Electrocution

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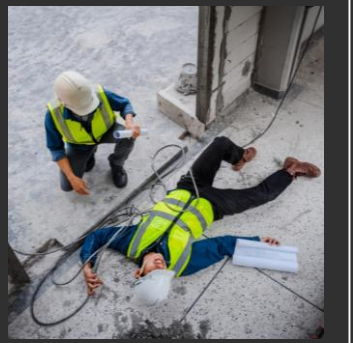
Nada Odeh



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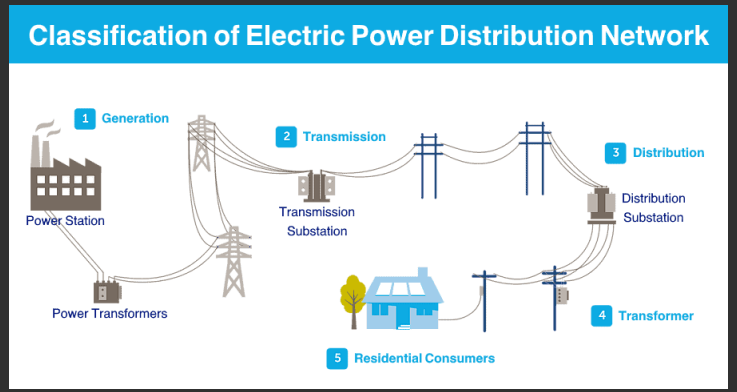
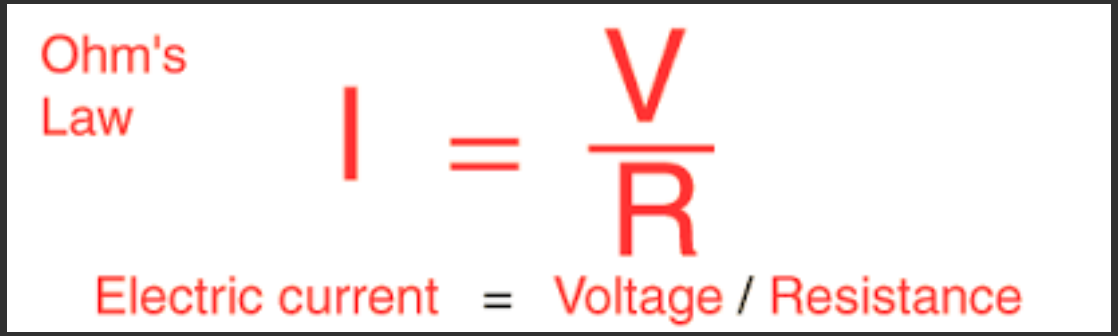
Overview

- What is electrocution?
- Where is electrical energy obtained from?
- When does tissue damage happen?
- What are the sources?
  - Domestic
  - Industrial/transport
  - Electricity distribution system
  - Lightning



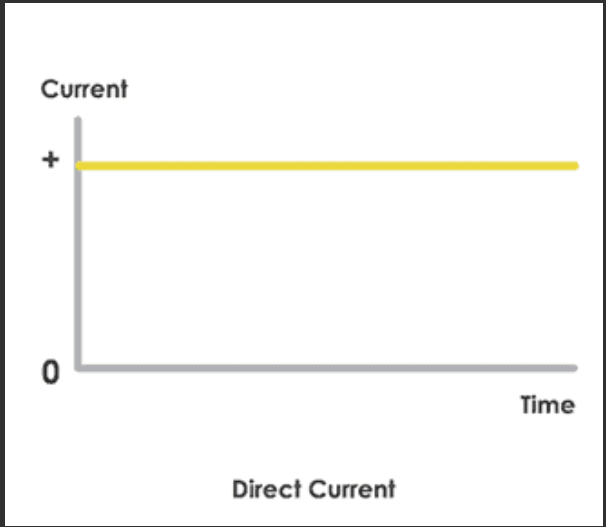
Physics

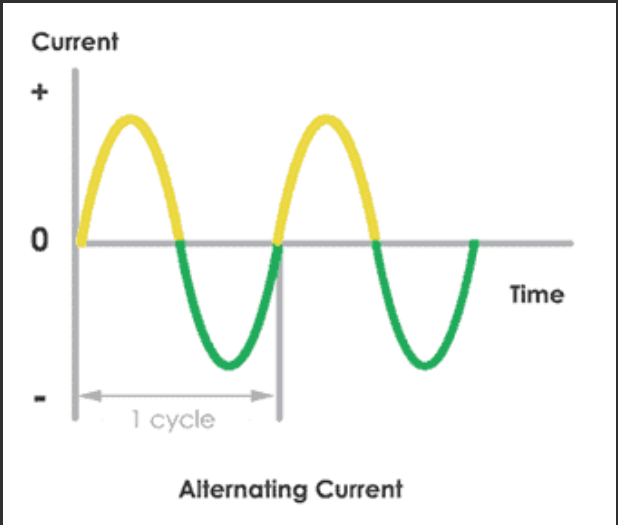


the current varies directly with the voltage and inversely with the resistance

Type of current

Physics / Devices / Heart / Danger & Fatality / Cycles





Mechanism of Electrocution

Regardless of the presentation of the individual who experienced an electrical injury, it is critical to determine details about:

- The source of electrical injury (AC vs DC, low vs high voltage)
- The length of contact
- Any resultant trauma

Mechanism of Electrocution

Low Voltage current : 110 V to 120 V
(more likely to result in tetany rather than burns)

Muscle tetany typically occurs in response to electrical stimulation at a frequency of 40 Hz to 110 Hz, a range in which most household currents exist.

If this muscle contraction occurs in the hand, contraction of flexors will cause the affected individual to grasp the source and prolong contact with the electrical source.

If the pathway of electrical current through the body crosses the thorax, there is a risk of chest wall muscle paralysis and concomitant respiratory arrest.

If the head is in the circuit, there may be paralysis of respiratory center or cardiac arrest due to inhibition of centers in brainstem.

Ventricular fibrillation may occur with exposure to voltage as low as 50 mA to 120 mA (i.e., lower than the highest accessible current in most households).
If prolonged leads to brain anoxia.

Children may experience a low-voltage injury without associated loss of consciousness or arrest by biting or chewing on an electrical cord.

In general, patients with a normal ECG who have experienced a low-voltage electrical injury, without any cardiac complaints or cardiac history, may be safely discharged home following a thorough physical examination. Similarly, children that experience a low-voltage, household current electrical exposure without any significant injury or pre-existing cardiac history may be discharged following a thorough physical examination.

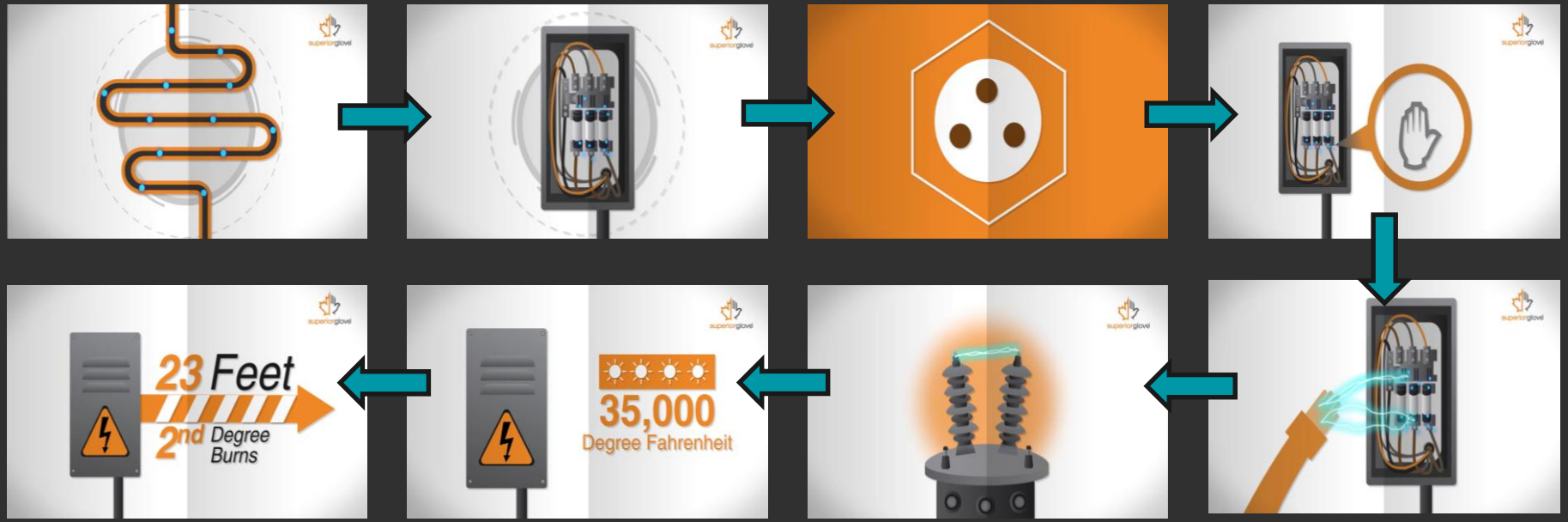
Low-voltage electrical current can result in severe injury, much like high-voltage current, depending on the length of exposure (e.g., if there is prolonged muscle tetany), the size of the individual, and cross-sectional area in contact with the electrical source.

A very high voltage that comes in contact with a larger surface area may have a field strength that is equal to or perhaps even less than a much smaller voltage coming into contact with a much smaller surface area. For this reason, low-voltage injuries (spread out over a smaller area) can often result in the same amount of damage as high-voltage injuries (spread out over a larger area).

Mechanism of Electrocution

- Arching (flash-over)
- Ignition of clothes & burns
- Secondary injuries due to fall

Arc Flash



Most of arc flame fatalities are attributed to burns

Mechanism of Electrocution

	Low voltage current	High voltage current
AC vs DC severity	AC	AC
Morbidity	Higher	Lower
Prognosis	Better	Worse

Causes of death in electrocution

Ventricular fibrillation

Cardiac arrest

Tetanic asphyxia

Cerebral anoxia

Secondary injuries sustained

Respiratory arrest

Burns

Types of electrical injuries (Contact injury)

close contact with an electrically live object

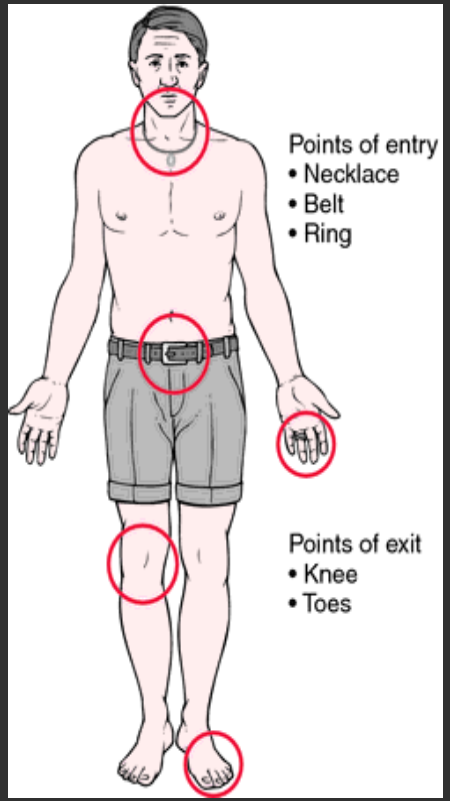
The damage varies from a small and superficial injury or burn to charring depending up on the time of contact that is maintained with the object

Contact electrical injuries involve an individual becoming part of an electrical circuit.

A characteristic electrical injury may be present at the point of entry (entry wound) and may be at the point of exit (exit wound).

Types of electrical injuries (Contact injury)

- The most common source is a hand, followed by the head, while the most common ground is usually a foot.
- Any current passing through the head may result in central nervous system (CNS) damage.
- The heart is most often affected if the current travels from hand to leg or hand to hand across the body, and this may result in a potentially fatal arrhythmia.



Types of electrical injuries (Spark burn)

- No actual contact but electricity sparks to the skin through a narrow zone of air or poor or intermittent contact with live electrical object/appliance/wire.

- When the contact of skin and the electric conductor is not firm so that an air gap, albeit small, exists between skin and conductor, the current jumps the gap as a spark. In dry air, 1000 V will jump several millimeters and 100 KV about 35 cm. The high temperature causes the outer skin keratin to melt over small area. On cooling, the keratin fuses into a hard brownish nodule, raised above the surrounding surface and usually sur- rounded by pale halo or areola. Such lesions are called as spark lesion.

Types of electrical injuries (Spark burn)

Skin > mucus membranes > nerves, blood vessels, muscles

- Water and electrolytes content
- Degree of moisture
- Skin thickness
- Current density
- External burns vs internal electrical injury

Types of electrical injuries (Flash burn)

Flash burns are due to contact with very high voltage (high- tension wires) and usually seen in lines-man working on the grid system and not frequently in thieves stealing wires from these overhead lines.

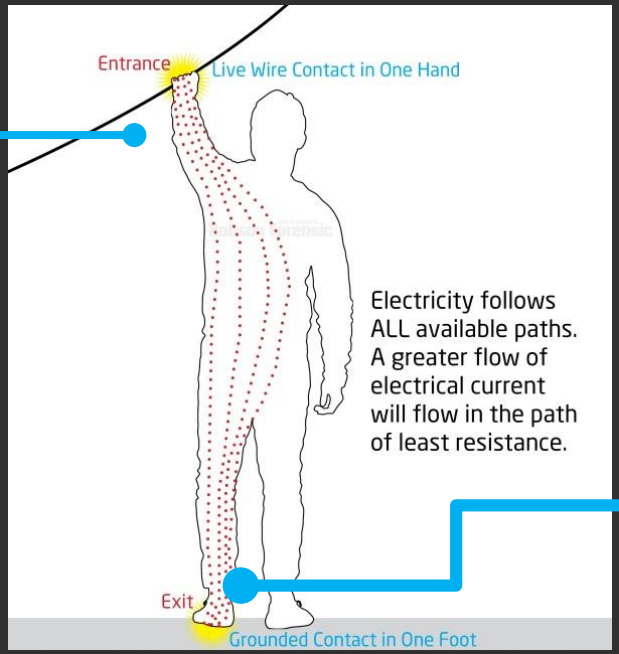
There may be actual arching of the current occur on the man approaching towards wire without actual contact

The heat may cause ignition of clothes and person sustains burn injuries.

Electrocution Marks

Entry

- The point of contact
- NOT observed; when point of contact is wet, or in a bathtub



Exit

- The site where the body was grounded
- NOT observed if applied at concealed part

What does the appearance of the lesion depend on?

1. Nature of current
2. Voltage
3. Ampere
4. Resistance
5. Earthing
6. Duration
7. Alertness
8. Area of contact
9. Point of entry

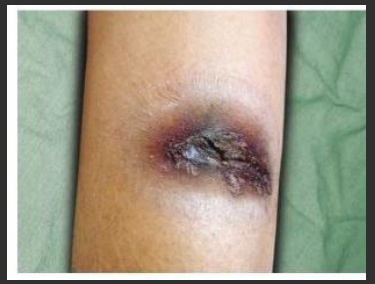
Electrical burns are self-limiting, why?

- Once the current ceases, no further skin and muscle damage is possible; amperage falls to zero

Electrocution Marks

Collapsed blisters

Spark lesion



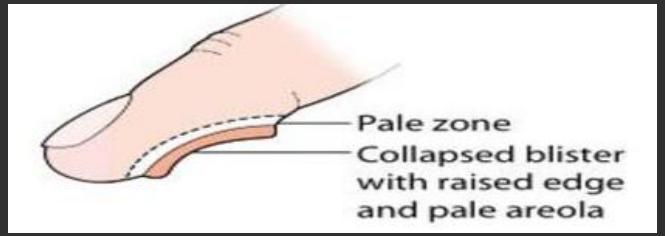
Blistering, peeling, charring

Crater lesion

Crocodile Skin

Electrocution Marks

1. Collapsed blisters



- Usually circular, raised gray or white ring, umbilicated center
- Mechanism: firm contact causes passage of current > production of heat > steam due to tissue fluids heating up > splitting the layers of epidermis / epidermo-dermal junction = blister
- Blister may or may not rupture, when the current ceases > cooling of the blister > it collapses > raised margin and depressed center

Electrocution Marks

2. Crater lesion

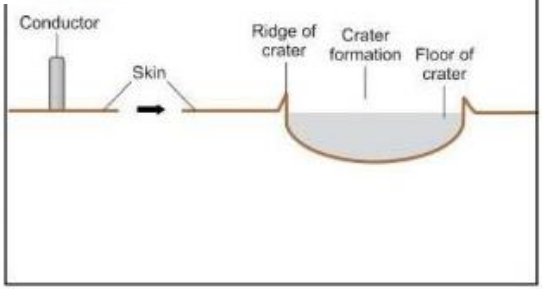


FIG. 14.39: Mechanism of crater formation

- Round or oval, shallow, bordered by a ridge 1-3 mm high, around a part or the whole of the lesion. Tough on palpation. Floor is lined by pale flattened skin, ridges pattern is preserved and they are broad. The crater may be surrounded by pale areola
- There may be cracking in the areas where the skin is hard and dry; soles and palms.
- Skin is usually pale, however due to the production of heat, blackening may be present.

Features of Electrocution Marks

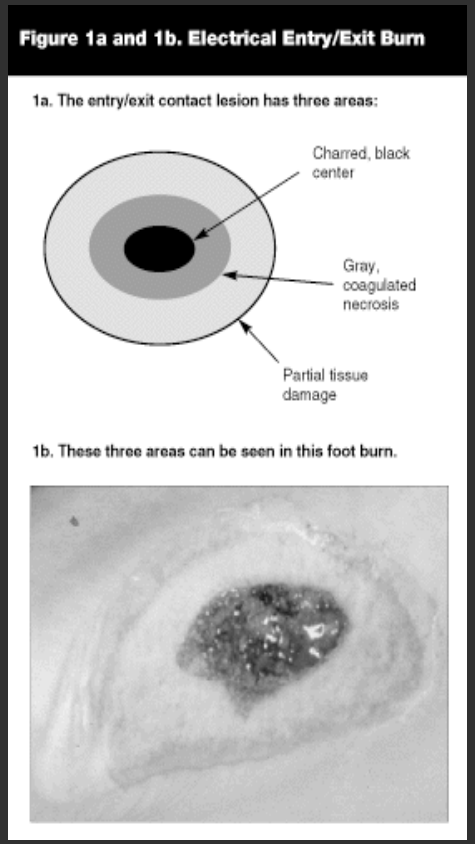
- Areola / pale halo

Pathognomic for electrical damage. Occurs at the periphery in form of blanched area > due to arteriolar spasms from direct effect of current on vessel wall.

- Patterned electrical marks

- Exit marks

Grayish white circular spots, firm to touch and free from inflammatory reactions. May show lacerated wounds instead of craters or blisters as in the entry sites



Features of Electrocution Marks

- Exogenous burns (flash)

- Endogenous burns (Joule)

In prolonged contact injuries. Brownish color > charring. At the site of entry due to production of heat

- Metallization

Metal conductor > electrolysis > metal ions in skin and subq tissue at entry site. Combination of these metal ions with tissue anions = metal salts

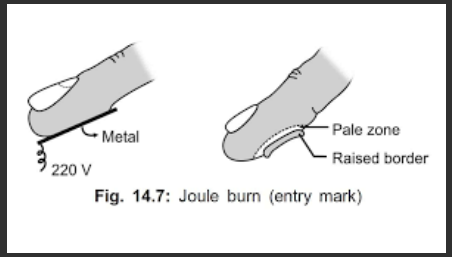
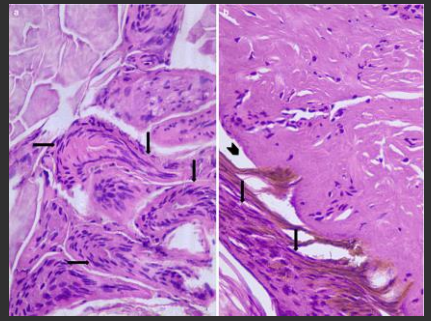


Fig. 14.7: Joule burn (entry mark)



Autopsy findings

Circumstances will reveal the live wire, the appliances, broken circuit etc. corroborative with electrocution

There may be metallization of electrocution mark.

External examination will reveal the electric marks dis- cussed. If the death is associated in bathtub, no marks may be evident.

Internal examination will reveal congested organs, pulmonary edema, and petechial hemorrhages over pericardium, pleura or brain.

Autopsy findings (Laboratory findings)

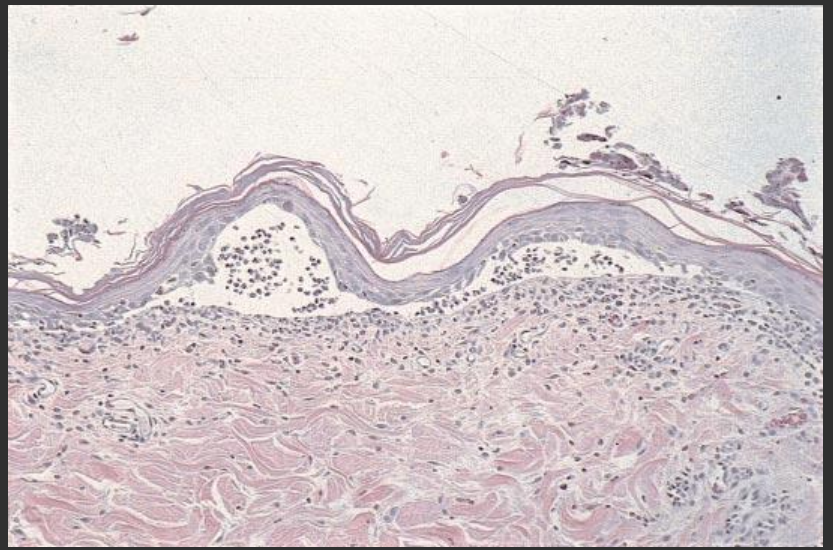
- Chemical analysis: Metal residue can be detected as discussed above.
- Acro Reaction tests can be done to detect metal ions. This test is not routinely done.
- Histopathological examination may reveal supportive findings of electrocution.
- Electron microscopy.
- Histochemical.

Histological findings of skin in electrocution

- **Vacuolation in epidermis and dermis**

Histological findings of skin in electrocution

Dermo-epidermal separation

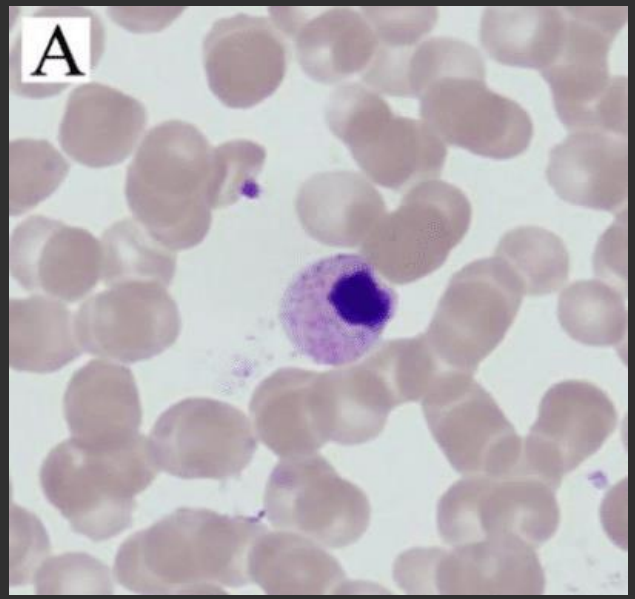


Histological findings of skin in electrocution

- **Hyperkeratosis**

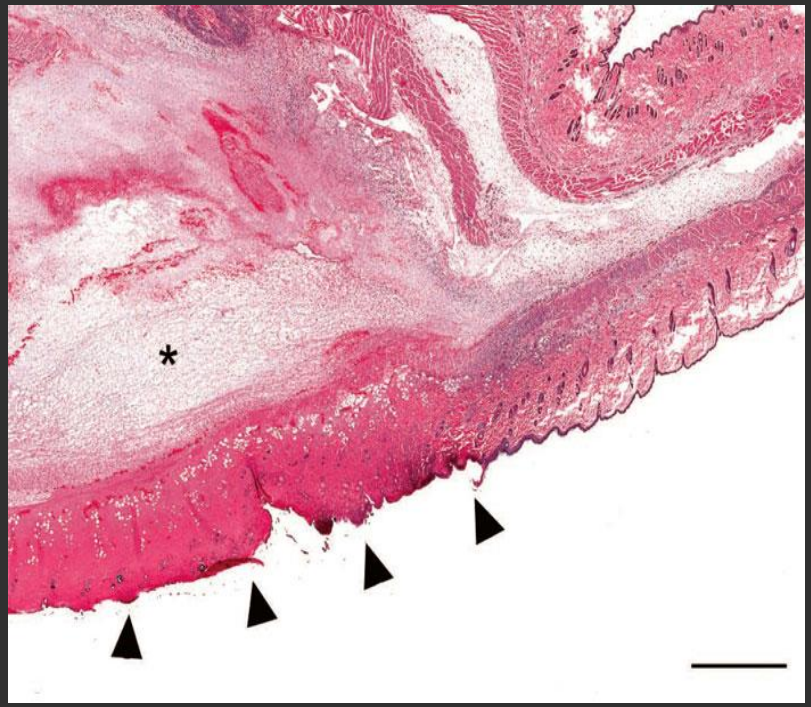
Histological findings of skin in electrocution

- **Pyknoses of nuclei**



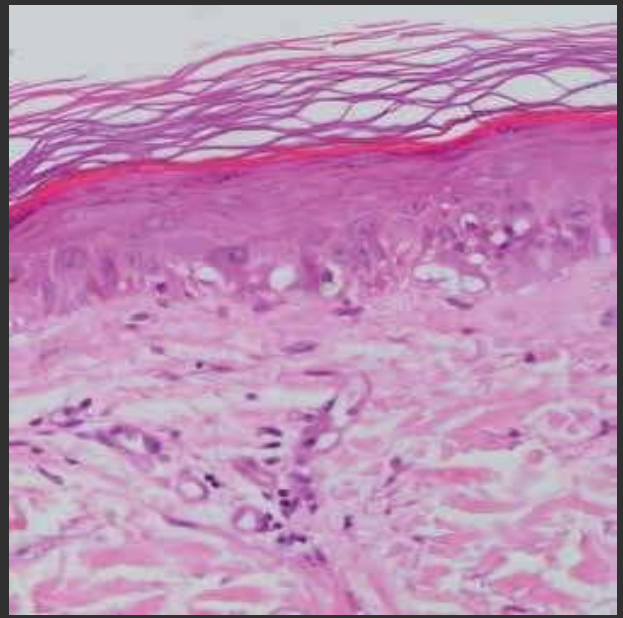
Histological findings of skin in electrocution

Degeneration of collagen in dermis with coagulative necrosis



Histological findings of skin in electrocution

- Degenerative changes in keratin layer
- Nucleus streaming



Medicolegal importance

- Accidental deaths
- Suicide
- Homicide
- Judicial electrocution
- Auto-erotic electrocution
- Child abuse

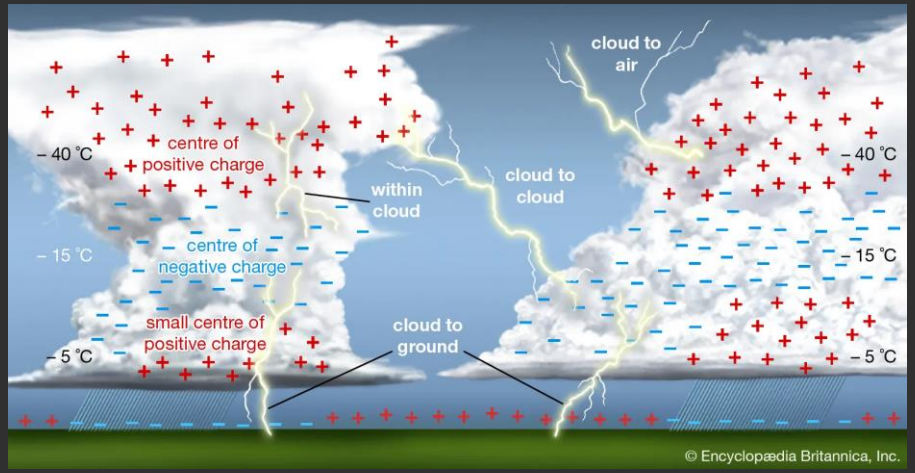
- Custodial torture

Lightning

Sources of lightning

1. Thunderstorms
2. Snow storms
3. Dust storms
4. Sand storms
5. Volcanic eruptions
6. Nuclear explosions

Physics


cloud to air
– 40 °C
centre of positive charge
within cloud
cloud to cloud
– 40 °C
– 15 °C
centre of negative charge
– 15 °C
small centre of positive charge
cloud to ground
– 5 °C
– 5 °C
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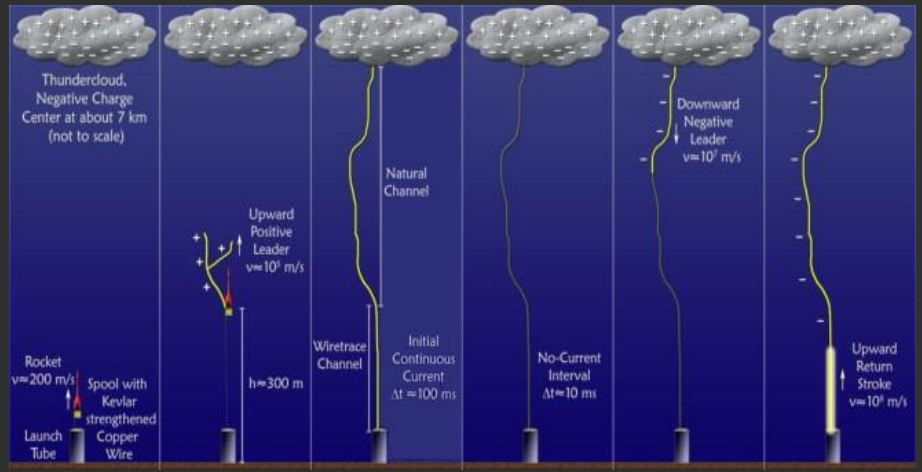
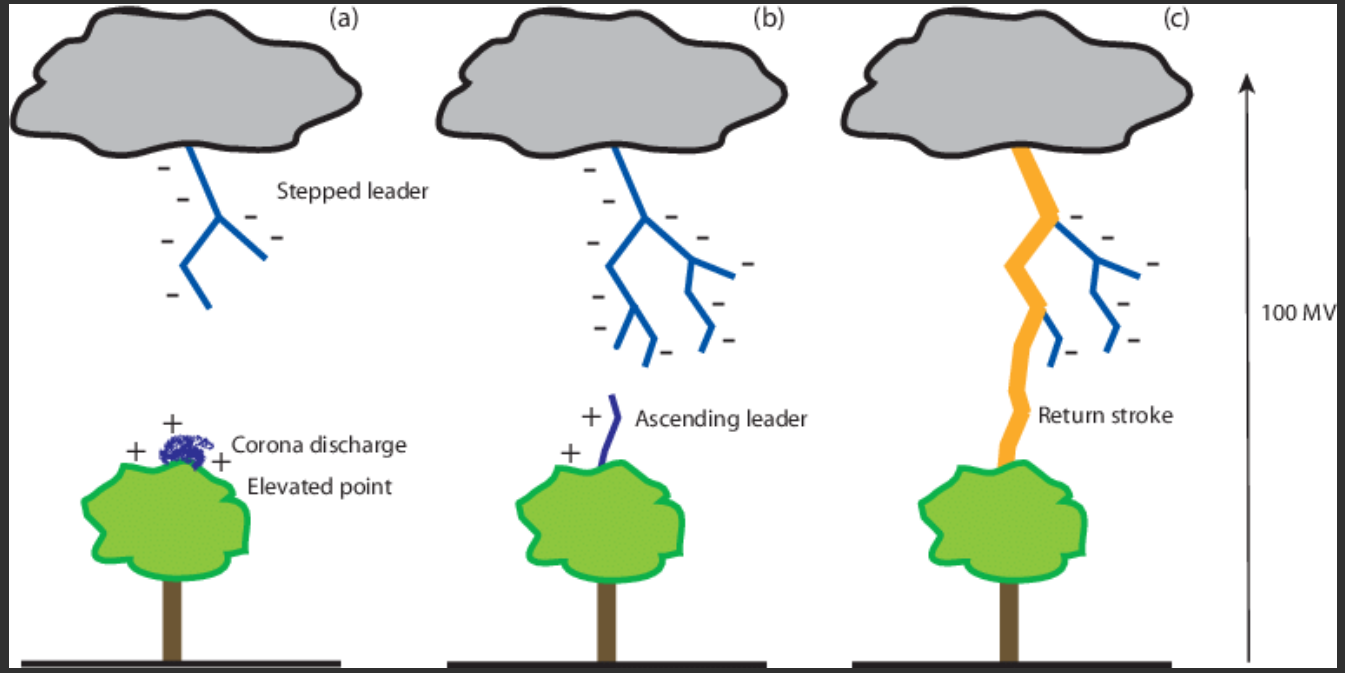

Thundercloud, Negative Charge Center at about 7 km (not to scale)
Upward Positive Leader v≈10⁵ m/s
Natural Channel
Downward Negative Leader v≈10⁷ m/s
Rocket v≈200 m/s
Spool with Kevlar strengthened Copper Wire
Launch Tube
h≈300 m
Wiretrace Channel
Initial Continuous Current Δt ≈100 ms
No-Current Interval Δt≈10 ms
Upward Return Stroke v≈10⁸ m/s



Very high voltage; DC of 10-100 million volts

Morphology of lightning stroke

Forked lightning

Streak lightning

Morphology of lightning stroke

Sheet lightning

Ribbon lightning

Ball lightning

Lightning strikes

Direct stroke
Here lightning strikes victim or objects immediately overhead such as umbrella or tree.

Splash strike
Here the lightning strikes an object nearby like building and then jumps to a nearby person.

Ground current
When lightning strikes the ground or an object on the ground, the discharge occurs in and along the ground surface (not deep into the ground). This creates a dangerous and potentially deadly ground current near the lightning strike.

Individuals can be struck indoors by lightning while using the telephone or electrical appliances.

Effects of lightning

Due to Electric Current

Lightning is very high voltage direct current (DC) between 10 million and 100 million volts. A person may die instantaneous due to electrocution or may remain unconscious. Rapid resuscitation of such person may have chances of survival.

Due to Heat Effect

Any degrees of burn may be sustained in lightning depending on the proximity of the flash. The burn injury varies from singeing to superficial burns to deep burns. Usually the exposure of lightning stroke is extremely short, less than one ten-thousandth of a second. Because of victim's exposure is so brief, no burns or only minor singeing of hair is seen.

Effects of lightning

Due to Successive Expansion and Regression of Heated Air

Due to successive expansion and regression of heated air, there will be blast effect. This causes extensive mechanical injuries like lacerations and contusions with tearing of clothes and shoes. Occasionally there may be gross distortion and mutilation of the body.

The sledge-hammer blow

Due to compression of air occurring constantly throughout the path, ahead of the high-speed return stroke (The return stroke is the very bright visible flash that we see as lightning, caused by the rapid discharge of electricity).

Autopsy findings

Circumstances

History of recent lightning
Scene; trees and walls
Ground; fern pattern

Clothes

Melting / catching fire
Torn off / tears
Boots / shoes / belts

Examination

Examination

- Rigor mortis
- Variation of the pattern of injury
- Areas of burning / Punctate burns
- Rupture of ear drums (explosive effects or muscular contractions)
- Petechial hemorrhage in brain, chromatolysis and fragmentation of axons
- Congestion of internal organs and pulmonary edema
- Heat may fuse or magnetize metals
- External marks of lightning classes by Spencer:
- . Linear burns
- . Surface burns
- . Arborescent Marks

External marks of lightning

Surface Burns

- **These are tissue burns and are usually related to metallic objects worn or carried by the victim**

- **Sometimes secondary burns from ignition of clothing are noted**

- **There may be blisters, fissures or charring of deeper tis- sues and bones depending upon the intensity and extent of burn.**

External marks of lightning

Linear Burns

- **Linear burns are of size 1 to 12 inches long and 1/8 to 1 inches wide may be found on body area where the skin of that part offers less resistance.**

- **The usual sites are moist creases and folds of skin.**

External marks of lightning

Arborescent Marks

- **These are also called as filigree burns or feathering or Lichtenberg figures or fern-leaf pattern**

- **Arborescent markings are characteristics of lightning**

- **Arborescent markings are multiple, superficial, irregular, tortuous markings on the skin resembling branches of tree. This fern-like pattern of erythema in the skin is commonly found over shoulder or chest.**

External marks of lightning

- The precise mechanism of their formation is not known but it was hold that they may be due to minute deposition of copper on the skin. Another view was that it might be caused due to staining of the tissues by hemoglobin from lysed RBCs along the path of electric current.

- These injuries fade over time. It was reported that the mark completely disappears by 2 to 3 days.

Thank you

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