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1. Learning Outcomes

After studying this module, you shall be able to know about-

- Early changes after death – rigor mortis
- The mechanism of production of rigor mortis and governing factors
- Late changes after death i.e. decomposition including putrefaction and autolysis
- Altered process of decomposition i.e. adipocere and mummification

2. Rigor Mortis

"A good pathologist holds knife just like a violinist holds a bow".

Dr Gyan Fernando

Early Changes after Death:

Rigor Mortis -

Rigor mortis or death stiffening or cadaveric rigidity is a state of stiffening of muscles, sometimes also with slight shortening of muscle fibres. During life the muscles are in a slightly contracted state.

After passing through the primary relaxation phase or primary flaccidity, soon after death, during which the muscles are totally relaxed, the muscles gradually get stiffened over a period of time, which is known as rigor mortis. Rigor mortis is a physico-chemical reaction which affects all the muscles of the body, both skeletal and smooth.

A voluntary muscle is made up of bundle of long fibres. Each muscle fibre in the bundle consists of densely packed myofibrils, which are the contractile element. These myofibrils are made up of two protein filaments, actin and myosin.

During lifetime, separation of actin and myosin is possible for the extensibility of the muscles. The contraction of the actin and myosin filaments are dependent on the energy provided by ATP (adenosine tri phosphate) and during life a constant supply of ATP is being maintained. Failure of re-synthesis of ATP after death results in the muscle becoming hard and rigid. Some amount of ATP still remains available after death till the glycogen reserve lasts.

Once the glycogen reserve is depleted, there is no more ATP available and the contractile elements are converted into dehydrated, stiff, gel like mass resulting in the muscles themselves becoming hard and rigid.

- **Order of appearance:**

All the muscles of the body, both voluntary and involuntary are affected. Nysten's rule states that, it does not start simultaneously in all muscles. It first appears in the involuntary muscles; the myocardium becomes rigid in an hour. It becomes noticeable in the eyelids, then the muscles of the face, jaw and neck.

Then it goes downwards to the upper limbs, thorax, abdomen and lower limbs and lastly the fingers and toes. In the individual limbs, it usually progresses from above downwards. It disappears in the same order in which it has appeared. With the passing away of rigor, the muscles once again become softened and this phase is called **secondary flaccidity.**

- **Development:**

It is generally considered that by first 12 hours after death, rigor affects the whole body. It is retained for another 12 hours and passes off in the next 12 hours with the onset of putrefaction. This **Rule of 12** is also known as **March of rigor.** However, in temperate climates, it begins 3 to 6 hours and takes further 2 to3 hours to develop.

- **Conditions altering onset and duration:**

- Rigor mortis does not occur in a foetus of less than seven months. In children and old people, it is feeble and rapid.
- Onset is early and duration is short in cases where death is from diseases causing great exhaustion and wasting. Eg, cholera, typhoid, tuberculosis etc. Onset is delayed in deaths due to asphyxia, severe hemorrhage, apoplexy, pneumonia, nervous diseases. In death due to strychnine or HCN, it starts early and persists longer. It may disappear very rapidly in case of bacterial infection, gas gangrene.
- In case of healthy muscles, duration is long and onset is slow. If there is fatigue or exhaustion, onset is rapid with short duration.
- In cold weather, onset is slow and duration is long. If the body is in extremely hot condition, rigor mortis may disappear in 12 hours after death.

- **Medico legal importance:**

1. It is the sign of death.
2. It helps in estimating time since death to some extent.
3. It indicates the position of the body at the time of death to some extent.

3. Cadaveric Spasm or Instantaneous Rigor

Cadaveric spasm is the rare state, where instead of primary flaccidity after death, the muscles usually belonging to small groups, go into sudden state of stiffening. The exact mechanism is unknown but possibly neurogenic and not the same chemical process as rigor mortis.

The muscles that were contracted during life become stiff and rigid immediately after death without passing into stage of primary relaxation. Hence, the change preserves the exact attitude of the person at the time of death.

- **Predisposing factors:**

Occurs especially in cases of intense physical or emotional activity such as excitement, fear, severe pain, exhaustion, injury to nervous system, fire-arm wound of the head, drowning, convulsant poison such as strychnine etc. This is usually limited to a single group of muscles and most commonly involves hand.

E.g., in drowning grass or weeds may be clutched in the hands or in suicide by shooting; the weapon may be clasped in the hand. No other condition stimulates cadaveric spasm and very great force is required to overcome this stiffness.

- **Medico legal importance:**

1) The weapon of offence in cases of suicide can be seen grasped in the hand.
2) If the deceased dies due to assault, then some part of the clothing of the assailant, like button or hair etc. may be seen firmly grasped in the hand.
3) In drowning grass or weeds may be clutched in the hands, which indicates that the person was alive on entering the water.
4) Cadaveric spasm helps in indicating the mode of death i.e., whether suicide or homicide or accidental.

TRAIT	RIGOR MORTIS	CADAVERIC SPASM
Mechanism	Known. Due to depletion of ATP	Not clearly known
Predisposing factor	Nil	Sudden death, excitement, fear, exhaustion etc.
Time of onset	1 to 2 hours after death.	Instantaneous.
Muscles involved	Both voluntary and involuntary.	Usually restricted to single group of voluntary muscles.
Muscle stiffening	Not marked.	Marked. Great force is required to overcome it.
Molecular death	Occurs.	Does not occur.
Electrical stimuli	Muscles do not respond.	Muscles respond.
Muscular reaction	Acidic	Alkaline.
Medico-legal importance	Indicates time since death	Indicates mode of death (whether suicide/homicide/accidental)

Other conditions resembling Rigor mortis:

1. **Heat stiffening:** When the body is exposed to temperatures above 65^0C, heat stiffening is produced which is much more marked than rigor mortis. Heat causes stiffening of the muscles because the tissue proteins are denatured and coagulated as in cooking. The muscles are contracted, desiccated or even carbonized. A zone of pinkish brown "cooked meat" is seen under this, overlying normal red muscle. The stiffening remains until the muscles and ligaments soften from decomposition.

2. **Cold stiffening:** The tissue becomes frozen and stiff when the body is exposed to freezing temperatures before acid metabolites appear in the muscle. This is because of freezing of the body fluids and solidification of subcutaneous fat, thereby simulating rigor. The body is extremely cold and markedly rigid and if joints are forcibly flexed, ice breaks in the synovial fluid with a sudden snapping sound. The stiffness disappears if the body is kept in warm atmosphere.

3. **Gas stiffening:** Gases evolving during putrefactive processes also stiffen the body. Usually, this poses no problem in distinguishing from true rigor.

4. Late Changes after Death

Decomposition:

Decomposition involves two processes i) Putrefaction ii) Autolysis.

i) Putrefaction:

Putrefaction is due to fermentation by bacteria. After death, the bacterial flora of the GIT spread throughout the body thereby producing putrefaction. At cellular level, putrefaction begins immediately after death, but changes are not visible grossly. Gross changes are visible externally after rigor mortis passes off. In summer, however changes may appear early.

The bacterial enzymes are derived mostly from the anaerobic organisms form the intestines, mainly being clostridium welchii. Others are B.aerogenes, B.capsulatus, B.coli, B.proteus, staphylococcus, and streptococcus.

The entry point of the bacteria is GIT (most common), respiratory tract, genital tract and open wounds. The spread of the bacteria is through the blood stream. The other sources of enzymes are fungal (penicillium, aspergillus) and larvae of insects.

The lecithinase produced by Cl. welchii plays an important role. This lecithinase hydrolyses the lecithin of cell walls and RBCs, causing postmortem hemolysis. There is also an extensive and progressive breakdown of soft tissues including proteins, carbohydrates and fats.

The factors which favor the growth of the bacteria are decrease in the oxygen concentration in the tissues, increase in the hydrogen ion concentration and proteins, carbohydrates and fats of the body which acts as excellent culture media.

ii) Autolysis:

Autolysis is the breakdown of cells and organs through an aseptic chemical process caused by intracellular enzymes. Soon after death cell membranes break down with release of cytoplasm containing enzymes i.e., glycolytic, proteolytic, lipolytic. The enzymes auto-digest the tissues even in the absence of bacteria. This process is accelerated by heat and slowed by cold.

The organs rich in enzymes will undergo autolysis faster than the organs with lesser amounts of enzymes e.g., pancreas autolysis earlier. Autolysis causes maceration of the dead fetus in utero.

Changes occurring during putrefaction

Greenish discoloration in the right iliac fossa is the earliest external manifestation of the onset of putrefaction, which occurs about 12 to 24 hours after death. This is the area where the caecum (with contents rich in fluid and bacteria) lies.

Hydrogen sulphide produced by the bacteria acts on the hemoglobin, which has now become extracellular due to hemolysis, to produce sulphaemoglobin. This imparts the greenish blue color. With passage of time, the greenish blue color spreads to the abdomen subsequently and also makes its appearance in the chest, face and the limbs.

Coalescence of these colored areas results in the entire body becoming greenish or greenish black. Later, in about 36 to 48 hours, a network of veins becomes visible in the form of a characteristic mosaic-like pattern (marbling), over various parts of the body, like root of the neck, shoulder etc.

This results from staining of the vessel walls due to diffusion of hemoglobin. By the time the color changes become visible externally, evolution of gases would have started internally, which possess very unpleasant smell The gases of putrefaction are hydrogen sulphide, ammonia, carbon di oxide, carbon mono oxide, methane etc.

These gases, by themselves are of not much medico legal significance, but the pressure effects produced by them bring forth the gross changes of the body. Evolution of the gases results in 1) Ballooning effect 2) Dispersion of postmortem lividity.

Ballooning effect: Gases easily collect in the hollow viscera resulting in their voluminous expansion. The stomach and the intestines which balloon out, increases the intra-abdominal pressure resulting in distension of the abdomen and pushing the diaphragm upwards. Lungs are squeezed by this pressure and froth oozes out from the mouth and nostrils.

The gases not only accumulate in the hollow viscera, but also penetrate into every tissue and organ. Soft tissues of the body like breast, scrotum, peri-orbital tissues etc. increase in their size enormously. Eyeballs protrude out of the sockets, the cheeks and lips puff out.

The tongue protrudes through the mouth and on exposure to air becomes dark in color. The facial feature completely alters and at this stage identification by external features extremely difficult. The percolation of the putrefactive gases in the undersurface of the skin results in the epidermal layer ballooning out, which resembles blisters of scalding.

In contrast to protein-rich fluid present in the blisters caused by scalding, putrefactive blisters contains only air. The epidermal layers from the hands and feet slip off like glove and stocking. This slipped off skin is important to preserve as it can yield full set of finger prints that may help in establishing identity. Increase pressure inside the abdomen may result in the expulsion of fetus in case of the deceased was pregnant. Uterus and rectum may protrude out. The evolutions of gases commence as early as 18 hours and it takes 48 to 72 hours to reach the full blown picture.

Dispersion of postmortem lividity: Evolution of gases moves the blood in the blood vessels. If the blood is clotted, it liquefies and hemolysis takes place. Movement of the blood results in dispersion of postmortem lividity in any direction. Therefore, assessment of the position of the body at the time of death based on lividity at this stage becomes difficult.

Colliquitive putrefaction: In 3 to 5 days, after death, the nails and hair become loose and can be pulled off with ease. The teeth become loose and can be pulled out from the socket. The abdomen, thorax burst open and skull sutures get loosened, through which the liquefied brain matter oozes out. With further progression from 5 to 10 days, the tissues and organs are converted into soft, thick, black mass totally losing their architecture.

However, even at this stage, organs such as the prostrate and non-gravid uterus can be identified, as they resist putrefaction, thereby helping in identifying sex of the individual. This liquefied, unrecognizable; pultaceous mass gradually falls off from the bony attachments leaving the skeleton exposed. If a dead body is lying in the open, it may take 1 to 3 months for complete skeletonisation. If the body is buried, skeletonisation may take place in two to six months. In case of body encased in coffin, the same may take more time.

Sometimes, environmental condition arrests the progression of putrefaction and may deviate it to either **Adipocere formation** or **Mummification.**

5. Adipocere or Saponification or Grave Wax

Adipocere is a modified form of putrefaction where the fatty tissues of the body change into a substance known as adipocere. This change is mainly due to the hydrolysis and hydrogenation of the body fats such as olein into higher fatty acids, which combine with calcium and ammonium ions to form insoluble soaps, which being acidic, inhibits putrefactive bacteria.

Ultimately, the whole fat in converted into palmitic, oleic, stearic and hydroxystearic acid, together with some glycerol and a mixture of these substances forms adipocere. At the time of death, body fat contains about half percent of fatty acids, but in adipocere they rise to 20% within a month and over 70% within 3 months.

The process starts under the influence of intrinsic lipases and is continued by the bacterial enzymes of the clostridia group, mainly Cl. perfringes, as the bacteria produce lecithinase which facilitates the hydrolysis and hydrogenation.

The pre-requisites of adipocerous change of the body fats are:

Damp and warm environment, humid climate, still air, abundant body fat, warm temperature and bacteria producing fat-splitting enzymes like clostridium welchii.

Thus, a body lying on damp soil, in a shady place, with optimum temperature and no free air current blowing over it, undergoes adipocerous change. Adipocere has the appearance of rancid butter and gives off a sweetish but disagreeable smell.

Transformation of the body fats usually seen over fatty areas such as cheeks, breasts, buttocks or limbs. Rarely, whole body may be involved. It takes generally 3 weeks (shortest time) for adipocere to fully develop. However, complete conversion in an adult limb requires at least 3 to 6 months.

The same may persist for a year or decade. As the progression of putrefaction is arrested, the facial features are recognizable which helps in identification of the deceased. Similarly, wounds are also preserved without much altercation and hence, the wound can be studied properly. The approximate time since death calculation also becomes possible.

- **Medico legal importance:**

1. As the features are well preserved, the deceased can be identified.
2. Time since death can be calculated for the same reason.
3. The cause of death can be determined because the injuries are well preserved.

6. Mummification

It is the modified form of putrefaction. Dehydration or drying and shriveling of the cadaver occur from the evaporation of water, but the natural appearances of the body and general facial features are preserved. It begins in the exposed parts of the body like face, hands and feet and then extends to entire body including internal organ.

The skin may be shrunken, contracted, dry, brittle, leathery and rusty-brown to black in color, stretched tightly across the anatomical prominences, such as cheek bones, chin, costal margins and hips, adheres closely to bones, and often covered with fungal growth.

As the skin contracts, some of the fat cells in the subcutaneous tissues are broken and the liquid oil is forced into the dermis which becomes translucent. The entire body loses weight upto 60 to 70%, becomes thin, stiff and brittle. In mummified bodies, the joints are often seen in flexed and abducted position, mainly due to shrinkage of muscles and tendons. Sometimes, the phenomenon may be partial.

If a mummified body is not protected, it will break into fragments and eventually will become powdery. But, if preserved, then will last for years. The time required for a complete mummification of a body varies from 3 months to a year and is influenced by the size of the body, atmospheric conditions and place of disposal.

Factors necessary for production of mummification: Absence of moisture in the air and continuous action of dry or warm air.

- **Medico legal importance:**

1. As the features are well preserved, the deceased can be identified.
2. Time since death can be calculated for the same reason.
3. The cause of death can be determined because the injuries are well preserved.

7. Summary

1. Rigor mortis appears in the body starting from top and going downwards. It is fully developed in about 12 hours in whole body. It persists for next 12 hours and afterwards disappears from whole body in next 12 hours following the same sequence.
2. Decomposition starts around 24 hours after death comprising of putrefactive and autolytic changes.
3. Marbling, colliquitive liquefaction and ultimately skeletonization occur after death upto 1 month.
4. Depending upon environmental factors instead of decomposition the dead body may go for adipocere formation as well as mummification.