A Gateway to all Post Graduate Courses

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Subject: **Law**

Production of Courseware

- Content for Post Graduate Courses

Paper : Forensic Science and Forensic Medicine

Module : Time since death: rigor mortis, liver mortis, algor mortis, decomposition

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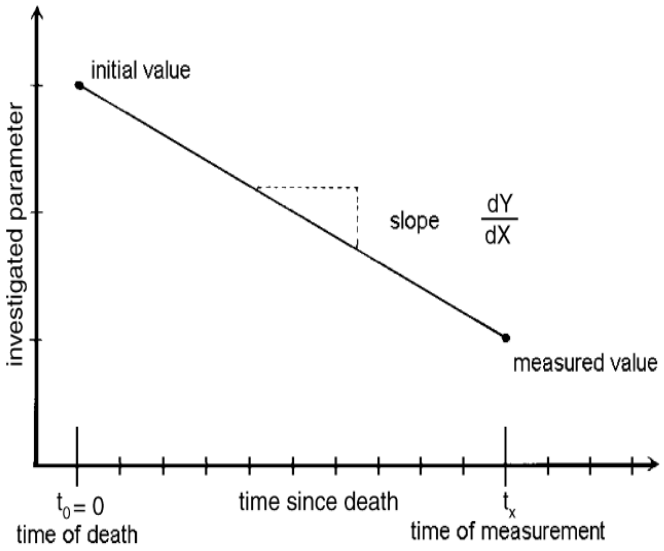
DESCRIPTION OF MODULE

Items	Description of Module
Subject Name	Criminology
Paper Name	Forensic Science and Forensic Medicine
Module Name/Title	Time since death: rigor mortis, liver mortis, algor mortis, decomposition
Module Id	LAW/CJA/VIII/35
Objectives	Learning Outcome: • To make the learners understand about an estimation of the time elapsed since death which is a request almost invariably aimed at forensic specialists summoned to the scene of a death. • To provide an estimation of the changes occurring at different stages of time. • To make the learners understand the changes occurring in the central temperature of the body as well as the environmental.
Prerequisites	General understanding of the changes or combination/integration of different estimators like temperatue, enviornment occuring in body at early and late stages.
Key words	Rigor mortis, lividity, algor morts, Cadaveric spasm, putrefaction.

Time since death

The time passed since death which is also known as post mortem clocking is of great medico-legal importance to correlate the crime with the criminal. The estimation of time since death is one among the necessary information to be addressed after an autopsy examination. Time of death can exonerate or focus the suspect; it can also substantiate or refute suspect/witness statements hence it is one of the most important functions of the medical examiner. Usually estimation of time since death is done during the autopsy of the deceased or the pathologist/expert may also be called upon at the scene of crime to find out the actual time of death through external examinations. 1,2,3

The main principle of the determination of the time since death is the calculation of a measurable date along a time-dependent curve back to the start point. Characteristics of the curve (e.g. the slope) and the start point are influenced by internal and external, antemortem and postmortem conditions.



4 (Source: C. Henssge, B. Madea / Forensic Science International 165 (2007) 182–184)

1 Claus Henssge, Burkhard Madea, Estimation of the time since death, January 17,2007 volume 165, isues 2-3, pages 182-184.
2 Parikh
3 DiMaio VJM, DiMaio D, eds. *Forensic Pathology (Practical Aspects of Criminal and Forensic Investigations)*. 2nd ed. Boca Raton, La: CRC Press, LLC; 2001.

Obviously, exact time cannot be calculated from a single parameter therefore, these influencing factors have to be taken into consideration quantitatively in order to improve the precision of death time estimation. However, a number of cadaveric or environmental factors are there which can influence the normal rate of post mortem changes. Longer the time since death, more difficult it is to estimate the time since death with precision. Hence, apart from post mortem changes, histological, biochemical and circumstantial evidences are also considered.5 Best estimate of time since death can be offered with reasonable degree of medical and scientific knowledge and experience. Although the estimation of time since death is impossible to be 100% accurate except in case where a witness gives testimony of exact time and events happened.

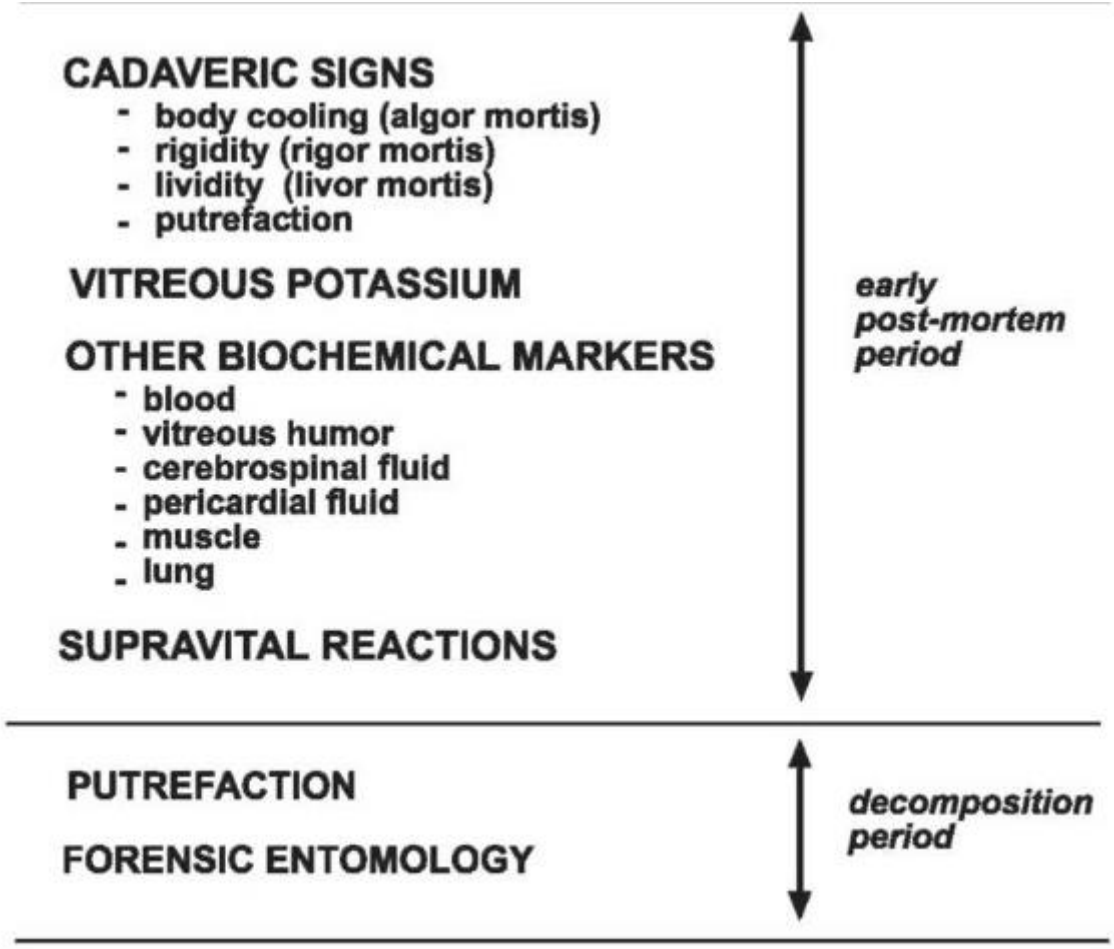
Categorising Time of Death 5

Time of death is broadly categorized in three ways:

- Physiological: when the victim's vital organs actually ceased to function.
- Estimated: A guess based on available information by the medical examiner.
- Legal: time that is shown - by law – time recorded on a death certificate.

4 (C. Henssge, B. Madea / Forensic Science International 165 (2007) 182–184).
5 (http://www.exploreforensics.co.uk/estimating-the-time-of-death.html)

Common estimator of time since death:



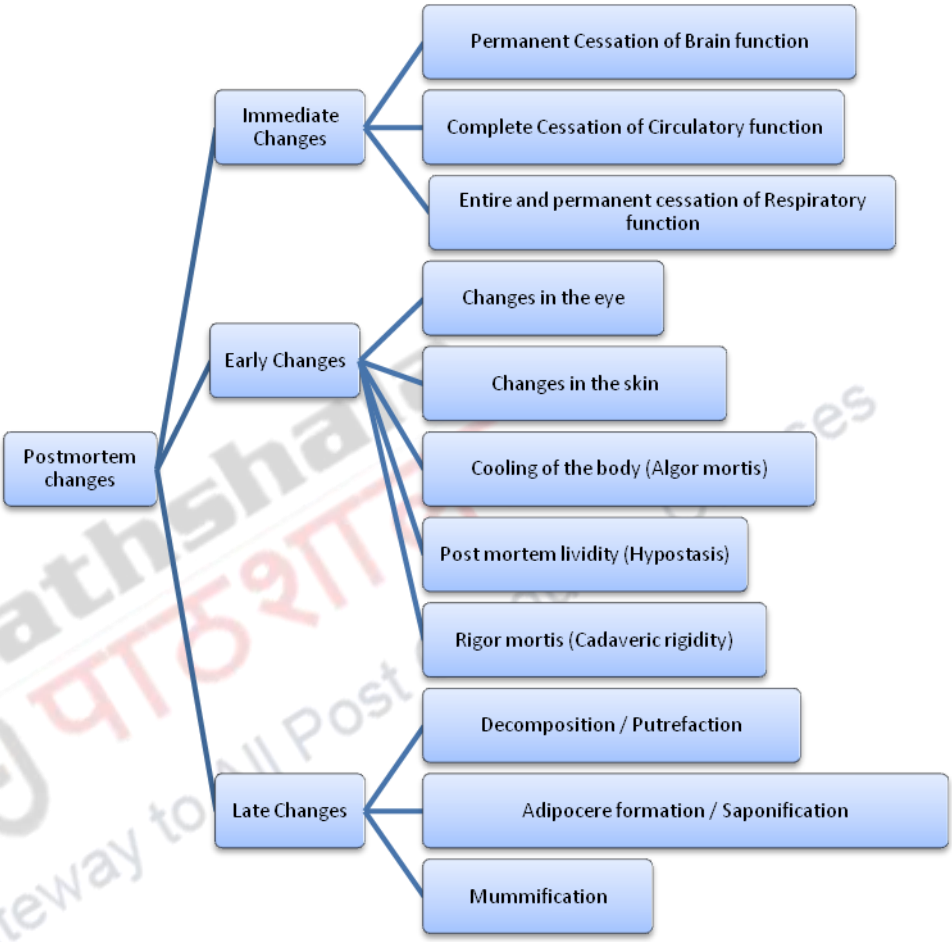
(Available at : http://what-when-how.com/forensic-sciences/time-since-death/)

Medico legal importance of determining time since death:

The fact, that most of the deaths are not witnessed. In case of natural death, it might come when person is sleeping, in accidental/suicidal cases usually the victim is alone and in cases like homicides, and the only witness is the culprit who is not likely to talk about it. That is why it becomes important for medical examiner to determine the time of death to exonerate the innocent or to apprehend the culprit. In criminal cases where it can eliminate some suspect can also focus attention on someone. But only an approximate estimate of time since

death can be made depending upon the environment surrounding the body, size of the corpse, clothing and other factors.

Postmortem changes can be broadly divided in three groups: (parikh)



5 Parikh's Text book of medical jurisprudence Forensic Medicine and Toxicology CBS publisher and distributors PVT.LTD.

6 Dikshit P C, Text book of Forensic Medicine and Toxicology, PEEPEE publisher and distributors (P) LTD.

7 Simpson's Forensic Medicine, 13th Edition, Jason Payne-James, Richard Jones, Steven B Karch, John Manlove, August 26, 2011 by CRC Press.

1- Immediate Changes; includes

- <u>Permanent Cessation of Brain function:</u>

✓ Loss of sensation (touch, pain & temperature)

✓ Absence of motor and sensory functions

✓ Loss of voluntary power to move

✓ Reflexes lost

- <u>Complete Cessation of Circulatory function (2,5,9)</u>

✓ Heart sounds are not found for continous five minutes

✓ ECG can be taken in doubtful cases

✓ Following are the tests that can be performed for stoppage of circulation/heart

➢ Icard's test

➢ Ligature test

➢ Magnus test

➢ Fingernail test

➢ Heat test

➢ Arterial spurting test

- <u>Entire and permanent cessation of Respiratory function (5)</u>

✓ Stoppage of respiration for more than 3-5 minutes (exception: yogic exercises, cheyne's stokes breathing, new born infants)

✓ Following are the tests that can be performed for stoppage of respiration

➢ Feather test

➢ Mirror test

➢ Winslow's test

2- Early Change (5, 7)

- Changes in the eye:

✓ Dilated or fixed pupils

✓ Absence of corneal and light reflex

✓ Marked decrease in intra-ocular pressure

✓ Cloudiness of cornea

✓ Increase in potassium levels

✓ Thin film observed over cornea within minutes

✓ Taché noire

✓ Absence of intraocular fluid suggests more than 4 days.

- Changes in the skin

✓ Pale/white appearance

✓ Loses elasticity

✓ Lips darken

Cooling of the body (Algor mortis)

1. Temperature fall after death is considered one of the prominent early sign of death. Extent of cooling can be used to determine the time since death given the fact that ambient temperature should be lower than the body temperature. As the time passes temperature of the body progressively decreases until it achieve the temperature of its surroundings. A body after death looses heat passively by three different mechanism namely, conduction (heat passes to any other object which comes in contact), convection (heat lost in air) and radiation (heat lost as infrared heat rays)(parikh). As far as temperate climate is concerned, the process of body cooling at the skin surface takes usually 8-10 h but the core of the body takes three times as long to cool down. Liver and brain are the organs taken for measuring core temperature. Such temperature estimates of time since death can be taken into consideration either for cold or for temperate climates. To measure the body temperature, there is a special type of chemical thermometer known as thanatometer. Temperature is measured inserting the thanotometer in the rectum ensuring there is no homosexual activity. In such cases, temperature is taken inserting the thermometer in auditory meatus or notril. Rate by which temperature falls after death is dependent on the temperature difference between the body and its surroundings. In a tropical country like India, fall in temperature is nearly 0.5-0.7 ˚C after death and body takes nearly 16-20 h to attain the ambient temperature. 8.9.10

A rough estimate of time since death can be drawn using a formula

$$\frac{\text{Normal body temperature (37.2C) - rectal temperature}}{\text{Average rate of fall of temperature per hour (0.6 C)}}$$

Or

$$\text{Time since death} = \frac{98.6°F - \text{Rectal Temp (°F)}}{1.5}$$

Factors affecting the rate of cooling: (2,6,7)

Body weight: larger the body weight, slower will be the cooling while less body weight indicates faster cooling.

Age and condition of the body: cooling of body directly depends on stature of the body. Small stature like of children and adults of small stature cools rapidly because of having large body surface as compared to their body weight. Lean or weak bodies looses haet rapidly in comparison to fat bodies as fat is bad conductor of heat.

Mode of death: heat loss from a body may start before sometime of death if the person was suffering from prolonged illness. If a healthy person dies suddenly, process of cooling will be quite low.

Surface area of the body: Larger surface area of body speeds up cooling rate.

Emaciation and clothing: also affects the rate of cooling of body.

Environmental temperature: high humidity enhances cooling rate, similarly, high air velocity also enhances cooling rate. Body looses heat rapidly if the difference in temperature between environment and body is great.

Surroundings: convection accelerates the heat loss because of air movement. Therefore, a body lying in an open area will lose heat more faster than one lying in a closed area. Naked body colls rapidlt than the body well covered with a clothes. Likewise, body found in water will lose heat rapidly than the body found on land because of convection.

8- Suzutani T, Ishibashi H, Takatori T. Studies on the estimation of the postmortem interval. 2. The postmortem lividity (author's translation). Hokkaido Igaku Zasshi 1978; 52:259-267

9- Henssge C, Knight B, Drompecher T, Madea B, Nokes L. The estimation of the time since death in the early postmortem period. London: Edward Arnold; 1995.

10 Sund-Levander M, Forsberg C, Wahren LK. Normal oral, rectal, tympanic and axillary body temperature in adult men and women: a systematic literature review. *Scand J Caring Sci*. 2002 Jun. 16(2):122-8.[Medline].

Post mortem lividity (Hypostasis)

Lividity is one of the reasonable post mortem change. It is also known as post mortem staining, livor mortis, suggilations, hypostasis or vibices. Postmortem hypostasis is defined as the intravascular pooling of blood in gravitationally dependent parts of the body after death (9). Basically lividity is the accumulation of blood in the capillaries and small veins in the dependent parts of the body due to gravitational forces and show up through the skin as livid red area of discolouration. The cessation of blood circulation at the time of death, the blood gravitates in the capillaries and venules and settles in the lowest part of the body available. Staining is same as that of colour of blood i.e. reddish-purple. (2) The lividity doesn't show where the body is in contact with something. Thus a body lying on its back will show lividity in the small of its back, its neck etc., but not parts of the body directly touching the ground. However, intense lividity can be associated with small hemorrhages in the skin, so-called postmortem hypostatic hemorrhages which is also known as Tardieu spots. 2, 9

9- Pollanen MS[1], Perera SD, Clutterbuck DJ, Hemorrhagic lividity of the neck: controlled induction of postmortem hypostatic hemorrhages. Am J Forensic Med Pathol. 2009 Dec;30(4):322-6. doi: 10.1097/PAF.0b013e3181c17ec2)

Medico-legal Importance of studying lividity:

Helps in determining-

- ✓ It is a sign of death
- ✓ Estimating the time of death
- ✓ In determining position of the body after death

- ✓ Determining Cause of death from color; generally post mortem staining colour is livid but in some cases of poisoning colour of post mortem staining will differ (in CO poisoning- cherry red colour, in HCN poisoning- bright red, in aniline dye poisoning- blue)

Appearance of lividity:

Lividity usually starts appearing within half an hour – one hour in case of a healthy individual in form of patchy area of discoloration. These blotches within 6-12 hour period gradually coalesce and manifests itself as reddish-purple discolouration. In northern India, lividity appearance starts within an hour after death and takes nearly 6-10 h to be well marked. In cases, where person is dying of narcotic poisoning, or agonal period is prolonged, before death circulation became stagnant, in a slowly dying person lividity starts appearing before death. Contrary to this, cases like death due to anaemia, acute lobar neumonia and haemorrhage its appearance is late due to intravascular clotting. 10 (basu and Krishan Vij)

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10 Vij K, Text book of Forensic Medicine and Toxicology, principle and practice, Reed Elsevier India Private Limited.

www.malthus.com.br

D.P.Lyle, carbon monoxide A Deadly Gas, april 4, 2013.

Livor mortis: Contact Flattening' where the pressure exerted by these areas prevents the pooling of blood in the vessels.

Tardieu spots are petechiae and purpuric hemorrhages that develop in areas of dependency secondary to the rupture of degenerating vessels under the influence of increased pressure from gravity (12)

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11 D.P.Lyle, carbon monoxide A Deadly Gas, april 4, 2013
12 (http://www.thepostmortempost.com/2015/10/01/stage-4-livor-mortis-2/)

Blanching: Thumb pressure indicates that the lividity is not fullyfixed.

Extent and distribution: 13

- ✓ It depends upon amount of fibrin or fibrino-lysin in the blood.
- ✓ Amount of still fluid blood in the circulation.
- ✓ The distribution of lividity depends upon the posture of the body after death.
- ✓ Where the body is lying on the back, lividity will be found on the posterior and dependent parts like back of neck, against the lumbar region, extensor surface of the upper limbs, sparing areas that prevent pooling of blood as these areas are pressed against the ground. These areas include back of head, back of thighs and calves, back of shoulders and are known as ‘areas of contact flattening’. These areas will remain pale and blenched between the areas of lividity. The areas which are covered with tight clothing like belt, constricting terminal parts of socks will also not be having lividity, it may occur ad strips or bands.
- ✓ In case of hanging, livor mortis can be seen on dependent areas like lower limbs, genitalia and hans.

- ✓ In case of drowning, livor mortis can be seen on face, upper part of chest, hands , feets and lower legs. If the body is constantly moving with water current, hypostasis may not develop.
- ✓ In face down death, in case of epilepsy or drunken victims, whitening can be seen around nose and lips.
- ✓ On the back if the body was in a supine position or on the face and front if the body remained prone.
- ✓ Hypostasis can also be seen in viscera (in heart, lungs and intestine)

Colour of hypostasis: 13

The colour appearing in hypostasis depends on oxygenation. The Usual colour is red to purple but when the person is dying of hypoxic state due to reduced haemoglobin, color apper is of little darker while those dying of hypothermia (cold or drowning), colour is comparatively light (may be of pink color) due to presence of much oxyhaemoglobin (cherry pink – in carbon monon oxide poisoning, coffee brown by potassium chlorate, potassium bihromate, nitrobenzene and aniline, dark brown by phosphorus and bright red in case of refrigerated dead body.

13 MEDICOLEGAL SIGNIFICANCE OF POSTMORTEM LIVIDITY IN DETERMINATION OF TIME SINCE DEATH, Anand P Rayamane , M P Kumar , S D Nanandkar , G S Chavan, S S Bhise, Dayananda R, Journal of Forensic Medicine & Toxicology Vol. 31 No. 1 & 2, January - June 2014.

Disappearance of post mortem staining:

Colour appeared in hypostasis tends to disappear with the onset of decomposition as the gases produced during decomposition like H2S by the decomposed tissues acts with the haemoglobin of blood anf convert it to sulphmethhaemoglobin and takes up the usual colour of decomposition.

Hypostasis is affected by: 14, 2

Victim's age

- ✓ Deceased pre-morbid health
- ✓ Type of drug taken/administered prior to death
- ✓ Level of activity at time of death
- ✓ Environmental conditions
- ✓ In dark complexioned people: although it develops but difficult to see
- ✓ In anaemics or person dyin of severe haemorrhage
- ✓ In bodies which keep changing their position

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14 I Gordon and H A Shapiro, Forensic Medicine. A Guide To Principles. The Diagnosis and the Early Sign Death: the phenomena that Occur After Death, 1st ed. Churchill Livingstone, 1975. p.18 – 25. 5. 2 Dixit. P. C. Changes after Death, A Text Book of Forensic Medicine and Toxicology, 1st ed. New Delhi: Peepee Publishers; 2007. p. 91-95.

Rigor mortis (Cadaveric rigidity)

Rigor mortis (rigor = rigid, mortis = death) which is also known as cadaveric rigidity, is basically the stiffness caused in body after death. chemical changes in the body makes muscle mass to become rigid. After death muscles are initially flaccid which can be moved easily which is followed by stiffness of muscles that subcides graduall and body becomes flaccid again. This can be broadly divided in three phases of change in state of muscles where muscles pass through three different phases, i.e. primary flaccidity, rigor mortis and secondary flaccidity. 15,16,17

Primary flaccidity: where muscles are comes just able to respond to electrical or chemical stimuli. This phase comes just after somatic death. Rigor mortis: body muscles start developing rigidity and no response towards electrical or chemical stimuli.

Secondary flaccidity: rigor passes away and that is the onset of putrefaction.

18 http://www.documentingreality.com/forum/f10/rigor-mortis-lower-limbs-101806/

15 I Gordon and H A Shapiro, Forensic Medicine. A Guide To Principles. The Diagnosis and the Early Sign Death: the phenomena that Occur After Death, 1st ed. Churchill Livingstone, 1975. p.18 – 25.
16 Parikh C.K. 6 th ed. New Delhi: C B S Publishers and distributors; 1999. p. 3.10-3.13.
17 Gradwohl's Legal Medicine. Changes after death. Francis E. Camps. 3rd ed. Year Book Medical Publishers INC; 17 1976. p. 81- 88 8. Modi's Medical Jurisprudence and Toxicology. Postmortem Change and Time since Death.
18 http://www.documentingreality.com/forum/f10/rigor-mortis-lower-limbs-101806/

Medico legal importance of rigor mortis:

- ✓ Can tell Time of Death
- ✓ Can tell whether the body has been moved
- ✓ May be able to tell cause of death

Pathophysiology of rigor mortis: 19,20

The proteins, actin and myosin built sarcomere (contractile unit of muscle). Contraction in the muscle is achieved by these two filaments. Myosin heads bind the ATP and form myosin-ATP complex which has high affinity for actin, thus results in

actin-myosin complex. When the actin- myoin complex is formed, the low ATPase activity exhibited by free myosin heads is enhanced and ATP is hydrolysed and energy released is used for dissociation of the actin-myosin complex. In daily life, there is a balance between utilization and resynthesis of ATP in the muscular tissues. ATP utilized in contraction is immediately synthesized. After death, ATP is not generated and after the consumption of stored ATP, actin-myosin complex is not split, and the muscles remain inextensible giving rise to rigor mortis.

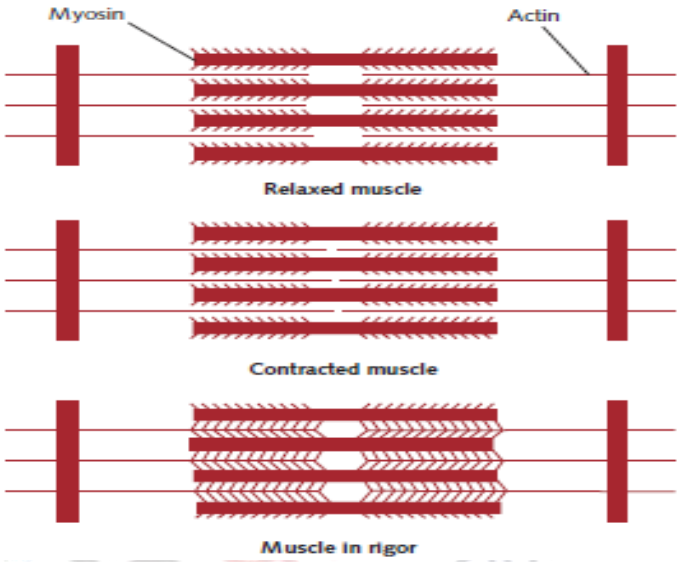

Figure: diagrammatic arrangements of actin and myosin filaments in muscle fibre

Process of development of rigor mortis:

After death, ATP is not generated hence the actin-myosin complex is not split and muscles become inextensible. This actin-myosin complex is the reason for development of rigor mortis. The process of development of rigor mortis can be studied under the following phases -

First phase: this is the phase where cellular death has not occurred and body is still able to utilizt the stored ATP(ATP already present and resynthesis from available glycogen stores).This represents onset of rigot mortis in circumstances like where depletion of glycogen due to vigorous exercise prior to death.

Second phase: this is the onset of rigor mortis when content of ATP is critically low and the muscles tend to turn into viscous, inextensible, dehydrated stiff gel.

Third phase: rigidity fully developed and is irreversible.

Fourth phase: in this phase muscles looses and rigidity disappears. This is also known as phase of resolution.

Time of onset and its duration:

- ✓ Rigor mortis can be seen within 30min- 1 hour following death.
- ✓ Gets well established in 8-12 hours
- ✓ complete rigor will Maintains for 8- 12 hours
- ✓ rigor begins to dissipate over next 12 hours.(depends on environmental temperature)
- ✓ fully flaccid by 36 hours
- ✓ in northern india, usual duration for rigor mortis during summer is 18-36 hour in summer and 24-48 hours in winter.

Order of appearance and disappearance:

It is considered to appear first in eyelids by 1-2 hour followed by muscles of face, neck , lower jaw, muscles of the chest, upper limb, abdomen and lower limbs. Since rigor mortis as a physicochemical process, it affects all the body muscles simultaneously.

Depending upon the progression of rigor mortis, corpses may be divided in three categories:

- ✓ Where the corpse is still warm, without showing any rigor indicates death within 1-2 hours previously.
- ✓ Body where the rigor is progressing but not established in full body, indicates death within 4-12 hour previously.
- ✓ Those corpses where the rigor is well developed in entire body, indicates death beyond 9-12 hours.
- ✓ The disappearance of rigor follows the same fashion as its appearance.

Factors influencing Rigor Mortis: 21

Environmental temperature: 'rigidity persists longer in cold'

- ✓ Cold and wet weather: onset will be slow, and duration will be longer
- ✓ Hot and dry weather: onset will be fast while duration is shorter

Muscular activity:

- ✓ If musles are healthy, robust and at rest before death: onset will be slow, and duration will be longer
- ✓ If muscles exhausted /fatigued: onset rapid

Nature of death:

- ✓ bodies of those who are emaciated or die of wasting diseases pass rapidly into state of rigidity which is of shorter duration.

Central nervous system:

- ✓ nerve supply or even removal of brain does not affect the rigor. Rigor mortis occur in amputated body parts too.

Age:

- ✓ Not occur in foetus less than 7 months
- ✓ May be found in stillborn infants
- ✓ In healthy adults-well marked
- ✓ Children and old people: weak and early

Cause of death:

- ✓ Asphyxia, pneumonia, muscle paralysis & dehydration: slow onset
- ✓ Septicemia & poisoning: rapid onset, may even be absent, especially in limbs affected by septicemia
- ✓ Emaciated or died of wasting disease: rapid onset, short duration

19 Perper J.A., Time of death and changes after death. Pt 1. Anatomical considerations, in Spitz W.U. (ed): Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation, 3rd ed. Springfield: Charles C. Thomas, 1993, pp 26-27.
20DiMaio D.J. and DiMaio V.J.M.: Forensic Pathology. New York: Elsevier, 1989.). (Graham M.A. and Hanzlick R.: Forensic Pathology in Criminal Cases. Carlsbad: Lexis Law Publishing, 1997.
21Subrahmanayam BV. Death in its medicolegal aspects. Medical Jurisprudence and Toxicology, 22nd Ed, Butterworth's India 1999; 140-43. 2. Parikh CK. Medicolegal aspects of Death.) (Parikh's Text Book of Medical Jurisprudence and Toxicology 6th Ed; CBS Publication, Bombay 1999; 148-54.
22 Vij K. Death and its medico-legal aspects. Text book of Forensic Medicine and Toxicology, 2nd Ed.; BI Churchill Livingstone, New Delhi 2002; 159-69.) Mant AK. Postmortem changes. Taylor's Principles and Practice of Medical Jusiprudence 13th Ed.; Sydney Smith, Chicago 1965; 140-43.

Cadaveric spasm (instant rigor/ cataleptic rigidity)

Cadaveric spasm is the stiffness of the muscles that has its onset immediately after death and basis of such investigation is to find out items gripped in hand of victim before the onset of rigor state.it is quite common but rare phenomenon. Usually after death muscles become flaccid which is followed by rigor mortis but in case of cadaveric spasm, the state of primary flaccidity does not come and muscles acquire stiffness at the time of death. It is usually associated with the violent deaths. Its mechanism or nature is still obscure but the reason can be attributed to the ATP stores in the affected muscles. Most of the times cadaveric spasm is associated with the emotional or physical stress. Cases are found where bodies are recovered from rivers with weeds or twigs grasped in their hands or fingers of person committing suicide found bend tightly.23,24,25,26,27,28

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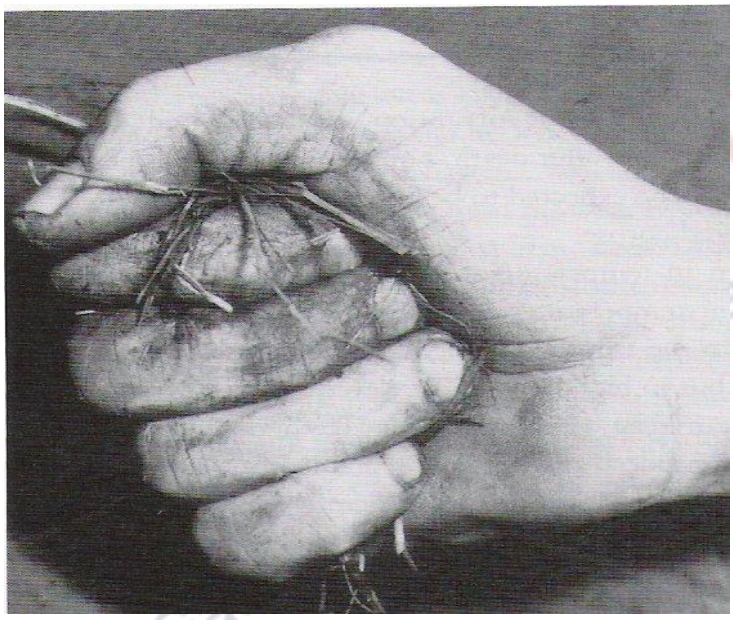
(23) Serafettin Demirci, Kamil Hakan Dogan, Zerrin Erkol, Idris Deniz Precautions Taken to Avoid Abandoning the Act of Hanging and Reducing Pain in Suicidal Hanging Cases. Am. J. Forensic Med. Pathol.2009; 30: 32–35. 2.
24 F.A. Benomran, S.E. Masood, A.I. Hassan. Masking and bondage in suicidal hanging: a case report. Med. Sci. Law.2007; 47(2): 177- 80. 3. Krill A, Griller W, Wilske J. Modern variant of hanging: use of timeprogrammed winch. Arch. Krminol.2002; 209(3-4): 110-5.
25 Kumar V. Hanging without knot in the noose. Journal of Forensic and legal medicine.2007; 14(1): 35-8.
26 Pollak S, Stellwag carion C. Deviations in findings in hanging by interposition of fingers between noose and neck. Arch. Kriminol.1986; 177(3-4); 76-84.
27 Kanchan T, Menezes RJ, Manipady S. Haemorrhoids leading to postmortem bleeding artifact. J. Clin. Forensic Med.2006; 13 (5):277-9.
28 Bharadwaj D N, Sharma SK, Gupta S. Haemorrhoids leading to postmortem artifact: a case report. Med. Sci. Law.2005; 45(3): 265- 6.



Cadaveric spasm in case of drowning: victim had grass from the river bank firmly grasped in the hand

Medico legal importance of cadaveric spasm:

- ✓ Diagnosis of cause of death as in case of weapon found in hand
- ✓ In cases like Drowning
- ✓ ID of assailant may be found in hand
- ✓ May allow one to know state of person prior to death

Difference between Rigor mortis and cadaveric spasm:

	Rigor mortis	cadaveric spasm
Onset	Onset delayed after death (1-2 hours)	Onset is immediate
Duration	Duration is approximately 12-24 hrs	Duration is a few hours, until and unless it is replaced by rigor mortis
Intensity	Intensity comparatively moderate	Intensity comparatively very strong
Mechanism	When breakdown of ATP is below critical level (less than 15%)	Mechanism of formation unknown but factors like Excitement, fear, fatigue, exhaustion, nervous tension, contraction of muscles at time of death might be the reasons.
Muscles involved	All muscles of the body are affected gradually	Selected muscles, which were in a state of contraction at the time of death, are affected.
Medico legal bearing	Mostly helps to know the time since death	It helps to suggest the manner of death, i.e. whether suicide, accident or homicide

3- Late Changes; includes

- Decomposition / Putrefaction.

There are changes in the body which takes place after 24 hour of death and is sure and certain sign of death. It basically represents the decay or decomposition of body. The process of decomposition include 29,30

1- Putrefaction
2- Adipocere formation
3- Mummification

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29 Davis JB, Goff ML (2000) Decomposition patterns in terrestrial and intertidal habitats on O'ahu Island and Coconut Island Hawai'i. J Forensic Sci 45:824–830

30 Early M, Goff ML (1986) Arthropod succession patterns in exposed carrion on the island of O"ahu, Hawaiian Islands, USA. J Med Entomol 23:520–531

Putrefaction

It is Last stage in the resolution of the body where complex organic body constituents get converted to the simple inorganic state. Putrefaction is mainly brought about by two processes: Autolysis and bacterial action. 30

- **Autolysis:**

✓ This is rise in level of enzyme in tissues after death.
✓ They soften and liquefy the dead tissues as the part of digestive action of the enzyme.
✓ The earliest autolytic changes can be seen in parenchymatous tissues or soft tissues.
✓ Autolysis Starts 3-4 hours after death and continues for 2-3 days, sometimes even longer.
✓ The process can be stopped by freezing.

- **Bacterial action:**

- ✓ Action of bacterial enzymes (aerobic and anaerobic) on tissue components like carbohydrates/fat/proteins.
- ✓ For bacterial growth – warmth, moisture are conditions favorable conditions.
- ✓ Clostridium, streptococci, E coli, Bacillus proteus are the bacteria known to decompose body tissue components.
- ✓ Clostridium welchii is the bacteria which initiates haemolysis of blood and starts the process of putrefaction.
- ✓ In warm climate putrefaction starts comparatively faster while in cold climate the process is retarded.
- ✓ Development of gases under the skin and hollow viscera takes 18-36 hrs. 24-48 hrs in case of solid viscera.
- ✓ Purefaction changes include:

Change in colour:

discolouration varies fron green to black due to formation of sulphmethaemoglobin.

Foul smelling gases:

Hydrogen sulphide ammonia phosphorated hydrogen and methane are the gases which formation creates foul smell.

Sufficient accumulation of these gases is the reason why body floats in case of drowning.

Pressure effect of putrefactive gases:

Pressure created displaces the diaphragm upwards.

Discolored fluid and liquefied tissue mixes with gases producing froth.

Shifting of the area of hypostasis.

Changes in skin, hair and wound.

Extrusion of fluid from the mouth and nose.

Emptying of the heart.

Changes in appearance of genitals.

Other sequale:

Fall of teeth

Skull sutures separation

Liquefied brain matter oozes out

Factors affecting putrefaction:

- ✓ Warmth and clothing
- ✓ Moisture
- ✓ Air
- ✓ Age
- ✓ Manner of burial
- ✓ Condition of body
- ✓ Sex
- ✓ Mode of death

Adipocere

After death, bacterial enzyme act upon body fats causing their hydrolysis and hydrogenation. Palmitic acid is the main component of adipocere. Its appearance is yellowish white with rancid smell. Adipocere can be formed at any site where fatty tissues are present.it takes nearly 3 weeks in summer while in tropics 5-15 days. 2,6,7

Medico legal importance of adipocere

- ✓ In establishing identity
- ✓ Determining cause of death
- ✓ To establish time since death
- ✓ To determine place of death

Optimal conditions for the formation of adipocere are:

- ✓ Abundant moisture
- ✓ Bacteria (*clostridium welchii*)
- ✓ Optimal temperature
- ✓ Relative air
- ✓ Abundance of adipose tissue

Mummification

It is a peculiar desiccation and modified form of putrefaction of a dead body where by its soft parts shrivel up but retain the natural appearance and the features of the body instead of liquefaction. Body attains rusty brown color, dry leathery skin which is adherent to bones while internal organs get transformed into thick brown mass. Mummification occurs in bodies buried in shallow graves, in dry sandy soils and takes time nearly 3 months to 1-2 yrs.

Medico legal importance:

- ✓ Identification
- ✓ Cause of death
- ✓ Time since death
- ✓ Place of death

The conditions necessary for its formation are:

- ✓ Warm and dry atmosphere
- ✓ Moisture deprived area so proliferation of putrefying bacteria or microorganisms can be prohibited.
- ✓ Free air circulation around the body.

Forensic entomology

Flies and *maggots* also provide an approximate time of death, very useful for cases where the body has been long dead. Only certain insects will feed and lay eggs on a dead corpse and forensic entomologists study these insects, their

larvae cycles and thereafter can determine whether a body has been dead for just one day or up to 3 or 4 weeks. 31

Time	Physical appearance of body	Insect present at that stage
0-3 days	Proteins and carbohydrates in the deceased body begin to break down.	Blowflies e.g. Bluebottle flies, Syrphidae flies
4-7 days	Body is starting to decay and causes the abdomen to inflate because of the gases inside.	Fly larvae and beetle e.g. Rove Beetles
8-18 days	Decay is well and truly setting in; the abdomen wall begins to break down.	Ants, cockroaches, beetles and flies
19-30 days	The decaying body enters a stage know as 'post-decay'; in wet, humid conditionsthe body is sticky and wet; in hot dry conditions, the body is dried out.	Beetles and mites e.g. Springtail beetle, Acari, as 'post-decay'; in wet, humid conditions, Nematocera (present only during the winter months),
31 days and onwards	The bones, skin and hair that remain no longer give off a powerful stench and smell just like the soil surrounding it.	

30 Gill-King H (1996) Chemical and ultrastructural aspects of decomposition. In: Haglund WD, Sorg MH (eds) Forensic taphonomy: the postmortem fate of human remains. CRC, New York

31 Lord WD, Goff ML (2003) Forensic entomology: application of entomological methods to the investigation of death. In: Froede RC (ed) Handbook of Forensic Pathology, 2nd Edn, College of American Pathologists, Illinois.