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Objectives

• Electrical and Lightening Injuries
• Tetanus
• Heat Illnesses
• Burns
ELECTRICAL INJURIES
Electrical Injuries

• Definitions
  – Electrical Injuries
    • Alternating Current Injuries
    • Direct Current Injuries
  – Voltage definition
    – Low Voltage < 1000 Volts
    – High Voltage > 1000 Volts
AC vs. DC Current

AC
Household Current

DC
Batteries
Railroad Tracks
Car Electric Systems
Lightning
AC vs. DC

- **Alternating Current**
  - Requires lower energy to cause damage
  - Findings:
    - Tetany
    - Resp Paralysis
    - Burns
  - Large Exit wounds
  - Ventricular tachycardia

- **Direct Current**
  - Single muscle spasm that throws victim from source
  - Decreased exposure but more blunt trauma
  - Smaller exit wounds
  - Asystole
AC: Low vs. High Voltage

- **Low-voltage (<1000 V)**
  - Can have with cardiac/respiratory arrest
  - Prompt BLS, can fully recover.

- **High-voltage injury (>1000 V)**
  - Don’t tend to arrest
  - Burns
  - Myoglobinuria
Factors leading to Severe Injury

- Higher voltage (> 1000 Volts)
- Current intensity
- Alternating current
- Resistance of tissue
- Duration of contact
- Current pathway (hand-hand vs. head-toe)
<table>
<thead>
<tr>
<th>Current intensity</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mA</td>
<td>Tingling sensation; almost not perceptible</td>
</tr>
<tr>
<td>3-5 mA</td>
<td>&quot;Let-go&quot; current for an average child</td>
</tr>
<tr>
<td>6-9 mA</td>
<td>&quot;Let-go&quot; current for an average adult</td>
</tr>
<tr>
<td>16 mA</td>
<td>Maximum current a person can grasp and &quot;let go&quot;</td>
</tr>
<tr>
<td>16-20 mA</td>
<td>Tetany of skeletal muscles</td>
</tr>
<tr>
<td>20-50 mA</td>
<td>Paralysis of respiratory muscles; respiratory arrest</td>
</tr>
<tr>
<td>50-100 mA</td>
<td>Threshold for ventricular fibrillation</td>
</tr>
<tr>
<td>&gt;2 A</td>
<td>Asystole</td>
</tr>
<tr>
<td>15-30 A</td>
<td>Common household circuit breakers</td>
</tr>
<tr>
<td>240 A</td>
<td>Maximal intensity of household current (U.S.)</td>
</tr>
</tbody>
</table>

Lightning Injuries

- Most Patients Die instantly
  - Asystole
  - Respiratory Center
- If alive, can have associated blunt injuries as well from being thrown
- Patients will need admission
  - Cardiac monitoring (arrhythmias)
  - Renal function monitoring
Lichtenberg Burn

Mix Bouda-Lycaon, [Wikimedia Commons](https://commons.wikimedia.org/wiki/File:Lichtenberg_Burn.jpg)
Laboratory Evaluation

- ECG
- CBC
- Electrolytes
- Creatinine
- CK
- UA
- Myoglobin
Management

• Stabilization and Fluid Resuscitation

• In CNS abnormality, avoid over-hydration and subsequent cerebral edema.

• Mannitol or furosemide for patients with elevated CK/myoglobinemia. Avoid ATN

• Lightening: CNS symptoms. If GCS =15 on arrival w/ no symptoms of impaired renal fxn & if CK is not > 2x normal, consider OBS & DC.

• Irregularities of pulse, ECG changes, myoglobinuria, or CNS abnormalities require hospitalization.
Admission Criteria

• High Voltage (>1000 V)
• Low Voltage with
  – Conductive flow through head, chest or abd
  – Pts with chest pain, abdominal pain, confusion
  – Digit involvement with possible neurovascular compromise
  – Abnormal EKG, or suspected dysrhythmia
  – Abnormal UA
Pediatric Considerations

• Electrical Cord
  – If bite through cord, oral involvement
  – 3-14 days after pts can have labial artery bleed
TETANUS
Tetanus

- C. tetani produces exotoxin that is the causative agent of Tetanus
- Tetanus: 4 forms
  - Localized Tetanus - muscle rigidity at or near site
  - Generalized Tetanus - most common, tetany of fist, sweating, tachycardia, significant mortality
  - Cephalic Tetanus - dysfunction of cranial nerves
  - Neonatal Tetanus - inadequate maternal immunization, high mortality

Sir Charles Bell, 1809, [Wikimedia Commons](https://commons.wikimedia.org/wiki/File:Tetanus.png)
Tetanus

• Prophylaxis
  – Clean Wound
    • Recent immunization (does not need booster)
    • No recent immunization (needs Td)
    • If never immunized pt needs Tetanus immunoglobulin (TIG and Td)
  – Dirty Wound = crush injury, saliva, burns
    • Recent immunization (needs Td)
    • No recent immunization (needs TIG and Td)
Tetanus

• Treatment
  • ABC’s
  • Clean contaminated wound
  • Muscle relaxants
  • Neuromuscular Blockade
  • Labetalol
  • Clonidine
HEAT ILLNESS
Heat illness

• Heat Gain
  – Metabolism heats up body 1.1 degree per hour
  – Environmental sources

• Heat loss
  – Convection - heat release from body to air and water vapor
  – Conduction - contact with cooler object
  – Evaporation - transform sweat and saliva to vapor
  – Radiation - heat transfer to air, vasodilatation, if temp higher then we gain heat

• At Risk Patients
  – Extremes of age
  – Medical illness (DT’s, hyperthyroid, Parkinson’s)
  – Dehydrated
  – Drugs- Amphetamines, Cocaine, ETOH, Anticholinergic
Heat Exhaustion

• Mild to Moderate dysfunction of temp control
• Symptoms similar to viral illness
  – Nausea, vomiting, cramps, headache, weakness
• Temp < 41 degrees
• Labs: Electrolytes, BUN/CR and liver function tests
• Treatment
  – Passive cooling, cool IVF
Heat Stroke

• Temp > 40.5 degrees
• Same symptoms of exhaustion but addition of neurologic involvement
  – Altered Mental Status, Hallucinations, Ataxia, Seizures
• Physical Exam
  – Altered Mental Status
  – Tachycardia- arrhythmias resistant to Cardioversion
  – Tachypnea
Heat Stroke

• Labs
  – Coagulopathy
  – Elevated Liver Enzymes
  – Hematuria
  – Elevated CK

• Treatment
  – Ice packs in groin and axilla
  – Cold gastric lavage
  – Peritoneal lavage
  – Control shivering with benzodiazepines

• Monitor
  – Cardiac monitoring
  – Hold on acetaminophen as it can worsen liver dysfunction
BURNS
Epidemiology of Burns

• 1-1.5% of population sees MD for burns/year in US
• 1.25-2.5 million burns each year
• 500,000 ED visits, 50,000 admits, 5,000 deaths
• Most burns cover less than 5-10% of body surface area
• Types of Burns
  – Thermal
  – Chemical
  – Electrical
Thermal Burns

• Contact
• Flame
• Heat
• Scalding

Kronoman, [Wikimedia Commons](https://commons.wikimedia.org/wiki)
Chemical Burns

• Both acids and bases can be defined as caustics, which cause significant tissue damage on contact.

• ACIDS produce a coagulation necrosis by denaturing proteins, forming a coagulum (e.g. eschar) that limits the penetration of the acid.

• BASES typically produce a more severe injury known as liquefaction necrosis
Chemical Burns

• Acids
  – Toilet bowl cleaners, drain cleaners, metal cleaners, automobile battery fluid, fertilizer manufacturing, rust removers, tire cleaners, tile cleaners, glass etching, dental work, refrigerant, and hair wave neutralizers

• Bases
  – Drain cleaners, bleach, oven cleaners, mortar, plaster, and cement
Electrical Burns

• Low-voltage
  – Electric burns almost exclusively involve either the hands or oral cavity.

• High-voltage
  – In burns from an electric arc, the current courses external to the body from the contact point to the ground
  – Electric current that passes between the power source and the anatomic point of contact (entrance wound), and between the patient (exit wound) and the grounding mechanism, causing hidden destruction of deeper tissues
General Skin Anatomy

- Skin Layers
  - Epidermis
  - Dermis

- Skin Function
  - Protection
    - Pathogens
    - Water loss
  - Temp regulation
  - Sensation
  - Vitamin D Synthesis

Daniel de Souza Telles, [Wikimedia Commons](https://commons.wikimedia.org/wiki/Category:Human_skin_anatomy)
Burn Classification

• Traditional Classification
  • 1st degree
  • 2nd degree
  • 3rd degree

• Current Classification
  • Superficial partial thickness
  • Deep partial thickness
  • Full Thickness
Burn Classification

K. Aainsqatsi, [Wikimedia Commons](https://commons.wikimedia.org)
Superficial Burn

- Redness
- Dry skin
- Painful to touch
- Pain lasts 48 to 72hrs
- Peeling skin
Partial Thickness Burn

- Involves the top layers of skin
- The skin is red and blistered
- Usually painful
- Takes up to 3-4 weeks to heal.
- May have scar formation

Westchaser, Wikimedia Commons
Full Thickness Burns

- Destroys all layers of skin and underlying structures
- Appears brown or black
- Underlying tissue may be white
- Usually not painful
Pathophysiology of Burns

• Cellular damage at >45° C
• Dependent on temperature and duration
  – Singer et al. Acad Emerg Med 2000;7:1
• Three zones of injury –
  • Central zone of necrosis
  • Zone of stasis (at risk of necrosis)
  • Zone of hyperemia
Pathophysiology of Burns

• Thermal injury triggers intense inflammatory response
  – Initial release of histamine, bradykinin
  – Increased capillary permeability with third spacing
  – Progressive vascular occlusion by PMN, RBCs
  – Release of free radicals, proteases
Clinical Evaluation

• History
  – History of events
    • Closed space, toxic fumes
  – Evaluate for inconsistencies or patterns suggesting child abuse
    • E.g. Immersion injuries
  – Past Medical History:
    • AMPLE
    • Tetanus immunization status
Clinical Evaluation

– Physical Exam

• Assess for inhalation injury
  » Signs not always present
  – Singed nasal hair
  – Carbonaceous sputum
  – Cough
  – Hoarseness
  – Dyspnea
  – Altered Mental Status

– Assess Severity of Injury
Clinical Evaluation

• Determine Severity of Injury
  – Size
  – Depth/Degree
  – Location-
    • Hands, face, genitals, feet, circumferential wounds
  – Rule of 9’s
Rule of Nines
Initial Burn Management

• ABCs/IV/O2/Monitor
• Identify and treat associated injuries
• Remove source, protect rescue
• Initial cooling with cool water (not cold)
• Cover with dressing, leave blisters intact as biological dressing
• Brush off any metal other material
• Irrigation for chemical burns
Acute Management

• Airway Management
  – Secure airway early even if only mild signs of impending airway edema
  – Signs of impending airway obstruction
    • Hoarseness, Stridor, Facial edema
  – Endotracheal intubation or surgical airway if Endotracheal tube placement not possible
  – Give 100% O2 for suspected smoke inhalation
Acute Management

• Fluid Resuscitation
  – Parkland Formula
    • 4 x (% body surface burned) x weight (kg)
    • This equals the amount of fluid (in ml) to replace in a 24hr period starting from time of injury
    • First half in the first 8hrs
    • Remaining half in the next 16hrs
  – Urine Output > 0.5-1.0 cc/kg/hr
  – Pediatric Considerations
Acute Management

• General Wound Care Principles
  – Biological Dressing
  – Wound Debridement

• Topical Antibiotic Agents
  – Silvadine cream
  – Covering the wound with clean linens

• Analgesia
  – Often very painful and require large amount of pain medication
Do’s and Don’ts of Burn Care

• Do’s
  – Brush off dry chemical while in a protective suit
  – Flush with cool water
  – Cover wound with dry dressing
  – Keep victim comfortable

• Don’ts
  – Apply ice
  – Touch the burn
  – Remove pieces of cloth from burned area
  – Clean severe burns
  – Break blisters
  – Use ointment on severe burns
Acute management

• Escharotomy
  – Deep circumferential burns over neck, chest limbs
  – Compromised ABC’s
  – May be life or limb threatening
  – Incision of eschar to sub Q fat
  – Avoid major vessels and nerves
  – Anesthetics usually not required
Escharotomy

Image removed of escharotomy (surgery to treat 3\textsuperscript{rd} degree burns)

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Acute management

• Inhalational Injuries
  – Responsible for most deaths
  – Evolution may require several days
  – Exposure of airways and lungs to toxic chemicals
    • Tracheobronchitis
    • Airway obstruction
    • Pulmonary edema within 2-3 days

• Carbon Monoxide Poisoning
  – Has higher affinity for hemoglobin than O2.
  – CO poisoning can lead to AMS, myocardial ischemia, and severe long term neurologic sequelae
  – O2 in higher concentrations accelerates CO elimination
  – Can also treat with amyl nitrate, sodium nitrite, sodium thiosulfate
Complications of Burn Care

– Infection
– Airway Considerations
– Circumferential Burns
Questions?