Acute Management of Burns in Children

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Conflict of interest

- No conflict of interest to disclose
Outline

- Epidemiology
- Pathophysiology of burns
- Acute management
- Burn depth
- Burn dressings
- Surgical management
Epidemiology

2/3 of burns in children <4 yr are scalds

- Microwave related
  - Exposure to contents
- Ages 6 mo → 2yr
  - Spillage of hot liquids most common
- Hot water burns most common in bathroom
  - Worse than hot food
Epidemiology

- Children and young adults
  - Contact with hot items
- Electrical burns
  - Electrical cords and outlets
Epidemiology cont’d

- Child Abuse
  - 10-30% overall
  - Look for other signs of abuse
  - Cigarette burns most common
  - Scalds in straight line suggest immersion
    - Feet, posterior legs, buttocks and hands
  - Burns often associated with other trauma
Pathophysiology of Burn Injury
Pathophysiology of Burn Injury

- In general, tissue destruction is related to the temperature and duration of exposure
  - E.g. scalds are usually less severe than grease burns
- Complement and coagulation activation leads to microvascular thrombosis and histamine and bradykinin release which leads to edema. Demling (1990)
Pathophysiology—Systemic

- Systemic inflammatory response with burn >30% TBSA
- Hypovolemia secondary to fluid loss
  - Decreased perfusion and DO₂
- Large burns
  - Catecholamines, vasopressin and AT cause peripheral and splanchnic vasoconstriction and may compromise end-organ perfusion
Pathophysiology—Systemic cont’d

- Myocardial suppression
  - TNF-α

- Hemolysis
  - Especially in deep 3rd and 4th degree burns

- Deterioration in pulmonary function
  - Independent of inhalation injury
  - Due to bronchoconstriction of histamine, serotonin and TXA₂
  - Decreased chest wall compliance
Pathophysiology—Systemic cont’d

- Increased evaporative water loss associated with increased heat loss
  - Loss of protective vasoconstriction
- Glucose intolerance
  - Secondary to catecholamine release
Pathophysiology—Other

- **Bacterial translocation**
  - Hypermetabolic state
    - Nutritional support prevents intestinal villous atrophy
    - Syndrome of decreased bowel mucosal integrity, capillary leak and decreased mesenteric blood flow (Deitch 1996)
    - Enteral nutrition plus glutamine help preserve mucosal barrier and prevent bacterial translocation to portal system
    - Adequate resuscitation ensures mesenteric blood flow

- **Immune Consequences**
  - Deficits in neutrophil chemotaxis, phagocytosis and intracellular bacterial killing
Key Physiologic Points

- **Burn Shock multifactorial**
  - Hypovolemia results from increased capillary permeability
    - Mediated by vasoactive amines, complement, prostaglandins and leukotrienes
  - Maximal edema occurs 8-12 hours after small burns and 12 to 24 hours after large burns
Key Physiologic Points cont’d

- Edema can be significant and can occur in both burned and unburned tissue
Why Resuscitate?

- Most initial tissue loss due to direct thermal coagulation
- Progression of Injury
  - Release of local mediators, changes in blood flow, tissue edema and infection
Why Resuscitate? Cont’d

- Jackson’s Zones of Injury
  - Central zone of coagulation (necrosis)
  - Middle zone of stasis
  - Outer zone of hyperemia
- Middle zone “at risk”
- With optimal resuscitation, zone can recover and heal
- Sub-optimal resuscitation increases necrosis
Resuscitation??
Who and How to Resuscitate?

- General acceptance that burns <10-15% TBSA in children can be treated with oral fluids only
- All formulae are used as guidelines only
  - Evaluation of resuscitation based on vital signs and U/O
- Fluid resuscitation based on 2 major factors
  - Total body surface area burned (2\textsuperscript{nd} and 3\textsuperscript{rd} degree)
    - Need Lund Browder Chart for children
  - Patient’s dry weight (in kg)
E – How much?—Lund Browder

<table>
<thead>
<tr>
<th>Area</th>
<th>Birth-1 yr</th>
<th>1-4 yr</th>
<th>5-9 yr</th>
<th>10-14 yr</th>
<th>15 yr</th>
<th>Adult</th>
<th>Partial thickness 2*</th>
<th>Full thickness 3*</th>
<th>Total</th>
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<td>Genitalia</td>
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<tr>
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<tr>
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</tbody>
</table>

Age: ____________________
Sex: ____________________
Weight: ____________________
Resuscitation—Exceptions

- Inhalation injuries
- Electrical injuries
- Polytrauma
- Electrical injury - Rhabdomyolysis
  - Sodium bicarbonate
  - Mannitol
## Resuscitation Formulae—Peds

<table>
<thead>
<tr>
<th>Authors/Reference</th>
<th>Formula for estimating fluid needs</th>
<th>Hydrating solution</th>
<th>Rate of fluid administration and special instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cope and Moore (1947) [6]</td>
<td>150 ml/% BSA burned per 24 h + (maintenance fluids)</td>
<td>½ plasma and ½ crystalloid, 5% dextrose in water</td>
<td>Half during first 8 h and half during subsequent 16 h; ceiling: 10%–12% of body weight in liters</td>
</tr>
<tr>
<td>Evans et al. (1952) [8]</td>
<td>2 ml/kg/% BSA burned per 24 h + 2,000 ml/24 h (maintenance fluids)</td>
<td>½ plasma and ½ crystalloid, 5% dextrose in water</td>
<td>Half during first 8 h and half during subsequent 16 h; ceiling: 50% burn</td>
</tr>
<tr>
<td>Gelin (1952) [10]</td>
<td>&lt;30% burn = 2 ml/kg/% BSA burned per 48 h 30%–60% burn = 2.5 ml/kg/% BSA burned per 48 h &gt;60% burn = 3 ml/kg/% BSA burned per 48 h</td>
<td>Dextran (low molecular weight)</td>
<td></td>
</tr>
<tr>
<td>Reiss et al. (1953) [9]</td>
<td>2 ml/kg/% BSA burned per 24 h + 2,000 ml/24 h (maintenance fluids)</td>
<td>½ plasma and ½ crystalloid, 5% dextrose in water</td>
<td>Half during first 8 h and half during subsequent 16 h; ceiling: 50% burn</td>
</tr>
<tr>
<td>Eagle (1956) [13]</td>
<td>30 ml/% BSA burned per 48 h + 10% of body weight in kg/48 h + 4,000 ml/m² BSA per 48 h</td>
<td>Dextrose 5%, 0.66 N saline containing 20 g of human serum albumin/l</td>
<td>Ceiling: 50% burn; burns &lt;15% do not administer the fluid equivalent to 10% of the body weight</td>
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<tr>
<td>Batchelor et al. (1961) [15]</td>
<td>Mean (children) 3 ml/kg/% BSA burned per 24 h Range (children) 1–5 ml/kg/% BSA burned per 24 h</td>
<td>Plasma and blood only</td>
<td>In children there is too wide a variation to rely on a single-figure formula</td>
</tr>
<tr>
<td>Welch (1962) [17]</td>
<td>A. 1.5 ml/kg/% BSA burned per 24 h + B. 1 ml/kg/% BSA burned per 24 h + C. 1,500 ml/m² BSA</td>
<td>a. Plasma b. Normal saline c. Dextrose 5% in water</td>
<td>Rate: ½ first 8 h, ½ second 16 h, ¼ 2nd day</td>
</tr>
<tr>
<td>Baxter and Shires (1968) [11]</td>
<td>4 ml/kg/% BSA burned per 24 h</td>
<td>Crystalloids only (isotonic salt solutions)</td>
<td>Half during first 8 h and half during subsequent 16 h; no ceiling</td>
</tr>
<tr>
<td>Carvajal (1975) [21]</td>
<td>5,000 ml/m² BSA burned per 24 h + 2,000 ml/m² total body surface per 24 h</td>
<td>Dextrose 5% lactated Ringer’s solution containing 12.5 g of human-serum albumin/l</td>
<td>Half during first 8 h and half during subsequent 16 h; no ceiling</td>
</tr>
<tr>
<td>Pruitt (1978) [12]</td>
<td>3 ml/kg/% BSA burned per 24 h</td>
<td>Crystalloids only (isotonic salt solutions)</td>
<td>Half during first 8 h and half during subsequent 16 h; no ceiling</td>
</tr>
<tr>
<td>Bowser and Caldwell (1983) [51]</td>
<td>2 ml/kg/% BSA burned per 24 h</td>
<td>Hypertonic lactated saline</td>
<td>Ceiling: 50% burn</td>
</tr>
</tbody>
</table>

BSA, Body surface area  
* Total fluid intake – no separate allowance for maintenance fluids
Resuscitation peds—Galveston

- Estimated fluid requirements in first 24 hours
  - 5000mL/m² TBSA burn plus 2000mL/m² TBSA maintenance
    - 50% infused in the first 8 hours post burn
    - 50% infused in the next 16 hours

- In 2⁰ 24hrs, 3750ml/m² plus 1500ml/m² TBSA maintenance
Resuscitation peds—Parkland

- 3 cc RL/%BSA/kg (instead of 4cc in adults)
  - 1st half in 8 hours
  - 2nd half over next 16 hour
- Add maintenance fluids
- In second 24hrs, 5% albumin in RL
Measures of Resuscitation

- Vital signs
  - Blood pressure and heart rate
- Urine output
  - 1-2 cc/kg/hr in children
- Base deficit
Measures of Resuscitation

- Invasive monitoring (PA catheter)
  - For elderly, pre-existing cardiac, renal or respiratory disease
  - Inhalation injury
    - Inability to tolerate large fluid loads
    - Patients requiring >150% of predicted fluid volume
Initial Burn Management—ATLS

- cABC’s
  - C-spine precautions
  - Airway
  - Breathing
  - Circulation
  - Disability
  - Exposure
A - Airway

- Main concerns are:
  - Inhalation injury
  - Do I need to intubate?
- Laryngeal edema can make later intubation difficult, if not impossible (those who hesitate…can’t intubate)
- Aggressive resuscitation can unmask occult laryngeal edema
Airway cont’d—Inhalation Injury

- Stridor
- Wheezing
- Hoarseness
- Carbonaceous sputum
- Singed nose hairs/eyebrows
- Soot in nose/mouth
- Facial burns
- Oropharyngeal burns
- Explosion
- LOC, exposure time
- Closed space
- Laryngeal edema may take up to 24 hr to become apparent
- In an otherwise well patient
  - 24 hr monitoring indicated
B - Breathing—Inhalation Injury?

- Three aspects
  - CO
  - Direct thermal injury
  - Combustion products

- Management
  - O2 sat
  - CO levels
  - COHb level
    - >10% concerning
    - >50% fatal
  - CXR
  - Pulmonary exam
  - 100% O₂ decreases t₁/₂ from 4 hr to 45 min

- Direct thermal injury
  - Mucosal edema
  - Steam can burn lower airway

- Combustion products
  - Aldehydes, ketones, organic acids
  - CN

- Suspect inhalation injury?
  - Intubate
  - Serial ABG’s
  - Consider 100% O₂
C - Circulation

Main concerns:

- Vitals: BP, HR (i.e. perfusion)
- Cardiac monitor – Electrical injury?
- IV access
  - 2 large bore IVs
  - Unburned skin preferred
    - If not available, burned skin preferred to cut-down and central lines (infection)
  - In children
    - Interosseus infusions preferred if venous access not otherwise available
D - Disability

- GCS
- Neuro exam
  - Head injury can accompany burns with electrical explosions, etc.
E - Exposure

- Remove all hot/burning clothing
- Sweep away any caustic materials
  - Irrigate until you think you’re irrigated enough…then irrigate some more
- Judge your burn BSA
- Judge your depth
Burn Depth

- **1st degree**
  - Sunburn

- **Superficial 2nd degree**
  - Papillary dermis

- **Deep 2nd degree**
  - Reticular dermis

- **3rd degree**
  - Subcutaneous tissue

- **4th degree**
  - Muscle and bone
Skin Anatomy

- Epidermis
  - S. corneum
  - S. lucidum
  - S. granulosum
  - S. spinosum
  - S. basale

- Dermis
  - Epidermis
  - Papillae of dermis

- Dermis

- Duct of sweat gland

- Body of sweat gland

- Subcutaneous fatty layer

- Sebaceous glands

- Hair follicle

- Arrector pili muscle

- Papilla of hair
Anatomy and Function of Skin

- Dermis (is our friend)
  - Contains skin appendages which can regenerate epidermis
  - Deep dermal burns take more time to heal and have a poorer final outcome
Traditional Burn Classification

- Burn Depth
  - 1st degree
  - 2nd degree
  - 3rd degree

Clinically Oriented Burn Classification

- Superficial dermal ↔ Deep dermal
<table>
<thead>
<tr>
<th></th>
<th>Superficial</th>
<th>Deep</th>
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<tbody>
<tr>
<td>Blisters</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Anatomical depth</td>
<td>Papillary dermis</td>
<td>Reticular Dermis</td>
</tr>
<tr>
<td>Early analgesia</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Color</td>
<td>Pink</td>
<td>White, mottled</td>
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<tr>
<td>Capillary refill</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Reepithel’n time</td>
<td>&lt;21 days</td>
<td>&gt;21 days</td>
</tr>
<tr>
<td>Hypertrophic scar</td>
<td>Rare</td>
<td>Frequent</td>
</tr>
<tr>
<td>Wound contract’n</td>
<td>Minimal</td>
<td>Potentially sig.</td>
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</table>
Current Burn Classification

- **Superficial**
  - Epidermis +/- superficial dermis
  - Erythematous
  - Sensate
  - Blanching
  - Moist
  - Hair follicles intact
  - Will heal <3wks with minimal scarring
  - No surgery!
Current Burn Classification

- **Deep**
  - Involves deep dermis
  - White with punctate hemorrhages
  - Non-blanching
  - Decreased/absent sens.
  - Dry
  - Hair pulls out easily
  - Will require >3wks to heal and will scar poorly without debrid’t + STSG
Who gets admitted?

- Any infant <1yr with >8% BSA
- 2\textsuperscript{nd} degree of >10% BSA
- 3\textsuperscript{rd} degree of >5% BSA
- Burns to face, eyes, ears, hands, joints, genitalia, feet, perineum
- Significant electrical and chemical burns
- Polytrauma
- Significant comorbidities
- Inhalation injury
How do I dress the wound?

- 1st – keep skin moist, aloe may help
- Superfical/Deep 2nd/3rd
  - leave blisters intact initially
  - Bacitigras/bacitracin ointment
  - Silverleaf – especially for larger areas
  - On face – bacitracin ointment usually sufficient
- F/U in Plastic Surgery clinic
Don’t forget…..

- Address tetanus status
- Analgesia
Do I give Antibiotics or Narcotics?

- No and Yes
Why/how do I do an escharotomy?

- Circumferential burns
- Respiratory embarrassment
- Cautery or knife
- Through eschar (not fascia)
Surgical management

- Non-viable tissue sharply and tangentially excised until healthy tissue reached
- Skin grafts applied to cover wound
Early excision and grafting cont’d
Early excision and grafting cont’d
Early excision and grafting cont’d
Conclusions

- Aesthetic and functional results from burns are far from perfect
- Require intensive post-operative or post-healing therapy (compressive garments, PT, etc)
- Prevention is key
Questions?

Thank you