Special Topics: Thermal Burns & Smoke Inhalation

MEDICAL RESPONDER AND RECEIVER SEMINAR: EXPLOSION AND BLAST INJURIES

Pathophysiology of the Burn Wound

- The burn wound is the source of virtually all ill effects seen in the burn patient.
- Removal of the burn wound results in much improved patient outcome.

Cellular and Tissue Effects

- Damage to the cells and tissue is a function of temperature and time.
- Sustained temperatures between 40°C and 44°C cause various enzymes to malfunction.
- Higher temperatures cause protein breakdown.
Cellular and Tissue Effects

- Zone of coagulation
  - Protein coagulation and cell necrosis
- Zone of stasis
  - Cell initially viable, but blood flow compromised
- Zone of hyperemia
  - Minimal cellular injury, but increased blood flow and vasodilatation

Zones of Injury

Systemic Effects

- Consumption of clotting factors and platelets
- Suppression of cellular immunity
- Myocardial depression
- Pulmonary dysfunction
- Hypermetabolism
- Fat and skeletal muscle catabolism
- Renal dysfunction
Primary Survey

- Airway:
  - Can deteriorate abruptly and rapidly
  - Airway obstruction due to progressive edema
- Breathing
  - Circumferential full-thickness burns
  - Lung injury can affect oxygenation
- Circulation
  - BP, Pulse, circumferential burns and third-spacing
- Disability
  - Neurologic status may be affected due to multiple causes
- Exposure
  - Pay attention to hypothermia-induced stress

Inhalation Injury

- Upper airway burns
  - Tracheobronchial injury
- Lower airway burns
  - Lungs
- Toxic compounds
  - Carbon monoxide
  - Cyanide

Smoke Inhalation

- Smoke particles
  - Clinical manifestations:
    - Stridor, cough, shortness of breath
    - Carbonaceous sputum, soot in airway, singed nasal vibrissae, facial burns
  - Can lead to rapid airway compromise
  - Surgical airway may be needed if oral intubation is not successful
Carbon Monoxide-Mechanism

• Binds hemoglobin to form carboxyhemoglobin that is unable to carry oxygen
• May inhibit to a certain degree cytochrome oxidase

Carbon Monoxide-Clinical

• Most common presentation:
  – Flu-like illness
• CNS
• CV

Carbon Monoxide-Labs

• Carboxyhemoglobin level (Arterial or Venous)
• Creatine kinase
• EKG, CXR
Carbon Monoxide

- 100% Oxygen therapy
- Hyperbaric oxygen therapy

Long-term Effects

Hydrogen Cyanide-Mechanism

- Inhibits cytochrome oxidase
- Cells are unable to use oxygen
- Anaerobic metabolism prevails
- Lactate accumulates
Hydrogen Cyanide-Clinical

- Clinical:
  - CNS
  - CV
  - Bitter almond: only 60% of population can detect it.
  - Cherry red skin, fundoscopic exam

Hydrogen Cyanide-Labs

- Lactic acidosis with a lactate > 7 mmol/l
- Elevated venous O2 saturation
  - >90%
- Low O2 extraction when comparing a Venous PO2 with and Arterial PO2
Cyanide Antidote Kit

- AKA the Lilly kit
- Contains:
  - Amyl nitrite pearls
  - Sodium nitrite
  - Sodium thiosulfate

Hydroxocobalamin

- 5 g IV over 15 minutes
- May repeat dose if no response and patient is critically ill

Adverse Effects of Hydroxocobalamin
Secondary Survey

- History
- Circumstances
- Cause

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Secondary Survey

- Duration of contact with flame
- Method used to extinguish the fire
- Substances placed on the burns during pre-hospital/bystander wound care

Secondary Survey

- Setting
  — Indoors versus outdoors
- Associated trauma
  — Blast injuries
- Associated smoke inhalation
Past Medical History

- Comorbid conditions
  - Diabetes, renal failure, cardiovascular disease
  - Immunocompromised state
  - Previous disabilities and special needs

AMPLE

- Allergies
- Medications
- Last meal
- Tetanus status

Depth of Burn

- First degree
- Second degree or partial thickness
  - Superficial and deep
- Third degree or full thickness
- Fourth degree
Burn Depth Estimation

- First degree: painful erythematous like a sunburn
- Partial thickness or second degree: painful, blisters, erythematous
- Full thickness or third degree: insensate, pale, without viable hair follicles, cadaveric/leathery consistency to palpation

First Degree Burn

[Image of first degree burn]

Full Thickness or Third Degree Burn

[Image of full thickness or third degree burn]
Second Degree Burn

Egg Explosion from Microwave

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Burn Surface Area Estimation

- The patient’s hand including fingers is approximately 1% of Total BSA

Rule of 9

![Rule of 9 Diagram]

Legend and Body Surface Chart

<table>
<thead>
<tr>
<th>AREA</th>
<th>AGE 0-1</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>ADULT</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAD</td>
<td>9.0</td>
<td></td>
<td></td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td>90% OF ONE TRUNK</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>2% OF ONE LEG</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>
The Berkow Chart

Table 1: Berkow Chart for Estimation of Burn Size in Children

<table>
<thead>
<tr>
<th>AREA</th>
<th>1 YR</th>
<th>1-4 YRS</th>
<th>5-9 YRS</th>
<th>10-14 YRS</th>
<th>15 YRS</th>
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</thead>
<tbody>
<tr>
<td>Head</td>
<td>15</td>
<td>17</td>
<td>13</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Neck</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ank. sp.</td>
<td>15</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Front. thorax</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Extremities</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Palms</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Uppers arm</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Lower arm</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hand</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Thigh</td>
<td>5.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Leg</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Foot</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Assessment for Perfusion/Ventilation

- Circumferential full thickness burns
  - Extremity perfusion may be compromised
  - Ventilation may be compromised
Special Consideration - Pediatrics

- Larger surface area of head
- More susceptible to hypothermia
- Moral support to patient and parents

Fluid Resuscitation

- Fluid is determined by the severity of injury
  - Amount of 2nd and 3rd degree burn
- Lactated ringers
- Initial fluid determined by parkland formula
  - 2.4 cc/kg %TBSA
  - ½ over the first 8 hours
- DO NOT BOLUS
- Titrate fluid to urine output
  - 30-50cc/hour

Fluid Resuscitation

<table>
<thead>
<tr>
<th>FORMULA</th>
<th>CRYSTALLOID</th>
<th>COLLOID VOLUME</th>
<th>FREE WATER</th>
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<tbody>
<tr>
<td>Parkland</td>
<td>4 ml/kg %TBSA burn</td>
<td>None</td>
<td>NONE</td>
</tr>
<tr>
<td>Brooke</td>
<td>1.5 ml/kg %TBSA burn</td>
<td>0.5 ml/kg %TBSA burn</td>
<td>2 L</td>
</tr>
<tr>
<td>Galveston (Pediatric)</td>
<td>5000 mL/m² burned + 1500 mL/m² total</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Adapted from Feliciano
Maintenance Fluids

- Note that maintenance fluids need to be added in children to the Parkland formula.
- When using the Galveston formula, maintenance fluids are already included.

Wound Care

- If the patient is to be transferred, cover the burns with sterile, dry, towels or sheets.
- Do not soak the burns or wrap with wet towels, this may induce hypothermia and worsen outcome.
Cleansing Solution

- Antisepctic scrub
  - Chlorhexidine versus Povidone-Iodine

Ointments

- Silver preparations (e.g., silver sulfadiazine)
  - 5 mm layer every 24 hours
    - Sulfur allergy
    - Staining of skin
- Silver nitrate (0.5%)
  - Can be used in sulfur allergy
  - Less burn eschar penetration
Ointments

- Acticoat® silver based dressing
  - No need for dressing change
  - Need for frequent application of silver nitrate
- Mafenide Acetate (Sulfamylon®)
  - Sulfonamide. Excellent antibiotic coverage
  - Cartilage

Ointments

- Neosporin®, Polysporin® and Bacitracin® are the most commonly used.
- Neosporin activity is due to the combination of three different types of antibiotics with different spectra:
  - Bacitracin (gram-positive activity)
  - Neomycin (gram-negative activity)
  - Polymyxin B (gram-negative activity)

Escharotomy- Indications

- Used to treat full thickness (third-degree) circumferential burns.
- Underlying tissues become constricted due to the eschar's loss of elasticity, leading to impaired circulation distal to the wound.
- The ability to ventilate a patient may be impaired by a circumferential chest burn.
Escharotomy- Description

- H shaped incision
Transfer to Burn Center

- Partial thickness burns >10% TBSA.
- Burns involving the face, hands, feet, genitalia, perineum, or major joints.
- Third degree burns in any age group.
- Electrical burns, including lightning.
- Chemical burns.
- Inhalation injury.
- Burns in patients with pre-existing medical problems.
- Combination of burns and trauma.