Updates in Pediatric Burn Care

Fred Mullins, MD, FACS
President, Burn & Reconstructive Centers of America
- Total beds – 190
- Patient Admissions (2016) – 5,414
- Outpatient Clinic Visits – 42,651

- 18% of ALL admissions to U.S. burn centers

Source: National Burn Repository
How often does it happen?

- 450,000 burns annually
  - 1 every 30 min
- Hospitalizations – 40,000 per year
- >6,000 deaths from burns
  - 75% at the scene
- Estimated cost for burn care = $7.5 billion annually
Who gets burned?

• 68% male
• 59% Caucasian
• 73% at home
• Average age: 32 years old
• Oldest Patient – 105 years old
• Youngest Patient – 2 days old

Most common cause of burns

Adults – flame
Child – scald
What about kids?

- 116,000 children suffer burns severe enough to required treatment
- 20,000 admitted to burn unit
- 1,000 die per year
- 70% of pediatric burns are caused by hot liquid
- Second leading cause of accidental death
Epidemiology (Pediatric)

Leading Causes of Burn Injuries

- Cooking liquids: 17%
- Hot beverages: 14%
- Gasoline: 9%
- Hot tap water: 8%
- Hot food: 7%
- House fires: 3%
- Camp fires: 2%
- Ignitable liquids: 2%
- Chemical: 2%
- Electrical: 2%
- Propane: 2%
Where do you treat them?

• There are only 125 Burn Centers in the United States
  – Average US Burn Center size is 15 beds
  – About half are verified by the American Burn Association
What has been the impact of Burn Center Evolution?

- The first US burn center was established in 1947 at the Medical College of Virginia
  - Direct result of 1942 Coconut Grove fire in Boston, which left 492 dead and 212 hospitalized

- American Burn Association
  - Founded 1967
  - Dedicated to supporting burn care, research, education, rehabilitation, and prevention
What has been the impact of Burn Center Evolution?

### Burn Mortality (LD50)

<table>
<thead>
<tr>
<th>Age Groups (years)</th>
<th>0-14</th>
<th>15-44</th>
<th>45-64</th>
<th>&gt;65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull &amp; Fisher (1942-52) 2807 Patients</td>
<td>49 (n = 1366)</td>
<td>46 (n = 967)</td>
<td>27 (n = 330)</td>
<td>10 (n = 144)</td>
</tr>
<tr>
<td>Bull 1967-70 1917 Patients</td>
<td>64 (n = 962)</td>
<td>56 (n = 565)</td>
<td>40 (n = 246)</td>
<td>17 (n = 144)</td>
</tr>
<tr>
<td>Curreri &amp; Abston 1975-79 1508 Patients</td>
<td>77 (n = 803)</td>
<td>63 (n = 413)</td>
<td>38 (n = 178)</td>
<td>23 (n = 114)</td>
</tr>
<tr>
<td>SBI/UTMB 1980-99 2164 Patients</td>
<td>98 (n = 1524)</td>
<td>70 (n = 450)</td>
<td>46 (n = 127)</td>
<td>19 (n = 63)</td>
</tr>
</tbody>
</table>
What has been the impact of Burn Center Evolution?

- TBSA versus mortality

**Glue Grant 10-year review**

Tompkins et al. *Inflammation and the Host Response to Injury* National Institute of General Medical Sciences National Institutes of Health.
What has been the impact of Burn Center Evolution?

- Age versus mortality

Sepsis is the most frequent cause of death

Criteria for Injuries Requiring Referral to the Burn Center

As established by the American Burn Association
Transfer Criteria

1. Partial thickness burn greater than or equal to 10% TBSA
2. Any burn involving the face, hands, feet, genitalia or major joint
3. Any third degree burn
4. Chemical burn injury
5. Electrical burn injury
Transfer Criteria

6. Inhalation injury
7. Burn injury in patients with pre-existing medical disorders
8. Burns involving concomitant trauma in which the burn injury poses the greater risk
9. Burned children in hospitals without qualified personnel or equipment for the care of children
10. Burn injury in patients who will require special social, emotional, or long-term rehab
Initial Assessment and Management
Overlook the BURN!

**Primary Survey**

A – Airway
B – Breathing
C – Circulation
D – Disability

**Secondary Survey**

- History
- Head to toe physical exam
- Labs
Assessment of the Thermal Injured Child

• Airway
  • Relatively small airway
  • Less edema is needed to develop obstruction
  • Larynx more anterior than in adult
  • Glottis more angulated and more anterior
  • Narrowest point is cricoid, not glottis
  • Insert NGT for decompression which will help to eliminate swallowed air
Assessment of the Thermal Injured Child

• Breathing
  • Normal use of abdominal muscles when breathing
  • Ensure bilateral breath sounds
  • Obtain CXR for tube placement
• Secure tubes
  • Most common cause of death during transportation
  • Avoid paralytics
### Airway and Smoke Inhalation

- 20% - 30% of all admissions
- 60% - 70% of all deaths
- 3 types of inhalation injury
  - Carbon Monoxide poisoning
  - Injury above the glottis
  - Injury below the glottis
Carbon Monoxide Poisoning

- Most common cause of pre-hospital mortality
- 200X greater affinity for hemoglobin
- Shifts oxygen dissociation curve to the left
Signs and Symptoms

- PaO2 is unaffected (oxygen dissolved in plasma not affected)
- Cyanosis and Tachypnea not present (CO2 removal not affected)
  - 0-10  None
  - 10-20 HA, dilation of cutaneous vessels, tightness over forehead
  - 20-30 HA, throbbing in temples
  - 30-40 Severe HA, weakness, dizziness, N/V, dimness of vision
  - 40-60 Syncope, coma, convulsions
  - 60-100 Death
Signs and Symptoms

**Oxygen**
- Room Air
- 100% FiO2
- HBO*

**Half Life of CO**
- 4 hours
- 1 hour
- <30 minutes

*Reserved for CO >25%
or severe symptoms
Cyanide

- Elevated cyanide levels found in many people found dead at the scene of the fire
- Often associated with elevated carboxyhemoglobin levels.
- Cyanide levels too delayed to be clinically useful
- Lactate >10 has strong correlation with elevated cyanide levels
Cyanide Signs/Symptoms

• General: weakness/malaise/collapse
• Neuro: headache/dizziness/vertigo progressing to confusion, then to seizures, then coma
• GI: abdominal pain, nausea, vomiting
• Cardiopulmonary: shortness of breath, chest pain, apnea
Cyanide Signs

- Variable vital signs including initial hypertension and bradycardia, reflex tachycardia, then hypotension
- Cherry red skin color, bright red retinal artery and veins
- Mydriasis (pupil dilation)
- Bitter almond smell on breath
Hydroxocobalamin

- Hydroxocobalamin combines with CN to form cyanocobalamin (Vit B12); this is renally excreted.
- Hydroxocobalamin not compatible with many ICU drugs, and alters laboratory valves
- Sodium Thiosulfate: Complications
  Shortage
Injury Above the Glottis

- Most common injury
- Most heat is dissipated above the cords
- Under resuscitated patient may have delayed onset of symptoms
Injury Below the Glottis

- Usually chemical or prolonged smoke exposure
- Increases mortality up to 50%
- Onset of symptoms unpredictable- so observe for at least 24 hours (mucosal sloughing in 4 – 5 days)
Anticipate Respiratory Involvement

- Burned in an enclosed space
- Singed nasal hairs
- Burns to the face, neck, or lips
- Carbonaceous material around nose/mouth
- Hoarseness, stridor, or respiratory changes
Intubate Early
Assessment of the Thermal Injured Child

• Circulation
• Initiate fluid resuscitation immediately
• Establish early IV access
• Routes of access:
  – First: Peripheral IV – Unburned Skin
  – Second: Peripheral IV – Burned Skin
  – Third: Central Access – Unburned Skin
  – Fourth: Central Access – Burned Skin
  – Fifth: Intraosseous Infusion
Time to Intravenous Access:
Survivors vs. Non-Survivors

Fluid Resuscitation
Goal of Resuscitation

- Maintain tissue perfusion and organ function while avoiding the complication of inadequate or excessive fluid therapy.
Systemic Effects of Burn Injury/Burn Shock

• Proportional to extent of injury
• Fluid loss is slow, but progressive
• Fluid replacement – Not rapid, but sustained
Pre-Hospital Fluid

• <5 years – 125 cc/hr

• 6-13 years – 250 cc/hr

• >13 years – 500 cc/hr
The Parkland Formula

- 2- 4cc of Lactated Ringers x %TBSA x weight in Kg
- Give 1st half in 8 hours
- Give 2nd half over next 16 hours
  - Consider glucose administration in children less than 2 years of age & < 10kg

- Children over 14 and adults – 2cc x Kg x TBSA
- Children under 14 and adults – 3cc x Kg x TBSA
- Electrical – 4cc x Kg x TBSA

*Calculate fluid from the time of injury*
Values to Calculate Fluid

• Weight in kilograms
• Body Surface area of 2nd and 3rd degree injury
Adult Body Surface Area

Calculate spotty areas by using the palm as 1% TBSA
Pediatric Body Surface Area

Subtract 1% TBSA from the head for each year over 1

Add ½% to each leg for each year over 1

Calculate spotty areas by using the palm as 1% TBSA
Urine output

- Adult Thermal /Chemical Burn – 30-50 cc/hr
- Electrical Burn – 75-100 cc/hr
- Pediatric – 1 cc/kg/hr
Remember

- Fluid calculation is an ESTIMATE
- Individual patient response dictates therapy
- Increased Fluid needs common in patients with
  - associated injuries
  - electrical injuries
  - inhalation injuries
  - resuscitation delay
  - prior dehydration
  - ETOH & or drug abuse
  - very deep burn injury
  - small children with large burns
Increased Vascular Permeability

- Altered microcirculation from direct heat injury and inflammation
- Increased protein permeability leading to large plasma leak
- Accumulation of protein rich edema below eschar
- Hypovolemia
Physiologic Effect of Burn Injury

- Response proportional to %TBSA injury
- Results in diminution and redistribution of tissue blood flow
- Adequate resuscitation ameliorates burn shock
Surgical Management of the Burn Injury
Assessment of the Burn Wound
1st Degree Burn

- Red
- Painful
- No blisters
- Heals in 5-7 days
2nd Degree Burn

- Red/Pink
- Painful
- Large blisters/wet appearance
- Heals 14-21 days
- Re-pigmentation in up to 2 years in kids
Deep Second Degree Burns

- Characteristics of 2nd and 3rd
- Immersion burns frequent cause
- Difficult to assess depth
- Ongoing cell injury/death
- Resuscitative measures
- Repeat trips to OR
- Debridement of non-viable tissue
3rd Degree Burn

- Charred appearance
- Leathery or white in color
- Dry to touch
- Insensate
- Skin grafting required for healing
4th Degree Burn

- Muscle
- Tendon
- Bone
Time to Burn

• 130 degrees
  – Child: tissue destruction in 10 seconds
  – Adult: tissue destruction in 30 seconds

• 160 degrees
  – Child: third degree burn instantly
  – Adult: third degree burn instantly
Burn Depth

Factors

– Temperature
– Duration of contact
– Dermal thickness
– Blood supply

Special consideration:
Very young or elderly patients have thinner skin
Categories of Burns

- Thermal – 85%
- Electrical – 10%
- Chemical – 5%
Thermal Burns
Scald
Hallmark Signs of Child Abuse

• Definite line of demarcation
• Frequent or repetitive hospital visits
• Symmetrical burn wounds

Remember, it is not your job to prove abuse - just to report possible abuse
Georgia Child Abuse

• Who must report?
  – Georgia mandated reporters include:
    • Physicians, physician assistants, interns or residents
    • Hospital or medical personnel
    • Registered Professional Nurses
    • Licensed Practical Nurses
    • Hospital or Medical personnel/ volunteer

• Reporting Time
  – “Immediately, but in no case later than 24 hours from the time there is reasonable cause to believe that suspected child abuse has occurred.”

Georgia Child Abuse

• Report to:
  • The Division of Family and Children Services of the Department of Human Services Child Protective Center
  • Phone: 1-855-GACHILD / 1-855-422-4453
  • Email: cpsintake@dhr.state.ga.us
  • Fax: 229-317-9663
  • Georgia DFCS Mandated Reporter Form available at: https://oca.georgia.gov/child-abuse-and-neglect-reporting
  • More info: http://dfcs.dhs.georgia.gov/child-abuse-neglect
Circumferential Burns
Escharotomy

• Incisions made through the skin to release pressure and restore circulation.
Electrical Burns

“The Great Masquerader”
Tissue Injury is Dependent on

• Voltage of the source
• Amperage of current passing through the tissues
• Resistance of tissue traversed by current
• Duration of contact
• Pathway of the current
Electrical Burn Injuries

• Entrance Wounds
• Exit Wounds
• Arc Wounds
• Thermal Wounds
• Hidden Wounds
Initial Treatment

- Turn off power source
- Start CPR if needed
- Remove all clothing and jewelry
- Document pulses
- Monitor for dysrhythmias
18-year-old working on air conditioner unit
28 year-old lineman contacted 48,000 volts
Special Considerations

- Lethal dysrhythmias
- Vascular compromise
- Compartment syndrome
- Renal dysfunction/failure
Myoglobinurea

- Mannitol
- Sodium Bicarb
- Increase IV fluids
- Urine output 75-100 ml/hr
Chemical Burns
Chemical Burns

• More than 30,000 different chemicals
• 5% of all burn admissions
• Severity of injury depends on
  — Duration of contact
  — Concentration of chemical
Common Agents

- Hydrochloric Acid-Muratic Acid
- Formic Acid
- Chromic Acid
- Hydrofluoric acid
- Sodium Hydroxide
- Potassium Hydroxide
Emergency Care

• Remove all Clothing
• Brush off the skin if the agent is a powder
• Irrigate
• Irrigate
  – Strong chemicals can contaminate large quantities of water (10ml of 98% sulfuric acid will reduce the pH of 12 liters of water to a pH of 5)
• DO NOT try to Neutralize
Photo removed due to lack of permissions to use provided
Hydrofluoric Acid

• Widely Used:
  – Industrial – dissolve silica, etching glass
  – Domestic – Aluminum cleaners
Hydrofluoric Acid

• Pathophysiology
  – Hydrogen ions cause dehydration of cells and corrosion of tissue which yields tissue necrosis
  – Flouride ion complexes with Calcium and Magnesium forming insoluble salts depleting cellular calcium and leading to cell death.
Hydrofluoric Acid

• Severity (depends on the concentration)
  >50% immediate pain and tissue destruction
  20%-50% pain several hour after exposure
  <25% pain in about 24 hours
• Skin initially is erythematous with longer exposure is assumes a gray appearance
• 7 cc of 99% HF can bind all available free calcium in a 70 kg person
• Burns >5% TBSA can be life threatening.
Hydrofluoric Acid

• Treatment
  – Irrigate !!!!!
  – Calcium Gluconate Gel
    • 42cc 10% calcium gluconate injection & mix with 6oz petroleum jelly
  – Calcium Gluconate injection
    • 0.5ml/sq cm of 10% calcium gluconate
  – Intrarterial Calcium
    • 10ml of 10% solution mixed in 50cc of 5% dextrose

• Treat until symptom free
• Systemic Affects
36-year-old male working in a manufacturing plant. A vat of hot liquid including sodium hydroxide tipped off of a warmer.
Hydrofluoric Acid

- Affinity of F⁻ ion for Ca and Mg:

- rust removal, window cleaners,
- Pain out of proportion to injury
  Predilection for subungual tissue
- Systemic effects: hypocalcemia, hypomagnesemia, lethal dysrhythmias,

- 7ml of 99% HF can theoretically bind all available free calcium in a 70kg person”

- Burns>5% TBSA: life threatening
Hydrofluoric Acid

- Prompt irrigation for 15-30’, clipping of the fingernails
- Erythema or discoloration of the nail bed: nail removal
- Topical application of 2.5% Ca gluconate gel, Mg oxide ointment
- Subeschar injection of 10% Ca gluconate via 30G needle 0.5ml/cm² tissue (*CaCl may be corrosive to tissue*)
- Intrararterial infusion of 5% Ca gluconate or CaCl, 50-100cc x4hrs
- IV infusion if Ca gluconate in a way analogous to the Bier Block
- Continuous cardiac monitoring, systemic Ca & Mg replacement
Friction Injuries – Treadmill
Advances in the Treatment of Burn Wounds
Integra

- Dermal Regeneration Template
- Bilayered Membrane
- Inner layer: bovine collagen and chondroitin 6 sulfate
- Outer Layer: silicone
- Decreases Insensible fluid loss
- Time Consuming
- Full Thickness and Reconstructive Procedures
Bone & Tendon Exposure

- Blood supply
- Integra
- VAC
- Burring
Amniotic Membrane

- Epifix/Grafix/Cygnus
  - Cellular repair matrix
  - Mesenchymal stem cells
  - Frozen or freeze dried
  - Deep second degree burns
  - Must stay moist for 24-48 hrs
Amniotic Membrane

Initial Injury 6 weeks post injury

Application process 1 week post application

6 weeks post injury

Children’s Healthcare of Atlanta
Cultured Epidermal Autograft

- Requires biopsy
- 3 to 4 weeks to delivery
- Expensive: $1,000 for 50 sq cm
- Prolonged Immobilization
- Thin and Friable
- Large full thickness burns
Cultured Epidermal Autograft
Laser Therapy
Stevens Johnson Syndrome/Toxic Epidermal Necrolysis (TENS)

• Rare, serious, potentially fatal skin reaction
• Sheet-like skin and mucosal loss
• Commonly associated with medications
• Classification
  – TENS – Greater than 30% TBSA
  – SJS – Less than 10% TBSA
Drugs commonly associated with SJS/TENS

- Sulfa drugs
- Anti-epileptics
- Antibiotics
- More than 200 other medications
Clinical Features

- Prodromal illness (3-5 days)
- Fever
- Cough
- Sore Throat
- Generalized aches and pains

- Abrupt on-set of tender, painful skin rash
  - Macules → Targets → Blisters
Clinical Features

• Prodromal illness (3-5 days)
  • Fever
  • Cough
  • Sore Throat
  • Generalized aches and pains

• Abrupt on-set of tender, painful skin rash
  Macules ➔ Targets ➔ Blisters
Clinical Features (Continued)

- Mucosal involvement
  - Eyes – red, sore, sticky
  - Lips/Mouth – crusted lips, mouth ulcers
  - Esophagus – difficulty eating
  - Gastrointestinal tract – diarrhea
  - Genitourinary tract – dysuria, ulcers
Diagnosis

• Full-thickness skin biopsy
• Keratinocyte necrosis – Death of individual skin cells
• Full-thickness epidermal/epithelial necrosis – Death of an entire layer of skin
• Minimal inflammation
• Direction immunofluorescence test is negative – disease not due to deposition of antibodies in the skin
TENS
Founded in 1994, the Joseph M. Still Research Foundation, Inc. is dedicated to furthering patient care through research and education at our location in Augusta, GA.

Our physicians have a long history of authored articles in medical journals, including more than 20 publications in both 2015 and 2016.

The BRCA Foundation focuses on improving burn care and assisting patients at our locations across the nation.
Questions?

855-863-9595
or 706-830-7511

Our goal is to accept the patient, guide the emergency care, and arrange transport for the best patient transfer outcome.