Death and post mortem changes

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Thanatology (Greek thanatos: death)

- is the scientific study of death in all its aspects including its cause and phenomena.
- It also includes bodily changes that accompany death (postmortem changes) and their medico-legal significance

Definition of death

Medically and scientifically, death is not an event; it is a process in which cellular metabolic processes in different tissues and organs cease to function at different rates

Legally defined as the irreversible cessation of function of 3 systems:

CNS

RS

CVS

Death occurs in two stages

- i. Somatic, systemic or clinical.
- ii. Molecular or cellular

Somatic death

- The question of death is important in resuscitation and organ transplantation. Skin and bone remains metabolically active for many hours and these cells can be successfully cultured days after somatic death.

- Complete and irreversible cessation of function of brain, and stoppage of the circulation and respiration

Molecular death

- Molecular death occurs piecemeal. Initial changes occur due to metabolic dysfunction and later from structural disintegration.
- Progressive disintegration of body tissues with death of individual tissues and cells
- Nervous tissues die rapidly, the vital centers of the brain in about 3–7 minutes (min), but muscles survive upto 1–2 hours (h).

Supravital reaction

- **Mechanical excitability of the skeletal muscle**
- i. Tendon reaction (Zsako's phenomenon): Contraction of the whole muscle (e.g. quadriceps) due to propagated excitation following a mechanical stimulation, seen within 2–3 h after death.
- ii. Localized idiomuscular contraction at the point of stimulation may be seen several hours after cessation of Zsako's phenomenon.

- **Electrical excitability of the skeletal muscles of the face may be observed for few hours after death**.

- **Pharmacological excitability of the iris muscle resulting in change of pupil diameter following the administration of miotic or mydriatic solutions can be seen during the first hours of the postmortem period**

	Somatic death	Molecular death
onset	Precedes molecular death	Succeeds somatic death (1–2 hours after stoppage of vital functions)
Tissues and cells of body	Alive and functioning	Dead and non-functioning with no metabolic activity
Response to external stimul	Muscle responds to thermal, electrical or chemical stimulus	Does not respond
Confirmation	Flat ECG and EEG, and absent breath sounds	Rigor mortis, algor mortis, postmortem staining, putrefaction
Resemblance	Suspended animation, coma, hypothermia	Does not resemble any condition

Cause, Mechanism and Manner of Death

- Two of the most important functions of the forensic doctor are the determination of the cause and manner of death

- **Cause of death :** is any injury or disease producing physiological derangement, briefly or over a prolonged period and which results in the death of the individual, e.g. a gunshot wound to the abdomen, a stab wound to the chest, adenocarcinoma of the lung or coronary atherosclerosis

- **Mechanism of death :** is the physiological derangement produced by the cause of death that results in death, e.g. hemorrhage, septicemia, metabolic acidosis or alkalosis, ventricular fibrillation or respiratory paralysis. A particular mechanism of death can be produced by multiple causes of death and vice versa. Thus, if an individual dies of hemorrhage, it can be produced by a gunshot wound or a stab wound or a malignant tumor of the lung eroding into a blood vessel. A cause of death, e.g. a gunshot wound of the abdomen can result in many possible mechanisms of death, like hemorrhage or peritonitis

- **Manner of death :** explains how the cause of death came about. Manner of death can generally be categorized as natural (death due to disease), homicide, suicide, accident or undetermined

- A cause of death may have multiple manners of death. An individual can die of massive hemorrhage (mechanism of death) due to stab wound of heart (cause of death), with the manner being homicide (someone stabbed him), suicide (stabbed himself), accident (fell over the weapon) or undetermined (not sure what happened)

- **Agonal period** is the time between a lethal occurrence and death.

- **Mode of death**: refers to an abnormal physiological state that pertained at the time of death, e.g. coma, congestive cardiac failure, cardio-respiratory failure, cardiac arrest and pulmonary edema.
- According to Xavier Bichat, a French physician, there are three modes of death depending upon the system most obviously affected, irrespective of what the remote cause of death may be:
- i. Coma.
- ii. Syncope.
- iii. Asphyxia.

Signs of death

- The accurate determination of time of death is important due to its role in explaining possible criminal acts and determination of appropriate civil repercussions.

Immediate Changes (Somatic Death)

- a. Irreversible cessation of the function of brain including brainstem:

This is the earliest sign of death with stoppage of functions of the nervous system. There is insensibility, and loss of both sensory and motor functions. There is loss of reflexes, no response and no tonicity of the muscles. Pupils are widely dilated.

- b. Irreversible cessation of respiration:

Complete stoppage of respiration for > 4 minutes (min) usually causes death.

- Irreversible cessation of circulation:

Stoppage of heart beat for > 3–5 min is irrecoverable and results in death.

Suspended Animation (Apparent Death)

- Suspended animation is a condition in which vital signs of life (heart beat and respiration) are not detected by routine clinical methods, as the functions are interrupted for some time or are reduced to a minimum.

- **Mechanism**: The metabolic rate is greatly reduced so that the requirement of the individual cell for oxygen is satisfied through the dissolved oxygen in body fluids

Types

- Two types:
- i. Voluntary: Seen in practitioners of yoga or in trance.
- ii. Involuntary: Seen in hypothermia, poisoning with barbiturates or opiates, newborns, drowning, electrocution, heatstroke, cholera, postanesthesia, shock, cerebral concussion or insanity.

- The patient can be resuscitated by cardiac massage or electric stimulator and artificial respiration. The death certificate should not be issued without an ECG or EEG record.

Early Changes (Molecular Death)

- a. Changes in the skin and facial pallor:

Skin becomes pale and ash-white due to stoppage of circulation and drainage of blood from the capillaries and the small vessels. The skin loses its elasticity, and the face looks younger due to loss of creases. The lips appear brownish, dry and hard due to drying

- b. Primary relaxation or flaccidity of the muscles:

Muscles loose their tonicity and become flaccid, but the muscular tissues are still alive, their chemical reaction is alkaline and responds to electrical stimuli.

c. Contact flattening and pallor:

The areas which remain in contact with the ground, become flat and the blood from vessels of these areas is pressed out, this continues even after the formation of postmortem staining over the surrounding areas.

d. Changes in the eye:

1. Loss of corneal and pupillary reflexes
2. Pupils: The pupils are dilated after death, because of the relaxation of muscles of the iris. Later, they are constricted
3. pupil can be changed in shape , and the change may persist during the stage of rigor mortis of the muscles.
4. Tache noire : If the eyelids remain open for 3–4 h after death, there is formation of two yellow triangles) on the sclera at each side of the iris, which become brown and then black. Cause: Drying/desiccation, and deposition of cellular debris, mucus and dust on the exposed conjunctiva and the sclera underneath.

- Loss of intraocular tension: Intraocular tension falls rapidly after death. It becomes zero in 4–8 h from 10–22 mmHg during life. The eyeballs look sunken in the orbit.

- Changes in the retina: The blood in retinal vessels appears fragmented or segmented (cattle trucking or shunting) within seconds to minutes after death, and persists for about an hour (Kevorkian sign).

Cooling of the Dead Body (Algor Mortis)

- is the cooling of the body that normally takes place after death, where the body temperature equilibrates with its environmental temperature

- The fall of temperature of the cadaver occurs due to cessation of energy production and inactivity of the heat regulating center after somatic death.

- For the purpose of estimation of time passed after death, the measurement of the inner core temperature is important and is more reliable than the outer surface temperature

- The average rate of fall of the body temperature is 1°C/h, and the body attains environmental temperature in 16–20 h after death.

Medico-legal Importance of Algor Mortis

- i. It is a sign of death.
- ii. It helps in the estimation of the time of death.
- iii. Rapid cooling of a dead body delays the processes of rigor mortis and decomposition. If the heat is preserved for a longer period, then both the processes start early

Postmortem Staining (Livor Mortis)

- Postmortem staining or PM staining is bluish or purplish-red discoloration resulting from gravitational settling of blood in the toneless capillaries and venules of the dependant parts of the dead body.

- Site: It is present at the undersurface of skin in the superficial layers of the dermis.

- Cause: After the stoppage of circulation, there is stagnation of blood in the vessels, and it tends to sink by force of gravity in the capillaries and venules of the dependent parts of the body.

Development of PM Staining

In early stages (30 min to 1 h), it consists of discolored patches of 1–2 cm in diameter on the dependant parts of the body, having the same color as blood which can be mistaken for bruises. Gradually, in 3–4 h, the small patches increase in size and coalesce with each other to form uniformly stained large areas. It is usually welldeveloped within 4 h, complete in 5–6 h

- After complete formation of the postmortem staining, if the body is undisturbed, the staining gets ‘fixed’ in 8–12 h and persists until putrefaction

- **Distribution of PM Staining**
- It depends on the position of the body.
- In a body lying supine, it appears in the neck, and then spreads over the entire back with the exception of the areas directly pressed on the ground or the bed, i.e. occipital area, shoulder blades, buttocks, posterior aspects of thighs, calves and heels, which do not show any staining and appear rather pale .This phenomenon is known as contact pallor

Medico-legal Importance of PM Staining1

- i. It is a sign of death.
- ii. The time since death can be roughly estimated from the formation, extension and fixation of the PM staining.
- iii. It indicates the posture of the body at the time of death.
- iv. It may indicate the moving of the body to another position sometime after death.
- v. Cause of death may be judged from the distribution and color of PM staining.
- vi. In the early phase of its formation, it may be confused with bruise when patchy and small
- vii. It may be confused with congestion of the organs, particularly of the internal organs
- viii. Hemorrhagic spots on skin due to blood dyscrasias may be mistaken for PM staining.
- ix. Some extraneous color or stain may be mistaken for PM staining; however, these can be easily wiped or rubbed off or washed out.

Rigor Mortis

- is that state of the muscles in a dead body when they become stiff or rigid with some degree of shortening

- The phase of primary relaxation of the muscles continues for about an hour which is followed by stiffening or rigidity. It indicates molecular death of the concerned muscles

- Mechanism:

Muscle fibers contain bundles of myofibrils which consist of two types of protein filaments—actin and myosin. At rest, actin filaments interdigitate myosin filaments only to a small extent and the muscle fibers also appear soft and supple. Maintenance of this condition of muscles is due to the presence of ATP (adenosine-triphosphate) above a certain level.

On nervous stimulation, hydrolysis of ATP occurs to ADP (adenosine-diphosphate) and phosphate with the liberation of energy which causes contraction of the muscle fibers and extension of the actin filaments more inside the myosin filaments. After death, there is continuous hydrolysis of the ATP, and as long as glycogen is available in the muscle, there is resynthesis of ATP.

In this process, once the muscle glycogen is exhausted, no further resynthesis of ATP is possible and the muscle loses softness, elasticity and extensibility due to formation of viscid actomyosin complex giving rise to rigor mortis in the muscle

- Muscles Involved

Rigor mortis occurs both in the voluntary and involuntary muscles. It occurs earlier in the involuntary or smooth muscles than in the voluntary or striated muscles.

- Onset and Duration

In tropical countries like India, roughly, it commences in 1–2 h after death, takes about 9–12 h to develop from head to foot, persists for another 12 h and takes 12 h to pass off

- Order of Appearance

Rigor mortis first appears in the heart muscle within an hour after death

Among the voluntary muscles, rigor mortis usually develops sequentially and follows a descending pattern

- The rigidity disappears in the same order in which it has appeared. In the whole body, it stays for maximum duration in the muscles of the lower limbs.

Effects of rigor mortis

- There is goose skin appearance of the body due to rigor mortis of the erector pilae muscles.
- Rigor in the muscles of the seminal vesicles may cause postmortem ejaculation of seminal fluid.
- Contraction of the heart muscle due to rigor mortis should not be mistaken for myocardial hypertrophy
- Rigor mortis in the uterine muscle cannot expel the fetus from the womb.
- The iris is also affected so that antemortem constriction or dilatation is modified. Hence, the postmortem position of pupil is an unreliable indicator of toxic or neurological conditions during life.

Medico-legal Importance of Rigor Mortis

- Its is a sign of death and indicates molecular death of the muscle involved.

During the early phase after death, it helps in estimating the time since death. During summer, if rigor mortis has not set in, death might have occurred within 2 h.

- If rigor mortis has involved the whole body then death might have occurred between 12–24 h back
- It indicates the position of the body at the time of death. For example, if the body is lying on its back with its lower limbs raised in air, it indicates that the body reached full rigidity elsewhere while lying in a position where the legs were flexed.
- Some conditions occur in dead bodies which may imitate/simulate rigor mortis:

25 z Cadaveric spasm or instantaneous rigor z Heat stiffening z Cold stiffening z Gas stiffening or putrefaction.

Cadaveric Spasm

- is a condition in which the muscles of the body which were in a state of contraction immediately before death, continue to be so after death without passing through the stage of primary relaxation.

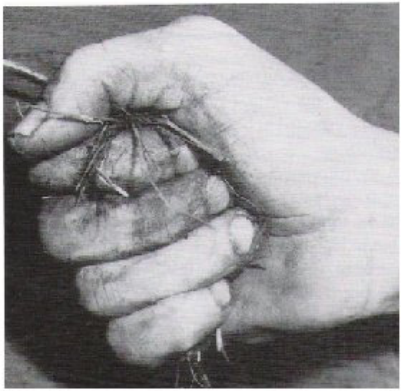
- It is a rare phenomenon of instantaneous rigor, which develops at the time of death with no period of postmortem flaccidity
- Predisposing conditions:

It occurs especially in cases of sudden death, excitement, fear, severe pain, exhaustion, cerebral hemorrhage, electrocution, injury to the nervous system, firearm wound of the head, or convulsant poisons.

- Muscles involved:

The spasm is primarily a vital phenomenon; it originates by normal nervous stimulation of the muscles.

it is usually limited to a single group of voluntary muscles, and frequently involve the hands



Cadaveric spasm in a drowning victim: had grass from the river bank firmly clutched in the hand

Medico-legal Importance Cadaveric spasm

Being an antemortem phenomenon, reflects the last act of the subject performed before and at the time of his death.

The cause and the manner of death may be judged.

- In case of drowning, the hand may firmly grip sand, mud, gravel or weed which are present in the pond or lake from where the body was recovered

- In case of firearm/stab injury over an approachable vital part of the body, the pistol/knife may be firmly grasped in the victim's hand which is a strong presumptive evidence of suicide. Although, attempts may be made to simulate this condition in order to conceal murder, but rigor does not produce the same firm grip of a weapon.

In homicidal cases, the deceased may grasp some part of clothing, button or foreign hair of the assailant(s) with whom he had a struggle prior to his death.

Heat Stiffening

- If the body is subjected to heat exposure at > 65°C, rigidity is produced which is much more marked than that found in rigor mortis.
- There will be coagulation of the muscle protein in which the flexors are affected more, giving rise to a pugilistic attitude of the body
- The muscles are contracted, desiccated or even carbonized on the surface
- A zone of brownish-pink ‘cooked meat’ is seen under this, overlying normal red muscle.

Cold Stiffening

- This is seen when a body is exposed to freezing temperatures for a reasonable period, the tissues becoming frozen and stiff, simulating rigor.
- It occurs due to:

1. Freezing of body fluids, particularly at the tissue level and in the synovial sacs of the joints
2. Hardening of the subcutaneous fatty tissue

Secondary Relaxation of Muscles

- After some hours of stay, rigor mortis passes away and the body becomes relaxed or flaccid for the second time. This is secondary relaxation or secondary flaccidity of the muscles. It occurs with the onset of decomposition or putrefaction of the dead body

Decomposition/Putrefaction

- is a process by which complex organic body tissue breaks down into simpler inorganic compounds or elements due to the action of saprophytic microorganisms or due to autolysis

- Putrefaction usually follows the disappearance of rigor mortis

- After death, the body's protective functions are absent and its defense barrier is lost. Saprophytic microorganisms, which cannot invade the body during life, physical and chemical agents which are present in the environment, all act on the dead body. Further, some body chemicals and enzymes which are helpful in different metabolic processes, in the absence of physiological control after death, start acting adversely

- Clostridium welchii main organism in putrefaction

- In dead born, maceration—an aseptic autolysis of dead fetus in utero is seen

External Signs of Decomposition

Decomposition changes (‘4 Ds’)

- Discoloration: Greenish discoloration in the lower abdominal quadrants.h2s
- Distension: Various gases produced during decomposition permeate into skin, soft tissue and organs which manifests as crepitus and distension.
- Degradation: Decomposition causes a loss of anatomic integrity of skin and other tissues such as localized peeling of skin (‘skin slippage’), loosening of skin of hands and feet (‘degloving’) and loosening of hair and nails.
- Dissolution: Progressive decomposition leads to liquefaction and disappearance of tissues and organs, and eventual skeletonization

- Discoloration

- The first external sign of decomposition is usually a greenish discoloration over the right iliac fossa over the region of the cecum which lies superficially, and the contents of the bowel are more fluid and full of bacteria. C. welchii are most abundant at the iliocecal zone of the intestinal tract.

- Internally, this is seen on the undersurface of the liver, where it is in contact with the transverse colon

Marbling’ of skin

The blood vessels provide an important route through which the bacteria can spread with ease throughout the body.

Their passage is marked by the decomposition of hemoglobin to sulphmethemoglobin in the blood vessels, which causes a greenish or reddish-brown staining of the inner walls of the superficial vessels.

This is seen as linear branching patterns, which gives a ‘marbled’ (‘road map’) appearance of the skin

Areas where visible: It appears first in the shoulder, roots of the limbs, thighs, sides of abdomen, chest and neck.

Internal Changes due to Putrefaction

- The organs composed of muscular tissue and those containing large amount of fibrous tissue resist putrefaction longer than the parenchymatous organs, with the exception of the stomach and intestine, which decompose rapidly because of their contents at the time of death.

- Prostate and uterus being the last organs to decompose, they help to identify the sex of the dead bodies in advanced state of decomposition

Adipocere (Saponification)

- is formation of an offensive, sweet rancid smelling, soft, whitish or grayish white, crumbly, waxy and greasy material (similar to soap) occurring in fatty tissues of a dead body. It is a modification of decomposition

- In hot and moist environment, it may occur by the end of 1 week In temperate countries, it starts in 3 weeks and completes in about 3 months.

Mechanism of formation:

Adipocere consists mainly of fatty acids formed due to postmortem hydrolysis and hydrogenation of body fats. The process needs water which is provided by the body fluid of soft tissues. The chemical reaction essentially involves conversion of unsaturated liquid fats (oleic acid) to saturated solid higher fatty acids, like palmitic

- A warm, moist and anaerobic environment favors adipocere formation.

Medico-legal Importance of adipocere

- i. Sign of death: It is the surest sign of death.
- ii. Time since death: It gives a rough estimate about the time since death.
- iii. Personal identification: When the process involves the face, the features are well-preserved, which helps in identification.
- iv. Recognition of injuries: The cause of death may be determined, since injuries can be recognized.
- v. Place of disposable of body: Some idea about the place of disposal of the body can be made, since its formation requires a warm place with high humidity or presence of moisture or water.

Mummification

- It is the rapid dehydration/desiccation and shriveling of the dead body from evaporation of water, with preservation of natural appearances and features of the body.

- It is a modification of putrefaction (dry decomposition)
- The entire body loses weight, becomes thin, stiff, brittle and odorless

- Time required for mummification: It varies between 3–12 months or longer

Factors Favoring Mummification

- i. Hot environment: As in the deserts.
- ii. Dry atmosphere: Mummification cannot occur in humid conditions.
- iii. Free air movement: It helps in rapid evaporation of body fluids. iv. Contact of the body with absorbing media: A dead body lying in shallow grave, in dry sandy soils mummifies early due to absorption of body fluid rapidly.
- v. Poisoning: Chronic arsenic or antimony poisoning favors the process of mummification

..... أذا جاءك من فقئت عينه شاكيا

فلا تحكم له عل المشكو عليه فقأت له عينان

الامام علي رضي الله عنه