolism
- Hypertensive disease of pregnancy
- Amniotic fluid embolism
- Early pregnancy death
- Sepsis
- Hemorrhage
- Genital tract Trauma
- Anesthesia related complication

Abortion related deaths:

Although, medical termination of pregnancy is legalized in our country, illegal abortions are still being carried out by both trained and untrained medical personnel. The rate of death in legal abortions has very low mortality as they are carried out in well-equipped facilities and performed by well-trained medical persons.

The usual methods are vacuum aspiration, dilatation and curettage and medically induced termination of pregnancy. Risks of death are still present, even when carried out in a fully functional setup, performed by well-trained medical person. The common causes of death for such scenarios include:

- Pulmonary embolism from leg vein thrombosis
- Anesthetic Mishap

- DIC and Cerebral damage when abortion was induced by intra-chorionic injection of hypertonic saline or glucose
- Air embolism following vacuum aspiration though rare
- When treatment failed in response to excessive bleeding and infection,

Death following illegal abortion:

When abortion is carried out by a doctor with aseptic and anti-septic environment with full antibiotic coverage, the chance of risk is minimal, as compared to the rough technique applied by the unskilled person using improvised instruments. The most common methods for illegal abortion are as follows:

Instrumentation

Here the main idea is to disturb pregnancy by damaging the sac usually by dilatation of cervical canal, using all kinds of instruments from surgical dilators to wooden cylindrical sticks. When abortion is performed by the doctor or paramedic, using sterile instruments, the risk of complications is minimal. On the other hand, when performed by laypersons or quacks, use of extreme force may lead to perforation of vault of vagina or fundus of uterus, even damaging the coils of intestine and the liver. The external os may be injured by repeated blind attempts to introduce thick objects into the undilated cervical canal. The perforation of vaginal wall and uterine cavity may lead to excessive bleeding and sepsis from generalized peritonitis. Another risk of instrumentation is cervical shock when dilatation is done without anesthesia.

Air insufflations

This procedure is absolute in all center where legal abortions are performed. Abortion is carried out by introducing fluid, under pressure, into the uterine cavity, with the help of rubber pump or enema syringe. This causes separation of chorionic sac from the wall of the uterus, exposing the placental bed. Complete separation of sac results in abortion. Apart from the dangers of bleeding and infection, air embolism is another risk. When empty syringe with air is pushed into the uterus, with exposed vascular channels of the placental bed, air can enter the venous sinus and pelvic veins to cause cardiac embolism.

Physical violence

Anxious pregnant women may seek violent treatment from husband or consorts such as violent punching and kicking of abdomen, resulting in rupture of liver, spleen or intestine. Death may ensue from complication.

Syringe aspiration

Syringing is safe, when compared with other methods of abortion, so long as aseptic precautions are undertaken. If product of conception are retained, they can acts as a source of infection and can lead to death.

Postmortem examination in maternal death from abortion:

Autopsy technique, in cases of maternal death, does not require significant deviation from a standard postmortem examination. Of course, special attention should be given to known causes of maternal death. In developing countries like Nepal, the cause of death associated with abortion is much more likely to be associated with infection and uncontrolled bleeding. In any case, doctor must use appropriate autopsy techniques and ancillary investigations.

Circumstances of death and detailed medical history should be obtained before starting the autopsy. If death occurs at hospital, it is always better to communicate with treating doctors and obtain medical records. This may help during postmortem examination by helping focus examination as well as for collection of samples for ancillary investigations.

In case of criminal abortion, a careful examination must be carried out as follows:

- In case of clostridial infection and liver damage, skin may appear bronze color.
- Abdominal distention and breast changes should be assessed for signs of duration of pregnancy.
- In genital examination, signs of recent or current pregnancy and attempted or successful recent abortion should be noted. Vaginal bleeding and injuries like abrasions, contusions and lacerations may be present over vulva from instrumentation.
- Any fluid present over the genital should be collection for chemical analysis. Swabs should be taken for microbiological culture.
- When pneumothorax or air embolism is suspected, X-ray of chest and abdomen should be taken before evisceration; if x-ray is not possible then it must be sought during dissection. Air embolism can be detected by visualizing air bubbles in the heart chambers, great veins and inferior vena cava, peritoneal cavity and pelvic veins.
- The main pulmonary artery should be dissected to check for thromboembolism. Lanugo hair, vernix or meconium may be seen, indicating amniotic fluid emboli.
- En-bloc removal of perineum and internal genitalia should be routinely performed

Examination of female pelvic organs by en-bloc resection:

The dissector must carefully examine pelvic organs in cases of suspected criminal abortion and inspect for vaginal, cervical and uterine injuries. Since, these areas lies deep within the pelvis, complete external examination is often inadequate. Pelvic organ need to be examined following en-bloc removal, which allows a more complete inspection and maintains the pelvic organs in their natural position during the examination.

After the completion of abdominal evisceration, the prosector first give a diamond shaped incision over the skin enclosing the vulva and anus. The incision should penetrate into the deep soft tissue bounded laterally by ischio-pubic rami, anteriorly by the pubic symphysis, and posteriorly by the coccyx. The internal incision is given along the pelvic inlet, enclosing the pelvic organ. The rectum and adjacent soft tissues are dissected away from the sacrum and urinary bladder is dissected away from the pubis.

Once the internal and external incision joins within the pelvis, the vulva, ureter, urinary bladder, vagina, uterus, fallopian tubes, ovaries, anus and rectum are removed as single tissue bloc. This tissue bloc can be removed superiorly from pelvic inlet or antero-inferiorly from ischio-pubic rami. The tissue bloc is thoroughly examined by placing over the cutting board. The anus and rectum is opened with long scissors along the posterior aspect and mucosa inspected for any lesions or injuries after washing with water. The vaginal wall may be opened along the anterior or posterior wall depending upon the injuries. This allows proper examination of vaginal mucosa, external os of uterine cervix, and the junction of vulva and vagina. The urinary bladder, uterus, fallopian tubes and ovaries are examined using usual technique.

Autopsy examination in deaths associated with sexual violence

Suspicious deaths of females should be examined methodically to assist in the investigation of sexual violence. These deaths result from sexual assault and are commonly associated with other forms of violence.

Background Information

The case information provides valuable insight into the death process, comprising of details of the incident, including the date and time, location, nature, and associated information of the scene of death. Background information should also include the deed of preliminary investigation (घट्नास्थल प्रकृति मुचुल्का) as well as the deed of examination of dead body (लाश जाँच मुचुल्का) which should describe the perceived events that led to the incident of death.

Personal history of the deceased should be collected with as much details as possible, including information recent and past medical and surgical conditions and procedures, obstetric and sexual history, history of substance abuse etc.

Preliminaries

Scene of death

The scene of death should be visited, as required or requested by Nepal Police, to help collect information to assist in the investigation of the death. The information that is vital include position in which body was recovered, clothing and any associated stains, presence of items near the body. Including drugs, alcohol, contraceptives, as well as disturbance in the scene,

Photography

Photographs should be taken, and should ideally include documentation of body and genital injuries, bite marks as well as stains.

Collection of swabs

As required, swabs should be collected to preserve evidence for further analysis. The collection of swabs should be performed before the area is manipulated.

Clothing

Clothing are integral in the examination of any victim of sexual offences. The clothing are the outermost layer that come into contact with the perpetrator and could possibly have evidences that are lodged onto the clothing. Clothing typically have fibers, plant and animal matter, as well as any other evidence that could assist in deducing the identity of the location of crime or the identity of the perpetrators.

Any significant evidences should be properly documented, including by photography, and material evidences should be secured before transporting the body.

Transport of the Body

Before the body is transported, trace evidence that could possibly be present on the hands and feet should be preserved by placing paper or plastic bags over the hands.

The body should be wrapped in a clean sheet or placed in a clean body bag to prevent trace evidence that might get lost while transporting the body and to prevent the body from picking up debris that might be confused with valid trace evidence.

EXAMINATION OF THE BODY

At the start of the examination of the body, all available evidences should be collected. Hands should be examined for presence of any foreign material. If indicated, nail clippings may be collected to examine for trace evidences. A fresh pair of scissors or nail clippers should be used to prevent contamination. Any material thus collected should be placed in labeled containers or envelopes. Swabs of bite marks as well as of the genitalia should be taken before the body is washed or manipulated. Relevant control samples should also be taken from corresponding areas of the body.

External findings in fatal sexual assaults

External examination is extremely important in cases of sexual assault, perhaps even more so than internal dissection. Examination follows the same principles irrespective of if the victim is alive or deceased.

A meticulous and systematic examination is required. The examination proper is divided into two parts, general examination and examination of genitalia and any specific parts of the body.

Oral cavity

Contusions in mouth and lips could possibly indicate injures of a sexual nature from rough kissing. Abrasions present over the inner aspect of the lips indicate pressure against the teeth. Lacerations of the buccal surface as well frenulum could indicate forceful manipulation of the oral cavity. Oral penetration may leave traces of seminal fluid in the oral cavity, and swabs from mouth should be collected.

Bites marks:

Bite-marks in a death due to sexual offences are predominantly seen over the neck, breasts, inner thighs as well as genitalia. Bite marks consist of an amalgam of injuries including contusions from suction, abrasions from friction with the teeth as well as lacerations due to penetration of the skin by the teeth. These marks should be swabbed with a sterile cotton swab that has been dabbed in normal saline. They should also be documented by photography.

General bruising and abrasion:

Linear abrasions may also be present over the back, and limbs in addition to the breasts and genitalia, usually representing injuries from fingernails. Bruises over the wrist and knees as well as over the inner thighs in additional to the breast and genitalia. Discoid bruises, around 1-2 cm in diameter usually represent finger pressure. In addition, abrasions and contusions may be seen on the back, following friction against uneven or hard surface. They may also be seen over the knees and palms.

Other general injuries:

Other general injuries could be present anywhere on the body. Deaths associated with sexual violence tend to have injuries over the limbs, in addition to injuries of a purely sexual nature. These tend to be from restraint applied in confining the victim. In addition, fingernails may be broken during struggle. In deaths with extreme violence associated with revenge and sadistic nature of the assailant, multiple cuts and stab injuries may be found over multiple parts of the body.

Genital Injuries:

The perineum should be examined, in detail, following general examination and should follow a methodical and systematic protocol to avoid loss of valuable evidence.

The vulva and anus should be inspected externally and documented for laceration, swelling, bruising, bleeding and discharge. Lacerations may be present over the perineum, as well as over the orifices. The coning and dilatation of anal and vaginal orifice should be interpreted with caution, following death; sphincters become patulous, and may open wide.

The pubic hair should be examined for external hairs, vegetation and other external material as well as dried seminal stains. All evidence should be collected, along with control samples of hair and combings. A fine comb may be used for combing hair, dried stains hair may be cut and placed in an envelope.

Following completion of external examination, samples should be collected. This could include samples for biological testing, for the presence of semen and venereal infection, as well as samples for DNA profiling. A sterile cotton-wool swab should be used to take samples from

a) Interior of vulval labia and around vaginal orifice
b) Margins and interior of anus
c) Mid-vagina, without contamination from lower vagina
d) Upper vagina, cervix and posterior fornix.

The swabs should be smeared on glass slides and air-dried. A piece of cloth, moistened with saline, should be used to obtain any seminal stains on the skin. Oral and rectal smears and swabs should also be retained, if indicated. Injuries to the genitalia should be examined and documented after all samples have been collected. Genital Examination should include examination of the hymen, with documentation of any injuries as well as scars.

Internal examination

The cranial, thoracic and abdominal cavities are opened routinely to examine for cause of death. In deaths associated with deaths associated with sexual violence, special pelvic dissection may need to be performed. The bladder should be emptied and urine samples collected, if indicated.

The pelvic dissection involves removing the pelvic organs *en bloc*. The skin and underlying soft tissue is dissected along the superior rami. The pubic bones are sawn a few centimeters lateral on each side to pubic symphysis, continued through the inferior rami. The pubic symphysis is then removed and the perineum deeply dissected to remove the vagina, rectum, anus, uterus, tubes and ovaries for detailed dissection.

The vagina should be opened with large scissors along the anterior midline and exposed to the posterior fornix. All injuries and findings should be carefully photographed and documented. The ovaries and fallopian tubes as well as pelvic soft tissue, including ligaments should be examined for injuries, hemorrhage or any other findings. Vaginal instrumentation may penetrate into the abdominal cavity, either via the posterior fornix or lateral vaginal walls.

The cervix and uterus are examined next. The uterus is exposed by dissecting along the vault. The cut is then opened along the anterior midline, to expose the entire uterine cavity as well as the cervix. All injuries and discharge should be documented.

Investigations to detect spermatozoa could include tests for sperms, prostatic acid phosphates, and prostate specific antigens. Blood group antigens and DNA profiling can be performed if indicated. Screening for HIV and Sexually Transmitted Diseases may also assist in the investigation. Lubricants present on the genitalia or perineum can be collected and the analysis of the chemical composition may help identify the offending material.

Autopsy examination in deaths associated with poisoning:

The autopsy procedure always begins with external examination of the clothing as well as the body followed by internal examination. In developed countries with resources available, blood, urine, bile, and vitreous should be routinely be collected and analyzed. However, this is not feasible in resource-scarce setting. As such, in our context, toxicological analysis is carried out in

- Suspicious deaths when no cause of death is found
- Suspected poisoning from circumstantial evidence
- Routine toxicological analysis in Air crash (Captain and Co-pilot),
- Drivers in road traffic accidents
- Surgical and anesthetic deaths

Preliminaries

Scene of death

Details regarding the scene should be documented, including scene disturbances, position of deceased, any vomitus as well as presence of poison container or spilled poison. Any poison or drug containers, vomitus or spilled poison present at the scene should be collected and sent to Forensic Science Laboratory for detection and estimation of drugs, chemicals and substances.

Medical history:

If the ingestion of poison was witnessed by anyone, details regarding substance ingested, symptoms after ingestion, as well as treatments and procedures should be documented. In addition, the access to the substance should also be documented, whether the poisoning was a result of an overdose of prescribed medicine.

Some heavy metals can mimic natural diseases, especially on chronic exposure. Chronic arsenic poisoning can mimic cholera or gastro-enteritis; chronic thallium poisoning can mimic peripheral neuropathy. It is therefore important to deduce relevant occupational and exposure history. Lack of anatomical evidence of these diseases should preclude a suspicion of heavy metal poisoning.

Treatment history:

If the deceased was admitted in hospital and received treatment, vomitus as well as first gastric lavage should be collected and analyzed. Where blood has been drawn, it may be sent for toxicological analysis, following death.

External Examination:

Any abnormal odor associated with the body should be noted. Kerosene like smell is associated with organophosphorus poisoning, while garlicky smell is seen in Phosphorus containing poisons like aluminum phosphide and arsenic, and cyanide poisoning presents with a bitter almond smell. Clothes should be examined for stains, which should be collected for analysis.

External examination should include examination for patchy alopecia as seen in chronic arsenic poisoning, Mees' line seen in nails in heavy metal poisoning, skin pigmentation in heavy metal poisoning, Icterus indicates hepatotoxic poisons and also a sign of multi organ failure when the patient is admitted in hospital for long time.

Examination should try to determine the route of administration by examining for chemical burns, puncture marks. In case of puncture marks, a few cm of skin surrounding the puncture mark should be excised and collected for analysis.

In addition, examination of post-mortem hypostasis may demonstrate color changes depending on the poisoning. For example, cherry red discoloration of lividity indicates carbon monoxide poisoning. Similarly, a bright red coloration may indicate cyanide poisoning while a yellowish-brown discoloration indicates phosphorus poisoning.

Internal Examination:

Internal examination of the deceased is extremely important in poisoning cases to rule out natural disease processes and to correlate the development of clinical features with the toxicity and effects of the poison.

Blood and muscle tissue appear cherry red in carbon monoxide poisoning. Examination of tongue, esophagus and stomach could reveal abnormal smell, stain, congestion, mucosal edema, erosion, ulceration and perforation.

Heart should be examined for signs of myocardial infarction, even if the coronary arteries are patent. Some drugs, cocaine in particular cause, cause death by causing severe

vasospasm resulting in myocardial infarction and arrhythmias. Lungs generally appear to show evidence of generalized edema. However, in inhaled poisons, lung parenchyma may demonstrate injuries, including contusions, hemorrhage and erosions.

Liver may appear enlarged and yellowish, showing signs of hepatitis. Kidneys may show signs of glomerulonephritis as well as other focal hemorrhages.

Diagnosis of the cause of death in a case of poisoning requires demonstration of poison or metabolites in the body in fatal dosage. While it may be possible to correlate and perhaps even diagnose, based on physical characteristics of poison as well as the symptomatology, however, it is highly recommended that samples be collected for toxicological investigations to provide an objective analysis.

Samples to be collected:

As already discussed, the samples to be collected depend on the type of investigation to be done and specifically with regards to sample collection in case of poisoning, the mode of administration, the site of metabolism, distribution and excretion of the drugs determines the samples to be collected. Currently in our context, the samples to be collected for toxicological analysis include:

- Stomach with its entire content (Preserved in saturated solution of sodium chloride).
- Part of liver (estimated 200-300gm) (Preserved in saturated solution of sodium chloride).
- Half of each kidney (Preserved in saturated solution of sodium chloride).
- In case of suspected alcohol intoxication and carbon monoxide poisoning, at least 10ml of blood is collected (preserved in sodium fluoride for alcohol analysis and for carbon monoxide poisoning blood sample is sealed with paraffin without any preservatives).

Depending on the nature of poisoning, additional samples can be collected, including 25-30cm of proximal small intestine, 2-3 cm of skin tissue, muscles etc., lung tissue, hair, bone and nails as well target organ tissue including lungs, heart, brain, pancreas, etc.

Autopsy Examination in Deaths associated with asphyxia

Asphyxia is derived from the Greek word ‘a sphuxis’ meaning without pulse. However, in forensic medicine, asphyxia describes a situation where there is a lack of oxygen in the body. The commonest form of asphyxia involves physical obstruction between the external orifices and the alveoli. Other forms of asphyxia involve hindrance to exchange of oxygen between the alveolar air and blood as well as interference with utilization of oxygen in target tissue.

Asphyxia is not frequently used in clinical medicine, perhaps appropriately, given the lack of understanding of the pathophysiology in many such deaths. In legal context as well, the variance of mechanisms causing lack of oxygen in the body makes the diagnosis of asphyxia insignificant. The underlying mechanism that caused the asphyxia is more important in investigating the cause of death, as is the manner or death.

Examples of Asphyxial Death:

Underlying Mechanism Of Death	Examples
Lack of oxygen in the inspired air	Suffocation
Blockage of the external orifices	Suffocation/smothering
Blockage of the internal airways by obstruction	Gagging/choking
Blockage of the internal airways by external pressure	Strangulation/hanging
Restriction of chest movement	Traumatic asphyxia
Failure of oxygen transportation	Carbon monoxide poisoning
Failure of oxygen utilization	Cyanide poisoning

Classification of asphyxia

Mechanical

- Smothering — physical obstruction of mouth/ nose - preventing effective breathing
- Gagging — physical obstruction in the upper respiratory tract
- Choking — physical obstruction in the lower respiratory tract
- Strangulation — pressure applied to neck, by means of ligature or hands
- Hanging — pressure applied to neck by means of ligature, due to weight of body
- Compression — obstruction to respiration due to pressure applied to chest/abdomen

Non-mechanical

- Suffocation — reduction of oxygen in the respired air
- Carbon monoxide poisoning — obstruction to transportation of oxygen by hemoglobin
- Cyanide poisoning — obstruction to utilization of oxygen in the cell

Miscellaneous

- Drowning — physical interference with respiration by replacing oxygen in the environment, obstructing airway as well as gaseous exchange

Asphyxial insults does not necessarily preclude death as shown by many reports of survival following hanging, drowning etc. The outcome is dependent on the nature, degree, and duration of the insult. It is possible to see complete recovery, with no significant long term sequelae, irreversible ischemic brain injury can result in brain death.

Phases and signs of 'asphyxia'

The general sequence of events in asphyxial insult consists of five stages –dyspneic phase, convulsive phase, pre-terminal phase, gasping phase and lastly terminal phase.

- Dyspnea phase — expiratory dyspnea with raised respiration, cyanosis and tachycardia (may last for a minute or more)
- Convulsive phase — loss of consciousness, reduced respiration, facial congestion, bradycardia, hypertension, fits (may last for a couple of minutes)
- Pre-terminal phase — no respiration, failure of respiratory and circulatory centers, tachycardia, hypertension (may last a couple of minutes)
- Gasping phase — respiratory reflexes – loss of movement, pupillary dilatation.
- Terminal phase — loss of circulatory and brainstem function

Traditionally, the 'classic signs of asphyxia' include

- Petechial hemorrhages — face, conjunctiva, mucosa, pleura, pericardium etc.
- Congestion and edema — face, conjunctiva, viscera
- Cyanosis — face, lips, fingertips

These 'classic signs', are caused by raised intravascular pressure in blood vessels in the head and neck. However, they are not specific for asphyxia, and can be seen in wide variety of deaths. Petechiae in face and neck requires an explanation, and any evidence capable of supporting a diagnosis of 'pressure applied to neck or chest' should be explored.

Types of mechanical asphyxial mechanisms

Pressure to the neck:

Three forms of pressure over the neck are predominant, namely manual strangulation, ligature strangulation and hanging. The sequence of events leading to death is extremely variable and can lead to variations in the development of 'classic signs of asphyxia'. Some cases may lead to death over a sustained period of time and may show prominent signs of asphyxia, while in other cases of sustained pressure, they may be absent. Extremely short periods of pressure over neck have demonstrated asphyxial signs.

The exact mechanism leading to asphyxia may vary and include at least one of the following:

- Obstruction of jugular veins, causing impaired venous return to the heart – resulting in cyanosis, congestion and petechiae
- Obstruction of carotid arteries causing cerebral hypoxia
- Stimulation of carotid sinus resulting in cardiac arrest (vasovagal stimulation)
- Elevation of larynx and tongue, obstructing the airway at the level of the pharynx. Trachea and tracheal cartilages are resistant to compression

Numerous recorded deaths have been studied and support assertions of rapid loss of consciousness, within 10 seconds. The time for a fatal outcome, however, is extremely variable, although analysis suggests lack of recognizable respiratory movements after 2 minutes and lack of muscle movements after 7.5 minutes. Experimental occlusion of tracheas in animals have shown survival for up to 14 minutes following obstruction.

'Vagal inhibition' or reflex cardiac arrest

The pressure baroreceptors present over the carotid body, at the carotid bifurcation, has been known to cause cardiac inhibition. This property has long been used in therapeutic cardiac sinus massage in patients with arrhythmia. These alterations, however, are unpredictable and fatalities have been described, with individuals collapsing after apparently minimal pressure being applied to the neck. This chain of events has been attributed to vagal inhibition due to carotid sinus stimulation. This is also called the cardiac reflex and afferent fibers run via the carotid sinus nerve, branch of glossopharyngeal nerve, to nucleus of tractus solitarus and vagal nuclei, in the medulla. Parasympathetic nerves then innervate the heart via the vagus nerve. The lack of general signs of asphyxia is thought to imply death due to vasovagal stimulation, where the individual died before the signs could develop.

Strangulation

Strangulation is used to describe death caused by application of pressure around the neck, where the pressure is anything other than the weight of the body. Strangulation is consistently homicidal, even though accidental strangulations have been known to occur from time to time. Suicidal strangulation, however, is extremely rare and should be treated with suspicion.

Manual strangulation

Manual strangulation describes the application of pressure to the neck using the hands. This is a relatively common method of homicide. This is extremely common in the extremes of ages, infants and elderly. Manual strangulation cannot be suicidal, as the loss of consciousness would cause release of pressure. Similarly, accidental strangulation does not exist. The only possibility of manual strangulation being anything other than homicidal is when the assailant is aware of his actions and so may not be found liable for homicide.

The external examination reveals bruises and abrasions on the neck. While many books describe the classic crescentic abrasions caused by fingernails, the dynamic nature of the assault often causes obscure bruises and abrasions. Similarly, typical fingertip – six pence – round or ovoid contusion, 1-2 cm in diameter may be seen. In addition to other features, it is important to remember that either the assailant or the victim may have caused these injuries.

The classical signs of asphyxia are frequently seen in abundance in strangulation, both manual and ligature. This is often because typically, more force than is required is applied when attempting to kill another person.

Ligature strangulation

Ligature strangulation describes death due to pressure over the neck, causing a constricting force. This constricting force can be due to any material and include cloth, rope, wires, metal rods etc. Ligature strangulations are usually homicidal or accidental, while suicidal ligature strangulations are a comparatively much rarer entity. As with manual strangulation, signs of asphyxia are usually pronounced and frequently, there is a clear difference in the congestion above the level of the ligature.

Frequently, a faint ligature mark is present over the neck and rarely may replicate the pattern of the ligature material. Careful documentation of ligature mark, with scaled photographs, may allow comparison with the suspected ligature material. Soft and broad

ligatures may leave no evidence of compression on the skin of the neck, or even underlying structures.

Ligature mark is commonly seen as an oblique continuous mark, completely encircling the neck, although clothing, or hair, may cause break in the continuity of the mark. Ligature may show crossing of the ligature or even knots in the ligature. There may be marks suggestive of crossover of the ligature, or knots, but nothing indicating a suspension point. Ligature marks frequently harden due to drying of the abraded skin, causing a brown parchmentization.

Pressure can be applied by means of more than hands or ligature – for example, arm-lock or chokehold. The damage to the tissue depends on the nature of force applied to the neck.

Dissection of neck structures should always be carried out in a bloodless field to minimize the occurrence of post-mortem artifacts. This can be done by first eviscerating the thoracic, abdominal and cranial contents, leading to drainage of vasculature of the neck from superiorly as well as inferiorly.

Dissection may reveal contusion over the strap muscles, sternocleidomastoid muscle as well as platysma. The superior horns of thyroid cartilage, with contusion of surrounding soft tissue, which are particularly vulnerable to compressive injury, may be fractured. Suspected fractures should be confirmed under the microscope. The greater horns of hyoid may also be fractured, although seen less frequently than thyroid fractures. Calcification and ossification of hyoid bone and thyroid cartilage makes them more prone to injury, and are so more frequently associated with neck compression in the elderly. Neck injuries are commonly less extensive in ligature strangulation, with hemorrhage more localized, underlying the ligature.

Hanging

Hanging is defined as ‘death due to suspension of the body by a ligature around the neck, with the compressing force being weight of part of or complete body of the individual.’ Hanging therefore confines to suspension of the body by the neck. Any material that is capable of forming a ligature can be used for hanging. It is not necessary for the body to be completely suspended. The lowest height of point of suspension describe in literature, in a case of hanging, is 15-20 cm from the ground, with the body completely supine and the posterior neck just above the ground level.

A ligature mark is almost invariably present, often deep and furrowed, often discontinuous at some points around the neck. Discontinuity could reflect the point of suspension, or the juxtaposition of hair or clothing between the ligature and skin.

The ligature rises from the point directly opposite to the point of suspension. The ligature mark forms a V-shape with the point away from the point of suspension as well as an inverted V where the noose suspended the body.

The precise mechanism of death in hanging is still being researched, but it is universally thought to be a combination of mechanisms described when discussing pressure over the neck. The various combinations of these mechanisms lead to a wide variety of features being demonstrated at autopsy. Death may occur faster than the time required for signs to appear, and may result in absence of signs of asphyxia, even in hangings, with complete suspension.

Hanging by judicial execution demonstrated fracture-dislocation of the odontoid process and impaction into the medulla. This usually involves a drop to a height that has been calculated to cause fracture-dislocation of the cervical spine without decapitation. This is not present in our context. However, such findings may be seen in drops from a considerable height as may complete decapitation. Excluding in autopsies following judicial execution hangings, neck structures in hanging are frequently inconspicuous, with no injuries.

Hanging is mostly suicidal, although some cases are accidental, following entanglement with cords and ropes. Homicidal ligature strangulation may be staged to resemble a suicidal hanging, and autopsy would demonstrate extensive injuries to the neck structures in such situations.

Post-mortem toxicological analysis should be performed in all hangings in order to determine whether the individual was capable of self-suspension.

Choking

Choking is defined as ‘obstruction of the lower respiratory tract by extraneous material’. This commonly occurs following accidental inhalation of foreign objects like food. Choking is also common following misplaced dentures in adults and inhaled objects such as small toys, balls, etc., in children.

Extracted teeth or blood from dental or ear, nose and throat (ENT) operations may occlude the airway and is an added precaution to be ensured, especially in a sedated patient.

Death is commonly due to respiratory distress, with autopsy demonstrating congestion and cyanosis of the head and face.

Café coronary

One of the commonest causes of choking is the entry of food into the air passages. If food enters the larynx during swallowing, unless the obstruction is released, it usually causes gross choking symptoms of coughing, distress and cyanosis. However, if the piece of food is large enough to occlude the larynx completely, it will prevent not only breathing but also speech and coughing.

This is usually seen where an apparently healthy individual having a meal suddenly collapses and dies. The cause of death was thought to be due to a heart attack, and hence the name Café Coronary Syndrome.

Compression asphyxia

Pressure on the trunk can cause hindrance to effective respiratory movements and result in an inability to breathe effectively, causing death. Workers buried in earth are unable to expand their chests, leading to respiratory distress. Similarly, individuals trapped under heavy machinery are unable to breathe effectively. Individuals may be crushed by the weight of other people fleeing danger. While the predominant causes of death in such situations are due to crush injuries, it is also possible for an individual to be uninjured but dies due to inability to execute respiratory movements due to the weight of the bodies on top. These examples of ‘compression asphyxia’ are called traumatic or crush asphyxia.

Another form of compression asphyxia is seen in the intoxicated or with impaired cognition, where the body is jammed in a position, rendering breathing ineffective. For example, the check may be stuck in small gaps while trying to squeeze through, causing difficulty in expansion of the chest. Similarly, intoxicated individuals may die due to compression of the neck or even the chest, against the edge of the bed, resulting in restriction to breathing. While this would normally not occur in an alert individual, one who is sedated or has a neurological disease may not be able to extricate themselves from such a situation. Another example is ‘cot death,’ where an infant gets wedged between the base and wall of the cot, called positional asphyxia.

Suffocation

Suffocation is used to describe death due to reduction of the concentration of oxygen in respired air. A reduction in atmospheric oxygen can occur in a decompressed aircraft cabin, an unused well or a grain silo. Reduction in the oxygen concentration of respired air can also occur due to mechanical causes like due to placing plastic bag around the head.

Postmortem examination reveals absence of classical signs of asphyxia. If the obstruction to the respiration is removed before examination, there may be no features attributing to death. Even in homicidal cases, where the victim is intoxicated or unable to defend, as seen in extremes of ages, there may no signs of injuries on the body.

Suffocation almost impossible to diagnose on post-mortem examination, if the offending object has been removed. However, as in most cases, homicidal deaths being masqueraded as natural or suicidal deaths tend to unravel following meticulous examination.

Smothering

Smothering describes the physical obstruction of the nose and mouth to cause respiratory distress and death. While smothering usually leaves signs such as abrasions, contusion and lacerations of the inner aspect of the lips and cheeks, they may have no evidence of injury, including around the mouth or nose. This is commonly seen if the individual is unable to struggle, owing to extremes of age or intoxication, and if the object used is soft, like a pillow or scarf.

Frequently though, examination will reveal intraoral injuries, including abrasions, contusions and lacerations of the lips or cheeks, especially the inner aspect, or contusion of the gums in edentulous individuals. Soft tissue of the face may reveal subcutaneous contusions around the mouth and nose. Fibers from the object may also be seen in and around the mouth and nose and may reveal the object used.

Smothering may also therefore be extremely difficult to diagnose at post-mortem examination. The items/objects alleged to have been used to smother, may have evidential value as it may have evidence that can be matched with the victim or the perpetrator. However, it should be remembered that common household items like pillows used by family members will tend to already be contaminated with their DNA and should be examined with caution. The value of evidence is of course far greater if matched with the perpetrator than with the victim.

Drowning

Drowning is defined as ‘death due to obstruction of the air passages by any fluid.’ While typically occurring in water, drowning can occur in any fluid. Finding a body in water does not necessarily indicate death due to drowning. Drowning can occur in a few inches of water, and complete knowledge of the circumstances and location of the body should be available to make a proper and accurate determination of the cause of death.

Drowning is a diagnosis of exclusion - a body found in water, with no other significant finding attributing to death will be diagnosed to have died due to drowning. Most deaths due to drowning are accidental or suicidal. Certain clues like presence of ligatures around hands and feet suggest a criminal act.

The investigation of death in a body recovered from water is difficult, given the variety of mechanisms possibly in play. The examination must investigate all these potential mechanisms as well as attempt to answer other questions that may assist in the investigation. Reason for death in a body that retrieved from the water:

- Died of natural causes before entering the water
- Died of natural causes while entering the water
- Died of natural causes after entering the water
- Died from exposure and hypothermia in the water
- Died of injuries sustained before entering the water
- Died of injuries sustained while entering the water
- Died of injuries sustained after entering the water
- Died from submersion, but not drowning
- Died from drowning – respiratory distress caused by aspiration of water into the lungs

Even when the cause of death is drowning, it is important for the investigation to examine the cause for entering the water as well as the reason for failure of survival. These questions are invariably linked to the manner of death and should consider the circumstances as well as all other evidences related to the case. When sufficient evidence is available, it may be reasonable to attempt to answer these questions. Lack of definite signs should be interpreted with caution due to the variety of mechanisms involved and should perhaps be left to the judiciary to perform a complete investigation of all evidences and provide a definitive answer as to the circumstances of death.

Evidence of immersion

Immersion of the body in water brings about a number of changes that are extremely variable. Many factors influence the changes including tidal or non-tidal, water temperature, clothing worn, base of the water body, animal activity etc.

Generally, skin of hands and feet appear wrinkled and macerated, fingertips appear swollen, within a few hours of immersion in cold water. In addition, cutis anserina undergo post-mortem rigidity and so cause the hair on skin to 'stand'. Soon, layers of skin separate, leading to peeling, 'degloving' and 'destocking'. Loss of epidermal layers due to peeling may cause pigmentation changes, which can mislead as to the ethnic origin of the deceased.

Estimation of post-mortem interval from signs of immersion, and post-mortem changes in a body recovered from water can be extremely erroneous and unreliable. A very generalized and arbitrary 'rule of thumb' states that 'decomposition in water in temperate climates occurs at roughly half the rate of a body left in air.'

Gaseous distension becomes apparent after a few days, after which skin and hair are loosened and detached. Despite the hair being detached from dermal attachments, the skin and hair remain apparently *in situ* for a few weeks. A few weeks after, gaseous decomposition and bloating causes the body to 'surface', leading to its discovery.

Post-mortem artefact and immersion

Bodies recovered from flowing rivers as well as tidal waters may sustain injuries following contact with sand, rocks, and other underwater structures. Collision of a body with propeller blades typically causes deep 'chop' wounds and/ or lacerations.

Other post-mortem artifacts typically seen in bodies recovered from water include damage by aquatic life. The decomposition and dissolution of soft tissue from around the joints causes loss of integrity of skeletal structure, especially of the hand and feet. These small bones may be detached and swept away by current.

In addition, ante-mortem injuries may get washed and appear pale on examination, in the absence of histopathological examination, this can lead to misdiagnosis as a post-mortem injury. Bodies recovered from water invariably tend to have some injuries and it becomes imperative for the post-mortem examination to seek histo-pathological investigation to help estimate the time of injury.

Pathophysiology of drowning

Immersion in fluid, results in obstruction to the gaseous exchange by replacement of oxygen by the fluid both in the environment as well as in the alveoli. As a result, there is mechanical obstruction due to replacement of air as well as electrolyte imbalance caused by the fluid. This results respiratory distress due to pulmonary surfactant insufficiency, pulmonary edema, alveolitis, hypoxaemia and metabolic acidosis. In addition, exposure to cold water can lead to hypothermia, causing cognitive impairment, thereby increasing the risks of wrong decisions and aspiration of water.

Fresh water is hypotonic, and entry into the alveoli can lead to rapid absorption into the blood stream, causing transient, non-significant hypervolemia and dilution. More importantly, it causes alveolar collapse due to changes in pulmonary surfactant tension, resulting in intrapulmonary (left to right) shunts. On the other hand, seawater is hypertonic and entry into the alveoli causes fluid shifts into the alveoli as well as concentration and hypovolemia of plasmas well as pulmonary surfactant insufficiency.

As a result, this induces systemic hypoxia, causing to myocardial depression, reflex pulmonary vasoconstriction and hypertension, increased pulmonary capillary permeability, all leading to pulmonary edema. Seawater is thought to be twice as lethal as fresh water with even small amounts, less than 30 ml, causing hypoxic changes.

Signs of drowning

The classing finding associated with drowning are the effects of submersion and could be seen in any death where the body is submerged post-mortem. They are neither diagnostic not sensitive for drowning. As already discussed, drowning is a diagnosis of exclusion and a complete autopsy examination with no other significant findings, in a body recovered from water, will lead to the conclusion of drowning.

Alternative mechanisms of death

Dry drowning is a form of death due to immersion where signs of aspiration are absent at autopsy. Alternative explanations include trauma, intoxication, cardiac arrhythmias etc.

Stimulation of trigeminal nerve in the pharyngeal/laryngeal mucosa causes reflex apnea, bradycardia and peripheral vasoconstriction called the ‘diving response’. This is seen to increase in anxiety/fear, temperature under 20°C and alcohol intoxication.

The cold shock response on contact with water causes respiratory effects including prolonged gasping, hyperventilation, and hypoxia, as well as cardiovascular effects like tachycardia, increased cardiac output, hypertension and cardiac irritability. These changes make the body susceptible to cardiac arrhythmias, especially ventricular fibrillation.

Sudden contact with water, as seen in drowning, causes activation of both diving and cold shock responses, which is thought to precipitate supraventricular tachyarrhythmia.

The role of alcohol in drowning

Alcohol levels are frequently elevated in victims of drowning. While the association has been shown to be significant, a causal relationship has not been established. One hypothesis, that is obvious, is the incapacitation caused by alcohol intoxication and the associated loss of inhibitions resulting in pursuit of dangerous tasks, with loss of co-ordination and fatigue causing submersion and eventual death. Another theory surmises that peripheral vasodilatation associated with intoxication results in hastening of the effects of hypothermia.

Investigations

The confirmatory diagnosis of drowning as cause of death is extremely difficult. In the past, post-mortem blood electrolyte levels, especially chloride concentration, and specific gravity have been analyzed to separate fresh and seawater drowning. However, such tests are of no utility in the diagnosis of drowning. Recent studies have proposed blood strontium analysis as a marker of drowning, but has not found widespread acceptance.

Diatoms

Diatoms are microscopic organisms ubiquitously present in sea and fresh water. They have a siliceous capsule that survives acid digestion. The presence of diatoms in organs (kidneys and brain) and bone marrow was widely accepted to be confirmatory for diagnosis of drowning.

However, recent studies have found diatom to be ubiquitous in food and the environment. Diatoms have been found in non-drowning deaths and have been absent in document cases of drowning. Some authors have proposed DNA analysis to match the species of diatoms found in the water with those found in the organs. However, this has also been challenged by assertions that diatoms vary at different depths in the same body of water.

Therefore, diatomology, study of diatoms, must be used with caution and only in context with other available evidence(s), where it may prove to be an important piece of corroboration.

Autopsy Examination in sudden unexplained death in adults

World Health Organization defines sudden death as ‘death within 24 hours from the onset of symptoms’, but most clinician accept sudden death to be death within one hour from the onset of symptoms.

Death can be attributed to the lack of functionality of the tissues. The state of death is conferred by absent electro chemical intercellular communication in the brain and heart. This electro-physiological disturbance leaves no anatomical traces or records except in cases where the individual had been monitored before death. Therefore, one should consider the circumstances before death as well as the surroundings of the body. Another important medical tool that should be availed of is the medical history of the deceased. These can help in determining the cause of death in cases where there are no anatomical abnormalities.

Some common mechanisms for functional deaths are:

- Increased excitability of the myocardium causing propagation of ectopics. These ectopic beats cause ventricular tachycardia or premature ventricular contractions. In the presence of circus pathways, these ectopics may lead to development of ventricular fibrillation causing ineffective circulation with lead to rapid death. Ventricular excitability can be enhanced by myocardial hypertrophy, Ethanol intoxication, Ischemia, Sympathetic discharge, Hyper-thyroids. Ventricular excitability is also enhance by Drugs like Caffeine, Sympathomimetic drugs, Epinephrine, Norepinephrine, Theophylline, Mono-Amine Oxidase inhibitors, Tri-cyclic Anti-depressants,
- Depression of the myocardial contractility causing failure of the propagation of impulses. In case of failure of propagation of electrical impulse from the SA node, the ectopic pacemakers start producing impulses. The failure of this safety mechanism will lead to cardiac asystole and death. Myocardial depression can be caused by Parasympathetic discharge, Myxedema, Hypothermia, Hyperkalemia

In addition to the causes mentioned above, the nervous system itself can produce strong electrochemical discharges that cause death by causing cardiac asystole, ventricular fibrillation or vascular redistribution. These are controlled by the vasomotor and the respiratory centers in the brain.

The important vasomotor centers are present in the mid-brain, region of the third ventricle and in the medulla oblongata. The centers influence the heart through the sympathetic and the parasympathetic pathways. The sympathetic pathways involve the intermediolateral columns of the spinal cord from where fibers pass to the sympathetic ganglia especially the stellate ganglion and finally via the sympathetic branches passing along the base of the heart to supply the heart. The parasympathetic fibers pass via the vagus nerve, passing through the mediastinum to supply the heart

The important respiratory centers are present in the medulla and are under the influence of the dorsal pontine centers. The respiratory center exert their influence via fibers in the upper spinal cord and the phrenic nerves originating from c3,c4 and c5 passing along the neck and through the pericardial sac to supply the diaphragm. Any abnormal discharge could cause either increased excitability or depression of the myocardium.

Following cessation of circulation due to whatever cause, consciousness is lost within 15 seconds, and cerebral function becomes irreversibly ceases within 5 minutes. In case of respiratory arrest, cerebral function is the same in that consciousness is lost in 15 seconds and death occurs with 5 minutes. However, cardiac function is not disturbed initially so that there is initial tachycardia followed by bradycardia and then complete electromechanical dissociation with presence of electrical activity but no circulation until death occurs.

Other biochemical changes that could lead to cessation of vital functions including electrolyte disturbances, diabetic ketoacidosis, drug overdoses and poisoning which might produce alterations of the intracellular composition causing death.

Death may appear sudden and unexpected to an uninformed or misguided outsider, but may not only be expected but may also not be so sudden to medical personnel. For example, a patient reporting to the emergency department with complaints of rigidity of the neck would appear apparently normal except for fever and pain over the neck to an outsider. However, a doctor would immediately elicit Kernig's sign and diagnose meningitis. Subsequent death within a few hours may be appear sudden to the family members. Similarly, the deceased may have been suffering from chronic disease, symptomless or unaware of the risks. The deceased may also not have shared any knowledge with other individuals. Hence, these deaths may not be sudden, may not be unexpected but are certainly unexplained. As a result, medico-legal investigation is advised to protect the medical doctor from future liabilities.

In some cases, even after complete autopsy examination as well as all appropriate investigations, the cause of death remains unclear. These deaths are known as functional deaths where the death was a result of a functional derangement and so may not have left any anatomical, gross or histological, proof behind.

Sudden death can be divided into 2 groups: those with functional abnormality and those with structural abnormality. In cases of sudden death due to functional disturbance, the cases can again be divided into those that has a significant anatomic alteration for which functional disturbance can be attributed or referred and those in which no anatomic alteration is evident at autopsy.

Those cases where there is no anatomic alteration are designated functional death. Examples of functional death are:

Vagal Cardiac Inhibition – Sudden death that occurs within seconds to within a minute or two after minor trauma or peripheral or internal stimulation of a relatively simple and ordinarily innocuous nature. These cases are often categorized as accidental in nature. E.g. Blow to the larynx, Blow to the solar plexus, Kick in the scrotum, Carotid sinus pressure, Cannulation of the cervix

Spontaneous ventricular fibrillation – history is of non-suspicious circumstances surround death associated with pre-mortem exertion, exercise or intense emotional situation. On complete autopsy, including toxicology and microscopy, no abnormalities are noted. Studies have shown that these cases are associated with patients with electrically unstable hearts that suffer a fatal dysrhythmia following adrenergic discharge.

Sudden Nocturnal Cardiac Death – There is a particular type of sudden cardiac death that was prevalent on in east and south Asia that has now been discovered to have occurred in the US as well following migration of Hmongs to the US. This syndrome is called by various names, in Japan, it is called Pokkuri, in Philippines, it is called Bangungut, and in the Thailand, Vietnam, Laos and Cambodia it is called laitai and nonlaitai. It is a case of sudden nocturnal cardiac death where ventricular dysrhythmias are demonstrated. This could be attributed to the night terrors occurring in non-REM sleep or due to the increased adrenergic discharge during the nocturnal cycle. These cases show negligible gross changes.

Another group of functional death are the ECG syndromes. These syndromes may clinically show evidences on ECG but are not associated with any gross abnormalities. Three common variants of this group are: Pre-excitation syndromes – most importantly Wolf-Parkinson-White syndrome. Long Q-T syndrome and lastly Sick sinus syndrome.

Wolf Parkinson White syndrome: In this syndrome, there are extra pathways communicating between the atria and ventricles. This leads to re-entry of impulses, which is recirculated and thereby causes ventricular tachycardia and ventricular fibrillations. The ECG findings are Wide QRS complex and Delta wave with a short P- δ interval.

Long Q-T syndrome – This is characterized by prolonged recovery phase from depolarization of the cardiac muscles. This leads to a tendency to syncope and could lead to death due to ventricular tachydysrhythmias. They are of two types: Congenital and acquired. Congenital long Q-T syndrome is seen in Romano-Ward syndrome and Jervell and Lange-Nielsen syndrome. Acquired cases are seen with drugs, electrolyte abnormalities, anorexia nervosa, Hypothermia, Toxic substances, Liquid diet.

Sick sinus syndrome – This can be seen in cases of surgical manipulation in the region of the SA node. May lead to spontaneous sinus bradycardia, syncope and rarely sudden death.

The most common cause of sudden death is dysfunction of the cardiovascular system. Other cause of deaths include cerebral hemorrhage, spontaneous subarachnoid bleeding, ruptured ectopic pregnancy, hemoptysis, hematemesis and pulmonary embolism.

Classification of Sudden Death

Cardiac Causes

- Coronary artery disease
    - Coronary atherosclerosis
    - Developmental anomalies
    - Coronary artery embolism
    - Others
        - Vasculitis
        - Dissection
- Myocardial diseases
    - Cardiomyopathies
    - Myocarditis and other infiltrative processes
    - Right ventricular dysplasia
- Valvular diseases
    - Mitral valve prolapse
    - Aortic stenosis and other forms of left ventricular outflow obstruction
    - Endocarditis
- Conduction system abnormalities

Non-cardiac causes

- Hemorrhage
    - Intra cranial hemorrhage
    - Diseases of the aorta
    - G.I. bleeding
    - Respiratory tract bleeding
- Intra-cranial causes other than hemorrhage
    - Epilepsy
    - Intracranial Tumors
    - Meningitis
- Miscellaneous
    - Primary Pulmonary Hypertension
    - Bronchial Asthma
    - Psychiatric
    - Pulmonary thromboembolism
    - Epiglottitis
    - Senescence

Sudden cardiac death

Cardiac causes of sudden death accounts for more than 300k deaths every year in the U.S. out of which 80% are due to coronary arteriosclerosis. Ischemic heart disease is the commonest cause of sudden death in most parts of the world. Coronary atherosclerosis - degenerative disease of the coronary arteries - is the largest contributor to ischemic heart disease. Coronary artery disease is accepted as synonymous with coronary atherosclerosis, although this should be avoided, as there are other diseases of the coronary arteries.

Ischemic heart disease comprises:

- Hypertensive cardiovascular disease
    - Coronary atherosclerosis
- Anomalies
- Cardiomyopathies
- Valvular diseases
- Myocarditis

Hypertensive cardiovascular disease

Uncontrolled hypertension can result in marked left ventricular hypertrophy and cardiomegaly. In the past, the thickness of the ventricular wall was used as a reference for hypertrophy, with measurements of left ventricular wall exceeding 15 mm and right ventricular wall thickness exceeding 0.3-0.5 cm taken as the criteria for diagnosis. Recent studies have shown that the weight is a more reliable indicator of hypertrophy. The ‘normal’ heart varies between individuals but normally weighs around 400 grams. Heart weighing more than 500 grams are generally accepted to be hypertrophied.

Hypertensive cardiovascular disease is associated with concentric thickening of the arterial wall. In case of plaque formation, there is eccentric thickening of the wall. In case of elderly, the vessel wall are rigidly calcified. The most commonly involved arteries are left main coronary artery and proximal left anterior descending coronary artery. For diagnosis of death due to coronary arteriosclerosis, the circumstances of death should be taken into account. After ruling out other causes beyond reasonable doubt, the diagnosis may be give as death due to coronary arteriosclerosis.

Coronary atherosclerosis

Coronary arteriosclerosis has been associated with a 9-fold increase in mortality. It shows increased incidence with increase in age and affects men more than women in all age groups. A positive stress test is associated with increased risk of myocardial infarction. Symptoms range from vague symptoms like tiredness and fatigue, generalized cardiac symptoms like to chest pain, palpitations and shortness of breath.

In one-fourth of patients, the first sign is death. About half of all sudden death victims present with history of atherosclerotic heart disease. The diktat for coronary arteriosclerosis is that it can result in death at any time and any place. Sudden death is the first and last symptom in 25% of individuals with cardiovascular disease. Half of individuals with coronary atherosclerosis die suddenly. Sudden dysarythmias occur in people with no distress previously. The mechanism of sudden death in an individual can be attributed to myocardial ischemia, which leads to an acute electrical event, most commonly a ventricular tachydysrhythmia, in the presence of a super-imposed transient risk factor.

Hypertension is the most important risk factor for sudden death in individuals with coronary arteriosclerosis. Hypertension and arteriosclerosis are risk factors for myocardial infarction and hence have a multi-fold increased risk of sudden death. Other risk factors include stimulation of vagal discharge, coronary artery spasm, thromboembolism, sympathomimetic drugs like caffeine, epinephrine.

The cause for this ischemia is occlusion of coronary arteries by atheromatous plaques. While the severity of stenosis before death occurs is debatable, most authors agree that at least 80 per cent of the lumen must be occluded for death to be attributable to coronary atherosclerosis. Myocardium may show evidence of fibrosis and even recent infarcts.

The difficulty in diagnosis of coronary atherosclerosis lies in quantifying the degree of stenosis. In addition, post-mortem examinations demonstrate empty vessels that are collapsed. The occlusal may be focal, of varying size and the rest of the artery may be normal. It is extremely easy to miss a focal lesion if the entire system is not examined with cuts no more than 3 mm apart. Opening the vessels lengthwise obviates this danger, but has the disadvantage of not being able to measure the degree of stenosis accurately.

Congenital Anomalies

Congenital anomalies of the conducting system may be compatible or incompatible with life. Those that are compatible with life may cease to be so following external insult. Some common anomalies found in healthy individuals are

- Persistent fetal dispersion of AV node
- Ectopic connections between the node and ventricles
- Ectopic His bundle, Ectopic AV tracts
- Marked sclerosis of the artery to AV node.

Role of these anomalies in sudden cardiac death is debatable and undecided.

Development anomalies

Other anomalies include developmental anomalies of the coronary arteries. These are some common developmental anomalies

- Left coronary artery arises from right sinus of Valsalva, and passing between aorta and pulmonary artery
- Single coronary ostium in right sinus of Valsalva with left coronary artery arising from proximal right coronary artery
- Origin of right coronary artery from left sinus of Valsalva
- Origin of left coronary artery from right sinus of Valsalva and passing dorsal to aorta
- Coronary artery hypoplasia - no diagnostic criteria has been set forth for this entity

Sudden death is more likely when the anomalous artery forms an acute angle with the sinus of Valsalva or produces a right angle in the artery itself.

Other congenital anomalies that are less compatible with life are bridging of the coronary arteries, Dissecting coronary aneurysm and coronary artery spasm.

Bridging of coronary arteries – This refers to the anomalous pathway of the epicardial arteries where the artery runs an intramural course. Therefore, on contraction of myocardium, the artery gets occluded; leading to ischemia and thereby may be a cause of sudden death.

Dissecting coronary aneurysm – may be primary or secondary to extension of the aortic root dissection. The extension of the aortic root dissection may be spontaneous or due to trauma. Seen more commonly in peri-partal females.

Atheromatous plaque can cause intimal defects and weakening of arterial wall media, allowing blood from the lumen to enter between the layers and dissect the weakened wall. The flow of blood being under pressure extends the dissection further along the aortic wall.

The commonest origin is in the thoracic aorta with the dissection extending distally, sometimes reaching the iliac or even the femoral arteries. The aneurysm may rupture at any point, resulting in massive hemorrhage into the thorax or abdomen.

Rarely, the aneurysm may extend proximally, around the wall of the arch of aorta and into the pericardial sac, resulting in hemopericardium, cardiac tamponade and sudden death. Dissecting aneurysms are common in hypertensive individuals, and commonly seen in younger individuals with connective tissue defects, like Marfan syndrome.

In elderly, the commonest site of aneurysm is the abdominal aorta. The aneurysms may be saccular or fusiform. The wall of the aneurysm is frequently calcified and the lumen lined by old laminated thrombus.

Many aneurysms remain intact throughout the lifetime and are found incidentally following autopsy for some other cause. Rupture of the aneurysm results in massive intra peritoneal hemorrhage, which may be repaired surgically if diagnosed in time. This typically affects older individuals that are hypertensive and of a poorer economic strata. As a result, many individuals die quickly before medical assistance can be availed. The bleeding is mostly in the retroperitoneal space. It may envelope an entire kidney in case of saccular aneurysms. Rarely, the aneurysm or hematoma may rupture into the peritoneum resulting in massive hemoperitoneum.

Coronary artery spasm – The coronary artery undergoes spasms, which cause significant constriction and decrease in blood supply leading to ischemia. Angina associated with acute MI-like symptoms are the primary complaints. However, on autopsy, infarct is not seen and neither is there any significant atherosclerosis. This is seen in Printzmetal's angina and unstable angina.

Cardiomyopathy

Cardiomyopathy is a group of diseases that is characterized by myocardial dysfunction. The cause may be known or unknown, and is not the result of arteriosclerotic, hypertensive, congenital or valvular diseases. It can be divided into 3 broad categories.

- Dilated or congestive
- Hypertrophic
- Restrictive or obliterative

Dilated or congestive cardiomyopathy

Dilated or congestive cardiomyopathy is associated with enlargement of the heart with dilatation of all four chambers on gross examination. It usually presents with presence of endocardial thrombi. Microscopically, it presents as extensive interstitial and perivascular fibrosis. Most common causes being chronic alcoholism, peri-partum cardiomyopathy, chronic myocarditis and idiopathic.

In chronic alcoholism, the effects are due to direct toxicity of alcohol on the cardiac musculature, nutritional effects of alcohol on the body and toxic effect of additives like cobalt.

Heart failure with gross enlargement of the chambers in the last month of pregnancy or in the first six months post-partum is designated Peri-partum cardiomyopathy. In about half of the individuals, the enlarged heart returns to normal in 6-12 months post-partum. If however, the failure becomes incompatible with life and death occurs, the finding on gross examination would be presence of grossly dilated heart with flabby myocardium. Presence of mural thrombosis is a common finding in these cases. Microscopically, signs of degeneration and/or hypertrophy may be present. It may also present as focal or diffuse interstitial myocardial fibrosis. Microscopically, one can find scattered mononuclear infiltrates as well as occasional fatty infiltrates.

In chronic myocarditis, the common cause is the exposure to toxic substances like cobalt and Adriamycin. The mechanism in these cases is due to the direct toxicity of the substance to the cardiac musculature, due to atypical reaction to the toxin and due to excessive dosage of the drug. This is clinically associated with arrhythmias leading to sudden death.

Hypertrophic cardiomyopathy

Hypertrophic cardiomyopathy is the single most common cause of sudden death in adolescent and young adults. It shows an autosomal dominant genetic inheritance. On gross, the left ventricle is hypertrophied without dilatation. The hypertrophy is disproportionate, asymmetrical in the septum as compared to the left ventricle. This causes obstruction to the outflow tract. Rarely, it may also present as concentric hypertrophy of the left ventricle similar to that seen in hypertensive patients. On microscopy, the myocardial fibers are in disarray with presence of hypertrophied bizarre myocardial cell. This is typically seen in the septal myocardium.

Valvular Disease

The commonest valvular diseases are mitral valve prolapse, aortic stenosis and acute bacterial valvulitis

Mitral valve prolapse also known as floppy mitral valve, myxomatous degeneration of the mitral valve or Barlow's syndrome is one of the commonest cardiac conditions in the world. It is thought that 15% of the world's population is inflicted with symptomatic or asymptomatic mitral valve prolapse. It is generally an asymptomatic condition that continues to remain undetected unless it becomes symptomatic due to some associated insult. Generalized cardiac symptoms are the primary indicators like angina, palpitation, shortness of breath etc.

Aortic stenosis has become more prevalent than mitral stenosis in today's world. This is due to the decrease in mitral stenosis of rheumatic fever as well as advancement in the field of surgery for mitral stenosis. Congenital aortic stenosis is the commonest etiology followed by Rheumatic, secondary calcification of congenital bicuspid valves and Primary degenerative calcification of normal aortic valves.

Thrombo-embolic accident following acute bacterial valvulitis is another common cause of sudden death that might be missed. It most commonly involved the tricuspid valve and is seen common in IV drug abusers.

Myocarditis

Clinical features of myocarditis could range from being asymptomatic to non-specific symptoms and could result in death. The causes could be infective, secondary to connective tissue disorders, due to physical agents, chemical poisons or drugs.

- Etiology
  - Infective:
    - Bacterial
    - Rickettsial
    - Viral
    - Protozoal
    - Fungal
  - Connective tissue disorders:
    - Rheumatic Disease
    - Rheumatoid Arthritis
  - Physical agents
  - Chemical poisons or drugs
  - Idiopathic

Intracranial vascular lesions

Several intra-cranial lesions cause death. However, most of these lesions tend to cause significant symptoms that would lead to diagnosis of the condition. However, a few lesions go undetected, asymptomatic until a fatal incident reveal the condition on autopsy.

Ruptured berry aneurysm

Sudden collapse and death of young men and women frequently demonstrate subarachnoid hemorrhage caused by rupture of a congenital aneurysm of arteries of circle of Willis itself or in its tributaries. While these aneurysms are not present at birth, the weakness in the media of the vessel wall is present at birth, leading to development of the aneurysm over time.

The aneurysms range from a few millimeters to several centimeters in diameter may be single or multiple, located in one or more arteries. The aneurysms may be asymptomatic or may cause severe headache, neck stiffness, and unconsciousness and sometimes even paralysis or other neurological symptoms.

Rupture of the aneurysm can cause extravasation of blood into the sub-arachnoid space, primarily over the base of the cerebrum but may also be seen over the cerebellum. If the aneurysm is embedded in the brain, it may cause hemorrhage into the brain tissue itself.

The mechanism for death is thought to be either due to vascular spasms causing hypoxia of the vital centers or direct effect on the centers by the blood itself.

The finding of a ruptured aneurysm in a case of documented assault, especially without any significant head injury, complicates the investigation. In such cases, the causal relation of blood pressure, caused by increased adrenergic release due to the ‘stress’ of the

altercation, is still controversial and requires further research. Alcohol intoxication is frequently associated in such cases and is another risk factor the rupture.

Demonstration of these aneurysms or ruptures of intracranial vessels requires tedious dissection, preferably under operating microscope, and should be examined thoroughly to rule out spontaneous rupture of pre-existing aneurysms caused by trauma to the head.

Cerebral hemorrhage, thrombosis and infarction

Cerebrovascular accidents are common in the elderly, especially with significant hypertension, and along with thrombosis and infarction, is the commonest cause of neurological signs of ‘stroke’.

Charcot-Bouchard aneurysm is a spontaneous intracerebral hemorrhage due to rupture of micro-aneurysm of lenticulo-striate artery. Hemorrhage are commonly seen in the external capsule/basal ganglia. The sudden expansion of a hematoma compresses the internal capsule and may lead to hemiplegia. Death in such circumstances is not usually sudden. The sudden hemorrhage may cause direct action on the vital centers or may cause pressure effects leading to death due to cardiac failure.

Respiratory system

The major cause of sudden death affecting the respiratory system is also vascular. Pulmonary thromboembolism is very common and the most clinically under diagnosed cause of death. In almost every case, the source of the emboli is in the deep veins of the lower limbs. Tissue trauma, especially associated with immobility or bed rest, is a very common predisposing factor in the development of deep vein thrombosis.

Most thromboses remain asymptomatic and rarely cause complication, but a proportion undergo embolism and migrate to the lungs where they block pulmonary arteries of varying sizes. Large saddle thromboembolism can occlude the origin, resulting in acute right-heart failure, whereas smaller thromboembolisms occlude smaller pulmonary blood vessels where they cause dissociation of gaseous exchange and lead to myocardial ischemia and death.

Significant predisposing factors include immobility following surgery or trauma, use of oral contraceptive, smoking, and history of metastatic cancer or clotting abnormality. However, some cases may have no significant clinical history or symptomatology and occurs unexpectedly in normal, ambulant individuals.

Other rarer causes of sudden respiratory death include massive hemoptysis from tuberculous cavitation or tumor. Fulminating infections, especially virulent forms of influenza tend to cause rapid death, though not fast enough to be classified as sudden.

Gastrointestinal system

Gastrointestinal hemorrhage for the main cause of sudden death in due to gastrointestinal condition. While generally treatable if diagnosed early, massive hemorrhages have been reported gastric or duodenal peptic ulcer resulting in sudden death. Mesenteric thrombosis and embolism, usually related to aortic or more generalized atherosclerosis, may result in infarction of the gut, leading to rapid deterioration but not sudden death, even if undiagnosed. Intestinal infarction due to other causes like strangulated hernia, or torsion due to diffuse adhesions can also prove rapidly fatal. Peritonitis, diverticulitis or perforation, can be rapidly fatal in our context with poor access to quality medical care. These conditions tend to present as unexplained deaths due to refusal to seek timely medical advice.

Gynecological conditions

Septic abortion remains one of the highest causes for sudden unexplained deaths in developing countries. Ruptured ectopic pregnancy, commonly in fallopian tubes, is another obstetric emergency presenting as sudden death due to lack of access to proper antenatal checks and is more common in the first trimester. Death occurs due to massive intraperitoneal bleeding.

Maternal and obstetric deaths are dealt with in detail on the chapter on maternal deaths. Gynecological deaths are less frequent and are usually associated with advanced carcinomas causing metastasis or due to aggressive tumors causing rupture of pelvic blood vessels leading to massive hemorrhage.

However, it should always be remembered that unexplained deaths in females of childbearing age should be suspected to be due to obstetric complications until findings prove otherwise.

In addition, any unexplained death in women should be examined methodically to rule out any sexual violence or assault. Rapid deaths are also seen in deaths associated with sexual assault; however, such cases are traumatic in origin and are not classified under

sudden death. They are discussed in the chapter on examination in deaths due to sexual violence.

Deaths from epilepsy

Repeated seizures are associated with recurrent episodes of hypoxia and cerebral injury, leading to an increased risk of mortality. Death may be caused by a epilepsy causing a specific sequence of events leading to death, for example a seizure while swimming causing death from drowning or seizure causing fall resulting in death from blunt trauma to head.

Sudden unexpected deaths in epileptics are classified as Sudden Unexpected Deaths in Epilepsy (SUDEP), and has been defined as ‘sudden unexpected, witnessed or unwitnessed, non-traumatic and non-drowning death in epilepsy, with or without evidence of a seizure, and excluding documented status epilepticus, where post-mortem examination does not reveal a toxicological or anatomic cause of death’. The mechanism of death in such cases is unknown, but has been proposed to be due to seizure-induced arrhythmia, respiratory center inhibition or a complication of treatment.

Post-mortem findings are nonspecific and include pulmonary edema and congestion and the presence of a tongue injury does not necessarily confirm seizure at the time of death. Detailed examination of the brain is essential to exclude underlying lesion causing the seizure, such as traumatic injury or arteriovenous malformation.

Some Common Natural Diseases and Their Possible Violent Antecedents

Disease	*Possible underlying injury, acute or chronic*
Central nervous system	
Meningitis; cerebral abscess	Fracture of skull, jaw, facial bones; injuries to middle ear, nasopharynx, air sinuses; infection introduced by surgical, anesthetic, roentgenologic, chemotherapeutic, diagnostic procedures
Intracerebral hemorrhage	Cerebral contusion enlarged by alcoholic coagulopathy, masquerading as hypertensive bleed
Subarachnoid hemorrhage	Blunt impact to head or neck; laceration of vertebral artery
Subdural hematoma	Blunt impact to head from fall
Cardiovascular system	
Coronary artery insufficiency	Emotional or strenuous physical effort related to occupation, or threat of assault
Ruptured heart valve; aortic aneurysm	Strenuous physical effort or blunt impact
Congenital anomalies	Teratogenic drugs
Seizure disorder, "Vasovagal attacks"	Shock; fright
Respiratory system	
Pneumothorax; subcutaneous and mediastinal emphysema; hemopneumothorax	Traumatic intubation, artificial ventilation with bag-mask, aspiration of foreign body, SCUBA diving, premature putrefaction in the setting of sepsis
Pneumonia; pulmonary embolism	Trauma, immobilization
Pulmonary fibrosis; mesothelioma; pneumoconiosis	Exposure to radiation; drugs; asbestos; industrial exposure
Alimentary system	
Ruptured viscus; perforated ulcer; peritonitis; intestinal obstruction	Impact to abdominal wall; burns; strenuous physical effort; foreign bodies by mouth or rectum, or left at laparotomy; diagnostic or therapeutic endoscopy; paracenteses; peritoneal dialysis
Fulminant toxic hepatitis; massive hepatic necrosis	Exposure to drugs; poison, anesthetic agents; pesticides; shock
Genitourinary system	
Renal tubular necrosis; papillary necrosis	Poisons; drugs; heavy metals; burns; shock; dehydration
Cystitis; pyelonephritis; ruptured bladder; ruptured uterus; ruptured ectopic pregnancy	Impact to abdomen; abortion; injudicious instrumentation
Hematopoietic and reticuloendothelial system	
Hemolytic anemia	Incompatible blood transfusion
Aplastic anemia; agranulocytosis; thrombocytopenia; leukemia	Drugs; poisons; pesticides; industrial and laboratory chemicals; antibiotics
Miscellaneous	
Malnutrition; failure to thrive	Negligence; parental cruelty; eccentric or unusual religious beliefs
"Crib death"	Accidental or homicidal suffocation