SECTION

A

Thanatology

"The secret of getting ahead is getting started. The secret of getting started is breaking your complex overwhelming tasks into small manageable tasks, and then starting on the first one."

Mark Twain

Chapter

1

Introduction to Forensic Pathology

Ashish Saraf, Sujatha P Lagali

This handbook is specifically aimed at what is commonly known as 'forensic pathology'. It is the application of knowledge of pathology for the purposes of law and administration of justice.[1] In practice, it deals with the interpretation of autopsy findings in a medicolegal investigation of death.[2] There has always been an overlap between forensic pathology and forensic medicine. The chapters covered in this manual mainly are related to the examination of the dead body for medicolegal purposes.

This manual aims to provide a ready reference while conducting postmortems in not so favourable conditions, guiding through the procedures and relevant information that are needed in the examination of a body found under suspicious or criminal circumstances. In our country, lack of manpower and resources, as well as considerations of distance and facilities, means that almost any registered medical practitioner may be called upon to perform the medicolegal autopsy when the need arises.[3]

Legislation and Guidelines Related to the Autopsy

The Indian laws related to the autopsy are described in the Indian Penal Code (IPC) and Criminal Procedure Code (CrPC). Several State Governments have also come out with their own orders which necessitate following in respective states.

Indian Penal Code

It was formed in 1860 by the British. It describes the offenses and the punishments prescribed for the offenses. It has 23 chapters and 511 sections. The offenses related to the body are relevant to the medical fraternity. This has been dealt within Chapter 16, i.e. Section 299 to 377.[4]

Criminal Procedure Code

This is the procedural law. It came into force in 1974. It describes the procedure to be followed by the law enforcement agencies during an investigation of a criminal case. It has 37 Chapters, 484 Sections and two Schedules.[5] Few of the sections in this code are relevant to the medical fraternity, viz. 53, 53A, 54, 164A,174, 176, etc. There are other laws but that is beyond the scope of this book.

174 CrPC:[5] *Police to enquire and report on suicide, etc.*

(1) When the officer-in-charge of a police station or some other police officer specially empowered by the State Government in that behalf receives information that a person has committed suicide, or has been killed by another or by an animal or by machinery or by an accident, or has died under circumstances raising a reasonable suspicion that some other person has committed an offence, he shall immediately give intimation thereof to the nearest executive magistrate empowered to hold inquests, and, unless otherwise directed by any rule prescribed by the State Government, or by any general or special order of the district or sub-divisional magistrate, shall proceed to the place where the body of such deceased person is, and there, in the presence of two' or more respectable inhabitants of the neighbourhood, shall make an investigation, and draw up a report of the apparent cause of death, describing such wounds, fractures, bruises, and other marks of injury as may be found on the body, and stating in what manner, or by what weapon or instrument (if any); such marks appear to have been inflicted.

(2) The report shall be signed by such police officer and other persons, or by so many of them as concur therein, and shall be forthwith forwarded to the district magistrate or the sub-divisional magistrate.

(3) When—

(i) the case involves suicide by a woman within 7 years of her marriage.

or

(ii) the case relates to the death of a woman within 7 years of her marriage in any circumstances raising a reasonable suspicion that some other person committed an offense in relation to such woman.

or

(iii) the case relates to the death of a woman within 7 years of her marriage and any relative of the woman has made a request in this behalf.

or

(iv) there is any doubt regarding the cause of death.

or

(v) the police officer for any other reason considers it expedient so to do, he shall subject to such rules as the State Government may prescribe in this behalf, forward the body, with a view to its being examined, to the nearest civil surgeon, or other qualified medical man appointed in this behalf by the State Government, if the state of the weather and the distance admit of its being so forwarded without risk of such putrefaction on the road as would render such examination useless.

(4) The following magistrates are empowered to hold inquests, namely, any district magistrate or sub-divisional magistrate and any other executive magistrate, specially empowered in this behalf by the State Government or the district magistrate.

176 CrPC:[5] *Inquiry by magistrate into cause of death.*

(1) When any person dies while in the custody of the police or when the case is of the nature referred to in clause (i) or clause (ii) of sub-section (3) of Section 174, the nearest

magistrate empowered to hold inquests shall, and in any other case mentioned in sub-section (1) of Section 174, any magistrate so empowered may hold an inquiry into the cause of death either instead of, or in addition to, the investigation held by the police officer; and if he does so, he shall have all the powers in conducting it which he would have in holding an inquiry into an offense.

(2) The magistrate holding such an inquiry shall record the evidence taken by him in connection therewith in any manner hereinafter prescribed according to the circumstances of the case.

(3) Whenever such magistrate considers it expedient to make an examination of the dead body of any person who has been already interred, in order to discover the cause of his death, the magistrate may cause the body to be disinterred and examined.

(4) Where an inquiry is to be held under this section, the magistrate shall, wherever practicable, inform the relatives of the deceased whose names and addresses are known and shall allow them to remain present at the inquiry.

Explanation: In this section, the expression 'relative' means parents, children, brothers, sisters, and spouses.

When a doctor receives a request for postmortem examination, he/she should make sure that he/she has received the request from the competent authority based on the history available. If that is not the case the doctor should request the person to do the necessary changes to avoid any complications in the future. This type of problem is faced more frequently in rural set up like the PHCs and CHCs. Magistrate here can be any magistrate mentioned above and not necessarily judicial magistrate. But in a ruling of Supreme Court[6] in 2014, the Honourable Court has ruled that in cases of police firing, the cases should be reported to the judicial magistrate.

Common Cases which Arrive in a Mortuary

Trauma

Cases of trauma for postmortem examination form a major part of the cases coming to any mortuary. The maximum cases are usually of road–traffic accidents. The autopsy surgeon conducting a case of trauma should be careful while conducting a postmortem, as the history might be misleading at times. A case of assault may be brought as a case of a road, traffic accident or vice versa. Many times, the medical officers conducting autopsies at PHCs or CHCs describe the injuries in such a manner that it ends up with multiple interpretations. It can provide a chance to the lawyer of the opposite party to try to discredit the autopsy surgeon.

Asphyxia

By asphyxia, we mean mechanical asphyxia. Cases that routinely come to mortuary are the cases of hanging, strangulation, smothering, etc. When such a case is brought, the neck dissection becomes a vital part during postmortem examination. The doctor performing should carefully look for signs of struggle, examine the neck structures and other signs of asphyxia and arrive at a conclusion. Another subcategory in this is drowning. Drowning has been a difficult area for an autopsy surgeon. The diagnosis is based on exclusion criteria.

Thermal Deaths

Though not necessarily, these cases can be related to dowry. Hence, the autopsy surgeon should make sure that the request is received from the appropriate authority as mentioned earlier. The determination of the cause of death is a little tricky in these cases. It might be possible that the body is burnt to a great extent, but the cause of death is head injury due to a fall of part of the building. Artifacts should be kept in mind.

Firearm/Bomb Explosion

These cases are not common; mostly concentrated in areas prone to violence. Though not very complicated, many fear performing autopsies in these types as they are not encountered regularly. Also, knowledge about firearms as well as the bomb, especially in recent times with extensive advances, is limited to an autopsy surgeon. Many times, due to ignorance the entry and exit wounds are described as simple lacerations. Evidence collection, photography, radiography, crime scene analysis, etc. too are important in such cases.

Decomposed Cases

The authors believe that the decomposed cases are the most difficult ones to be performed. The autopsy surgeon performing on these cases requires good experience to interpret the findings. Due to decomposition, the findings get variedly altered; hence interpretation becomes difficult.

Poisoning Cases

If the case has had treatment before death, clinical notes are of great help to the autopsy surgeon. But in cases 'brought dead' due to the involvement of a poisonous substance, the postmortem findings are usually minimal and may not conclusive. The only evidence at times maybe only the detection of poisonous substance at chemical analysis. Here, the autopsy surgeon should not only be vigilant but also knowledgeable enough to collect relevant samples before they get contaminated.

Skeletal/Fragmented/Charred/Dismembered Remains

Cases under this category aren't uncommon these days. Usually resorted to hiding the crime by destroying the evidence. Yet, a careful autopsy can answer most of the required questions or at least provides valuable clues to investigating officer for furthering the investigations.

Unknown/Unclaimed Cases

These deaths are usually due to natural causes, though unnatural manners cannot be completely ruled out. To cite one example, there have been a series of cases of homicidal cyanide poisoning in the state of Karnataka. These cases were subjected to postmortem examination as unknown/unclaimed bodies and the postmortem examination was also done where no obvious findings were noted, and viscera was also not preserved for chemical analysis as no doubt was there.

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Chapter

2

Diagnosis of Death and its Medicolegal Importance

Mandar Ramchandra Sane, Ashish Saraf

Traditionally, medical men have been diagnosing death by clinical signs. In earlier times, cessation of respiration and heart was considered as diagnostic of death. However, in conditions like apneic newborns, electrocution, shock, drowning, etc. individuals were observed to revive after the death was pronounced. The phenomenon observed was of suspended animation where there was a reversible stoppage of the cardiac or respiratory system, or vitals were at such minimal level that their activity was unrecordable. Hence, the concept of death was defined as the irreversible cessation of the circulatory or respiratory system.

However, the definition of death has evolved further due to the advent of advanced resuscitation techniques and advanced life-supportive measures (heart–lung bypass machines, dialysis machines, and ventilators). Similarly, it was compelled to change death declaration criteria due to the development of transplantation techniques. Whereas the functions of the lungs or heart may be managed, those of the brain cannot be taken over. Hence, a person is not dead unless his brain is dead. The evolved criteria are focused on brain death, which is a vital component of Bishop's triad.

Section 46 of the Indian Penal Code states, 'the word death denotes the death of a human being unless the contrary appears from the context'.[1]

The Registration of Births and Deaths Act, 1969, defines death as 'permanent disappearance of all evidence of life at any time after live birth has taken place'.[2]

Ad Hoc Committee of the Harvard Medical School defines death as unreceptive and unresponsive, no movements, no spontaneous respiration, no reflexes, and isoelectric EEG.[3]

The Transplantation of Human Organ Act, 1994 (THOA) defines a deceased person as a person in whom permanent disappearance of all evidence of life occurs, by reason of brainstem death or in a cardiopulmonary sense, at any time after live birth has taken place.[4]

Hence, practically, and clinically, deaths can be categorized into two modes:

a. Death due to cardiorespiratory arrest
b. Death due to brain death

Though the death defining criteria have changed, these criteria cannot be implemented uniformly in all circumstances. Routinely, modes of death are diagnosed by assessing cardiorespiratory parameters. However, when a patient is on heart–lung machine (life-supporting measures), cardiorespiratory parameters are not useful for diagnosing death. In such cases, criteria for diagnosing brain death must be used. Diagnosing criteria for both types of death are elaborated for practical reference.

Cardiorespiratory Arrest

Diagnosing the occurrence of death and determining processes that lead to cardiorespiratory arrest (cause of death) are two different processes. Determining 'cause of death' and its certification is an altogether exhaustive topic and is beyond the scope of the present discussion. Death has to be diagnosed using acceptable criteria for medical practice.

Obsolete tests for testing stoppage of the circulatory system like Magnus's test, Icard test, diaphanous test, finger–nail test exist. Similarly, obsolete tests for testing stoppage of the respiratory system like mirror test, feather test, Winslow's test, etc. too have been described.[5] However, in the present scenario of more objective means of testing, the tests, as mentioned above, do not justify further elaboration here.

Death due to cardiorespiratory arrest has to be diagnosed if resuscitation (CPR) fails to revive the patient. (CPR has to be done unless explicitly prohibited by 'Do not resuscitate' directives. It is essential to rule out chance revival in cases of suspended animation). Death due to cardiorespiratory arrest is diagnosed by following features:

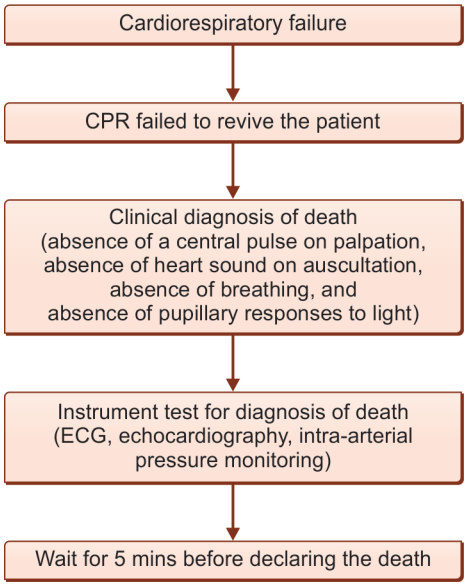
- Unresponsiveness,
- Absence of breathing or only occasional gasps, and
- Absence of circulation

The above conditions can be tested clinically by:

- absence of a central pulse on palpation,
- absence of heart sound on auscultation,
- absence of breathing, and,
- absence of pupillary responses to light

If available, instrumental tests, like ECG, absence of pulsatile flow during intra-arterial pressure monitoring or absence of contractile activity using echocardiography must be performed to document isoelectric line indicating the absence of cardiac activity. After performing the above tests, it is necessary to wait several minutes (at least 5 minutes) to ensure that there is no spontaneous return of cardiac or respiratory function. The waiting duration of 5 minutes is arbitrary, and it varies in different regions according to prevalent medical practice. The following working algorithm is recommended for diagnosing death due to cardiorespiratory failure/arrest (Flowchart 2.1).

Flowchart 2.1: Algorithm for diagnosing death due to cardiorespiratory failure[6]



Brain Death[7,8]

Brain death implies brainstem death as vital centers like the respiratory center, cardiac center, and reticular activating system (center responsible for consciousness and awareness) are situated at the brainstem. Various criteria have been developed for the diagnosis of brainstem death. Harvard criteria, Minnesota criteria, Philadelphia criteria, etc. are among a few of them. Brainstem death defining criteria mandated by the Transplantation of Human Organ Act, 1994 (THOA), is derived from the criteria mentioned above.

Following are the requisites before brainstem death can be declared (Fig. 2.1):

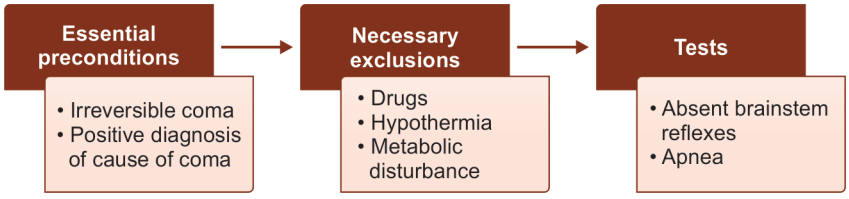


Fig. 2.1: Preconditions, exclusions and tests for declaring brainstem death

Essential Preconditions

Coma must be irremediable, and its cause must be clearly known. The most common cause of such a coma is structural brain damage.

Necessary Exclusions

Some conditions may impair brain functions reversibly. Common conditions may be drug intoxication, hypothermia (<35°C), or metabolic disturbance.

Preconditions and exclusions must be unequivocal. It must be strictly applied and may take a few days to meet the criteria. After these two filters are passed, the brainstem should be checked for its functions. It can be done by testing cranial reflexes and by apneic test. Except for smell and vision, all cranial nerves originate from the brainstem. Thus, by systematic examination of cranial reflexes, the brainstem can be examined 'slice-by-slice' (Table 2.1).

If doctor (or team of doctors) is in doubt about completeness or adequacy of clinical testing, then he should not diagnose brainstem death (Table 2.2). The structural and functional damage of the brainstem may be diagnosed depending upon the following observations:

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

Table 2.1: Cranial nerve reflexes[9]

Reflex	Cranial nerve		Location in the brainstem
Pupillary light reflex	Afferent	II	Midbrain
	Efferent	III	
Vestibulo-ocular reflex	Afferent	VIII	Midbrain, pons
	Efferent	III, VI	
Corneal reflex	Afferent	V	Pons
	Efferent	VII	
Grimace response due to painful stimulus over face/limbs	Afferent	V	Pons
	Efferent	VII	
Pharyngeal (gag) reflex	Afferent	IX	Medulla
	Efferent	X	

Apnea Test

The basis of the apnea test is to test whether the brainstem can trigger off respiration. The respiratory drive must be stimulated at the critical level of CO_2. The patient must be pre-oxygenated thoroughly, so that he should not face hypoxia. Thereafter, the patient must be disconnected from the ventilator, and blood CO_2 must be monitored.

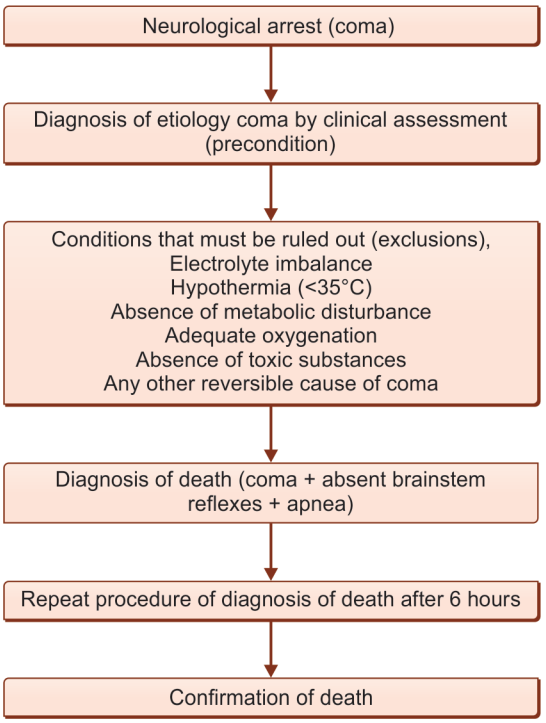
Table 2.2: Constitution of medical team for diagnosis of brain death [THOA][4]

1. The medical administrator-in-charge of the hospital where brain death has occurred.
2. An independent specialist, from a panel of doctors, as approved by the appropriate authority.
3. A neurologist or neurosurgeon, if either of them is not available then, an anesthetist or intensivist, physician, or surgeon as nominated by the medical administrator-in-charge of the hospital
4. The registered medical practitioner treating the patient
   - The certification of brain death requires to be done twice with a minimum time interval of 6 hours between two certificate processes.
   - The doctor involved in the transplantation procedure must not be involved in the death diagnosing/certification team.

There should no arbitrary time limit up to which the ventilator shall remain disconnected. One should not wait till respiration starts; the cut-off point for the apneic test should be a CO_2 level of 50 mm Hg. At this level of blood CO_2, it is assumed that respiration is triggered if cells at the respiratory center are still surviving. The protocol of conducting the apneic test must be stringent, and care should be taken that patient must not become anoxic throughout the test.

It must be remembered that the apneic test aims to diagnose brainstem death, and not to cause it. Cranial nerve reflexes and the apneic test must be repeated after a few hours. Harvard criteria recommended 24-hour time duration while Minnesota criteria suggested 12 hours (Flowchart 2.2).

Flowchart 2.2: Algorithm for diagnosing death due to neurological failure[6]



However, the Transplantation of Human Organ Act, 1994 (THOA) mandates that all the above tests must be repeated after 6 hours. Unequivocal agreement about the absence of response of the above tests signifies the occurrence of brainstem death.[10]

Death is a process and not an event. Death will be invariably either due to cardiorespiratory failure or neurological failure. Death must be diagnosed only if the cessation of life is certain, irreversible, and unequivocal. However, for obvious reasons, diagnosis of death need not meet strict criteria in cases where early changes after death have set-in like primary flaccidity of muscles, changes in the eye, rigor mortis, livor mortis, or algor mortis, etc.

Medicolegal Importance of Diagnosis of Death

- Declaration of death
  - If a person is wrongly declared as dead and the body is either transferred to the mortuary or taken for cremation, it creates a big hue and cry and the attended doctor is liable for disciplinary action by the respective State Medical Council.
  - The act of wrong death certification by the doctor makes him liable for disciplinary action by the respective State Medical Council
- Issue of a cause of death certificate
  - A cause of death certificate is to be issued to the relative of the deceased, once the death of the person is confirmed
  - This is required for registration of death at the local registrar of births and deaths
  - The same certificate is also required for insurance purposes also
- Manner of death
  - Needs to be determined in every case of death
  - In cases of natural death, no investigation is required to fix responsibility for the death
  - But in cases of unnatural deaths, the investigation by law enforcing agencies is required to fix the responsibility for the death
  - For insurance claims,
    i. It usually becomes 'no claim' in case of suicidal deaths within 1 year of taking the policy
    ii. In case of accidental death, the claims are usually doubled (as per the policy)
- Disposal of body

  Cannot be cremated unless death is certified by a registered medical practitioner
- Presumption of death
  - As per Indian Law, if a person has lived for 30 years; goes missing, and is not seen alive by his near and dear ones for a continuous period of 7 years, it gives a legal presumption of death, and certification can be obtained from Court of Law
- Organ transplantation
  - Tissues for organ transplantation can only be removed only after the person has been declared as dead (brainstem death/somatic death)

Duties of a Registered Medical Practitioner for Attending a Person in Terminal Illness/ Already Dead Person

- Diagnose death (beware of 'suspended animation')
- Pronounce death

- Fill up Form No. 2
  - If sure to the best of his knowledge and belief, the cause of death, fill up the MCCD form (4 or 4A)
  - If unsure about the cause of death, inform the concerned authorities for further investigations
- Reporting and certification
  - Both are separate entities
  - Reporting

    Any person who knows the event as covered under RBD Act, 1969
    - Form 1—Birth report (pink form)
    - Form 2—Death report (yellow form)
    - Form 3—Stillbirth report (blue form)
  - Certification
    - By a medical practitioner as specified by respective State Governments

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Chapter

3

Medical Certification of Cause of Death

Swapnil Sudhirkumar Agarwal

Introduction

Medical certification of cause of death (MCCD) scheme is basically a part of the international statistical classification of diseases (ICD) and health-related problems formulated by WHO. The purpose of ICD is to permit systematic recording, analysis, interpretation, and comparison of morbidity and mortality data collected in different countries or areas at different times. It is because of this importance, a provision has been made in the Registration of Births and Deaths Act, 1969 for certification by a medical practitioner who has attended the deceased during his last illness.

Rules as per Registration of Birth and Deaths Act, 1969 (as amended) relevant to a medical practitioner:[1]

A medical practitioner-in-charge of a hospital, maternity home, health center, nursing home, or other like institutions has to notify births as well as deaths within 21 days of occurrence (the **Forms 1 and 2** are given at the end) **[Section 8 (1-b)]**. Every State Government has made a provision to obtain a cause of death certificate from a medical practitioner **[Section 10 (2)]**. With regards to section 10 (2), in case of death of a person, a certificate of cause of death has to be issued by a medical practitioner who attended the deceased in his last illness without charging any fee in the prescribed form ***stating to the best of his knowledge and belief, the cause of death*** and the same has to be delivered to registrar of births and deaths at the time of notifying death **[Section 10 (3)]**. Any person on payment of required fees and postal charges subject to any rules made by respective State Government can obtain an extract from the register relating to any birth or death, without disclosing confidentiality of the cause of death **[Section 17 (1-b)]**. If a medical practitioner neglects or refuses to issue a cause of death certificate as per Section 10 (3), he is liable to be punished with a fine up to ₹50/- **[Section 23 (3)]**.

Responsibilities of Medical Practitioner

All hospital deaths including medicolegal case deaths are to be covered under MCCD. As per the MCCD scheme, any medical practitioner attending the deceased in his/her last illness, after the death of the person shall fill in **Form No. 4** (for institutional deaths) and **Form No. 4A** (for non-institutional deaths).

Medical practitioners are instructed not to fill and submit just form 4/4A for stillbirths. For stillbirths, separate **Form 3** is made available. He has to send the completed form to the respective district registrar of birth and deaths by the 5th of every month that in turn has to send it to the chief registrar of the state who shall send it to the Registrar General, India.[2] The information on the cause of death is kept confidential and is not indicated on the death certificate that is later issued by the registrar of births and Deaths **(Form 6)**. This safeguard is intended to enable the doctors to bestow sufficient care and attention in writing the certificate, so that mortality statistics will reflect the best medical opinion, concerning causes of death. **Form 5** is the birth certificate issued by registrar's office following intimation from registered medical practitioners about birth as per **Section 8 (1-b)** as stated above.

Precautions to be Taken during the Issue of Cause of Death Certificate

1. Every certificate should be issued in the prescribed form only.
2. No fee is to be charged for the cause of death certificate nor its issue withheld for want of payment of one's fees.
3. More than one cause of death certificate must never be issued. If for any reason, a duplicate is required, only a true copy should be provided.
4. Under no circumstance, should a medical practitioner sign a blank certificate before the death of the patient and leave the task of filling in the details on someone else.
5. Under no circumstance should a medical practitioner issue a death certificate if he is not certain about the cause of death.
6. No death certificate should be issued under the following circumstances:
   a. When a practitioner is called to see a person, who has died suddenly and whom he had never before examined, he must not issue a cause of death certificate even though he may personally know the patient or be able to conclude the cause of death from the history supplied to him.
   b. When a patient is brought to the emergency and if found already dead or dies within minutes where no reason as to cause of death can be ascertained, one must not rely on history and never issue a cause of death certificate.
   c. When a practitioner is not sure of the cause of death of his patient or if he has some suspicion regarding the true cause of death, he must not issue a cause of death certificate.

(In 1st instance, the relatives must be asked to inform the nearest police station and get a postmortem done to have a cause of death. In second and third instance, the practitioner must himself inform the concerned police station and get a medicolegal postmortem done).

It is an offense to issue any false medical certificate (including the cause of death certificate), punishable under Section 197 IPC with imprisonment up to 7 years with a fine.

Who can Issue a Cause of Death Certificate?

Following medical practitioners can issue cause of death certificate, as allowed by respective regulatory councils:

1. Registered medical practitioner qualified in Western medicine
2. Medical practitioner qualified in homeopathic medicine

3. Medical practitioner qualified in Indian medicine
4. Medical practitioner qualified in dentistry (A registered dental surgeon involved independently in the treatment of dental and oral surgical problems may be called upon to sign certificates, notifications, reports, etc. He is bound to issue such certificates and to sign them. Documents relating to disability, injury in the oral and maxillofacial region and deaths occurring while under the care of such dental surgeons should be signed by them in their professional capacity for subsequent use in courts or administrative purposes, etc.)

Instructions on How to Fill the Certificate

- The name of the deceased should be in full—not in initials.
- In case of infants not yet named at the time of death, write S/o or D/o followed by names of father and mother. If the deceased is above the age of 1 year, give the age in completed years, if below 1 year, give the age in months, if below 1 month, give the age in the completed number of days and if below 1 day, give it in completed hours.
- The sex of the deceased should be clearly stated.
- The column for the cause of death is divided into two parts:
  - Part I and part II. Part I has three parts (a), (b), and (c). The cause of death includes any disease or injury responsible to a chain of events incompatible with life resulting in the death of a person.[3] In single morbid condition, it should be written on line (a) of part I. Nothing else needs to be written. The immediate cause is reported in line (a). It is the disease/injury/complication that preceded death. It may be the sole entry. But there must be an entry. The mode of dying (heart failure/respiratory failure/cardiorespiratory arrest) should never be entered. Mode or mechanism of death is the physiological disturbance or derangement resulting from the cause of death being incompatible with life.[3] It serves no purpose. If the condition on line (a) is due to another condition, record that in line (b). It is antecedent to the immediate cause of death. If the condition on line (b) is due to another underlying condition, mention it in line (c). It is the condition antecedent to condition on line (b). If the condition on line (b) is the underlying condition, then nothing more should be entered. When many conditions are involved, write the full sequence. There should only be one condition per line with most recent condition at the top; example: (a) Perforation—(b) intestinal obstruction—(c) inguinal hernia; septicemia—(b) gangrene foot—(c) diabetes.
  - In part II, other conditions/diseases that unfavourably influenced the course/modified/contributed to the fatal outcome, should be written. It may even not relate to the disease-causing death.
- The next column is for the interval between onset of diseased condition and death. Write exact period when it is known. When unknown, an approximate period should be written. It provides a useful check on the sequence of events.
- The last column is for the ICD code. That is not to be filled by the certifying medical practitioner. It shall be filled at the registrar's office after consulting the International Statistical Classification of Diseases 10 and National List prepared from ICD 10.

  The list is exhaustive, available with the district registrar and online too.

- Below the cause of death column, there is provision for indicating the manner of death; being natural, accidental, suicidal, homicidal or if pending investigation. Manner of death is the fashion in which the death occurred.[3]
- The certifying practitioner is expected to write how the injuries occurred, as the case may be.
- Lastly for female deaths, one has to mention whether the death was associated with pregnancy. If yes, whether there was delivery or not?
- Below the certificate, every medical practitioner is expected to sign and write his full name and designation along with the date (preferably use seal).

The last part is a detachable portion of the certificate which has to be duly filled and given to the next of kin of the deceased along with the body. In this part, confidentiality regarding the cause of death is to be maintained. The purpose of giving the last portion is to enable the relative to register the death of the deceased.

Perceived Lacunae Regarding Medicolegal Cases in Certification of Cause of Death

- **Firstly,** in case of deaths from violence, not admitted to hospital, the interval between onset of terminal events and cause of death cannot be mentioned. The column will have to be left blank.
- **Secondly,** in case of spot deaths and dead bodies being brought to the hospital, it is not possible to find out and write the chain of events leading to death. Here, only the immediate cause of death will have to be given after postmortem examination. The certificate may be filled by the medical examiner based on evidence noticed by him. The fact of death in such cases should, however, be communicated to the local registrar in the prescribed format *(Form 2)* pending the final filling up and transmission of the medical certificate to the registrar concerned.[4]
- **Thirdly,** it is not always possible to correctly comment on the manner of death as many cases turn out the other way after the police investigation. A case being brought as natural death may turn out to be homicidal after the police investigation. Here, one should comment on the manner of death only when there is surety about it, otherwise better to leave the column blank.
- **Fourthly,** in medicolegal cases, being treated at a hospital and having subsequent death, it is expected that the treating doctor should not write a cause of death certificate. Instead, the doctor performing the autopsy should issue Form 4 after conducting the autopsy along with the autopsy report mentioning the same cause of death. This Form 4 certificate is to be given to police or hospital authorities for subsequent submission to the registrar is yet not clear. At one training session, a reference has been quoted that *Form 4* should be given to the police and the respective registrars should collect from the police stations. This seems impractical.
- **Fifthly,** if at postmortem, the cause of death is kept pending for some investigation like chemical analysis, histopathological examination, etc., then MCCD cannot be filled and sent. Instead, it has to be filled and submitted mentioning the cause of death after obtaining the reports of investigation. The certificate should bear the MLC no. and PM no. along with other particulars to help identify the case.[4]

References

1. The Registration of Birth and Deaths Act, 1969 (Act No. 18 of 1969). Available at World Wide Web https://www.indiacode.nic.in/bitstream/123456789/11674/1/the_registration_of_births_and_deaths_act%2C_1969.pdf
2. Office of the Registrar General of India, Vital Statistics Division. Physicians' Manual on Medical Certification of Cause of Death. 4th ed. New Delhi: Ministry of Home Affairs, Government of India; 2000.
3. Mathiharan K, Patnaik AK: Modi's Medical Jurisprudence and Toxicology. 23rd ed. New Delhi: Lexis Nexis; 2005. p 357.
4. State Bureau of Health intelligence, Gujarat state. Manual on Medical Certification of Cause of Death (MCCD Scheme). Gandhinagar: Commissionerate of Health, Medical Services and Medical Education, Government of Gujarat; 2002.

REPORTING OF BIRTH [FORM 1]

BIRTH REPORT **[See Rule 5]**

Statistical information

This part to be detached and sent for statistical processing

Legal information To be filled by the informant

This part to be added to Birth Register

To be filled by the informant

1. Date of birth	
2. Sex	
3. Name of child	
4. Name of father	
5. Name of mother	
6. Place of birth 1. Hospital/ Institution Name: Address: 2. House: 3. Other	
7. Informant's name: **Address:**	

Date:

Signature or left thumb mark of the informant

To be filled by Registrar

Registration No.:

Registration Date:

Registration Unit:

Town/Village: District:

Taluk:

Remarks [if any]

Name & signature of Registrar

To be detached and sent for statistical processing

8. Town or Village of Residence of the Mother:

a) Name of the Town/Village

b) Is it a town or village (Tick the appropriate entry below)

1) Town 2) Village

c) Name of District:

d) Name of State:

9. Religion of the family: (Tick the appropriate entry below)

1) Hindu 2)Muslim

3) Christian

4) Any Other Religion(write name of the religion)

10. Father's level of Education:

11. Mother's level of education:

12. Father's Occupation:

13. Mother's Occupation:

14. Age of the mother at the time of marriage(in completed years)

15. Age of the mother at the time of this birth(in completed years)

16. Number of children born alive to the mother so far including this child:

17. Type of attention at delivery:

1) Institutional – Government

2) Institutional – Private or Non-Government

3) Doctor, Nurse or Trained midwife

4) Traditional Birth Attendant

5) Relatives or others

18. Method of Delivery: 1) Normal 2) Caesarean 3) Forceps/Vacuum **19. Birth weight** (in kgs.): **20. Duration of pregnancy** (in weeks): (Columns to be filled are over. Now put Signature at left)	**Procedure** 1. Enter the exact day, month and year the child was born e.g. 1.1.2000) 2. Enter "male" or "female" do not use abbreviation 3. If not named, leave blank 4. Full name as usually written (Same for sl.no.5) 5. Tick the appropriate entry 1 or 2 below and give the name of the Hospital/Institution or the address of the house where the birth took place.
To be filled by Registrar Name: Code No: District: Tahsil: Town/Village: Registration Unit: Registration No: Registration Date: Date of Birth: Sex: 1)Male 2)Female Place of Birth: 1) Hospital/Institution 2) House Name and signature of the Registrar	6. Place where the mother usually lives. This can be different from the place where the delivery occurred. The house address is not enquired to be entered. 7. Enter the completed level of education e.g. if studied upto class VII but passed only class VI, write class VI. 8. Enter the completed level of education e.g. if studied upto class VII but passed only class VI, write class VI. 9. If no occupation write 'Nil 10. If no occupation write 'Nil 11. If married more than once, age at first marriage may be entered. 12. Number of children born alive to include also those from earlier marriage(s), if any 13. Tick the appropriate entry below 14. Tick the appropriate entry below *I. In the case of multiple births, fill in a separate form for each child and write 'Twin birth' or 'Triple birth' etc, as the case may*

REPORTING OF DEATH [FORM 2]

DEATH REPORT [SEE RULE 5]

Legal information

Statistical information
This part to be detached and sent for statistical processing

This part to be added to Death Register

To be filled by the informant

1. Date of death	
2. Name of deceased	
3. Permanent address	
4. Name of father/mother/ husband	
5. Sex of deceased	
6. Age of deceased	
7. Place of death 1. Hospital/ Institution Name: Address: 2. House: 3. Other	
8. Informant's name: **Address:**	

Date:

Signature or left thumb mark of the informant

To be filled by Registrar
Registration No.:
Registration Date:

Registration Unit: District:
Town/Village: Taluk:

Remarks [if any]

Name & signature of Registrar

To be detached and sent for statistical processing

9. Town or Village of Residence of the Deceased:
a) Name of the Town/Village
b) Is it a town or village (Tick the appropriate entry below)

1) Town 2) Village

c) Name of District:
d) Name of State:

10. Religion: (Tick the appropriate entry below)
1) Hindu 2) Muslim
3) Christian
4) Any Other Religion (write name of the religion)

11. Occupation of the Deceased:

12. Type of the medical attention received before death(Tick the appropriate entry below):
a. Institutional
b. Medical attention other than institution
c. No medical attention

13. Was the cause of death medically certified
(Tick the appropriate entry below)
1. Yes 2. No

14. Name of Decease or actual cause of death

15. In case of this is a female death did the death occur while pregnant, at the time of delivery or within six weeks after the end of pregnancy: (Tick the appropriate entry below)

1. Yes 2. No

16. If use to habitually smoke for how many years?

17. If used to habitually chew tobacco in any form – for how many years?

18. . If used to habitually chew arecanut in any form (including pan masala**) – for how many years?**

19. If used to habitually drink alcohol for how many years?

To be filled by Registrar

Name: Code No:

District:

Tahsil:

Town/Village:

Registration Unit:

Registration No:

Registration Date:

Date of Death:

Sex: 1) Male 2) Female

Age: Years/months/days/hours

Place of Death: 1) Hospital/Institution

2) House 3) Other place

Name and signature of the Registrar

REPORTING OF STILL BIRTH [FORM 3]

FORM NO.3 STILL BIRTH REPORT

Legal information

This part to be added to the Still Birth Register

To be filled by the informant (After completing all items 1 to 12, informants will put date and signature after item 6)

1. Date of birth:

2. Sex:

3. Name of father:

4. Name of mother:

5. Place of birth:

1. Hospital/ Institution — Name:
2. House — Address:
1. Other place

6. Informant's name:

Address:

Date: Signature or left thumb mark of the informant

To be filled by the registrar

Registration No :

Registration Unit :

Registration Date :Town/Village :

Taluk :

District :

Remarks : (if any)

Name and Signature of the Registrar

To be detached and sent for statistical processing

STILL BIRTH REPORT

(See Rule 5)

Statistical information

This part to be detached and sent for statistical processing

7 Town or Village of residence of the mother :

a) Name of the Town/Village:

b) Is it a town or village : (Tick the appropriate entry below)

1. Town 2.Village

c) Name of District:

d) Name of State:

8 Age of the mother(in completed years) at the time of this birth :

9 Mother's level of education :

10 Type of attention at delivery : (Tick the appropriate entry below)

1.Institutional - Government
2. Institutional - Private or Non-Government
3. Doctor,Nurse or Trained midwife
4. Traditional Birth Attendant
5. Relatives or others

11 Duration of pregnancy : (in weeks)

12 Cause of foetal death : (if known)

Note: See instructions over leaf carefully for filling items 1 to 12

(Send this to the Registrar within 21 days) *To be filled by the Registrar* Name Code No.:	***Item Instructions***
District: Taluk: Town/ village: Registration unit: Registration no.: Date of birth: Date of registration: Sex: 1. Male 2. Female Place of birth: 1. Hospital/ Institution 2. House 3. Other place Name & signature of registrar	1 Enter the exact day, month and year e.g. 1-1-2000 2 Enter "male" or "female" Do not use abbreviation 3 Full name as usually written 4 Full name as usually written 5 Tick the appropriate entry below and give the name of the Hospital/Institution or the address of the house where the birth took place e.g. 1.Hospital 6 Place where the mother usually lives. This can be different from the place where the delivery occurred. The house address is not required to be entered. 7 Enter the completed level of education e.g. if studied upto class VII but passed only class VI, write class VI 8 Tick the appropriate entry below. E.g. 1. Institutional – Government ***In the case of multiple births, fill in a separate form for each child and write 'Twin birth' or 'Triple birth' etc., as the case may be, in the remarks column in the box below left.***

MEDICAL CERTIFICATION OF CAUSE OF DEATH (MCCD)

(Directions for completing the form)

Name of deceased: To be given in full. Do not use initials. If deceased is an infant, not yet named at time of death, write 'Son of (S/o)', or 'Daughter of (D/o)', followed by names of mother and father.

Age: If the deceased was over 1 year of age, give age in completed years. If the deceased was below 1 year of age, give age in months and if below 1 month give age in completed number of days, and if below one day, in hours.

Cause of death: The attending physician should always complete this part of the form personally. The certificate of cause of death is divided into two parts, I and II. Part I is again divided into three parts, line (a), (b) and (c). If a single morbid condition completely explains the deaths, then this will be written on line of part I and nothing more is needed to be written in the rest of part I or part II, for example, gastroenteritis, lobar pneumonia, rabies are sufficient cause of death and usually nothing more is needed.

Often, however, a number of morbid conditions might be present at death and the doctor must then complete the certificate in the proper manner so that the correct underlying cause will be tabulated. First enter in part I, line (a) the immediate cause of death. This does not mean the mode of dying, e.g. heart failure, respiratory failure, etc. These terms should not appear in the certificate at all since they are modes of dying and not the cause of death. Next consider whether the immediate cause is a complication or delayed result of some other cause. If so, enter the antecedent cause in Part I, line (b). Sometimes, there will be three stages in the course of events leading to death. If so, line (c) will be completed. The underlying cause to be tabulated is always written last in part I.

Morbid conditions or injuries may be present which were not directly related to the chain of event causing death but which contributed in some way to the fatal outcome. Sometimes, the doctor finds it difficult to decide, especially for infant deaths which of the several independent conditions were the primary cause of death; but only one cause can be tabulated, so the doctor must decide. If the other diseases are not the effects of the underlying cause, they are entered in part II.

Do not write two or more conditions on a single line. Please write the names of the diseases (in full) in the certificates as legible as possible to avoid the risk of their being misread.

Onset: Complete the column for interval between onset and death whenever possible, even if very approximately, e.g. 'from birth, several years'.

Accidental or violent deaths: Both the external cause and the nature of the injury are needed and should be stated. The doctor or the hospital should always be able to describe the injury, stating the part of the body injured and should give the external cause in full when it is shown. Example: Hypostatic pneumonia, fracture of neck, femur, fall from ladder at home, etc.

Maternal deaths: Be sure to answer the questions on pregnancy and delivery. This information is needed for all women of childbearing age, even though the pregnancy may have had nothing to do with the death.

Old age or senility: Old age or senility should not be given as a cause of death, if a more specific cause is known. If old age was a contributory factor, it should be entered in part II, for example, chronic bronchitis in old age.

Completeness of information: A complete case history is not required but if the information is available, enough details should be given to enable the underlying cause to be properly classified.

Examples: Anaemia—give the type of anaemia; If known neoplasms—indicate whether benign or malignant with site of neoplasm, whenever possible; in heart diseases, describe the condition specifically—if congestive heart failure, cor pulmonale, etc. are mentioned, give the antecedent conditions; tetanus—describe the antecedent injury, if known; operation—state the condition for which the operation was performed; dysentery—specify whether bacillary/amoebic, etc. if known complications of pregnancy or delivery—describe the complication specifically; tuberculosis—give the organ affected.

Symptomatic statement: Convulsions, diarrhoea, fever, ascites, jaundice, debility, etc. are symptoms that may be due to any one of number of different conditions. Sometimes, nothing more is known, but whenever possible, give the disease which caused the symptom.

Manner of death: Deaths not due to external cause should be identified as 'natural'. If the cause of death is known, but it is not known whether it was the result of accident/suicide/homicide and is subjected to further investigation, the cause of death should invariably be filled in and the manner of death should be shown as 'pending investigation'.

MEDICAL CERTIFICATION OF CAUSE OF DEATH [FORM 4]

(For hospital in-patient deaths; not to be used for stillbirths)

TO
THE REGISTRAR OF BIRTH AND DEATHS

District _____

Name of the hospital _____. I hereby certify that the person whose particulars are given below died in the hospital in Ward No. _____ on _____at _____AM/PM.

NAME OF THE DECEASED					For use of statistical office
SEX	Age at death				
	If 1 year or more, age in years	If less than 1 year, age in months	If less than 1 month, age in days	If less than 1 day, age in hours	
1. Male 2. Female					
Cause of death 1. Immediate cause State the diseases, injury or complication which caused death, not the mode of dying such as heart failure, asthenia etc. (a) _____ (Due to/as consequence of) Antecedent cause morbid conditions, if any, giving rise to the above cause stating underlying conditions last (b) _____ (Due to/ as consequence of) (c) _____ 2. Other significant conditions contributing to the death but not relating to the disease or conditions causing it _____ _____				**Interval between onset & death**	

Manner of death

1. Natural 2. Accident 3. Suicide
4. Homicide 5. Pending investigation

How did the injury occur?

If the deceased was female, was the death associated with pregnancy? 1. Yes 2. No
If yes, was there a delivery? 1. Yes 2. No

Name and signature of the Medical Practitioner certifying the cause of death
Date of verification

(To be detached and handed over to the relatives of the deceased)

Certified that Shri/Smt./Kum. _____ S/W/D of Shri _____ R/o _____ was admitted to this hospital on _____ and expired on _____ at _____ AM/PM.

Doctor _____
(Medical superintendent and name of the hospital)

MEDICAL CERTIFICATION OF CAUSE OF DEATH (FORM NO. 4A)

(For non-institutional deaths; not to be used for stillbirths)

TO
THE REGISTRAR OF BIRTH AND DEATHS

District _____

I hereby certify that the deceased Shri/Smt./Kum. _____
S/W/D of _____, resident of _____ was under my treatment from _____ to _____ and he/she died on _____ at _____ AM/PM.

NAME OF THE DECEASED					For use of statistical office
SEX	Age at death				
	If 1 year or more, age in years	If less than 1 year, age in months	If less than 1 month, age in days	If less than one day, age in hours	
1. Male 2. Female					
Cause of death 1. Immediate cause — State the diseases, injury or complication which caused death, not the mode of dying such as heart failure, asthenia etc. (a) _____ (Due to/as consequence of) Antecedent cause morbid conditions, if any, giving rise to the above cause stating underlying conditions last (b) _____ (Due to/as consequence of) (c) _____ 2. Other significant conditions contributing to the death but not relating to the disease or conditions causing it _____ _____				**Interval between onset & death**	

Manner of death

1. Natural 2. Accident 3. Suicide
4. Homicide 5. Pending investigation

How did the injury occur?

If the deceased was female, was the death associated with pregnancy? 1. Yes 2. No
If yes, was there a delivery? 1. Yes 2. No

Name and signature of the Medical Practitioner certifying the cause of death
Date of verification

(To be detached and handed over to the relatives of the deceased)

Certified that Shri/Smt./Kum. _____ S/W/D of Shri _____ R/o _____ was under my treatment from _____ to _____ and he/she died on _____ at _____ AM/PM.

Doctor _____
(Medical Superintendent and Name of the hospital)

FORM NO. 5
(See Rule 8)

BIRTH CERTIFICATE
(Issued under Section 12/17)

This is to certify that the following information has been taken from the original record of birth which is registered for (local area) .....of ..... Tahsil .....of District ..... of State .....

Name: .....
Sex:.....
Date of Birth: .....
Place of Birth: .....
Name of Father: .....
Name of Mother: .....
Registration No.: .....
Date of Registration: .....

Date :..... Signature of issuing authority
Seal

No disclosure shall be made of particulars regarding the cause of death as entered in the Register. See provision to Section 17(1).

FORM NO. 6
(See Rule 8)

DEATH CERTIFICATE
(Issued under Section 12/17)

This is to certify that the following information has been taken from the original record of death which is registered for (Local Area) ....of Tahsil ..... of District .... of State .....

Name: .....
Sex: .....
Date of Death: .....
Place of Death: .....
Registration No. .....
Date of Registration: .....

Date .....

Signature of issuing authority
Seal

No disclosure shall be made of particulars regarding the cause of death as entered in the register. See provison to Section 17(1).

Chapter

4

Basics of Postmortem Changes

Sujatha P Lagali, Mandar Ramchandra Sane

Postmortem changes are the changes that take place after the death of an individual.[1] They are divided based on their order of appearance as shown in Table 4.1.

Table 4.1: Postmortem changes[2]

(I) Immediate (somatic death)	1. Insensibility and loss of voluntary power
	2. Cessation of respiration
	3. Cessation of circulation
(II) Early (cellular death)	4. Pallor and loss of elasticity of the skin
	5. Changes in the eye
	6. Primary flaccidity of muscles
	7. Cooling of the body
	8. Postmortem lividity
	9. Rigor mortis
	10. Secondary flaccidity of muscles
(III) Late (decomposition and decay)	11. Putrefaction
	12. Adipocere formation
	13. Mummification

Immediate Changes

These are the changes that occur at the time of somatic death, i.e. the death of the body as a whole. These occur due to the stoppage of the functioning of 3 vital organs/ Bishop's tripod of life, viz. brain, heart, and lungs.

- Insensibility and loss of voluntary power: This is the first sign to occur after death due to the stoppage of functions of the brain. However, this condition can be seen in cases of vagal inhibition, epilepsy, catalepsy, narcosis, trance, electrocution, etc. It can be confirmed by flat EEG.
- Cessation of respiration: The absence of breath sounds for more than 5 minutes indicates somatic death.

- Cessation of circulation: A complete absence of heart sounds for more than 5 minutes indicates somatic death. Flat ECG can be taken as evidence of death.

The doctor should declare death only after confirming all the above signs.

Early Changes

- **Changes in the skin:**

Within a few minutes of death, face and skin become pale due to the stoppage of circulation and drainage of blood. Skin loses its elasticity and becomes lusterless. In cases of death associated with agonal spasm and where there has been an obstruction to the venous return due to compression over the neck or in cases of traumatic asphyxia, the face remains congested for some time after death.[3]

- **Changes in the eye:**

Loss of corneal reflex: Even though corneal reflex is lost after death, it can be encountered in living persons in cases of deep insensibility like narcotic poisoning, after general anesthesia, epilepsy, etc. Hence, it is not a reliable sign of death.

The opacity of cornea: After death, the cornea becomes dull and opaque due to drying. As eyelids are partially closed after death due to primary flaccidity, after few hours of death a film of cell debris, mucus, and dust settles on each side of the cornea over the exposed parts of the sclera, in the form of yellow triangles, which later become reddish-brown and then black, these are called **'tache noire'** (Fig. 4.1).

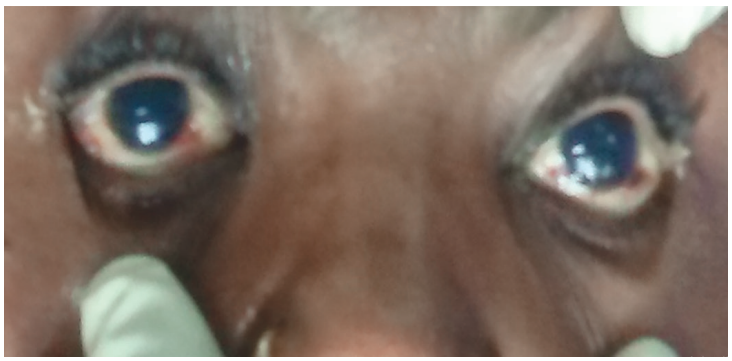


Fig. 4.1: Tache Noir De La Scelrotique (*Courtesy:* Sujatha P Lagali)

Flaccidity of eyeball: The eyes appear sunken and become softer immediately after death due to a reduction in the intraocular pressure. During life, the intraocular pressure varies between 14 to 25 g; soon after death it is less than 12 g; within half an hour it is less than 3 g and becomes nil at the end of 2 hours.[2]

Status of pupil: Pupils will be mid-dilated and fixed immediately after death due to loss of muscle tone, later they may become constricted after the onset of rigor mortis. Pupils react to chemical stimuli up to 2 hours after death.

Changes in the retinal vessels: Within few minutes of death, the bloodstream in the retinal vessels becomes segmented due to loss of blood pressure. This condition of 'trucking' is known as the Kevorkian sign, and it is one of the early and positive signs of death.

- **Primary flaccidity of the muscles:**

  Immediately after death, muscles lose their tonicity and become flaccid, loose, and lax. However, the muscles respond to electrical/mechanical stimuli during this period.

- **Cooling of the body (algor mortis/chill of death)**

  After death, the body starts losing heat. In a dead body, heat is lost by conduction (absorption of heat by objects in contact with the body), radiation (loss in the form of infrared heat rays), and convection (movement of air). Thus, loss of body heat is passive.[4] The usual temperature of a healthy adult at rest is about 98.4°F (37°C) when determined by mouth, whereas the temperature at the rectum under the same conditions is about 99°F and, in the axilla, about 97°F.

  The cooling curve is 'sigmoid shape' or inverted 'S' shaped with an initial plateau due to heat generation because of cellular metabolism for some time after death. Later the curve shows flattening.

  If one needs to determine time since death by body temperature, it can be done using the formula:

$$\text{Time since death} = \frac{\text{Normal body temperature} - \text{Rectal temperature}}{\text{Rate of temperature fall per hour}}$$

Recording the Temperature of the Dead Bodies

This is done by inserting a mercury thermometer with graduation from 0 to 50°C into the rectum. The bulb must be inserted at least 10 cm into the rectum. Multiple readings should be taken at an hourly interval without withdrawing the instrument. Alternative sites are axilla, deep nasal passage, or intra-abdominal (subhepatic) regions.

Factors Affecting the Rate of Cooling

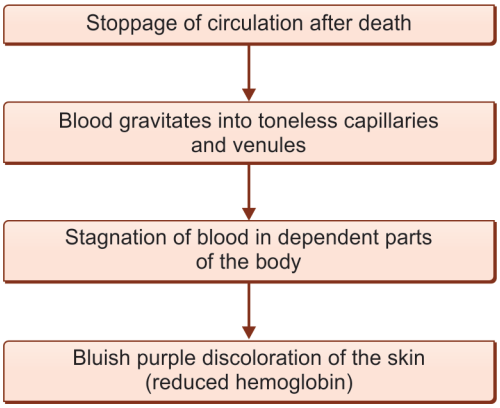
- *The temperature difference between body and surrounding atmosphere:* The rate of cooling is directly proportional to the excess temperature of the body than that of the surrounding atmosphere.[5]
- *Built of the body:* The rate of cooling is proportional to the body weight and its surface area.
- *The physique of the body:* As fat is a bad conductor of heat, cooling in fat bodies is slower than in lean bodies.
- *Medium around the body:* The cooling of the body depends on the medium in which the body is found. It is faster in moist air compared to dry air. Cooling is faster in water than in air.
- *Coverings on the body:* Cooling is slower in bodies covered well with the clothes.
- *Cause of death:* In cases of shock and hemorrhage, cooling is faster than in other cases due to loss of blood, as blood is warm.[6]

Cooling of the body helps in the estimation of time since death, more useful in cold and temperate climates.

There is another condition in which body temperature is raised for a few hours after death called ***Postmortem caloricity***. It is seen in the following conditions:

- Failure in the heat-regulating mechanism before death, e.g. sunstroke.
  - Increased heat production in muscles, e.g. strychnine poisoning, tetanus.
  - Excessive bacterial actions, e.g. septicemia, cholera.
- **Postmortem lividity/livor mortis** ***(postmortem hypostasis, postmortem staining, suggillations, vibices, darkening of death)***
  - This is the bluish-purple or purplish-red discoloration, which appears beneath the skin in the most superficial layers of the dermis of the dependent parts of the body after death due to capillovenous distention.

Mechanism



It starts appearing about 1 to 2 hours after death in the form of small red–blue patches beneath the skin, which later unite to form uniform purplish discoloration in another few hours (4–6 hours). It reaches a maximum of between 6 to 12 hours (primary lividity) and persists until putrefaction sets in.

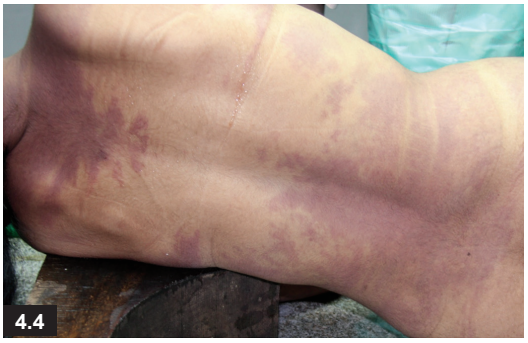
If the body is moved within a few hours after death, patches of lividity will disappear, and new ones will form on dependent parts (secondary lividity) if it is not fixed. Fixation means that the discoloration does not change with a change in the position of the body. This is tested by applying pressure over the area of postmortem staining, which will blanch if lividity is not fixed due to the movement of the blood, whereas if the lividity is fixed, it will not show any blanching (Figs 4.2 and 4.3). It can be differentiated from contusion by the absence of any swelling, its location on dependent parts, and blanching, when not fixed. In cases of doubt, put an incision over the stained area with an adjoining normal area and try to wash the staining with water (lividity, if not fixed, shall fade away on washing).

One may not find t in deaths due to excessive hemorrhage, severe anemia, or in cases of a dead body thrown in running streams.

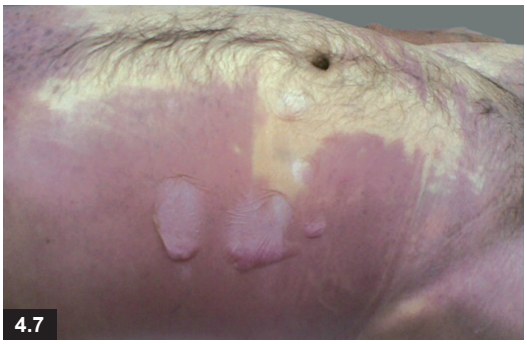
The distribution of postmortem hypostasis depends on the posture of the body after death. In a supine position, it will be more marked over the posterior and dependent parts like area against the lumbar region, posterior aspects of the flanks of the

Figs 4.2 and 4.3: Showing fixation of postmortem staining and blanching after removal of pressure (not fixed) (*Courtesy:* Swapnil Sudhirkumar Aggarwal)

abdomen, back of the neck, extensor surfaces of upper limbs, and flexor surfaces of the lower limbs. However, it is spared in areas that prevent the pooling of blood as they are pressed against the ground's surface. These areas are known as '*areas of contact flattening*,' which include the back of the head, back of shoulders, buttocks, back of thighs, and calves. Therefore, these areas will stand out depressed, flattened, pale, and blanched amidst the areas of discoloration due to hypostasis.[3] In the prone position, it is marked in front of the body (Figs 4.4 to 4.7).



Figs 4.4 and 4.5: Postmortem staining over the back and front of the body (*Courtesy:* Sujatha P Lagali)



Figs 4.6 and 4.7: Absent lividity over areas of tight clothing and surface contact; sides of the body even in a prone position (*Courtesy:* Swapnil Sudhirkumar Agarwal)

PM hypostasis is more marked on the either side in a body lying on either side, while if a body is suspended for a prolonged period after death, e.g. in case of hanging, lividity is mainly seen in lower limbs and distal portions of the upper limbs (Figs 4.8 to 4.10).

Figs 4.8 and 4.9: Livid areas of palms and soles due to suspension after death like in hanging (*Courtesy:* Swapnil Sudhirkumar Agarwal)

Fig. 4.10: PM staining in the lower limb in case of hanging (*Courtesy:* Sujatha P Lagali)

In drowning, postmortem hypostasis is usually found on the face, the upper part of the chest, hands, lower arms, feet, and the calves, as they are the dependent parts. If the body is continuously moving and changing its position, the staining may not develop after drowning in flowing water.

Vibices (postmortem ecchymoses/death spots) are tiny, spot-like, oval-to-round, bluish-blackish hemorrhages of postmortem origin exclusively limited to areas of livor mortis. Vibices result from postmortem mechanical rupture of subcutaneous capillaries and smaller vessels (predominantly veins) resulting from an increase in intravascular pressure from a pooling of erythrocytes in these vascular compartments under the influence of gravity during livor mortis formation.[7]

Hypostasis in internal organs develops in the same way as that on the skin. The site of distribution depends on the position of the body at the time of death. When a body is in a supine position, hypostasis is seen on posterior aspects of the ventricles of the heart, dorsal portions of the lungs, dorsal portions of the liver, kidneys, and the lowermost coils of the intestine.[8]

Postmortem lividity helps in estimating time since death, provides information about the position of the dead body after death or movement of the body within

6 hours after death; even manner of death as in hanging. Change from the usual colour also indicates the cause of death (Table 4.2).

Table 4.2: Colour changes of PM hypostasis in different conditions

Sl. No.	Colour	Reason
1.	Bluish-violet or purple	Asphyxia
2.	Brownish	Methemoglobinemia
3.	Bronze/greenish	Septic abortion due to *Clostridium perfringes/welchii*
4.	Pink	Hypothermia/refrigerated bodies
5.	Cherry red (Fig. 4.11)	Carbon monoxide poisoning
6.	Bright red	Hydrocyanic acid poisoning
7.	Dark-brown or yellow	Phosphorus poisoning
8.	Bluish green	Hydrogen sulphide poisoning

Fig. 4.11: Cherry red discoloration of PM staining in CO poisoning (*Courtesy:* Mandar Ramchandra Sane)

- **Rigor mortis**

Also known as stiffening of muscle after death is a temperature-dependent physico-chemical change that occurs within muscle cells due to lack of oxygen.[9]

It starts *appearing* in about 1–2 hours after death, gets well-established in the entire body in about 9–12 hours. It is maintained for about 12 hours and then gradually passes off in the same order as it appeared in another 12 hours. However, these timings are approximate and are variable depending on the various intrinsic and extrinsic factors.

Rigor develops *uniformly* throughout the body, but it is first detectable in the smaller muscle groups such as those around the eyes and mouth, the jaw, and the fingers. It appears to 'spread' down the body from the head to the legs as larger and larger muscle groups are rendered stiff.[10] It involves both involuntary and voluntary muscles. It first appears in the heart muscles within an hour after death. Among voluntary muscles, it first appears in the muscles of eyelids, then progresses proximo-distally involving muscles of the face, neck, lower jaw, muscles of the chest, upper limbs, abdomen, and lower limbs.

The development of rigor is tested by lifting the eyelids, depressing the jaw, gently bending the neck, and trying to lift the various joints of the body. It is best to test rigor across a joint using very gentle pressure from one or two fingers only.[9]

In healthy adults, it develops slowly and lasts longer, while in children and older people, it is feeble and disappears rapidly.

Seen to have early onset and short duration in deaths from diseases causing great exhaustion and wasting, e.g. cholera, typhoid, tuberculosis, cancer, etc. and in violent death as by cut-throat, firearms, electrocution, lightning while onset is late in deaths from asphyxia, severe hemorrhage, apoplexy, pneumonia, and nervous disease, causing paralysis of the muscle.

Rigor mortis helps in estimating the time of death and indicates the position of the body at the time of death. If the body is lying on its back with its lower limbs raised in the air, it indicates that the body reached full rigidity elsewhere while lying in a position where the legs were flexed, or the feet suspended and was later moved to the latter position where the support is no longer present (Figs 4.12 and 4.13 show rigor mortis in an unusual position). Deepak H D'Souza et al.[11] presented/witnessed a case of rigor mortis in an unusual position, which also gave a clue regarding the manner of death.


4.12


4.13

Figs 4.12 and 4.13: Rigor mortis in an unusual position (*Courtesy:* Mander Ramchandra Sane)

Few conditions simulate rigor mortis. Autopsy surgeons must be aware of them so as not to mistake them for rigor mortis. These are:

Heat stiffening is seen whenever a body is subjected to intense heat, i.e. the temperature of 65°C or more either by burning or exposure to high voltage electric current or immersion in a hot liquid; rigidity develops due to coagulation of muscle proteins. The body may assume pugilistic or boxer's attitude due to the flexion of the limbs. This heat stiffening cannot be broken down by extending the limbs as in rigor mortis and will persist until decomposition starts.

Cold stiffening is observed when a body is exposed to freezing temperatures, i.e. below 3°C, the tissues become frozen and stiff due to freezing of the body fluids and solidification of subcutaneous fat simulating rigor. Once the body is exposed to a warm temperature, true rigor mortis appears very rapidly and passes off quickly.

Cadaveric spasm, also called instantaneous rigor, is a condition where muscles contracted during life become stiff and rigid immediately after death without passing into the stage of primary relaxation. It involves only a group of muscles. It cannot be produced by any other method. The presence of this condition indicates sudden death associated with high emotional tension, muscles in physical activity at the time of death, and helps determine the manner of death.

Secondary Relaxation

Once rigor mortis passes off, the muscles become soft and flaccid. At this stage, they do not respond to mechanical or electrical stimuli.

Late Changes

- **Decomposition**
  It is the final stage of the dissolution of body tissues resulting in the breaking down of complex organic body constituents into simple inorganic substances involving two processes, namely autolysis and putrefaction.
  Autolysis is the self-digestion of tissues occurring due to digestive enzymes released from the cells, which causes the disintegration of tissues and organs. It occurs in aseptic conditions, while *putrefaction* occurs due to the action of both aerobic and anaerobic microorganisms, which invade the body after death. *Clostridium welchii* is the primary organism involved in this process. Its features include changes in the colour of the tissues, production of foul-smelling gases in the tissues, and the liquefaction of tissues.

An autopsy surgeon should look for the following changes in a body undergoing putrefaction:

- *Discoloration*, seen first over right iliac fossa between 12 and 18 hours in summer and 1–2 days in winter, then spreads to the entire abdomen and chest at about 24 hours in summer.
- *Marbling*, where the blood in the vessels gets hemolyzed, leading to staining the vessel walls and the adjacent tissues, giving rise to a marbled appearance (Figs 4.14 and 4.15). The marbling of the skin becomes prominent about 36–48 hours after death in summer and distinctly appreciable in the superficial veins of the abdomen, shoulders, chest, and inguinal region.
- *Distension* occurs due to the accumulation of foul-smelling gases. Accumulation of gas between the epidermis and dermis results in the formation of blisters. Gases in subcutaneous tissue lead to bloating of the face, neck, breast, penis. Distension of the abdomen occurs due to the collection of gas in the coils of the intestine. It occurs about 24 to 48 hours after death (Figs 4.16 and 4.17).
- *Skin slippage* occurs due to the rupture of blisters. The skin of the hands and feet may come off in a 'glove and stocking' fashion; it can be seen between 3 to 7 days.

Figs 4.14 and 4.15: Marbling (*Courtesy:* Swapnil Sudhirkumar Agarwal)

Figs 4.16 and 4.17: Changes of putrefaction (*Courtesy:* Swapnil Sudhirkumar Agarwal) and infestation by maggots (*Courtesy:* Mandar Ramchandra Sane, Sujatha P Lagali)

Changes seen in internal organs

Reddish-brown discoloration of the intima of vessels is the earliest sign and occurs at about 36 hours after death. There will be a collection of fluid in serous cavities in about 36–48 hours. The amount of fluid will be less than 100 ml; this is one of the differentiating features from death due to drowning, in which fluid in the pleural cavity will be more than 100 ml. Discoloration and softening of viscera occur by 48–72 hours. Colliquative putrefaction begins in 5–10 days leading to bursting of abdomen and thorax, loosening, and softening of tissues and cartilages.

The organs show putrefactive changes in the following order:

(l) Larynx and trachea, (2) stomach, intestines, pancreas, and spleen, (3) liver, lungs, (4) brain, (5) heart, (6) kidneys, bladder, (7) prostate, uterus, (8) skin, muscle, tendon, (9) bones.[2]

Decomposition may differ from body-to-body, from environment-to-environment, and from one part of the same body to another.

Many factors affect the rate of putrefaction. It is due to them, time of appearance of these changes is never constant and even varies at the same place at different times. It is the experience of the autopsy surgeon over the years at a certain place that can be more reliable rather than values given in different textbooks. The values given only suggest estimates and cannot be presumed to be perfect.

External factors include *air*, where moist air and free movement of air increases the rate of putrefaction; *moisture*, which accelerates putrefaction as compared to the presence of dry environment or moving air; *temperature*, where putrefaction begins above l0°C and is optimum between 21°C and 38°C; *clothing*, which initially increases the rate of putrefaction by maintaining the body temperature and later delays decomposition by protecting the body against the flies/insects, etc.; *Manner of burial*, where putrefaction is less in case of bodies buried immediately after death, buried in dry soil, sandy soil, and lime.

Internal factors include *age*, where bodies of children putrefy faster than that of adults; *condition* of the body, where fat and flabby bodies putrefy faster; *cause of death*, where putrefaction is rapid in deaths due to asphyxia, inflammatory conditions, septicemia while delayed if death occurs due to anemia, debility, wasting diseases, poisons—heavy metal, strychnine, carbolic acid; *mutilation*, where putrefaction is rapid if the body has more wounds.

Casper's dictum states that the time taken for the same amount of putrefaction to occur when the body is in air, water, and buried in the earth is in the ratio of 1:2:8. Putrefaction occurs faster in the air and the slowest on earth.[12]

Putrefaction helps in giving a rough estimate about the time of death and cause of death (which may become difficult to determine, except in cases of skeletal injuries, firearm injuries, drowning, and some poisons which can be detected in hair and bones).

Skeletonization is the last stage of putrefaction in which the body is converted to a bare skeleton due to the destruction of all the tissues. The time required for it depends on many factors. **Adipocere/saponification** is a modification of putrefaction, in which the fatty tissues of the body change into a substance known as adipocere. It is seen most commonly in bodies immersed in water or a damp, warm environment. When present, it has a characteristic rancid or sweetish smell; fresh adipocere is a soft, greasy material but becomes hard, dry, brittle, and yellowish if exposed to air; floats in water and dissolves in alcohol and ether; and found in areas, where subcutaneous fat is more, e.g. face, cheeks, breast, abdomen, buttocks (Fig. 4.21). **Mummification** is another modified form of putrefaction, characterized by drying and desiccation of the tissues instead of liquefaction. It occurs as a result of the continuous action of dry air. Hot and dry environment, the absence of moisture favors the formation of mummification. It begins in exposed parts later involves the entire body; the body loses weight, becomes hard, shrunken, and black (Figs 4.18–4.20).


4.18


4.19


4.20


4.21

Figs 4.18 to 4.21: Changes of mummification and saponification (*Courtesy:* Swapnil Sudhirkumar Agarwal)

Both adipocere and mummification help in identification as the facial features are maintained, determine the cause of death as tissue structures are maintained, and indicate the place where the body had been lying after death. A rough time estimate can also be made as detailed in Section F.

Apart from gross changes, estimation of various biochemical changes in blood, vitreous fluid, and other body fluids after death may also help determine time since death (Table 4.3).[10,12]

Table 4.3: Biochemical changes after death in various body fluids[10,12]

Parameters	Blood	CSF	Vitreous*	Pericardial fluid
Glucose	Increases	Decreases	Decreases	–
Lactic acid	Increases	Increases	Increases	–
Potassium	Increases	Increases	Increases	Increases
Non-protein nitrogen	Increases	Increases	–	–
Amino acid nitrogen	Increases	Increases	–	–
Creatinine	Increases	Increases	–	–
Chloride	Decreases	Decreases	–	–

* Number of studies available.

All these parameters are not commonly used because of feasibility issues and lack of substantive data given the conditions where most of our medical officers are conducting autopsies.

While conducting an autopsy on a deceased who wasn't attended when he breathed his last, one is always expected to find out what is called 'postmortem interval'—it is the interval between death and the time of examination of a body. Its importance lies in (Table 4.4):

1. Knowing when the crime was committed
2. Providing the police, a starting point for their inquiries
3. Enabling to exclude some suspects
4. Confirming or disproving an alibi
5. Checking on authenticity of suspect's statements[2]

Table 4.4: Postmortem changes and presumed time since death[13,14]

Temperature	Eye changes	Postmortem lividity	Rigor mortis	Decomposition	TSD
Body—warm	Cornea transparent, pupils react to chemical stimuli	No patches	Muscles flaccid, react to electrical stimuli	Absent	Within 1 hour
Body surface—cold	Cornea bit hazy		Appreciable in the jaw		More than 1 hour
	Intraocular pressure zero, cornea opaque, tache noire (in some cases)	Patches on the dependent parts	Appreciable in the muscles of the face		2 to 3 hours
	Cornea becomes cloudy	Well-developed but not fixed	Developed in the upper part of the body		3 to 6 hours
	Presence of tache noire	Well-developed and fixed	Well developed		6 to 8 hours
Body—cold	Eyeballs sunken, disc and retinal vessels are blurred		Rigor mortis all over the body	With or without greenish discoloration over right iliac fossa	Around 12 hours
Body—cold attains an environmental temperature	–	Not appreciated due to discoloration of decomposition	Developed all over the body; may pass off from jaw/neck	Greenish discoloration over the right iliac fossa; eggs of flies seen over the body	12 to 24 hours
Body—cold	Softening of eyeballs	–	Passed off from jaw, neck and upper limbs	Greenish discoloration over chest and abdomen	24 to 36 hours
	Bulging of eyeballs		Passed off from the whole of the body	Marbling, distended abdomen, and thorax, presence of maggots, postmortem blisters, face unrecognizable	36 to 48 hours
				Prolapse of rectum and uterus, nails and hair loosened and easily pulled off	48 to 72 hours

Contd.

Table 4.4: Postmortem changes and presumed time since death[13,14] (Contd.)					
Temperature	**Eye changes**	**Postmortem lividity**	**Rigor mortis**	**Decomposition**	**TSD**
				Skull sutures separate, brain matter is liquefied, grown maggots or pupae all over the body, nails, and hair easily pulled off	3 to 5 days
				Colliquative necrosis appreciated, internal organs reduced to a black unrecognizable pultaceous mass	1 week
				Most of the soft tissues gone, organs that putrefy late like prostate and non-gravid uterus recognizable	2 weeks
				Skeleton exposed bare	1 to 3 months

Note: Timings of all these changes are arbitrary. They may change depending on various intrinsic and extrinsic factors, also from one place to another.

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