ELECTRICAL INJURY

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I HAVE NO DISCLOSURES

WE HAVE OBTAINED APPROVAL FOR USE OF IDENTIFIABLE PATIENT PHOTOS

SCOPE OF THE PROBLEM

- 3-4% of Burn Injuries
- 3000 Burn Center Admissions
- 1,000 deaths annually
- Often work-related
- Significant public health and economic impact

OBJECTIVES

1. Physics!
2. Types of Injury
3. Management

DEFINITIONS

**Electricity** → Flow of electrons

**Current** → Amount of electrons flowing per second

**Alternating Current (AC)** → Switches direction

**Direct Current (DC)** → Direction is constant
OHM’S LAW

Voltage (V) → The force driving electrons

Resistance (R) → Hindrance to flow

Current (I)

\[ I = \frac{V}{R} \]

CURRENT KILLS

<table>
<thead>
<tr>
<th>Current (mA)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tingling, no effect</td>
</tr>
<tr>
<td>3-5</td>
<td>“Let go” for a Child</td>
</tr>
<tr>
<td>6-9</td>
<td>“Let go” for an Adult</td>
</tr>
<tr>
<td>16-20</td>
<td>Tetany – Can’t let go</td>
</tr>
<tr>
<td>20-50</td>
<td>Respiratory paralysis</td>
</tr>
<tr>
<td>50-100</td>
<td>Ventricular Fibrillation</td>
</tr>
<tr>
<td>&gt;2000</td>
<td>Asystole</td>
</tr>
<tr>
<td>15,000 – 30,000</td>
<td>Your circuit breaker trips!</td>
</tr>
<tr>
<td>240,000</td>
<td>Maximum household current</td>
</tr>
</tbody>
</table>

Koumbourlis, Crit Care Med, 2002

CURRENT TYPE

Alternating Current

- Electricity flows back and forth from power source to anatomic contact point of patient
- Repeatative contraction, victim grasps source
- Contact sites, but no true entrance / exit sites

Direct Current

- Travels in one direction
- Single muscle contraction, throws victim
- Entrance & exits sites may be seen
**Joule's Law**

Heat = current (I) x voltage (V) x contact time (t)  

\[ \text{Heat} = I \times (I \times R) \times t \]

**Resistance**

Assumptions:
- Normal skin resistance: 100K Ohms
- Wet skin resistance: 1,000 Ohms
- Open wound resistance: 500 Ohms
- Household current 120V  
  \[ I = \frac{V}{R} \]

So:
- \( \frac{120}{100,000} = 1.2 \text{ mA} \) → perceive a "shock", tingling
- \( \frac{120}{1,000} = 120 \text{ mA} \) → possible v. fibrillation
- \( \frac{120}{500} = 240 \text{ mA} \) → v. fibrillation arrest

Source: OSHA.gov

**Voltage Drives it**

- Power generators produce 25,000V
- Power transformers boost voltage to 400,000
- Transmission lines:  
  - Seattle City Light: ~15,000V
  - Puget Sound Energy ≥ 30,000V
- Household current:  
  - 120V for lights, small appliances
  - 240V for larger appliances
INJURIES

INJURY DEFINITIONS

Primary injury: caused by electric current

Secondary injury: after effect
  • Fall
  • Tetanic contractions → may lead to fractures
  • Diaphragm paralysis → respiratory arrest

INJURY TYPES

• High voltage injury → > 1000 Volts
• Low voltage injury → < 240 Volts
• Electrocution → death by electricity
• Arc (Flash) burns- electricity in the air burns the body
• Flame Burns → Clothing or other material catches fire
Ionization of air particles between two conductors

- Heat can reach 4,000 °C
- Can vaporize metal
- Causes clothing to ignite, resulting in flame burns
- Explosion dissipates excess energy
- May result in associated blunt trauma

ARC

1 in 280,000
30,000,000 Volts
>200,000 A
DC Current

Burns are RARE
Associated Trauma
30% Mortality
70% Serious Complications

WHEN LIGHTNING STRIKES...

Lichtenberg Sign
3
MANAGEMENT

TRIAGE

Refer to Burn Center?  Admit?  Home?

SIGNS OF HI-VOLTAGE INJURY?

- Loss of consciousness
  - Amnesia for event
- Paralysis or mummified limb
- Loss of peripheral pulse
- Flexor surface burns (antecubital, axillary, inguinal, popliteal)
- Myoglobinuria
- Serum CK above 1,000 IU
- Cardiac &/or pulmonary arrest at scene
INITIAL EVALUATION: EKG

- Concern for abnormal rhythm and ischemia
- Most common EKG abnormality → non-specific ST changes
- Most common rhythm abnormality → atrial fibrillation
- Life threatening rhythm → ventricular fibrillation
- Cardiac monitoring mandatory for ANY changes seen on EKG
- Rarely EKG changes present on a delayed fashion

RESUSCITATION OF HIGH VOLTAGE INJURY

- 2 large bore IV lines
- Initiate LR fluid therapy
  - Calculate surface burns
  - Initial estimate of fluid requirements based on surface burns
- Deep tissue injury may exist without surface burns
- Fluid requirement may be increased significantly in the presence of myoglobinuria

TISSUE RESISTANCE

- Bone has high resistance
- Current flows along bone surface
- Generated heat damages adjacent muscle
- K+ release
- Deep muscle injury may occur when superficial muscle appears normal
INITIAL EVALUATION: EXTREMITIES

Look for:
- abnormal neurologic exam
- vascular compromise
- tissue necrosis

Compartment pressures measurements are an **adjunct** to physical exam.

PERIPHERAL CIRCULATION

Surgical Intervention
- Escharotomy: if compromise is related to circumferential cutaneous burn
- Fasciotomy

- Needed in face of subfascial edema
- Muscle compartment pressure elevation

STEALING COPPER WIRES

MIGHT NEED FASCIOTOMY
SECONDARY SURVEY

- Head to toe exam
- Remove clothing & jewelry
- Identify contact points
- Estimate extent of surface burn
- Perform a detailed neurological exam
- Document changes over time
- Assess for orthopedic injuries, occult internal injuries, evidence of compartment syndrome

DON’T FORGET ASSOCIATED INJURIES

- Fall from power substation

SMALL CONTACT POINT

Admission | One month later
ELECTRICAL INJURIES IN KIDS

Characteristics
- Low voltage most common
- Generally occur in households
  - Faulty insulation
  - Electrical appliances
  - Frayed electric cords
  - Insertion of metal objects into socket

Wound Care
- Usually a minimal cutaneous injury
- Oral commissure burns may result in delayed bleeding

AT THE CORNER OF THE MOUTH

LONG-TERM CHALLENGES

Mostly with high voltage injuries

Often on the job → Loss of work and productivity

Medical issues
- Cataracts
- Rehabilitation, reintegration
- Neurological problems
- Spinal cord and peripheral nerve palsies
- Neuropsychiatric problems: depression, attention deficits

Legal issues (L&I, lawsuits)
RESOURCES

- Northwest Regional Burn Model System (NWRBMS) website
  www.burnrehab.washington.edu
- Burn Fact Sheets for patients and providers
  - Employment
  - Sleeping difficulties
  - Managing pain
  - Social interaction
  - Itchy skin
- Return To Work website

Thank You