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1. Learning Outcomes

After studying this module, you shall be able to-

- Know about the classification of thermal injuries
- Understand what are burns and its classification
- Learn about the causes of death in burn injuries, and
- Analyze postmortem changes and medico-legal aspects

2. Introduction - Thermal Injuries

These are the injuries produced by exposure of body to extremes of temperature and may be classified as

(A) Injuries due to high temperature - HEAT

1. Generalized effects of Heat
 - (a) Heat Stroke
 - (b) Heat Hyperpyrexia
 - (c) Heat Cramps (Miner's cramps)
 - (d) Heat Exhaustion
2. Localized effects of Heat
 - (a) Burns due to dry heat
 - (b) Scalds due to moist heat

(B) Injuries due to low temperature - COLD

1. Generalized effects of cold=Hypothermia
2. Localized effects of cold
 - (a) Chilblain
 - (b) Frost Bite
 - (c) Trench foot or Immersion foot

1) Generalized Effects of Heat-

They are produced when victim is exposed to abnormal hot environmental conditions like prevailing in our country. These conditions although frequent but not of much medico-legal significance of the attending circumstances are self-explanatory. The importance lies in the fact that such cases owing to their presenting symptoms may be as meningitis. Another medico-legally important situation may rise in cases of death occurring in mine-workers in which question of compensation arises. Of course that has to be dealt as per Workmen's Compensation Act.

a) Heat Stroke: There occurs failure of thermoregulatory mechanism in body leading to sudden unconsciousness hence the name 'Stroke'. It may further lead to fatality in a span of 5 minutes or delayed 3 day. It is seen usually when a person is exposed to direct sunlight during summer for considerably long period. The onset is usually sudden with symptoms like headache, nausea, vomiting, feeling of exhaustion with lethargy, weakness in limbs & excessive desire for micturition. Face is flushed with dry, hot skin because of impaired sweating. Pupils contracted may be even pin pointed also with sluggish light reaction. Body temperature may rise up to 43°C (109°F). Pulse becomes irregular respiration is labored & person develops oliguria. The person becomes delirious and may have convulsion before being comatosed.

b) Heat Hyperpyrexia: Some authors equate hyperpyrexia with heat stroke but both are different entities. Heat hyperpyrexia occurs because of malfunctioning of thermoregulatory centre (not the failure) in which body temperature exceeds 41°C (106°F). Other than environmental factors hyperpyrexia may be associated with overdose of certain drugs like Atropine, Amphetamine and substances of abuse like cocaine. Several anesthetic agents like halothane & muscle relaxants like suxamethonium several mel mits have been lodged against anaesthetic surgeons in, like USA & UK.

c) Heat Cramps (Miner's Cramp, Fireman's Cramp)

There occurs excessive loss of salt or water or both by way of perspiration. Painful spasms of voluntary muscles with flushing and dilatation of pupil is seen. It is slow in onset & non-fatal.

d) Heat Exhaustion (heat collapse/heat prostration)

It is a condition of collapse i.e. effect of heat over circulatory without any rise body temperature and usually seen following exposure to hot & humid atmosphere. Characteristic feature is prostration accompanied by evidence of peripheral vascular failure like hypotension, pallor and poor venous return. The patient recovers soon & lethality is unusual due to sudden failure of heart.

All the above mentioned condition are frequently encountered in person working in mines furnace bakeries, sugar, laundries etc. & soldiers on march. Alcoholism, hunger, lack of sleep, fatigue further predisposes a person to these generalized effects of heat.

Treatment- the victim/person should be removed immediately from the hot environment to a cooler place. Water should be given orally if possible. Hydrotherapy should be started at the earliest so as to bring down the body temperature. Intravenous fluids should be given with monitoring of electrolyte imbalance chiefly sodium (hyponatremia).

PMF- No specific findings are observed except the body is dry & postmortem calorificity which is appreciable in early period. Rigor mortis starts early as well as passes off early. Internal organs are congested and petechial hemorrhages may be found on lungs.

MLI- Deaths are usually accidental in manner.

2) Localized Effects of Heat-

Various factors which determine the effects produced include-

- a) Intensity/Degree of Heat
- b) Period of contact/Duration
- c) Material used for transmission of heat
- d) Nature i.e. dry or moist

The more the intensity of heat the greater is the damage caused. Minimum 45⁰C temperature is required to produce any invisible damage. However temperature of 60⁰C will produce the injury instantaneously. Duration of contact is directly related with visible damage. Hot metals/glass produces more damage in comparison to flame heat. The damage produced by dry heat (burns) & moist heat (scalds) vary greatly in appearance & are being discussed in detail.

3. Burns

Definition:

Injury produced in the body by application of dry heat like flame/fire/ heated substance or radiant heat. However Section 324 & 326 I.P.C. specifies any 'hurt' or 'grievous hurt' which is caused by 'fire or any heated substance' or 'corrosive' or 'explosive substance' is punishable more severely in comparison to unspecified means.

The usual circumstances under which a person sustains burn injuries are catching of fire by clothes worn by victim while doing household chores like cooking on a gas stove or Kerosene oil stoves. To know the extent of burn injuries various scientists have classified them into various ways.

1) Wilson's Classification:

It is most commonly used in medico-legal practice. According to this, various burn injuries can be categorized into 3 types depending upon body layer involved.

a) Epidermal: There occurs reddening (erythema) and blister formation. These blisters contain serum rich in protein & chlorides and are surrounded by a zone of hyperemia (red line). These are painful & heal without formation of any scar.

b) Dermo-epidermal: When full thickness of skin is involved in burn injury including hair follicles, sweat and sebaceous glands. These are extremely painful due to involvement of sensory nerve endings and heal with formation of scar due to damage to all layers of skin.

c) Deep: When deeper tissues below skin are involved viz. subcutaneous tissues, muscles and bones etc. These are relatively less painful owing to destruction of nerve endings and heal with scar and contracture formation. Thus, they cause much disfigurement and loss of function of the part of body involved chiefly when near a joint.

2) Dupytren's Classification:

According to depth of tissue involved he classified burn injuries into six categories:

- i) **First Degree:** when low degree heat is applied for very short duration, there occurs an erythema or redness over area of contact. It remains painful for a day or two and redness fades in few hours or a day. The covering superficial layer of epidermis may get devitalized and sheds off in few days.
- ii) **Second Degree:** The epidermis is affected completely. There occurs blister formation surrounded by a zone of hyperaemia. The blisters contain serous fluid which is rich in protein and chloride. These are very painful and if extensive; also produce hypovolumic shock. They usually heal in one week, without scar formation, may rupture & get infected.
- iii) **Third Degree:** The epidermis is completely destroyed with involvement of dermis. There occurs blister formation with red line. They ulcerate and may get infected and are extremely painful. They heal with formation of scar.
- iv) **Fourth Degree:** Whole thickness of skin is involved. These are not much painful owing to destruction of nerve ending. Usually followed by sloughing after some days.
- v) **Fifth degree:** Depth of lesion extends further and subcutaneous tissue is involved. These are less painful owing to total destruction of sensory nerve endings. These heal with deep scarring, produce contractures and when close to a joint, seriously hamper the movement at joint.
- vi) **Sixth Degree:** In this muscles and bone are also involved. There occurs charring of the limb and heal with much difficulty with contracture formation.

3) Hebra's Classification:

According to this, the burn injuries can be categorized into 3 only by clubbing together the injuries classified by Dupuytren i.e.

- i) **Epidermal:** 1st and 2nd degree
- ii) **Dermo-epidermal:** 3rd and 4th degree
- iii) **Deep:** 5th and 6th Degree

4. Factors affecting prognosis of burns

1. Body surface area involved:

It is most important parameter which affects the prognosis in case of burn injury. To estimate the body surface area involved, “**Rule of Nines**” given by Alexander Wallace (As per table given below) is practiced clinically for calculating the amount of fluid i.e. “ration” to be given to injured adult. However, it also helps in knowing the prognosis of injury.

Head and neck	9%
Front of chest	9%
Back of chest	9%
Front of abdomen	9%
Back of abdomen	9%
Right upper limb	9%
Left upper limb	9%
Front of right lower limb	9%
Back of right lower limb	9%

Front of left lower limb	9%
Back of left lower limb	9%
Perineal area/Pudendal area	1%
Total	100%

For calculating percentage of body surface area involved in children in practice **“Rule of five”** may be more appropriate. Accordingly the body can be divided into following 5 parts each assigned as 20%. They are further subdivided into 4 quadrants/parts and assigned 5% for each.

1. Head & neck -20% (5% x 4)
2. Abdomen -20% (5% x 4)
3. Chest -20% (5% x 4)
4. Upper Limb -20% (5% x 4)
5. Lower Limb -20% (5% x 4)

For calculating percentage in case of scattered burn injuries **‘Palm rule’** has been found handy. According to it the surface area of the palm of victim is approximately 1% of total body surface area.

Generally speaking involvement of about $\frac{1}{3}^{\text{rd}}$ (33%) of total body surface area has grave prognosis and about 50% involvement of total body surface area is expected to be fatal in present Indian circumstances. However with recent advances in modalities of treatment prognosis is expected to improve. A recent Delhi High Court judgment for enforcing Government to construct separate burn wards in various hospitals with better treatment and patient care, one expects further improvement in near future.

2. Depth of burn injury:

Deeper the burns, difficult are the healing process giving rise to more complications. Superficial burns will produce more pain thereby causing neurogenic shock whereas in deep burns although pain is less but hypovolemia is much.

However, when we talk about the prognosis/fatality, body surface area involved is more important than depth of burn injury. To elaborate one can say a deep wound over a small area has better prognosis than superficial burn over large area.

3. Site of burn injury:

Burns on neck, chest and abdomen have grave prognosis and over perineal region has worst prognosis.

4. Age of Victim:

Victims in extreme age groups are vulnerable to lethal complications and succumb easily. In case of children about 20% burns have been found to be fatal.

5. Sex of victim:

Males can cope up burn injuries better than females.

6. Intensity of Heat:

More the intensity of heat greater is the damage produced. A minimum temperature of 45°C is required to produce burn injury, though the time needed will be few hours. A temperature of about 60°C produces effect of burns in few minutes. A temperature of about 1000°C will completely incinerate the body in about an hour.

7. Duration of Exposure:

Longer the duration of contact/exposure to heat the severer will be the burns produced.

5. Cause of Death in Burn Injuries

1. Immediate Causes

- (a) **Neurogenic Shock:** Death may occur within few hours due to severe pain especially in extensive superficial burn injuries.
- (b) **Suffocation:** Death may occur due to inhalation of smoke, CO, CO₂ and other irrespirable gases during conflagration. Cases are frequently encountered where practice of lighting 'Angithi' during winter season inside the room is prevalent. It burns slowly and because of incomplete combination of coal, CO and smoke are produced. Person while sleeping gradually inhales and succumbs to suffocation. Simultaneously the cotton quilt which a person wraps to cover himself, accidentally catches fire with slow burning angithi. It heads to production of huge amount of irrespirable gases and the person dies due to suffocation. Similarly if a person tries to commit suicide by pouring Kerosene oil over himself, smoke might enter the respiratory passage thus person dies due to combination of suffocation & shock.
- (c) **Injuries:** The victim dies while attempting to escape from site of fire, by sustaining injuries from falling structure of building or hitting an object.

2. Early Causes

- a) **Hypovolumic Shock:** Death occurs within 24-36 hours due to loss of fluid from burnt surface. More than half of fluid loss is fatal immediately.
- b) **Pulmonary edema:** Death occurs in a day or two due to pulmonary edema, glottic edema or laryngeal edema.
- c) **Electrolyte imbalance** mainly hypokalaemia can also lead to death in early period after sustaining burn injuries.

3. Late/Delayed Causes

- a) **Toxaemia:** There occurs systemic absorption of various toxins in blood which are produced at ulcerated areas after burns. Death due to shock as a result of toxaemia usually occurs in 36-48 hours.
- b) **Septicaemia:** Signs of systemic infection usually appear by 48 hrs after sustaining burn injuries. Most of deaths occurring after 48 hours are due to infection of serous membrane and internal organs like meningitis, pneumonitis, pericarditis, peritonitis, pleurisy and other complications
- c) **Renal Failure:** There occurs acute tubular necrosis which leads to renal failure and death occurs usually on 3rd/4th day.
- d) **Gastro-intestinal Ulceration:** Initially there occurs ulcer formation in stomach due to prolonged confinement which is called as *Dupuytren's ulcer*. Afterwards ulcers may also be formed in duodenum which is called as *Curling's Ulcer*. These are late complications of burn injuries produced as a result of stress and local ischaemia and person may succumb to death when there occurs uncontrollable bleeding from there.
- e) **Anaemia and Hypoproteinaemia:** The victim may die even after weeks, as he develops anaemia and hypoproteinaemia.

6. Postmortem Changes

a) **External:** The body must be carefully examined; as remnant of clothing (especially synthetic) may got stuck on body parts where they are tightly placed. They should be removed carefully and examined for presence of any inflammable substance like Kerosene, petrol etc. Even if no smell is perceivable, they should be preserved and sent to concerned Forensic Science Laboratory as they can be chemically identified. While preserving the clothing, an extra precaution is to be taken by putting them into glass containers first and then sealing them before handing over to police official. The reason for it is that mostly inflammable materials are volatile substances and simply preserving them in a sealed cloth will defeat the purpose of preservation.

b) Internal Findings: The nasal and oral cavities may show presence of carbon soot and are inflamed. Soot are often mixed with mucus and adhered on wall of lumen of respiratory tract as below as lumen of bronchioles. Mucosa over tongue and larynx may be edematous & shows blistering.

1. Due to presence of excessive amount of CO₂ and CO which produces asphyxiant effects, the tissues may assume bright red coloration owing to excessive amount of carboxyhaemoglobin. The blood in the vessels is bright pink/red, thick and more fluid.
2. All the organs are usually congested. Lungs may be deeply congested and edematous. In few cases, there may be blood tinged discharge through nostrils which occurs due to excessive secretion in lungs and rupture of capillaries. The mucosa of upper GIT is invariably reddened and may show ulcer formation (As described earlier; Curling's and Dupuytren's Ulcer).

Heat Haematoma: Due to intense heat, the capillary wall may get damaged & blood oozes out in the extradural space of skull & deposited as a firm, friable and cherry-red or chocolate-red coloured clot & honeycomb in appearance, owing to vaporization of liquid part of blood consequent upon boiling of blood by intense, external heat. It is usually present over the side opposite to site of greatest damage e.g. occipital & frontal regions. It is a postmortem phenomenon & therefore must be differentiated from ante-mortem extradural hemorrhage.

Most important findings are to be observed in the respiratory passage and blood, which will be extremely clinching towards the fact that whether the victim was alive when the fire commenced. The tongue, fauces, larynx, trachea and bronchi are usually inflamed and contain soot often intimately mixed with mucous. If the deceased had inhaled very hot gases or fumes or rarely the flame itself, then the mucosa over the tongue and larynx may be oedematous and exhibit blistering or shredding. Sometimes, some vomitus (presumably due to bouts of coughing) may also be present in the respiratory passages. Carbon-impregnated mucus may be swallowed and found in the oesophagus and/or in the stomach.

Together with the soot, the inhaled smoke usually contains some carbon monoxide, which is therefore absorbed by the blood. The presence of carbon monoxide in the blood is often obvious from the bright pink appearance of the blood, the muscles and even the cut surfaces of the organs.

7. Medico-legal Aspects

The questions which usually arise in case of alleged death due to burns are-

- (a) Whether the death is due to burns
- (b) Manner of death i.e. Suicide, Accident or Homicide.

a) Whether the victim was alive at the time of burning or dead; is ascertained by Ante mortem or Postmortem nature of burns. The points which help in differentiating these are:

- i) Presence of red line in the adjacent normal skin to burnt area
- ii) Presence of blisters which contain a serous fluid comprising of albumin & chloride. On puncturing, it shows red inflamed base surrounded by a zone of erythema /hyperemia.
- iii) Presence of smoke in respiratory passage: It indicates the victim inhaled smoke & was alive when fire spread. The presence of soot over mouth & nostrils does not have any diagnostic value. The quality of soot inside respiratory passage depends upon type of fuel, combustibility of fuel, type of article burnt & of course the period of survival of victim.
- iv) Laryngeal edema which is caused by passage of hot gases into respiratory tract.
- v) Raised carboxyhaemoglobin level in the blood; exceeding 10%. Chain smokers may develop blood level upto 8%-10%; therefore it needs careful interpretation in such cases.
- vi) Histological Investigation reveals the same changes as occur in any other injuries.

8. Summary

- Thermal injuries are the injuries produced by exposure of body to extremes of temperature.
- Heat hyperpyrexia occurs because of malfunctioning of thermoregulatory centre (not the failure) in which body temperature exceeds 41°C (106°F).
- Localized effect of heat produces burns (dry heat) and scalds (moist heat).
- The more the intensity of heat the greater is the damage caused. Minimum 45°C temperature is required to produce any invisible damage. However temperature of 60°C will produce the injury instantaneously.
- Rule of 9 is applied to know body surface area involved in case of burns in adults. In children rule of 5 is applied.
- More than 50% burns lead to fatality.
- Cause of death varies depending upon survival period of victim.