

Lightning injuries and Hyperthermia

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Goals

- Discuss basic Pathophysiology driving injuries
- Field management
- Avoidance
- Son's advice

Lightning vs High Voltage

- **Lightning:**
 - Millions of DC volts
 - Very short duration
 - Severe burns/muscle damage rare
 - Cause of Death: Asystole or apnea
- **High voltage:**
 - >1000 volts AC or DC
 - Prolonged
 - Severe, deep tissue damage: “invisible”
 - Cause of Death: Ventricular fibrillation



Types of Strike

- Direct strike - you are the electrode
- Contact strike - touching the electrode
- Splash strike - arcing off of the electrode
- Ground current



Brief Physics Review

- Ohm's Law:

Voltage = Current * Resistance

$$(V = I * R)$$

- Joule's Law:

Heating Power \propto Current² *
Resistance ($P \propto I^2 * R$)



- Resistance of a dry human = 100,000 Ohms
- Resistance of wet human = 1,000 Ohms
- Ideal gas Law
$$\frac{PV}{nT} = R$$

(R is a constant, in this case n is essentially constant)
- Any increase in Temperature, increases Pressure and Volume

Direct strikes

- Majority of strikes are to upper torso
- Sheep studies in Australia - Dr. Cooper
- Some enters eyes and ears - affects brainstem producing apnea and myocardial stunning
- Lichtenberg figures



Blunt Injuries

- Diffuse muscle spasm
- Due to concussive effects of change in Temperature:
 - Ruptured Eardrums (common)
 - Liver/spleen shearing
 - Long bone fractures (rare)



Field Management



- Stay out of strike zone
- ABCDE's
- CPR in field until respiration/pulse
- Oxygen
- IV: gentle hydration
- Cardiac monitor

Prevention

- Non-metallic shelter
- Insulation from ground
- Avoid tall and/or metal structures
- Stay dry
- Crouch, but don't lie down



HYPERTHERMIA

Hyperthermia is elevated body temperature due to failed thermoregulation that occurs when a body produces or absorbs more heat than it dissipates.

Human Thermoregulation 101

HEAT PRODUCTION

- *Basal Metabolic Rate (BMR)* (100 kcal/hr)
- *Shivering* (500 kcal/hr)
- *Physical activity* (200+ kcal/hr)
- Medications

HEAT LOSS

- *Radiation* (60%)
- *Evaporation* (sweat/lungs)
- *Conduction* (cold/wet surface)
- *Convection* (wind)
- Medications

What causes hyperthermia?

Risk Factors:

- Dehydration
 - Lack of acclimatization
 - Humidity
 - Exercise
 - Impaired temperature regulation (Alcohol)
- Average daytime July temp in Qatar - 106 F
 - Players burn 700-900 kcal/hour



Heat Illnesses

- *Heat Exhaustion*

- Nausea/vomiting
- Cramps
- Sweating/chills
- Dizziness

- *Heat Stroke*

- Core temp: $>40-41^{\circ}\text{C}$
- AMS
- Profuse sweating or dry (late finding)



Field Management



- Shade
- Fan - ideally with mist or wet cloth covering
- Ice bags/cool water immersion
- Cool oral liquids
- Wipe sweat to renew evaporative surface area

ED/EMS Management

- Cool IV fluids
- Warm mist and fan
- If comatose: intubate and paralyze - decrease BMR
- Treat seizures with benzodiazepines



Prevention

- Hydration
- Loose clothing with a loose weave +/- dark colored
- Avoid alcohol
- Acclimatization, if possible
- Timed exertion, if possible



“Why do Bedouins wear Black Robes in Hot Deserts” *Nature* 283, 373 - 375 (24 January 1980)

Questions?

The background features a dark blue gradient on the left, transitioning into a series of bright blue, curved, and overlapping lines on the right, creating a sense of depth and movement.