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1. Learning Outcomes

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

- The meaning and mechanism of electrocution
- The signs and symptoms of electrocution
- The post- mortem findings in case of electrocution

2. Introduction

“Only a crisis actual or perceived produces real change”... Milton Friedman

When electric current passes through human body it is capable of producing variety of effects ranging from localized muscular spasm to tiny marks of contact burn or even immediate death with little or no apparent burns to severe charring. Injuries caused by electrocution follow various laws of physics hence are predictable to great extent. Voltage is the fundamental force or pressure that causes electricity to flow through a conductor. Voltage is measured in volts. Resistance, measured in ohms is anything that impedes the flow of electricity through a conductor. Current is the flow of electrons from a source of voltage through a conductor and the same is measured in amperes.

The injury caused by electric current depends on:

1. The kind of current:

An alternating current is more dangerous than a direct current of an equal voltage as an alternating current reverses its direction at regular intervals. When alternating current comes in contact with muscles, it produces titanic stimulation and doesn't let the person loosen the grip of the electric source. An alternating current of 70-80 mA can be fatal while a direct current 200 to 250 mA is tolerated without much damage. All the modern home appliances run on alternating current.

2. The amount of current:

Electrocution is rare at less than 100 volts and most deaths occur at more than 200 volts. In India, the voltage for domestic supply is usually between 220 volts to 240 volts, alternating current with 50 cycles per second. Currents of 10 mA cause pain and muscle contractions, over 60 mA are dangerous and 100 mA is fatal. High voltage of around 1000 mA may cause the victim to be thrown clear.

3. The path of the current:

If the brain stem or heart is in the direct path of the current, then death is likely.

4. Duration of the current flow:

The severity is directly proportional to the duration of the current flow.

For an electric shock to occur, the body has to be in contact with a positive pole and a negative pole or alternatively to the earth (any object not insulated from the ground). When the earthing is poor, e.g. if the person is wearing rubber shoes or walking on carpet or wooden floor or on upstairs premises, electrocution is uncommon. The effect of electricity depends on the voltage and the resistance offered by the body. In a properly insulated body, no harm will be done. Dry skin offers resistance but moist skin is good conductor of electricity. Blood has a low resistance and some of the predisposing factors are shock, anxiety, fear, exhaustion, cardiovascular diseases etc.

An electric injury consists of 1) Fatal electrocution. 2) Electric shock and 3) Burns.

3. Local Effects

Local effects are mainly due to the current passing through the skin, producing endogenous heat, which causes boiling and electrolysis of tissue fluids. The skin then explodes and rolls back from the surface. A dry skin shows better marked burn rather than a well moistened skin.

(A) The electric burn or Joule burn:

This is the specific and diagnostic of electrocution and is found at the point of entry of the electric current. Joule burn is the endogenous thermal burn due to the heat generated in the body from the electricity. The characteristic features of Joule's burn are:

- They are round or oval, shallow crater like with a diameter of 1 to 3 cm and have a ridge of skin of about 1 to 3 mm high around the part or whole of their circumference. The crater floor is lined by pale flattened skin. Sometimes, it may resemble a broken blister when the skin within or near the margin of the crater breaks.

- When in prolonged contact, the skin on the mark may become brown and with further duration of contact, charring may occur. Sometimes the mark may take distinct pattern of the shape of the conductor, especially when there is a linear wire. An area of blanched skin is seen at the periphery of the electric mark and the same remains present intact even after death. This is considered to be pathognomonic of electric burn. Outside the blanching there may be area of hyperemia. Occasionally, an alternating pattern of blister-reddening-pallor-reddening is seen and found mainly in the exposed parts of the body.
- When subjected to histological examination, the electric mark usually shows coagulation of the dermis with separation of the epidermis in some areas and in other areas cells become elongated and arranged in parallel rows at an acute angle or right angles to the dermis.

(B) Flash or Spark Burn:

- A flash burn resembles an exogenous burn and is produced due to the intense heat resulting from the flash-over. In spark burn, an air gap is produced in between the metal and the skin, and then a central nodule of fused keratin, brown or yellow in color, surrounded by an areola of pale skin is produced. These burns may be either very small or pin point or deeply seated and contracted, depending on the duration and the degree of voltage which comes in contact. E.g., if the area of contact is very large, the person getting electrocuted in a bathtub or in contact with an electric pole with wide surface area, there may not be any external signs present.
- Brief contact with live wire may produce burns and the person may collapse due to ventricular fibrillation.
- Even severe charring, massive destruction of tissues with loss of extremities and rupture of the organs may occur in very high voltage burns. When bone is involved, then periosteum may be elevated or superficial layers of the bone may be destroyed leading to fracture of the bones. Multiple lesions may be found in and around the region of the flexures of the limb, if the current passes across the joints.
- High tension electric currents may produce multiple, small, discrete, pitted burns due to arcing from the conductor of the current from the conductor to the body. Due to the dancing of the arc over the body, multiple burnt or punched out lesions are produced over large body surface areas and is called “crocodile flash burns”. Flash over often produce “arc eye”.

(C) Electric burns or Splits:

- In cases where the electric conductor is a wire, then a linear burn is produced. The metallic ion gets embedded in the skin and subcutaneous tissues when the current passes from the conductor to the body.
- A bright green imprint may be seen if the conductor is made of copper or brass. The splits are dry, hard, firm, charred, and insensitive with ragged edges with a round or oval form and linear or irregular shape.
- The depth of the lesion may be greater than what appears through naked eye. The superficial layer of skin may be shed and may be found attached to the conductor.
- Localized edema and wrinkling of the skin may be found. Aseptic necrosis may occur beyond the area of burn which may lead to sloughing.
- Owing to the cooking effect of the current, microblisters occur within the squamous epithelium and in the external thorny layer of the skin. These blisters represent the defects through which the steam exited. Larger vacuoles are produced within the epidermal cells, the nuclei of which are fusiform, hyperchromatic and show typical pallasading pattern (peculiar distortion with stretching and narrowing of the contour). This is called streaming of the nuclei and these flattened cells stains darker than the normal cells by hematoxylin and eosin. In the vascular media, the nuclei tend to be twisted to resemble spirals and the same may be seen at distant points from the site of the contact with electrode. There may be localized degeneration of the intima and secondary thrombosis may occur due to tearing of the elastic fibres and overlying intima.

Exit marks:

Exit marks are variable in appearance but may have same features of the entrance wound. There may be more damage to the tissues and often splits are seen at points where the skin has been raised as ridges due to the passage of the current.

4. Post-Mortem Appearance

(A) External:

- Externally, the deceased's clothing, shoes, gloves, head gear etc should be properly examined for burns. Most of the time the examination of the scene of occurrence is of utmost importance in concluding the case as electrocution.
- If the victim dies of cardiac arrhythmia, the deceased will appear pale and if dies due to respiratory paralysis, then will appear cyanosed.
- The eyes are congested with dilated pupils. Rigor mortis appears early in electrocution and post mortem lividity is well developed.
- In about 60% of the cases, external findings of electrocution may be there in the form of electric burn, or contusion and laceration at the point of entrance and exit which may extend till the depth of muscle and bones. Multiple grayish-white circular spots, which are firm to touch and free from zone of inflammation may be found at the site of the entrance and exit.
- The deceased may have fracture of the limbs due to severe convulsion. Extensive ecchymosis with occasional singeing of hair may be seen. But sometimes, the external findings may be very minimal and a very thorough and careful examination is needed to diagnose a case of electrocution.
- Arcing of the current may produce characteristic pit like defects on the surface of the hair.
- Sometimes the electric entry point may be hidden inside the natural orifices like oral cavity or the urethra, in cases where live wire is put inside the mouth or path of the current is through the flowing water which the deceased was drinking or if the path of current is the urine flow, due to urination on a high voltage live wire.
- Sometimes, the entrance and exit marks cannot be differentiated grossly. The site of the entrance may be diagnosed histochemically by seeing deposition of metal particles on the skin. This metallization of the skin is due to volatilization of the metal and the same being driven into the skin. It is also very difficult to differentiate between ante mortem and post mortem electric burns.

(B) Internal:

- Usually asphyxial signs are present internally. The lungs are congested and edematous and the brain, meninges and other solid organs are congested as well.
- Along the line of passage of the current, petechial hemorrhages may be found. e.g., under the endocardium, pericardium, pleura, brain and spinal cord.
- The intima or the complete vessel wall may undergo necrosis. Vascular thrombosis may be seen in the vicinity of the electric burns.
- Zenker's degeneration is seen in the skeletal muscle along the path of the current. Small balls of molten metal, derived from the metal of the contacting electrode may be seen carried deep into the tissues and are called **current pearls**.
- Heat generated by calcium phosphate is seen typically as round density foci in radiological examination and is termed as **bone pearls** or **wax drippings**. The bone may undergo micro-fractures at multiple planes and necrosis.
- Focal petechial hemorrhages may be seen in brain and spinal cord and in some cases irregular tears and fissures in the brain tissue and rupture of the walls of the arteries are seen.
- Occasionally, no lesions may be found both on external and internal examination and in such cases, death is usually due to vagal inhibition.

5. Cause of Death

- ❖ The circuit may pass through any of the limbs to the head involving the brain stem or the upper cervical cord or arm to arm involving the brain stem or the upper cervical cord. In these cases, death is probably due to the paralysis of the respiratory centre.
- ❖ An arm to arm circuit or left arm to either leg circuit involves the heart. In such cases death is due to ventricular fibrillation or cardiac arrest without fibrillation.
- ❖ Sometimes death is not instantaneous and the person may survive for few minutes to hours before collapsing. In cases where contact time is more but the current is slow, then death occurs due to muscle paralysis along with secondary asphyxia.

- ❖ In high voltage current exposures, death is due to respiratory arrest or electro dermal injuries.
- ❖ Sometimes, in non-fatal cases, the victim may suffer from paraplegia or hemiplegia, loss of sight, hearing or memory impairment.
- ❖ Death may occur even after few days due to superadded infection from hemorrhage due to rupture of the blood vessels.

6. Medico-Legal Aspects

- Death is mainly accidental in nature which may be due to faulty appliances or negligence while using the appliances or from short circuit.
- People working in electric department, may get accidental electrocution while repairing a faulty connection.
- Some people protect the boundaries of home or door knobs from thieves and trespassers by electrifying them with live wire.
- In industry, death may result from handling of charged lamp or accidental contact with overhead live wire etc.
- Death from electrocution is rare when electric current is used as a part of electro convulsive therapy.
- Suicidal electrocution is rare but may be seen in mentally unsound persons.
- Homicidal electrocutions have occurred.
- **Judicial electrocution** is carried out in the electric chair in some states of USA. This was first introduced in the mid-19th century in New York, USA and was considered to be the best method of quick and certain death due to unpredictability of hanging. The condemned man is strapped to the wooden chair and one cap like electrode is put on the shaven head scalp, which is moistened with the conducting paste and other on the right lower leg. Then a voltage of 2000 volts and 7 amperes is passed for one minute through the body. After a titanic spasm and loss of consciousness, the same process is repeated for a second time. The site of the contact may show third degree burn. The brain is heated up to 60⁰ C and vacuolation occurs around the vessels. However, the actual protocol and voltage varies from state to state. Judicial electrocution is widely practiced in various states of USA. But in most of the states, the condemned person is first given the option of death by lethal injection as an alternative method to judicial electrocution.

7. Summary

1. Injuries caused by electrocution follow various laws of physics hence are predictable to great extent.
2. An alternating current is more dangerous than a direct current of an equal voltage as an alternating current reverses its direction at regular intervals.
3. The effect of electricity depends on the voltage and the resistance offered by the body. In a properly insulated body, no harm will be done.
4. Joule burn is the endogenous thermal burn due to the heat generated in the body from the electricity.
5. The site of the entrance may be diagnosed histochemically by seeing deposition of metal particles on the skin.
6. Death from electrocution is rare when electric current is used as a part of electroconvulsive therapy.