Burn Resuscitation for the Non-Burn Center

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Disclosures

None
Why resuscitate?

• Burn patients are in multifactorial shock
  • Loss of fluid similar in composition to plasma across the microvasculature
  • Intense vasoconstriction immediately postburn
  • Decrease in intense myocardial contractility
Why resuscitate?

• Burn patients are in multifactorial shock
  • Loss of fluid similar in composition to plasma across the microvasculature
  • Intense vasoconstriction immediately postburn
  • Decrease in intense myocardial contractility
• Decreased cardiac output \(\rightarrow\) inadequate end-organ perfusion
• Resuscitation is a key life-saving intervention in the early hours after burn
Who to resuscitate?

- Burns in excess of 20% TBSA
Who to resuscitate?

- Burns in excess of 20% TBSA
- 20% TBSA equivalents:
  - Inhalation injury (moderate-severe)
  - High-voltage (>1000V) electrical injury
How to resuscitate?

• Crystalloids
  • Lactate ringers is the fluid-of-choice
  • NS, in large volumes, may case
    hyperchloremic metabolic acidosis
How to resuscitate?

- Crystalloids
  - Lactate ringers is the fluid-of-choice
  - NS, in large volumes, may cause hyperchloremic metabolic acidosis

- Colloids
  - Timing debated
  - Albumin most commonly used
  - Use of fresh frozen plasma (FFP) increasing, being studied

- Peripheral IV route is adequate
# Common Resuscitation Formulas

<table>
<thead>
<tr>
<th>Formula</th>
<th>First 24 Hours Post Burn</th>
<th>Next 24 Hours Post Burn</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evans Formula</strong></td>
<td>NS: 1 mL/kg/%TBSA burn</td>
<td>NS: 0.5 mL/kg/%TBSA burn</td>
</tr>
<tr>
<td></td>
<td>Colloid: 1 mL/kg/%TBSA burn</td>
<td>Colloid: 0.5 mL/kg/%TBSA burn</td>
</tr>
<tr>
<td></td>
<td>D5W: 2000 mL</td>
<td>D5W: 2000 mL</td>
</tr>
<tr>
<td><strong>Brooke Formula</strong></td>
<td>NS: 1.5 mL/kg/%TBSA burn</td>
<td>NS: 0.5 mL/kg/%TBSA burn</td>
</tr>
<tr>
<td></td>
<td>Colloid: 0.5 mL/kg/%TBSA burn</td>
<td>Colloid: 0.25 mL/kg/%TBSA burn</td>
</tr>
<tr>
<td></td>
<td>D5W: 2000 mL</td>
<td>D5W: 2000 mL</td>
</tr>
<tr>
<td><strong>Modified Brooke Formula</strong></td>
<td>LR: 2 mL/kg/%TBSA burn</td>
<td>LR: None</td>
</tr>
<tr>
<td></td>
<td>Colloid: None</td>
<td>Colloid: 0.3–0.5 mL/kg/%TBSA burn</td>
</tr>
<tr>
<td><strong>Parkland Formula</strong></td>
<td>LR: 4 mL/kg/%TBSA burn</td>
<td>LR: None</td>
</tr>
<tr>
<td></td>
<td>Colloid: None</td>
<td>Colloid: 5% albumin given at 0.3–1 mL/kg/%TBSA burn/16 per hour</td>
</tr>
<tr>
<td><strong>Shriners Cincinnati (For Children)</strong></td>
<td>LR: 4 mL/kg/%TBSA burn + 1500 mL/m², ½ given over first 8 h and the remaining over the next 16 h (older children)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LR: 4 mL/kg/%TBSA burn + 1500 mL/m² + 50 mEq sodium bicarbonate for the first 8 h, followed by LR alone in second 8 h, followed by 5% albumin in LR in third 8 h (younger children)</td>
<td></td>
</tr>
<tr>
<td><strong>Galveston Formula (For Children)</strong></td>
<td>LR: 5000 mL/m² burn + 2000 mL/m² total, ½ volume in first 8 h, followed by remainder in 16 h.</td>
<td></td>
</tr>
</tbody>
</table>
ABA Consensus 2012

Modified Brooke formula = 2cc/kg/%TBSA burn

https://www.ameriburn.org/
ABA Consensus 2012

Modified Brooke formula = 2cc/kg/%TBSA burn

Adults (40-80kg): \[
\text{TBSA} \times \text{weight (kg)} = \frac{\text{Rate (mL/hour)}}{8}
\]

Children: \[
\text{TBSA} \times \text{weight (kg)} \times 1.5 = \frac{\text{Rate (mL/hour)}}{8}
\]

BURN (%TBSA) times WEIGHT divided by EIGHT, gives the RATE
For Peds: just multiply by 1.5

https://www.ameriburn.org/
Calculating TBSA Burn

[Diagram showing percentage areas for different body parts for adult and child]
Calculating TBSA Burn

- 18% front
- 18% back
- 18% hand
- 14% hand

1% Paediatric
0.5% Paediatric
0.8% Adult
0.5% Adult
# Lund-Browder Chart

<table>
<thead>
<tr>
<th>Area</th>
<th>Birth-1 yr.</th>
<th>1-4 yrs.</th>
<th>5-9 yrs.</th>
<th>10-14 yrs.</th>
<th>15 yrs.</th>
<th>Adult</th>
<th>2°</th>
<th>3°</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>9</td>
<td>17</td>
<td>13</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Anterior trunk</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td></td>
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</tr>
<tr>
<td>Posterior trunk</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Right buttock</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Left buttock</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
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<td></td>
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<tr>
<td>Genitalia</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td></td>
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<tr>
<td>Right upper arm</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Left upper arm</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Right lower arm</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
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<td>3</td>
</tr>
<tr>
<td>Left lower arm</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Right hand</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Left hand</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Right thigh</td>
<td>5.5</td>
<td>6.5</td>
<td>8</td>
<td>8.5</td>
<td>9</td>
<td>9.5</td>
<td></td>
<td></td>
<td>9.5</td>
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<tr>
<td>Left thigh</td>
<td>5.5</td>
<td>6.5</td>
<td>8</td>
<td>8.5</td>
<td>9</td>
<td>9.5</td>
<td></td>
<td></td>
<td>9.5</td>
</tr>
<tr>
<td>Right lower leg</td>
<td>5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>6.5</td>
<td>7</td>
<td></td>
<td></td>
<td>7</td>
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<tr>
<td>Left lower leg</td>
<td>5</td>
<td>5</td>
<td>5.5</td>
<td>6</td>
<td>6.5</td>
<td>7</td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Right foot</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td></td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td>Left foot</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td>3.5</td>
<td></td>
<td></td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Only 2° and 3° burns are included in the total TBSA burn percent**
<table>
<thead>
<tr>
<th></th>
<th>Superficial Epidermal eg sunburn</th>
<th>Superficial Dermal Thickness (partial) ‘2nd degree’</th>
<th>Mid Dermal Thickness (partial) ‘2nd degree’</th>
<th>Deep Dermal Thickness (partial) ‘2nd degree’</th>
<th>Full Thickness ‘3rd degree’</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPEARANCE</td>
<td>Dry and red, blanches to pressure. No blisters.</td>
<td>Pale pink. Smaller blisters. Wound base blanches with pressure.</td>
<td></td>
<td>Blotchy red or pale deeper dermis where blisters have ruptured</td>
<td>White waxy charred. No blisters. No capillary refill</td>
</tr>
<tr>
<td>SENSATION</td>
<td>Maybe painful</td>
<td>Increased sensation</td>
<td></td>
<td>Decreased sensation</td>
<td>No sensation</td>
</tr>
<tr>
<td></td>
<td>Very painful and tender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIRCULATION</td>
<td>Normal, increased</td>
<td>Hyperaemic</td>
<td>Rapid capillary refill</td>
<td>Sluggish capillary refill</td>
<td>Nil</td>
</tr>
<tr>
<td>COLOUR</td>
<td>Red, warm</td>
<td>Pink</td>
<td></td>
<td>White/Pale pink/Blotchy red</td>
<td>White/Charred/Black</td>
</tr>
</tbody>
</table>
Escharotomies

https://link.springer.com/chapter/10.1007/978-3-319-78367-3_28
Monitoring Response

• Hourly monitoring and titration of response

• **Urine output most commonly used**
  • Adults – 30-50ml/hr
  • Children less than 30kg – 0.5-1mg/kg/hr
  • Infants – 1-2mg/kg/hr
Monitoring Response

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• **Urine output most commonly used**
  • Adults – 30-50ml/hr
  • Children less than 30kg – 0.5-1mg/kg/hr
  • Infants – 1-2mg/kg/hr

• Vital signs – HR, MAP

• Lab values – lactate, base deficit

• Increasing use of echocardiography
Fluid Creep and Overresuscitation

- Infusion of greater volumes of fluid than predicted by formulas
Fluid Creep and Overresuscitation

- Infusion of greater volumes of fluid than predicted by formulas

- **Life-threatening complications**
  - Abdominal compartment syndrome
  - Airway and pulmonary edema
  - Extremity compartment syndrome
  - Orbital compartment syndrome
  - Cerebral edema
Fluid Creep and Overresuscitation

- Infusion of greater volumes of fluid than predicted by formulas

- **Life-threatening complications**
  - Abdominal compartment syndrome
  - Airway and pulmonary edema
  - Extremity compartment syndrome
  - Orbital compartment syndrome
  - Cerebral edema

- Ivy Index = 250mL/kg
  - Increased risk of ACS if this volume exceeded in 24 hours
Fluid Creep and Overresuscitation

• Prevention strategies

• Reduction in fluids
  • Initiate colloids
  • Tolerate sub-target urine output
  • Initiate CRRT to address acidosis or renal insufficiency
Fluid Creep and Overresuscitation

- Prevention strategies
  - Reduction in fluids
    - Initiate colloids
    - Tolerate sub-target urine output
    - Initiate CRRT to address acidosis or renal insufficiency
  - Address edema
    - Elevate extremities
    - Monitor extremity compartment pressure, bladder pressure, intraocular pressure
Inhalation Injury

• Damage to the respiratory tract or pulmonary parenchyma by heat or chemical irritants

• **Prolonged exposure to smoke**

• **Independent risk factor for mortality!**
  - Increased fluid requirements
  - Risk of pneumonia, ARDS, multi-organ failure
Diagnosis

• Physical exam
  • Burns to face, singed hair, soot on face, carbonaceous sputum

• Bronchoscopy is gold standard
  • Soot deposits, erythema, edema, mucosal blisters and erosions

<table>
<thead>
<tr>
<th>Injury Grade</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (None)</td>
<td>Absence of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction</td>
</tr>
<tr>
<td>1 (Mild)</td>
<td>Minor or patchy areas of erythema</td>
</tr>
<tr>
<td></td>
<td>Carbonaceous deposits in either proximal or distal bronchi</td>
</tr>
<tr>
<td>2 (Moderate)</td>
<td>Moderate degree of erythema, carbonaceous deposits, bronchorrhea</td>
</tr>
<tr>
<td></td>
<td>With or without bronchi compromise</td>
</tr>
<tr>
<td>3 (Severe)</td>
<td>Severe inflammation with friability</td>
</tr>
<tr>
<td></td>
<td>Copious carbonaceous deposits, bronchorrhea</td>
</tr>
<tr>
<td></td>
<td>Bronchial obstruction</td>
</tr>
<tr>
<td>4 (Massive)</td>
<td>Evidence of mucosal sloughing, necrosis, endoluminal obliteration</td>
</tr>
</tbody>
</table>
Treatment

- Supportive
  - Inhaled heparin (5000u in 3mL NS q4h)
  - Albuterol
  - N-acetylcysteine

- No specific therapeutic interventions, except
  - Cyanide poisoning
  - CO poisoning
Unnecessary Intubations?

- Parkland Burn Center
  - Retrospective analysis of 879 pre-burn center intubations
    - “airway swelling”
    - “prophylaxis”
    - “vent/oxygen needs”
  - 11.9% extubated on day of admission
  - 41.1% extubated within 48 hours of injury—none had to be reintubated
  - Many patients may have been exposed to the risks of intubation without commensurate benefit

Eastman et al. JBCR. 2010.
Carbon Monoxide Toxicity

- Odorless, colorless gas produced by combustion of cellulolytic products (wood, paper, cotton)
- CO has 200x higher affinity for hemoglobin
- Diagnosis:
  - COHb level in blood

<table>
<thead>
<tr>
<th>Table 16.2</th>
<th>Symptoms and Signs at Varying Concentrations of Carboxyhemoglobin (COHb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COHb %</td>
<td>Symptoms</td>
</tr>
<tr>
<td>0–10</td>
<td>None</td>
</tr>
<tr>
<td>10–20</td>
<td>Tightness over forehead, slight headache, dilation of cutaneous blood vessels</td>
</tr>
<tr>
<td>20–30</td>
<td>Headache and throbbing in the temples</td>
</tr>
<tr>
<td>30–40</td>
<td>Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting, collapse</td>
</tr>
<tr>
<td>40–50</td>
<td>As above; greater possibility of collapse, syncope, increased pulse and respiratory rate</td>
</tr>
<tr>
<td>50–60</td>
<td>Syncope, increased pulse and respiratory rate, coma, intermittent convulsions, Cheyne-Stokes respirations</td>
</tr>
<tr>
<td>60–70</td>
<td>Coma, intermittent convulsions, depressed cardiac and respiratory function, possible death</td>
</tr>
<tr>
<td>70–80</td>
<td>Weak pulse, slow respirations, death within hours</td>
</tr>
<tr>
<td>80–90</td>
<td>Death in less than 1 h</td>
</tr>
<tr>
<td>90–100</td>
<td>Death within minutes</td>
</tr>
</tbody>
</table>
Carbon Monoxide Toxicity

• **Treatment:**
  - 100% FiO2
    - Half life of COHb 4hr at 21%
    - Half life of COHb 45mins at 100%
  - Face mask sufficient but may require intubation
  - Hyperbaric oxygen
    - No consensus on indications or treatment parameters
    - Not widely available
Cyanide Toxicity

- Colorless, odor of bitter almonds, produced by plastic products
- Binds mitochondrial cytochromes and prevents O2 utilization
- Diagnosis:
  - Cyanide level > 0.1ug/mL
  - AGMA and lactic acidosis

<table>
<thead>
<tr>
<th>Symptoms in Low or Moderate Inhaled Cyanide Concentrations</th>
<th>Symptoms in Moderate or High Inhaled Cyanide Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faintness</td>
<td>Prostration</td>
</tr>
<tr>
<td>Flushing</td>
<td>Hypotension</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Tremors</td>
</tr>
<tr>
<td>Excitement</td>
<td>Cardiac arrhythmia</td>
</tr>
<tr>
<td>Perspiration</td>
<td>Convulsions</td>
</tr>
<tr>
<td>Vertigo</td>
<td>Stupor</td>
</tr>
<tr>
<td>Headache</td>
<td>Paralysis</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>Coma</td>
</tr>
<tr>
<td>Tachypnea</td>
<td>Respiratory depression</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>Respiratory arrest</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>Cardiovascular collapse</td>
</tr>
</tbody>
</table>
Cyanide Toxicity

- **Treatment**
  - **Methemoglobin generators**
    - Amyl nitrate (inhaled)
    - Sodium nitrate (intravenous)
    - Dimethylaminophenol (intravenous)
  - **Direct binders**
    - Dicobalt edetate
    - Hydroxycobalamin 5-10g (often given empirically)
  - **Cyanide metabolizers**
    - Sodium thiosulfate (cyanide → thiocyanate)
ABA Burn Center Referral Criteria

- Partial thickness burn >10% TBSA
- Burns involving face, hands, feet, genitalia, perineum, major joints
- Full thickness burn in any age group
- Electrical burn, including lightning injury
- Chemical burn
- Inhalation injury
- Patients with pre-existing medical problems that could complicate care
- Burns and concomitant trauma, when the burn injury poses the greatest risk of morbidity and mortality
- Burned children in hospitals without resources for the care of children
- Patients who require special social, emotional, or rehabilitative intervention

https://www.ameriburn.org/
Questions?