

Burn Resuscitation for the Non-Burn Center

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<https://www.jems.com/patient-care/scorched-skin-a-guide-to-prehospital-burn-management/>

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

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- 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 → 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

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- 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 cause hyperchloremic metabolic acidosis



How to resuscitate?

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 - 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

Formula	First 24 Hours Post Burn	Next 24 Hours Post Burn
Evans Formula	NS: 1 mL/kg/%TBSA burn	NS: 0.5 mL/kg/%TBSA burn
	Colloid: 1 mL/kg/%TBSA burn	Colloid: 0.5 mL/kg/%TBSA burn
	D5W: 2000 mL	D5W: 2000 mL
Brooke Formula	NS: 1.5 mL/kg/%TBSA burn	NS: 0.5 mL/kg/%TBSA burn
	Colloid: 0.5 mL/kg/%TBSA burn	Colloid: 0.25 mL/kg/%TBSA burn
	D5W: 2000 mL	D5W: 2000 mL
Modified Brooke Formula	LR: 2 mL/kg/%TBSA burn	LR: None
	Colloid: None	Colloid: 0.3–0.5 mL/kg/%TBSA burn
Parkland Formula	LR: 4 mL/kg/%TBSA burn	LR: None
	Colloid: None	Colloid: 5% albumin given at 0.3–1 mL/kg/%TBSA burn/16 per hour
Shriner's Cincinnati (For Children)	LR: 4 mL/kg/%TBSA burn + 1500 mL/m ² , ½ given over first 8 h and the remaining over the next 16 h (older children)	
	LR: 4 mL/kg/%TBSA burn + 1500 mL/m ² + 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)	
Galveston Formula (For Children)	LR: 5000 mL/m ² burn + 2000 mL/m ² total, ½ volume in first 8 h, followed by remainder in 16 h.	

ABA Consensus 2012

Modified Brooke formula = $2\text{cc/kg/\%TBSA burn}$

ABA Consensus 2012

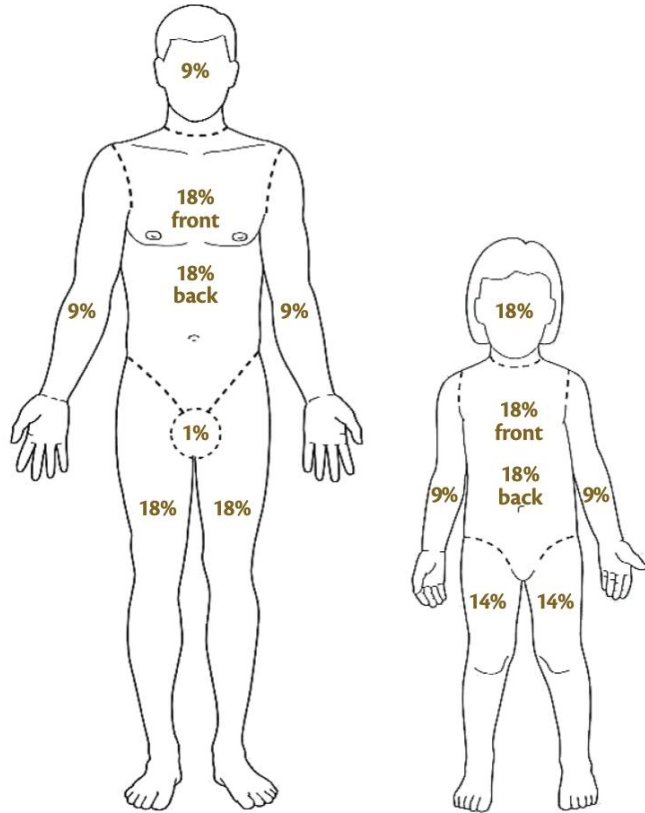
Modified Brooke formula = 2cc/kg/%TBSA burn

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

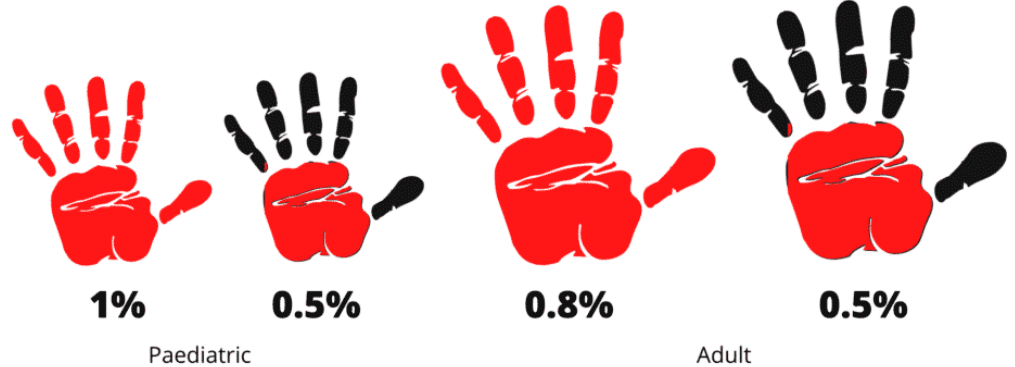
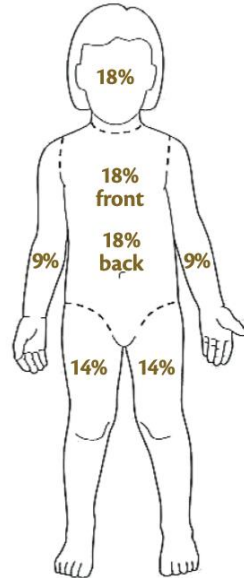
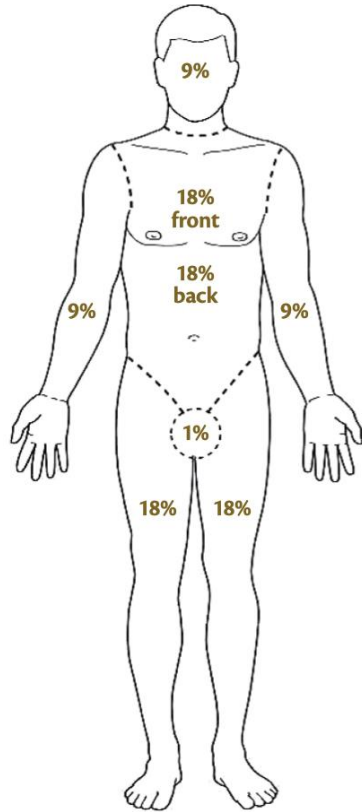
$$\text{Children: } \frac{\text{TBSA} \times \text{weight (kg)}}{8} \times 1.5 = \text{Rate (mL/hour)}$$

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

Calculating TBSA Burn








Calculating TBSA Burn



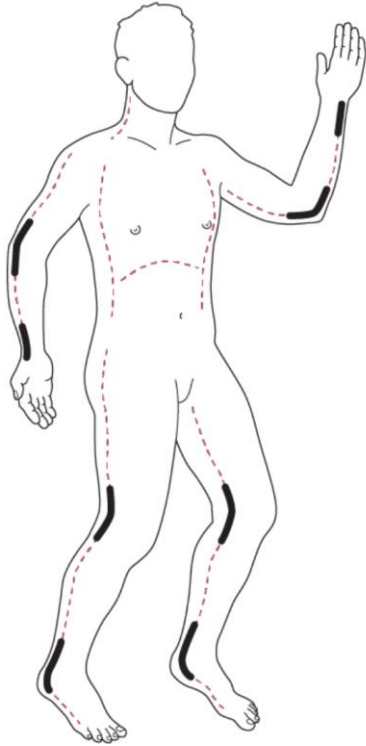
Lund-Browder Chart

Area	Birth-1 yr.	1-4 yrs.	5-9 yrs.	10-14 yrs.	15 yrs.	Adult	2°	3°	TOTAL
Head	9	17	13	11	9	7			
Neck	2	2	2	2	2	2			
Anterior trunk	13	13	13	13	13	13			
Posterior trunk	13	13	13	13	13	13			
Right buttock	2.5	2.5	2.5	2.5	2.5	2.5			
Left buttock	2.5	2.5	2.5	2.5	2.5	2.5			
Genitalia	1	1	1	1	1	1			
Right upper arm	4	4	4	4	4	4			
Left upper arm	4	4	4	4	4	4			
Right lower arm	3	3	3	3	3	3			
Left lower arm	3	3	3	3	3	3			
Right hand	2.5	2.5	2.5	2.5	2.5	2.5			
Left hand	2.5	2.5	2.5	2.5	2.5	2.5			
Right thigh	5.5	6.5	8	8.5	9	9.5			
Left thigh	5.5	6.5	8	8.5	9	9.5			
Right lower leg	5	5	5.5	6	6.5	7			
Left lower leg	5	5	5.5	6	6.5	7			
Right foot	3.5	3.5	3.5	3.5	3.5	3.5			
Left foot	3.5	3.5	3.5	3.5	3.5	3.5			
**Only 2° and 3° burns are included in the total TBSA burn percent							TOTAL		

	Superficial Epidermal eg sunburn '1 st degree'	Superficial Dermal Thickness (partial) '2 nd degree'	Mid Dermal Thickness (partial) '2 nd degree'	Deep Dermal Thickness (partial) '2 nd degree'	Full Thickness '3 rd degree'
					
APPEARANCE	Dry and red, blanches to pressure. No blisters.	Pale pink. Smaller blisters. Wound base blanches with pressure.	↔	Blotchy red or pale deeper dermis where blisters have ruptured	White waxy charred. No blisters. No capillary refill
SENSATION	Maybe painful	Increased sensation Very painful and tender	↔	Decreased sensation	No sensation
CIRCULATION	Normal, increased	Hyperaemic Rapid capillary refill.	↔	Sluggish capillary refill	Nil
COLOUR	Red, warm	Pink	↔	White/Pale pink/ Blotchy red	White/Charred/ Black

<https://trauma.reach.vic.gov.au/guidelines/burns/secondary-survey>

Escharotomies



https://link.springer.com/chapter/10.1007/978-3-319-78367-3_28
<https://www.merckmanuals.com/professional/injuries-poisoning/how-to-do-skin,-soft-tissue,-and-minor-surgical-procedures/how-to-do-burn-escharotomy>

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

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 - Adults – 30-50ml/hr
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- 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

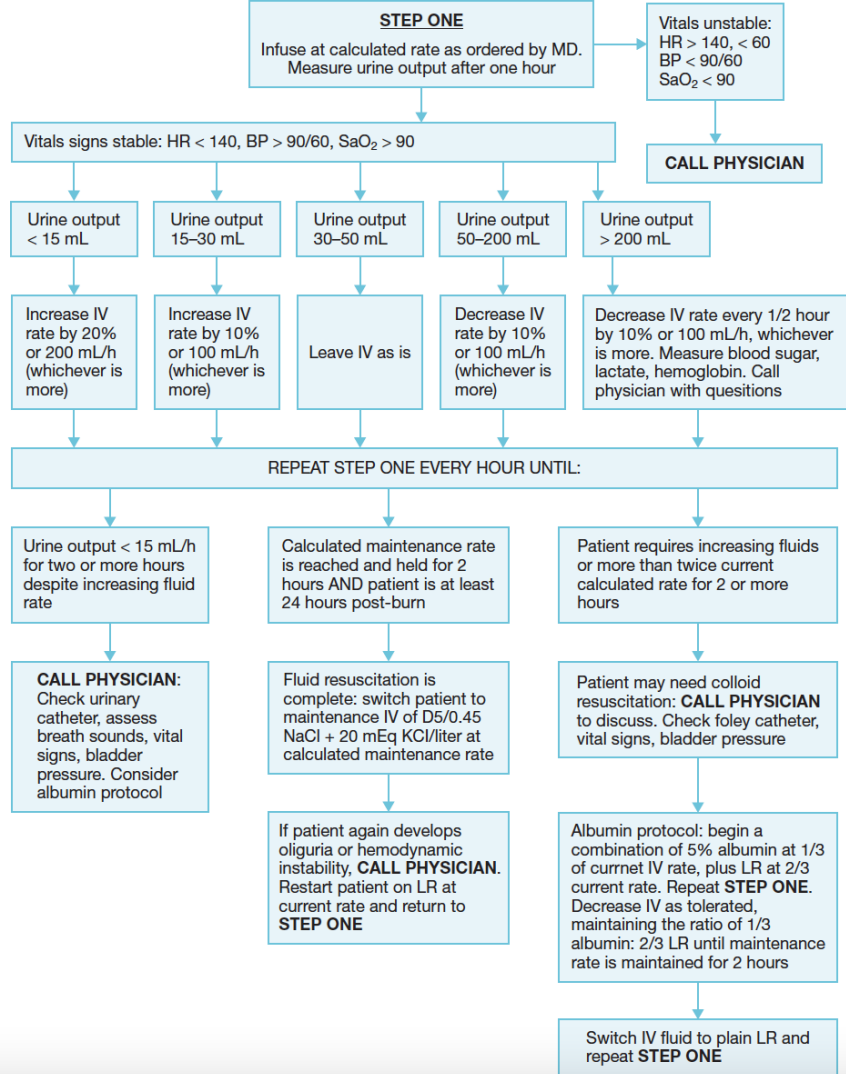
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 - Cerebral edema
- Ivy Index = 250mL/kg
 - Increased risk of ACS if this volume exceeded in 24 hours

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
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 - Initiate CRRT to address acidosis or renal insufficiency
 - Address edema
 - Elevate extremities
 - Monitor extremity compartment pressure, bladder pressure, intraocular pressure

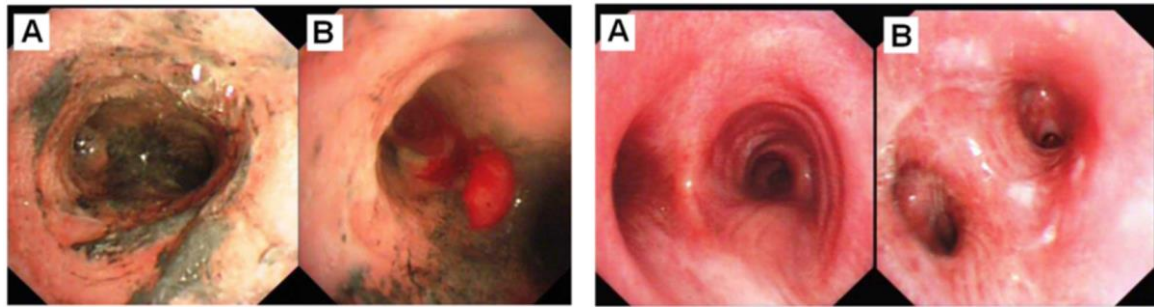


Inhalation Injury

- 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



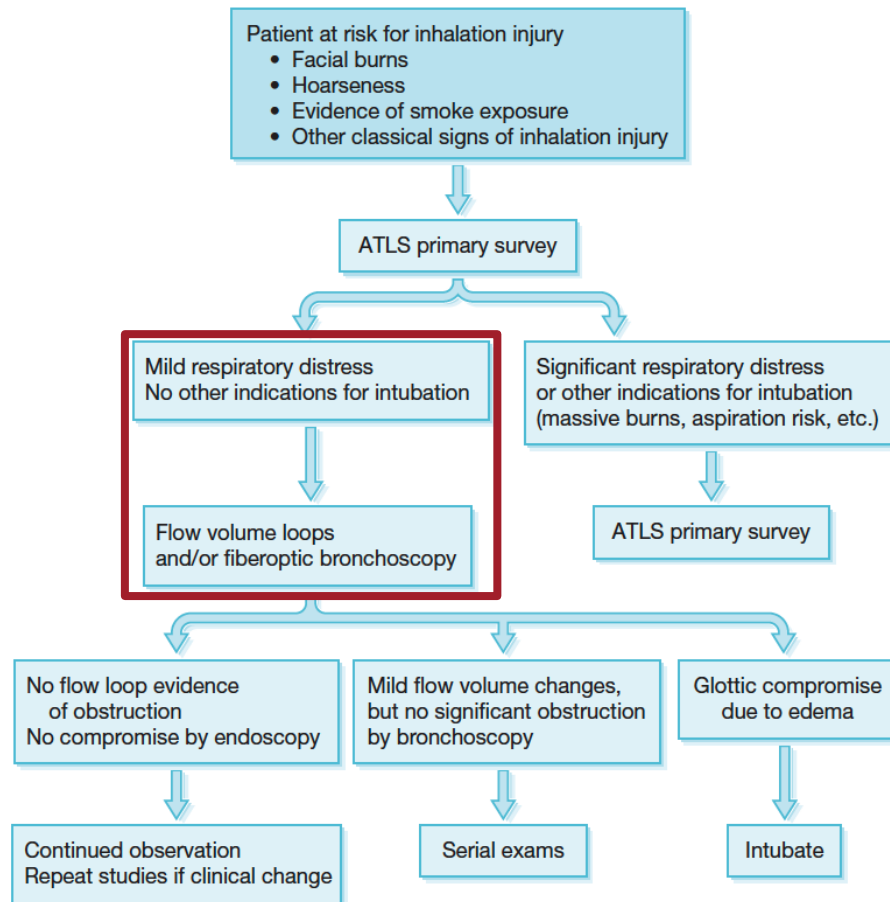
Injury Grade	Findings
0 (None)	<ul style="list-style-type: none">• Absence of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
1 (Mild)	<ul style="list-style-type: none">• Minor or patchy areas of erythema• Carbonaceous deposits in either proximal or distal bronchi
2 (Moderate)	<ul style="list-style-type: none">• Moderate degree of erythema, carbonaceous deposits, bronchorrhea• With or without bronchi compromise
3 (Severe)	<ul style="list-style-type: none">• Severe inflammation with friability• Copious carbonaceous deposits, bronchorrhea• Bronchial obstruction
4 (Massive)	<ul style="list-style-type: none">• Evidence of mucosal sloughing, necrosis, endoluminal obliteration

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



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 16.2 Symptoms and Signs at Varying Concentrations of Carboxyhemoglobin (COHb)

COHb %	Symptoms
0–10	None
10–20	Tightness over forehead, slight headache, dilation of cutaneous blood vessels
20–30	Headache and throbbing in the temples
30–40	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting, collapse
40–50	As above; greater possibility of collapse, syncope, increased pulse and respiratory rate
50–60	Syncope, increased pulse and respiratory rate, coma, intermittent convulsions, Cheyne-Stokes respirations
60–70	Coma, intermittent convulsions, depressed cardiac and respiratory function, possible death
70–80	Weak pulse, slow respirations, death within hours
80–90	Death in less than 1 h
90–100	Death within minutes

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 16.3 Symptoms of Cyanide Toxicity

Symptoms in Low or Moderate Inhaled Cyanide Concentrations	Symptoms in Moderate or High Inhaled Cyanide Concentrations
Faintness	Prostration
Flushing	Hypotension
Anxiety	Tremors
Excitement	Cardiac arrhythmia
Perspiration	Convulsions
Vertigo	Stupor
Headache	Paralysis
Drowsiness	Coma
Tachypnea	Respiratory depression
Dyspnea	Respiratory arrest
Tachycardia	Cardiovascular collapse

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

Questions?