

Electrocution

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Danger
Electric
shock risk

Electrocution

- ◇ Electrocution is death or severe injury caused by electric shock from electric current passing through the body, that may be accidental or deliberate. It can occur with:
- ◇ 1. Low Voltage (<1000 V)
- ◇ 2. High Voltage (>1000 V)
- ◇ 3. Lightning ($> 100,000,000$ V)

Epidemiology

- ◆ In the US, there are approximately 1000 deaths/year, 400 of which are due to high-voltage electrical injuries, and lightning causes 50 to 300. There are also at least 30,000 shock incidents per year that are non-fatal. The incidence of these injuries is highest in toddlers and adolescents, usually occurring at home. Whereas in adults, they occur mostly in occupational settings and are the fourth-leading cause of workplace-related traumatic death,

Factors affecting the severity of the electrical burn

- ◇ Voltage: higher voltage leads to more severe injuries
- ◇ Site of injury
- ◇ Resistance: different tissues in the body have varying levels of resistance. Unexpectedly, the higher the resistance the more likely it will result in greater degrees of injury. That is because tissues with higher resistance tend to produce higher thermal energy to the adjacent tissues.
- ◇ Type of current (AC or DC)
- ◇ Amount of current (Amperage)
- ◇ Duration
- ◇ Route of current

Type of current

- ◇ Direct current (DC): the unidirectional flow of electric charge. Direct current is produced by sources such as batteries
- ◇ Alternating current (AC): the flow of electric charge periodically reverses direction,
- ◇ AC is more dangerous than DC at lower ampere as it is more likely to cause cardiac arrhythmias, tetanic spasm of muscles of the hand, and is 4-6x likely to cause death than DC.

Amount of current

Amount of Current	Effect
1 mA (milliAmperes)	Barely perceptible tingle
16 mA (milliAmperes)	Current can be grasped and released
16-20 mA (milliAmperes)	Muscular paralysis
20-50 mA (milliAmperes)	Respiratory paralysis
50-100 mA (milliAmperes)	Ventricular fibrillations
>2000 mA (milliAmperes)	Ventricular standstill

Voltage

- ◇ Death is more common if the voltage is higher than 1000V
- ◇ High voltage electrocution may occur by arcing, Arcs generate extremely high temperature up to 50000C
- ◇ Deaths may occur at low voltage if humidity reduces resistance or if contact is prolonged

Resistance

- ◇ Dry skin has a higher resistance than wet skin.
- ◇ Skin has moderate resistance variable based on thickness and wetness.
- ◇ Bones, fat and tendon have high resistance.
- ◇ Nerves, blood, mucous membrane & muscles have low resistance.

Duration of event

- ◇ Minimum 9 seconds contact is required at low voltage to produce a 1st degree skin burn.
- ◇ Deaths have been reported with as low as 24 volts when contact is maintained for several hours

Route of current

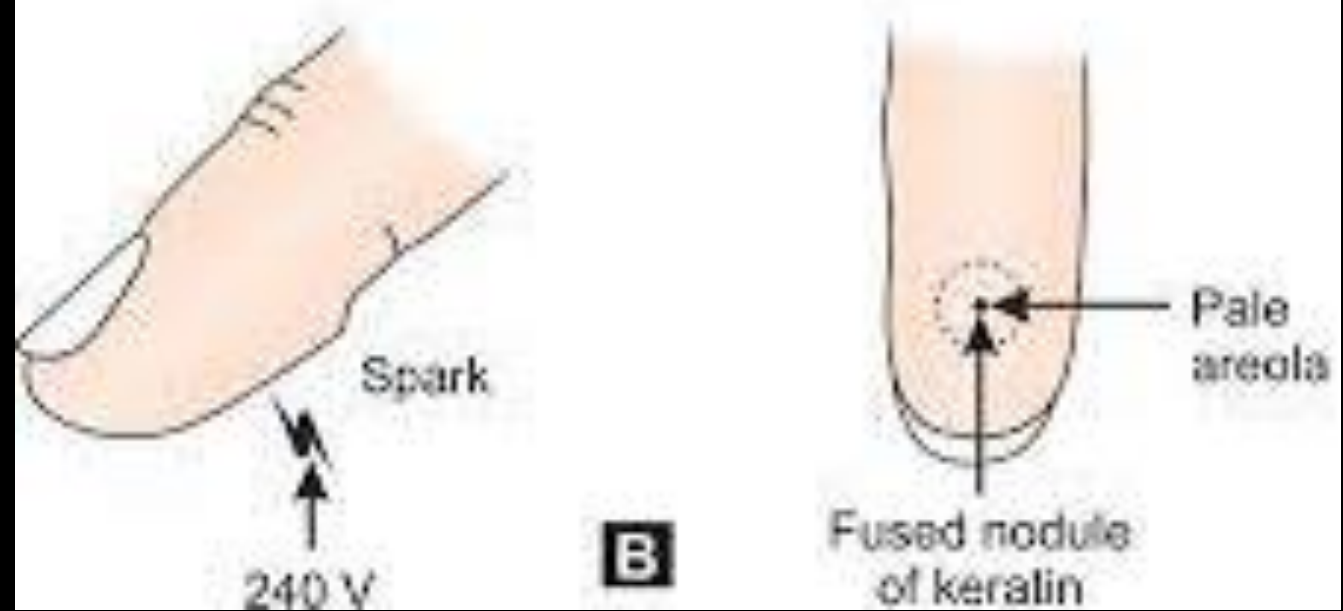
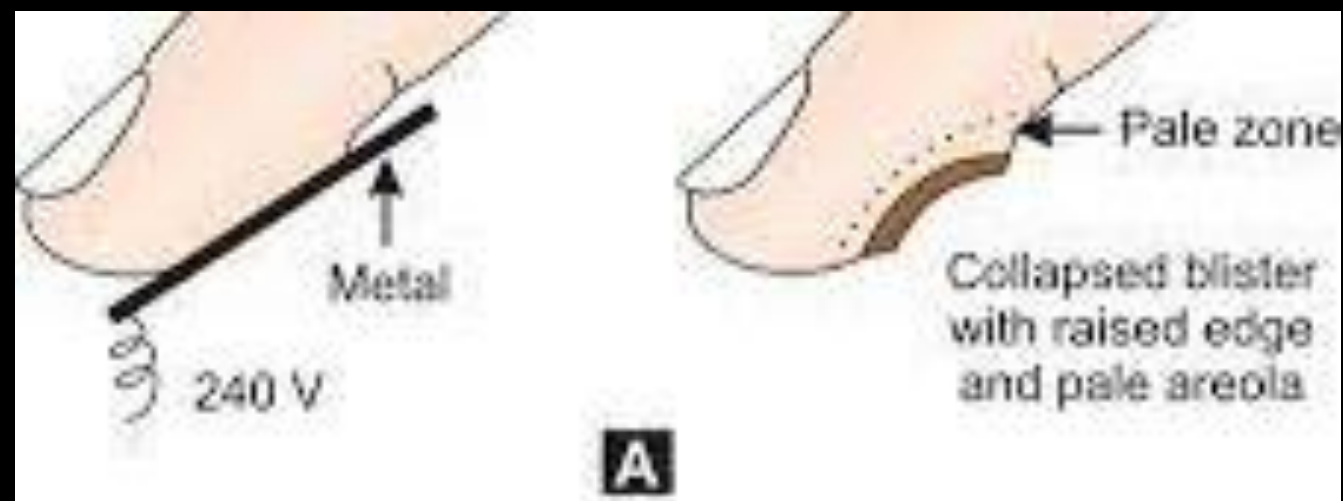
- ◇ Most common route current passes is from hand to foot or hand to hand.
- ◇ Current passes from point of contact to nearest earthed point.
- ◇ Passage of current through heart or brain increases mortality
- ◇ Passage of current through thorax associated with 60% of mortality
- ◇ If connection from one leg to another the mortality is 20%
- ◇ Passage of current across the chest cause cardiac arrest

1- Low or medium voltage electrical injury

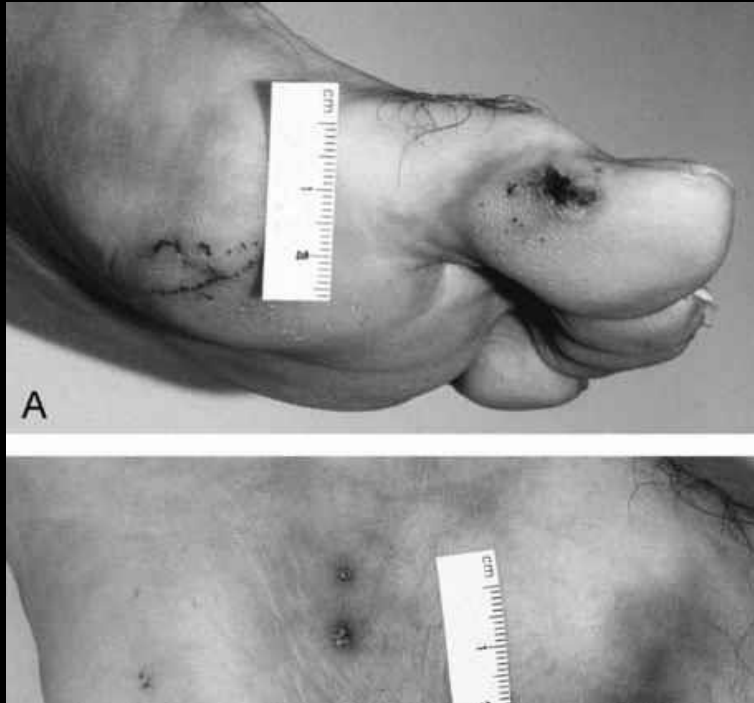


Joule burn

- ◆ Joule burns, also known as electrical burns/mark is specific and diagnostic of electric burns and is found at the point of entry.
- ◆ These marks are round, oval or irregular, chalky white shallow centrally collapsed blister, from few millimeters to 1-1.5 cm in diameter and have a raised border of about 1-2 mm.
- ◆ The blister is created by the steam produced in the heating of the tissues by the electric current, the so-called endogenous burns.
- ◆ When the current ceases, the blister cools and collapses to leave a Crater with a raised rim. It may sometimes reproduce the shape of the conductor.
- ◆ When contact is more prolonged, skin mark becomes brown and with further contact—charring occurs.

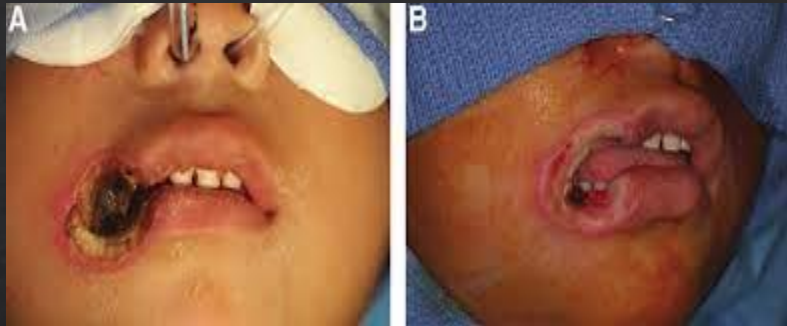


Exit marks



- ◇ Variable in appearance
- ◇ There may be more disruption of tissues.
- ◇ Often as splits with raised ridges , or lacerations.
- ◇ Burns and perforations of the clothing or shoes may be seen over the site of exit.

Oral burns



- Caused by biting or sucking on electrical cords
- Most commonly in children
- Electrical current typically passes from one side of the child's mouth to the other, causing deformity



2- High voltage electrical injury

High voltage burns



- Charring of body
- Burns are large and irregular
- Chalky white
- Raised borders and central crater
- Yellow black discoloration at burn site
- Massive tissue destruction
- Organ rupture



Crocodile skin



- Large areas of the skin. Leathery
- Multiple sparks burns
- Punched out lesions

Arc current



- As body approaches high voltage line , an electrical arch may pass through it in relation to the voltage.
- Effects are same as flame burn (charring)

Flash burns



- Flash burns are caused by electrical arcs that pass over the skin. The intense heat and light of an arc flash can cause severe burns in a fraction of a second
- Although the burns can cover a large area of skin, they are largely superficial and the tissues beneath the skin are generally undamaged and unaffected

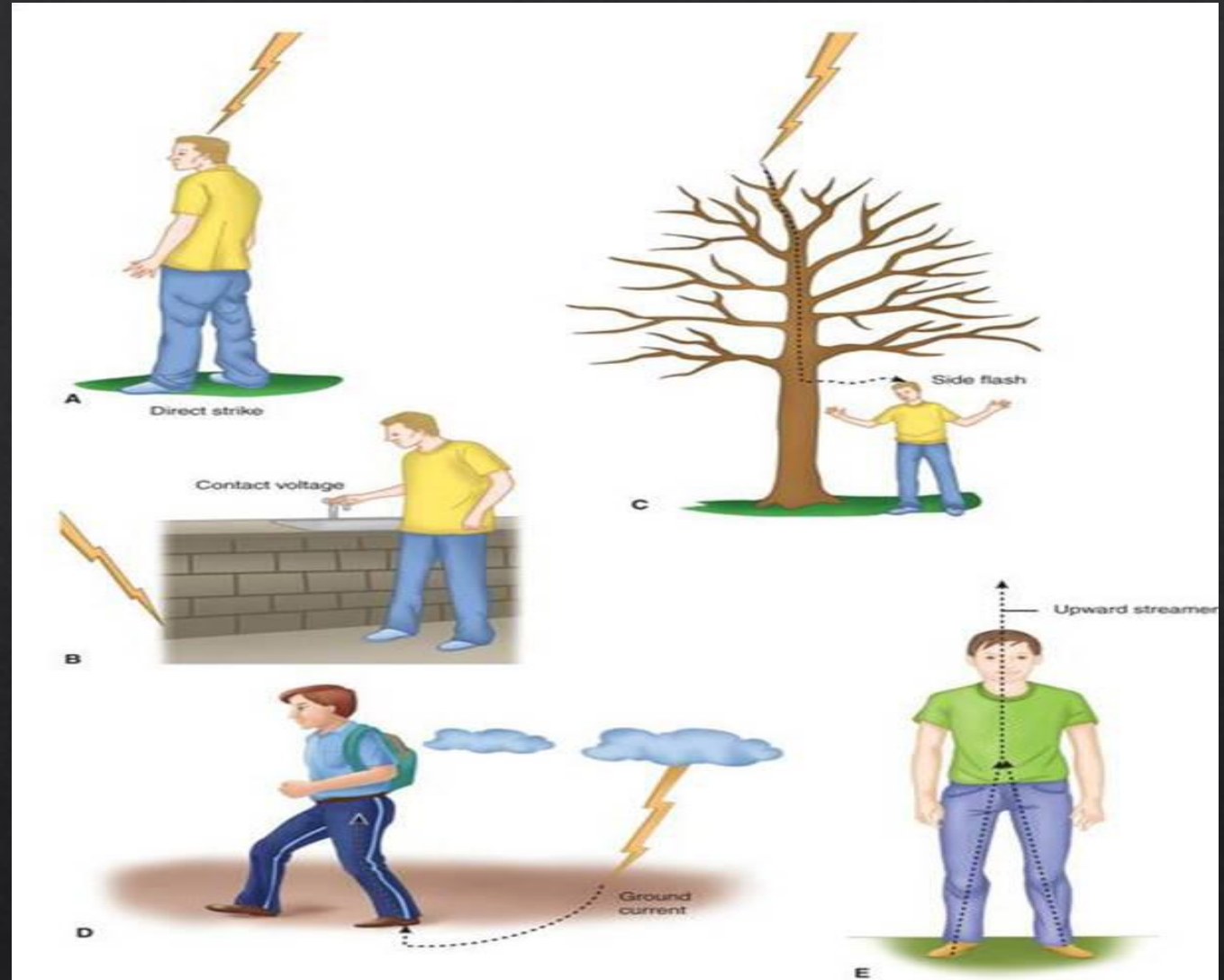
3- Lightning



- A small subset of electrical injuries that is caused by a lightning strike.
- Approximately 30% of victims die & 74% may have permanent disabilities
- 2/3rds of deaths occur within 1 hour of injury & are generally due to a fatal arrhythmia or respiratory failure

Types of lightning injury

- ❑ Direct strike (5%)
- ❑ Contact injury (15%) – victim in contact with structure that received direct strike
- ❑ Side splash (30%) – current jumps to victim not in physical contact with structure that received direct strike
- ❑ Ground strike (50%) – current travels through the ground to the victim (strike point)



Features



- **Tip Toe Sign:** (punctate burn) Small full thickness burn involving the soles of the feet & the tips of the toes. Marks the **exit point** of the lightning
- Development of **edema** of skin at the **entry point**
- As the exit is often in the feet, shoe may be ripped apart or blown off the foot.
- **Fusing & magnetization** of metallic articles, watches may be stopped, & some metal substances might dissipate.
- Injuries like **contusions**, **lacerations**, rupture of tympanic membrane & organs and spinal cord damage.
- **Linear /Flash burns**; sweat turns into steam (similar to scald burn)
- The skin lesions caused by lightning may range from very superficial **stellate-type** injuries to **Lichtenberg figures**



Filigreee burns / Lichtenberg figure



- It appears within few mins to 1 hour of Lightning injury
- It's a **branching** (fern-like), **erythematous** patterns on the skin (pathognomonic for lightning injury)
- Superficial, thin, irregular tortuous markings
- The erythematous marks are not burns —> indicate path taken by current, & are caused by local hyperemia
- It gradually fades within 24 h

Metalization



- deposition of metal particles into the skin at places where metallic objects (e.g., jewelry) touch the body
- Electrical current is transmitted to metallic objects, which can become very hot and cause local burns. Depending on the type of metal, metalized skin may appear [**brown, black** —> Iron] or [**yellow.**—> copper]
- Singed hair and patterned skin burns mark underneath metal article of jewelry

Causes of death



Death due to electrical energy is a “ functional “ death type in most cases.

- **Cardiac** : Asystole, Arrest, VENTRICULAR FIBRILLATION (low voltage current)
- **Respiratory** : Spasm of the respiratory muscles, paralysis of the respiratory center (high voltage)
- Trauma: death takes place because of the complications of electrical burns i.e., **infections**, **rhabdomyolysis** etc. (high voltage)

Death Continued



- Fatal electrocution can occur with no visible skin mark, and the doctor may have to reach the diagnosis by exclusion of all the other possible causes and by attending to the circumstances of death.
- Gross damage is usually observed in the high-tension currents, and prolonged contact with low or medium currents.

Post mortem findings

- Categories of electrical injuries:
 1. **Tissue damage** caused by **direct** effect of electrical current
 2. Conversion of electrical energy to **thermal energy**, resulting in deep & superficial burns (mc)
 3. **Blunt mechanical injury** from lightning strike, muscle contraction, or as a complication of a fall after electrocution

Comparison among lightning, high-voltage, and low-voltage electrical injuries

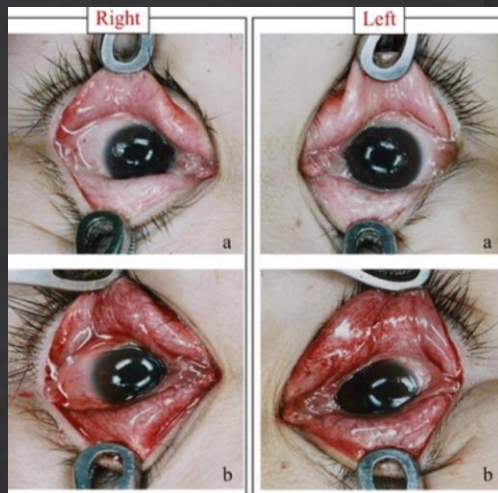
	Lightning	High voltage	Low voltage
Voltage, V	>30 x 10 ⁶	>1,000	<600
Current, A	>200,000	<1,000	<240
Duration	Instantaneous	Brief	Prolonged
Type of current	DC	DC or AC	Mostly AC
Cardiac arrest	Asystole	Ventricular fibrillation	Ventricular fibrillation
Respiratory arrest	Direct CNS injury	Indirect trauma or tetanic contraction of respiratory muscles	Tetanic contractions of respiratory muscles
Muscles contraction	Single	Single (DC); Tetanic (AC)	Tetanic
Burns	Rare, superficial	Common, deep	Usually superficial
Rhabdomyolysis	Uncommon	Very common	Common
Blunt injury (cause)	Blast effect (shock wave)	Fall (muscle contraction)	Fall (uncommon)
Acute mortality	Very high	Moderate	Low

DC: direct current; AC: alternating current; CNS: central nervous system.

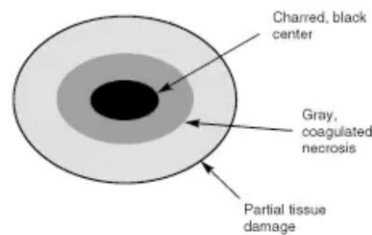
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Postmortem findings (external)

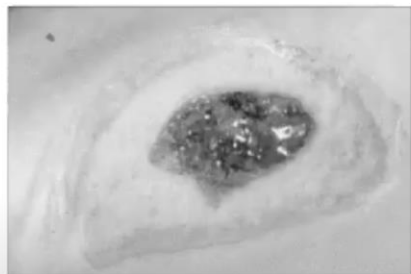
- Face is pale
- **Congested eyes** with **dilated pupils**
- **Petechia** on eyelids & conjunctiva
- **Rigor mortis** appears **early** & **post mortem lividity** is well developed
- **Fractures** due to severe convulsions
- **Burn marks** if there are metallic objects on the body
- In about 60% of cases, external findings are in the form of electric burn, **contusion** or **laceration** at the point of entrance & exit. Multiple **grayish-white circular spots**, firm to touch & free from zone of inflammation may be found at the site of entrance & exit
- It is very difficult to differentiate between antemortem and post mortem electric burns



1a. The entry/exit contact lesion has three areas:



1b. These three areas can be seen in this foot burn.



linear burns (was wearing earbuds)



Postmortem VS Antemortem blisters

Antemortem burns

- Line of redness
- Vesicles / blisters contain serous fluid with albumin & chlorides
- Infection—pus & sloughing
- Base of blister inflamed
- Healing with----- granulation
- Soot in upper respiratory tract
- Vital reaction present
- Increase in enzyme reaction & -SH group in periphery of burns
- >5% COHb in blood

Postmortem burns

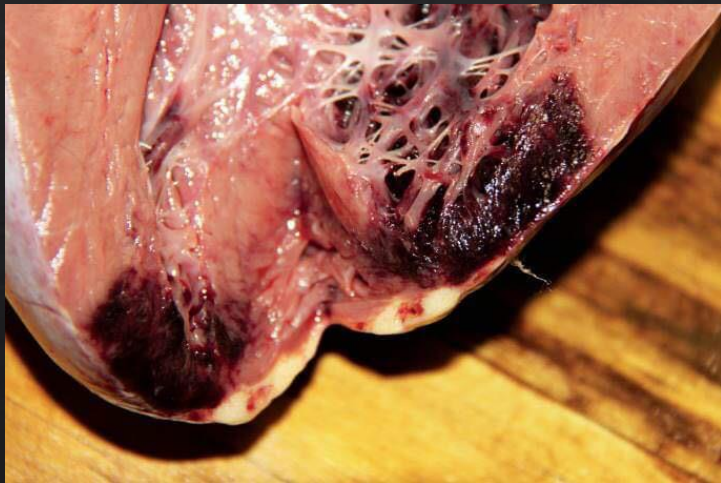
- no line of redness
- vesicles contains air only
- base is dry,hard & yellow
- vital reaction absent
- no increase in enzyme reaction
- no carboxyhemoglobin in blood,usually <5% COHb

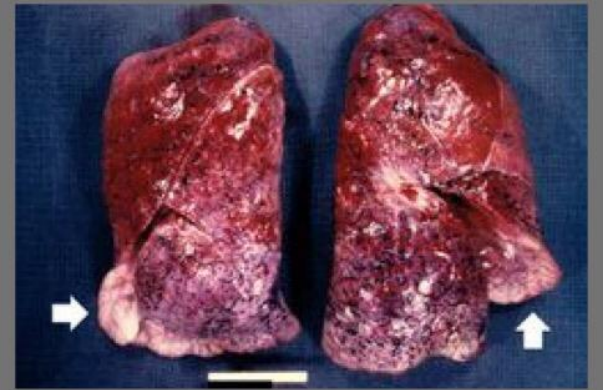
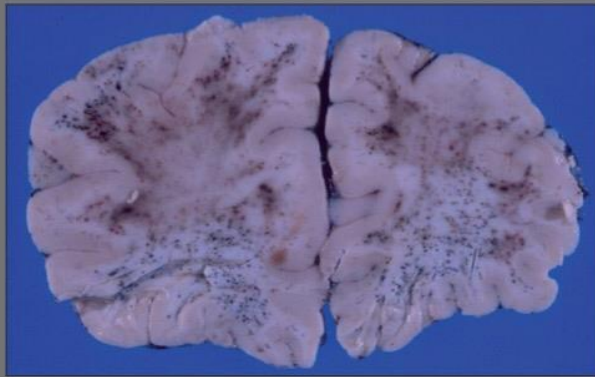
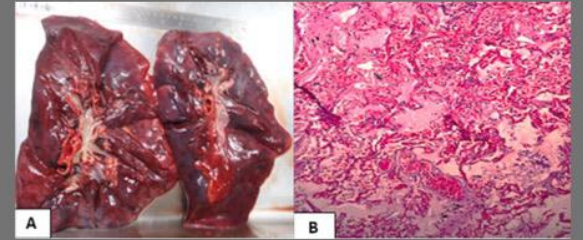
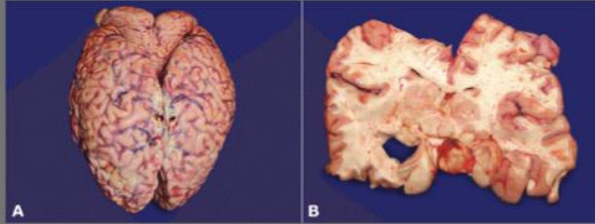
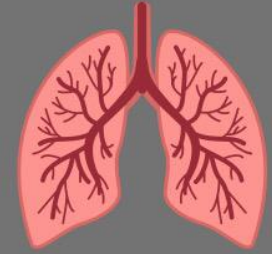
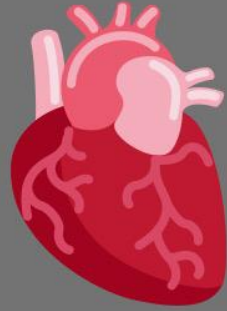




Postmortem findings (internal)

- Non specific
- **Lungs**: Congested & edematous
- **Heart**: Focal **necrosis** with variable **hemorrhage** & acute contraction bands in the myocardium & conduction system
- **Brain edema** mainly due to hyponatremia
- **Petechial hemorrhage** may be found along the line of passage of the current, under the endocardium, pericardium, pleura, brain & the spinal cord
- The petechiae seen in electrocution is caused by a combination of venous congestion due to cardiac arrest & a sudden rise in blood pressure induced by muscle contractions.







Postmortem findings (internal)

- Skeletal muscle: **Zenker's degeneration** (is a severe glassy or waxy hyaline degeneration or necrosis of skeletal muscles)
- **Current pearls** : small balls of molten metal derived from electrode, carried deep in tissue
- Bones: heat generated by current melts Ca phosphate (**Round dense Foci on X-ray**) bone pearls, **wax dripping**, **bone necrosis**



Medico-legal aspects

- ◇ Death by electric current is usually accidental, due to defective appliances or negligence in the use of equipment
- ◇ Suicide/homicide are relatively rare
- ◇ Rarely, death may occur during ECT to psychiatric patients
- ◇ Some states use judicial electrocution as a form of death penalty to some criminals



Accidental



- Work related deaths: construction, transportation , public utilities , manufacturing, and agriculture.
- Defective tools or electrical devices
- Improper preventive measures

Suicide



- The victim usually winds wire round the wrists or other parts of the body, makes their connection with the wall socket and switches it on.
- Rare

Homicide



- Rare, but most commonly by dropping an electrical appliance into a bath. There are no signs of an electrical burn and if the device is removed, the cause will be missed

Judicial



- By electrical chair
- Currently seen as cruel and unusual punishment

PRESENTATION HAS ENDED

THANK YOU

