

Epidemiology

- Electric burn injuries account for about 3-4% of burns unit admissions.
- Electricians and linesmen are at highest risk. Also those working with electrical tools.
- ~20% of all electrical injuries occur in children (toddlers and adolescents), usually involving cable extensions or wall outlets.
- 9M:1F
- 2-3% mortality for electrocution, 30% for lightning strikes.
- Water greatly increases the risk of fatality.

Severity factors

Current

- Type: AC more dangerous than DC: titanic spasm prolonging contact, if $>10\text{mA}$ induces sweating & $\downarrow R$, more likely to induce VF. Lightning is DC.
- Amount: 1mA = tingling, $>2\text{mA}$ = pain, $20\text{-}50\text{mA}$ = respiratory inhibition, $>100\text{mA}$ = VF, $>2\text{A}$ = burns, $>10\text{A}$ = asystole.
- Path: hand to hand (transthoracic) most dangerous

Voltage

- $<50\text{V}$ = no danger, 240V = small, deep entrance/exit wounds, $\geq 1000\text{V}$ = extensive tissue damage and limb loss, $>70,000\text{V}$ = invariably fatal.
- Taser: $50,000\text{V}$ but low amps - can cause R on T & so VF
- 100million V = lightning - but duration only few ms. See below.

Resistance (Heat generation)

- Bone \rightarrow Fat \rightarrow Tendon \rightarrow Skin \rightarrow Muscle \rightarrow Blood vessels \rightarrow Nerves. Dry skin has $100\times R$ of wet skin.
- Current follows the path of least resistance thus nerves & blood vessels greatest risk.

Contact duration

- Longer = more damage. Mostly short unless AC or LOC.

Point of entry

Pathophysiology of electrical injury

Electrical current causes damage through:

- Direct process of physiological changes (altering cell resting membrane potential)
 - Vascular/muscular/nerve injury \rightarrow thrombosis, muscular contraction/necrosis, respiratory depression, dysrhythmias
- Conversion of electrical energy into thermal energy \rightarrow burns & coagulative necrosis
 - Deep internal thermal burns. More likely with High Voltage than lightning.
 - Arc burns to skin/mucous membranes
 - 'Kissing burns' are produced in flexor creases when muscle tetany causes the joint to flex and the current flows through opposing skin.
 - Flame burns occur when the current ignites clothing.
 - May be several entry/exit wounds. Lightning splash - diffuse superficial burn.
 - Lichtenberg flowers - feathery lightning burns
- Blunt trauma, crush injury, blast injury in high voltage (chest, tympanic membrane, GIT)
- Secondary damage associated with falls and violent muscle contractions

Systems injury

Cardiac system

- VF usual cause of immediate death. Also asystole (>50%) in lightning. RBBB, SVT, AF.

Nervous system

- Acute complications: these include respiratory arrest, seizures, ↓LOC, amnesia, coma and expressive dysphasia. Motor deficits have also been reported.
- Delayed complications: incl. spinal cord injury (common) & complex regional pain syndrome.
- Peripheral nerve injury.

Renal system

- ATN→ARF 2° myoglobinuria, direct damage to renal vessels and inadequate rehydration.
- More common in electrocution than lightning.
- Transient renal changes: oliguria, albuminuria, haemoglobinuria, renal casts.

Effects on the vascular system

- Large and small vessel thrombosis
- Wounds: immediate or delayed haemorrhage.

Musculoskeletal effects

- Muscle cell disruption occurs, releasing myoglobin and creatinine phosphokinase.
- Tetanic muscle contractions → bone fractures and dislocations as well as muscle tears.
- There may be patchy swelling and necrosis with delayed development of sepsis.
- Compartment syndrome can develop.
- Secondary injuries arise from being thrown back from the source.

Additional complications

- Organ perforation may occur due to damage of the visceral walls.
- Tympanic membrane rupture quite common.
- The most common electrical injury seen in children <4y is mouth burns.
- Late cataract formation after significant electrical injury.
- Complex Regional Pain Syndrome may develop weeks to months later.
- Psychological sequelae: May be chronic & not related to severity of physical injury.
- Pregnancy: Sig risk to foetus if transuterine current (lightning: ~50% death in utero)). Otherwise IUGR, oligohydramnios, ↓fetal movements and spontaneous abortion common.

Investigations

Urine: ?myoglobin

Blood: FBC, UEC, CMP, LFT, CK, Trop (likely to be raised even w/o cardiac damage), βhCG, coags

ECG:

Imaging: PRN for ?2° injuries (e.g. C-spine, jt dislocs), CT/MRI brain. USS/CTG if pregnant

Management

Turn off power if appropriate and safely remove the patient from source.

Resuscitation: Secure airway. Protect C-spine. Commence CPR if required. Defibrillate VF.

ECG monitoring: if >1000V, seizures, init ECG changes, LOC, pregnant or ?transthoracic current

Supportive: Fluids - replace losses (e.g. Parkland formula), maintain hydration to ↓risk myoglobin RF. Analgesia. Tetanus booster.

Treat secondary injuries: e.g. consult burns unit

Disposition

Admit if >1000V or sig symptomatic. Discharge home if ≤240V and asymptomatic with normal ECG. Otherwise obs 6h ± cardiac monitoring and reassess.