Pediatric Burn Care – An Overview

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Changing What's Possible

Disclosures

- none

Objectives

- Re-introduce the anatomy of a burn
- Reinforce burn measurement principles and resuscitation guidelines
- Introduce the surgical treatment of burns
- Cases

Pediatric Burn Care in SC – Where We Stand

- SC Burn Center is the only burn referral center in the state
  - ~1000 burn admissions in total from SC per year

- **Pediatric Burn Unit**
  - **Responsible for patients <16 years of age**
  - **ACS Pediatric Level 1 Trauma Center**
  - ~300 patients annually
    - 250 outpatients/year
      - 500 outpatient visits
    - 60-70 inpatients/year
  - Twice weekly outpatient Burn Clinics
  - Wide variety of burn mechanism and injury

The Medical University of South Carolina
Shawn Jenkins Children's Hospital

7 yo male in house fire with thermal burns to face, neck, bilateral upper extremities, and torso (31% TBSA)

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- Injury day 1/2– stabilization, fluid resuscitation, burn wound excision
  - Full thickness burns in Acticoat
  - Deep Partial thickness burns in Xenograft
- Injury day 3– further debridement of wounds secondary to possible burn wound infection – allograft placed
- Injury day 7– debridement and STSG placement on bilateral shoulders, upper back
- Injury day 10– further debridement of neck and arms, STSG
- Injury day 15– repeat debridement and xenografting of lower back

Post Injury Day 12

Post Injury Day 18

Post Injury Day 30

Post Injury Day 35

Post Injury Day 90

Donor Site

- Excellent recovery
- Back to school, sports
- Ongoing physical therapy and burn scar laser therapy
- Engaged with pediatric psychotherapy

A History of Burns

Stone Age

1500BC Smith Papyrus

Honey

Pig Fat

400BC Hippocrates

1-200AD Galen Rhases

Vinegar
Cold H2O

Wound Excision

1500s Ambroise Pare

1800s Marjolin, Dupuytren, and Curling

SCC
Burn Depth
Gastric Ulcers
1st Hospital (UK)

1947 Truman Blocker and Texas City

1960s Zora Janzekovic

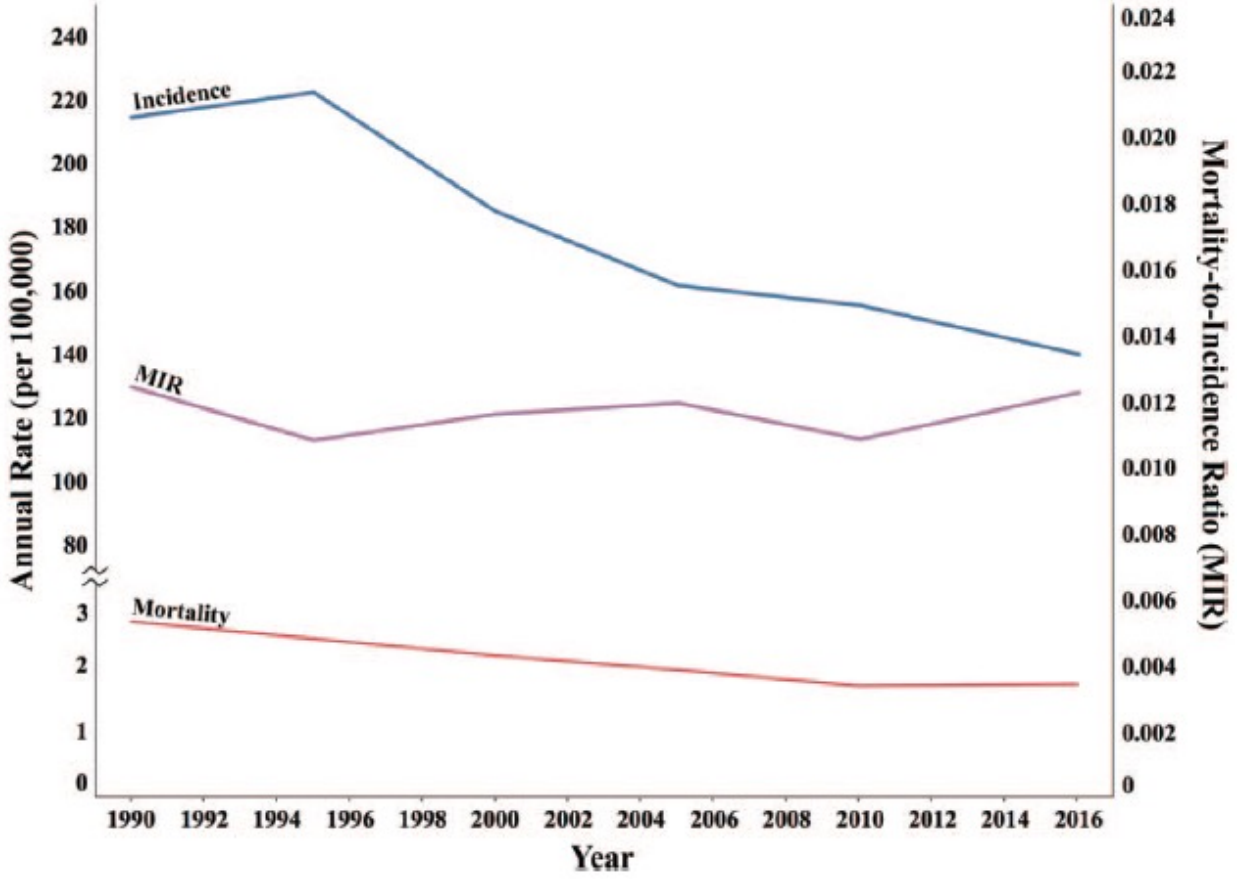
Tangential excision
Grafting

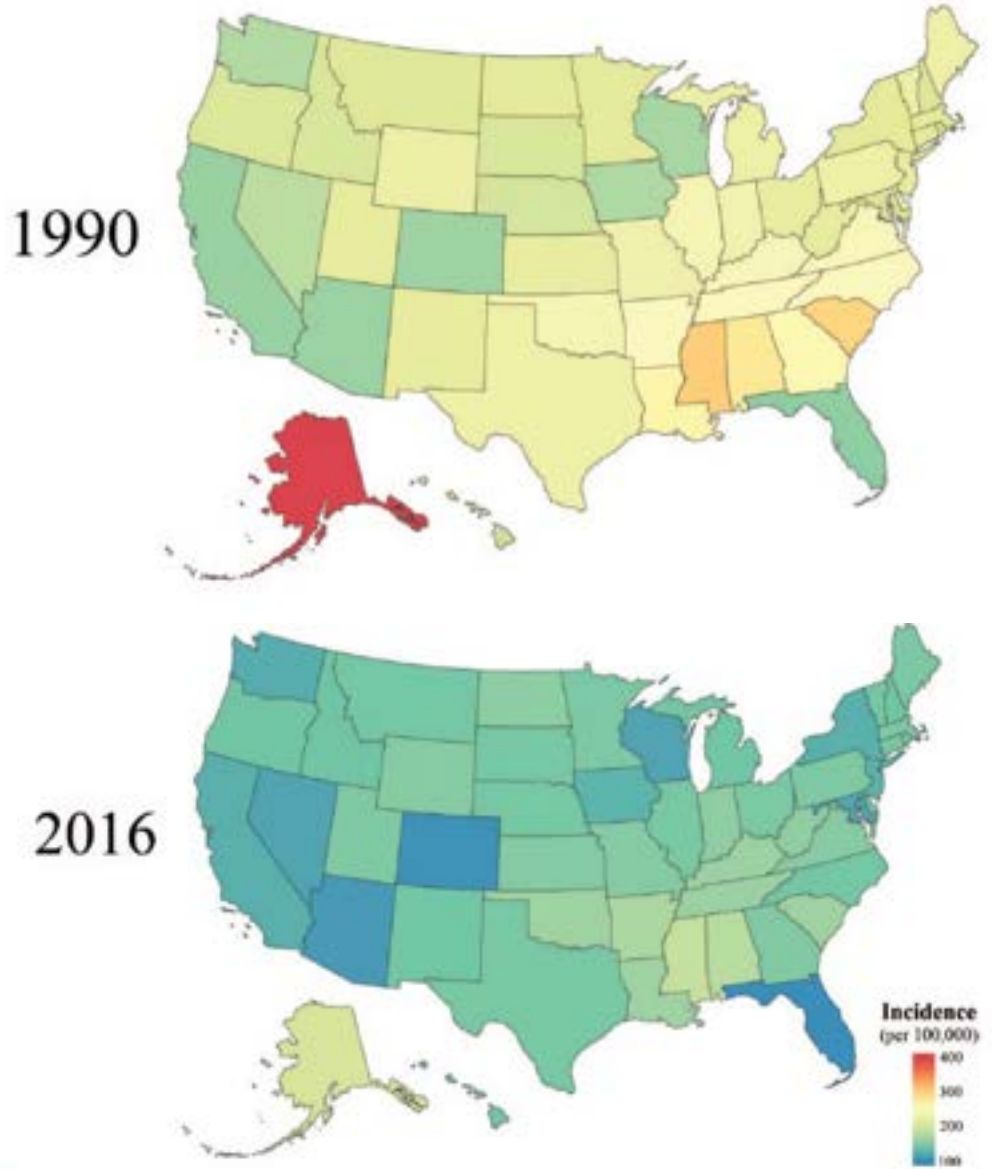
Present

Trends of Burn Injury in the United States

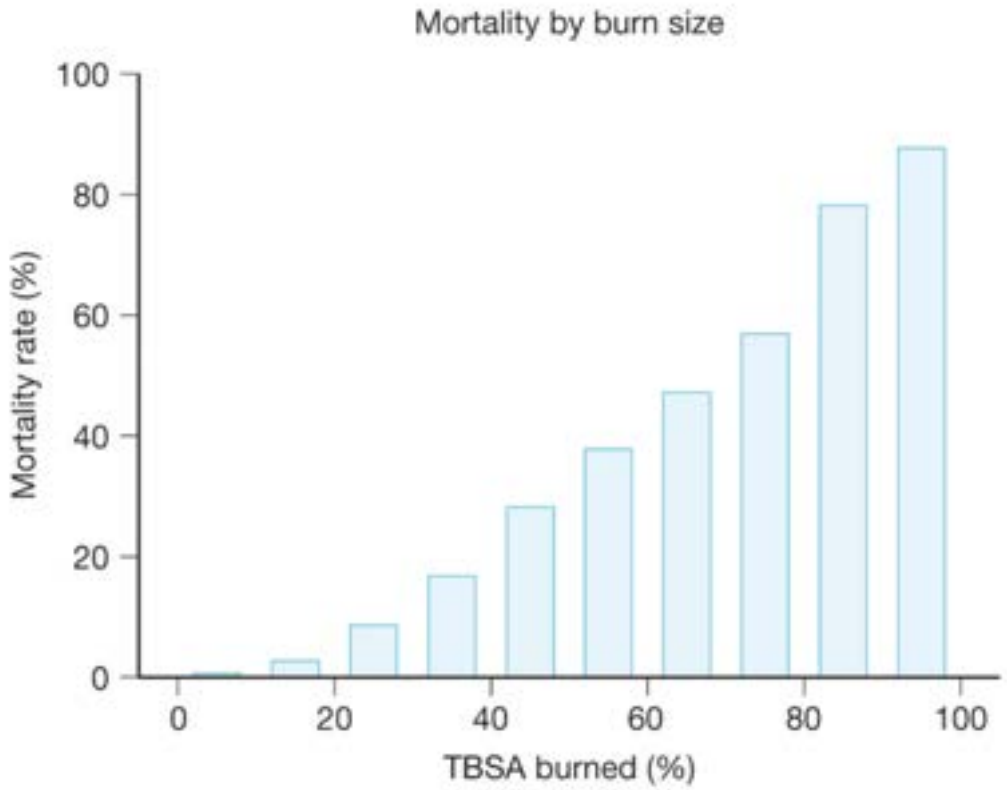
1990 to 2016

Christopher S. Crowe, MD, Benjamin B. Massenburg, MD,* Shane D. Morrison, MD, MS,* Mohsen Naghavi, MD, PhD,† Tam N. Pham, MD,‡ and Nicole S. Gibran, MD‡*





Mortality



- Significant improvements in mortality in modern era
- All comers
- Doesn't account for:
  - Age
  - Comorbidities
  - Inhalation Injury

TABLE 12.1 Mortality Following Burn Over Time for Different Age Groups, Shown as the Burn Size at Which 50% Live or Die

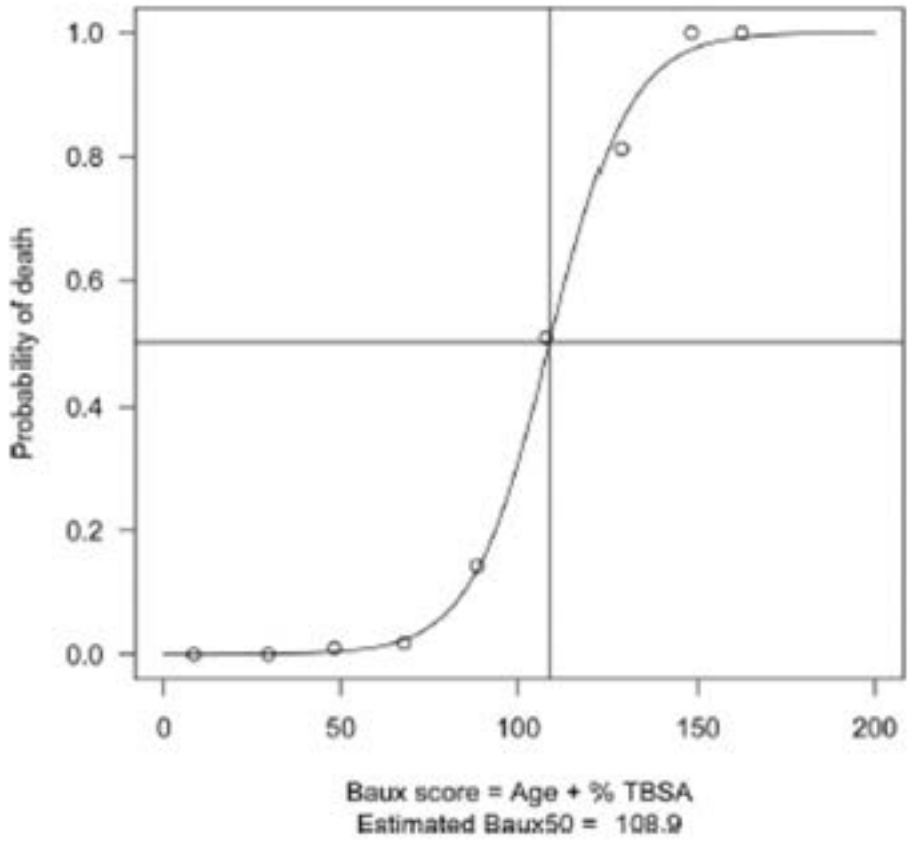
From Branski LK, Barrow RE, Herndon DN, unpublished data, 1992–2004.

Age [years]	LA50 (% TBSA)		
	1942–1952	1980–1991	1992–2004
0–14	49	98	99
15–44	46	70	88
45–64	27	46	75
>65	10	19	33

TBSA, Percentage of total body surface area burned; *LA50,* lethal burn area for a 50% mortality.

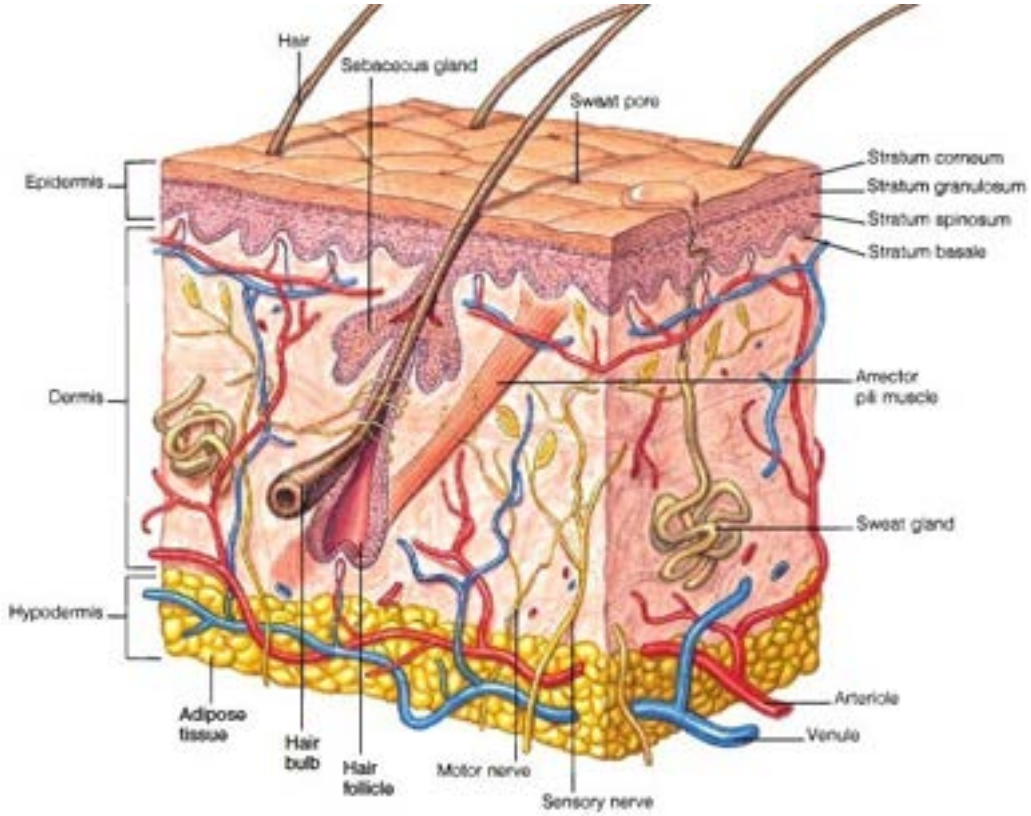
Baux Score

- 1960s
- Age + %TBSA + 17 (inhalation injury) = score
- Predictive of mortality
  - >100 in 1960 = Futile
- 21st century burn care:
  - 5200 pts treated 2000-2008 England
  - 110 = 50%
  - Now, >160 = futile
- Mortality significantly improved in the last 50 years
  - Remains high in the elderly
  - With increasing survival, emphasis on rehabilitation and reconstruction of the burned patient

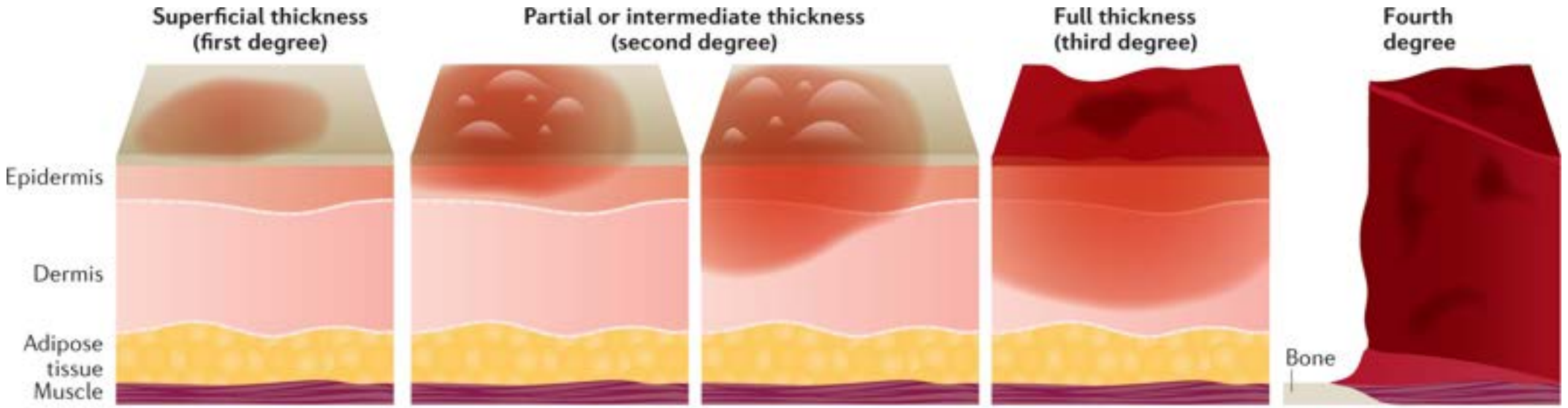


The Skin

- Largest organ in the body!
  - 8 lbs, 2 square meters in an adult
  - Temperature regulation, innate immune fxn
- The basal cell layer is the site of reproductive healing, where actively dividing keratinocytes and melanocytes live
- The dermis is composed of fibers, blood vessels, nerves, and connective tissue. ***There are minimal to no regenerative capabilities and the dermis heals by scar formation.***



Burn Wound Depth



- Painful
- Does not blister
- Does not scar

Superficial partial thickness burns do not require surgery, but may scar and be more painful

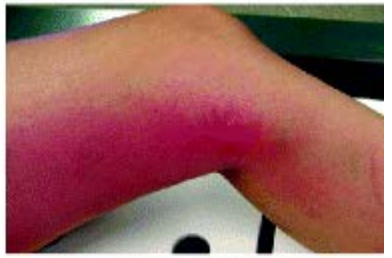
Deep partial thickness burns require surgery and form more scars and are less painful

- Blisters and weeps
- With increasing depth, increased risk of infection
- With increasing depth, increased risk of scarring

- Dry
- Insensate to light touch and pin prick
- Small areas will heal with substantial scar or contracture
- Large areas require skin grafting
- High risk of infection

- Involves muscle or bone
- Leads to loss of the burned part

Burn Depth

Nomenclature	Burn depth	Appearance	Healing		Example
Superficial-thickness burn	Epidermis	Erythema, minimal swelling, pain	7–14 days		
Superficial-partial-thickness burn	Papillar dermis	Wet, pink, blisters, moderate pain	2–4 weeks		
Deep-partial-thickness burn	Reticular dermis	Less wet, red, ± blisters, minimal pain	3–8 weeks with severe scar formation, need graft		
Full-thickness burn	Epidermis, Dermis, (Eschar formation)	Dry, white, insensate	Need graft		

The skin

- When the epidermis has been destroyed, but a layer of dermis remains, epithelial cells can migrate from the skin appendages

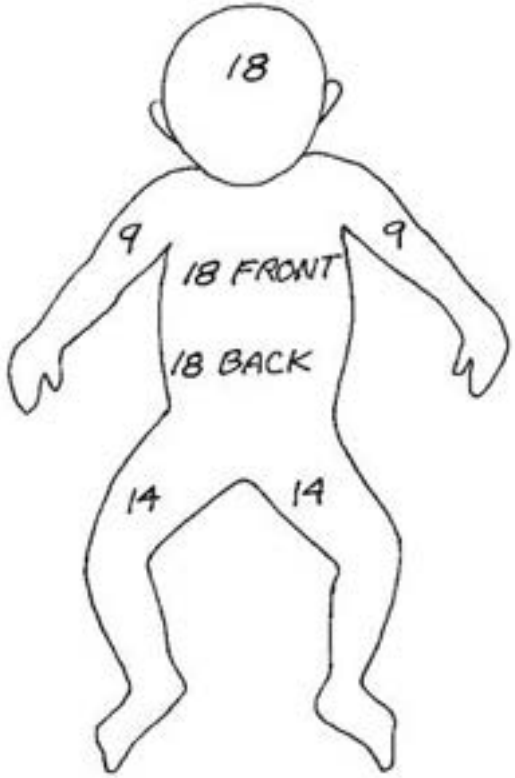
- This cannot happen until the dead dermis (eschar) is removed
  - Autolytic debridement
  - Daily cleansing
  - Weck blade (OR)

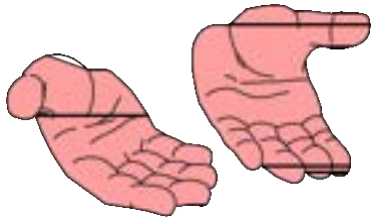
Basics of burn wound evaluation

- Significant difference in treatment plan based on
  - Depth of burn
  - Extent of burn (%TBSA)
  - Age of patient
  - Pre-existing factors and co-morbid conditions

TBSA Calculation – Pediatrics

- Bigger head
- Smaller legs
- Palmar method (patient's palm + fingers equals 1%)





MUSC Health

HISPHYS

Burn Evaluation

Form Origination Date:

Version: Version Date:

This form may be completed on line. Tab or move cursor to text field and type in text.

For HIPAA Compliance reasons, this form IS NOT TO BE SAVED with patient information.

Selecting the PRINT button will clear all information from the note.

Patient Name _____

MRN _____

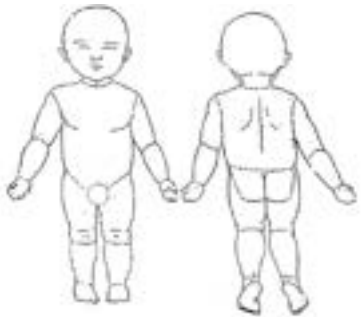
PATIENT IDENTIFICATION LABEL

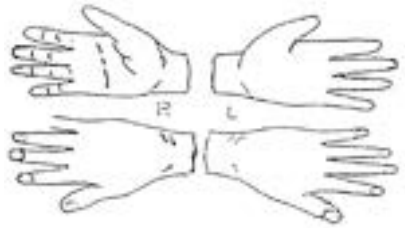
Weight _____ kg

Height _____ cm

Type of Burn _____

% Total Body Surface Area (TBSA) Burn _____%



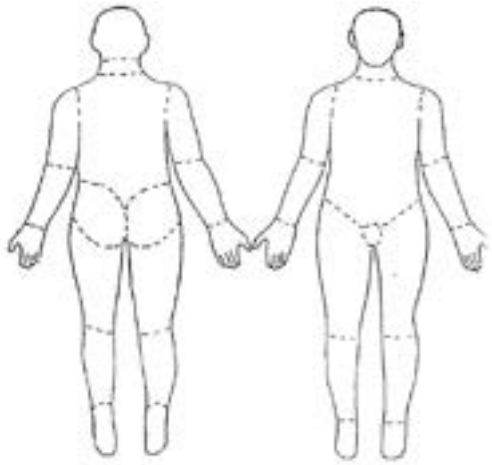


LUND AND BROWDER CHART									
AREA	0-1 YEARS	1-4 YEARS	5-9 YEARS	10-14 YEARS	15 YEARS	ADULT	% 2ND	% 3RD	% TOTAL
HEAD	19	17	13	11	9	7			
NECK	2	2	2	2	2	2			
ANT. TRUNK	13	13	13	13	13	13			
POST TRUNK	13	13	13	13	13	13			
R BUTTOCK	2.5	2.5	2.5	2.5	2.5	2.5			
L BUTTOCK	2.5	2.5	2.5	2.5	2.5	2.5			
GENITALIA	1	1	1	1	1	1			
RU ARM	4	4	4	4	4	4			
LU ARM	4	4	4	4	4	4			
RL ARM	3	3	3	3	3	3			
LL ARM	3	3	3	3	3	3			
R HAND	2.5	2.5	2.5	2.5	2.5	2.5			
L HAND	2.5	2.5	2.5	2.5	2.5	2.5			
R THIGH	5.5	6.5	8.5	8.5	9	9.5			
L THIGH	5.5	6.5	8.5	8.5	9	9.5			
RL LEG	5	5	5.5	6	6.5	7			
LL LEG	5	5	5.5	6	6.5	7			
R FOOT	3.5	3.5	3.5	3.5	3.5	3.5			
L FOOT	3.5	3.5	3.5	3.5	3.5	3.5			
						% TBSA			

Key

1st Degree	
2nd Degree	
3rd Degree	

Note: Do not include 1st Degree in % TBSA calculation



Clinician Signature _____ Pager ID _____ Date _____ Time _____ AM/PM

Lund and Browder Form

Pediatric Burn Injuries

- **Scald Injuries**
- Flame burns
- Contact burns
- Electrical injuries
- Chemical injuries

Scald Burns

- Hot liquid
  - Temperature and contact time
- Wide spectrum
- Common mechanisms
  - Dunking/dipping into hot liquid – NAT
  - Spills -- ***SOUP***
  - POSB – pull over scald burn
  - Hair care burn
  - Bathing

Goals of initial resuscitation

- Airway
  - Patent airway! (chin lift, jaw thrust)
- Breathing
  - CO and cyanide toxicity
- Circulation
  - circumferential full thickness burns
  - may need escharotomies
- Disability
- Exposure – temp instability, fluid losses

Note: Don't forget possible associated injuries (bleeding, fractures, open wounds, etc)

Airway/Breathing

Endotracheal intubation should be considered in all children with:

- any airway compromise
- oxygen requirement
- large burns
- prior to transport
- large volume resuscitation
- other significant injuries

Circulation--Escharotomies

Escharotomies

Fluid Requirement Guidelines - *for burns > 20% TBSA*

Category	Age and weight	Fluid needs in first 24h
Flame or scald	Adults and older children (≥14 years old)	**2** ml LR x kg x % TBSA
	Children (<14 years old)	**3** ml LR x kg x % TBSA
	Infants and young children (≤30kg)	**3** ml LR x kg x % TBSA Plus D_5LR at maintenance rate – 2 different bags!
Electrical injury	All ages	**4** ml LR x kg x % TBSA

- Fall back on Parkland Formula: 4 mL LR x kg x %TBSA

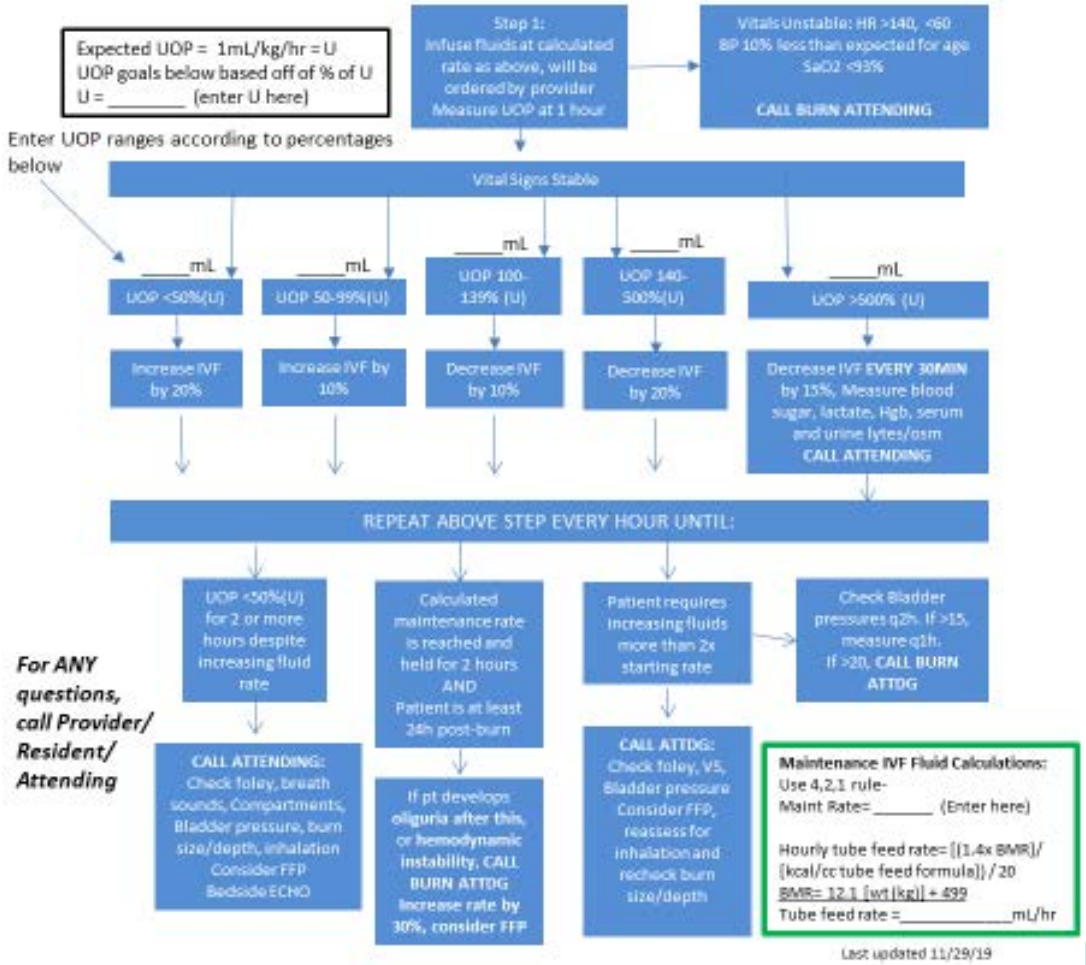
Pediatric Burn Resuscitation Guidelines*

Medical University of South Carolina

FOR 10-19% TBSA BURNS: Give 1.25 maint IVF

Indications: 2nd/3rd degree burns of ≥20% TBSA , ages 13 and under
Exclusions: >13 years of age, Heart Failure, Renal Failure, Electrical Injury

1. Use Sage Diagram to calculate burn size, screen shot and paste in EMR as "Lund Browder Diagram
2. Calculate 24 hour fluid estimates: 3mL of LR x Body Weight (kg) x %TBSA
3. Divide this number by 16: this is your initial IVF rate. If too little fluid has been given prior and delay in presentation, consider adding 25% to initial rate, call burn attending to discuss initiating plasma.
4. If weight is <30 kg, add D5 LR to above amount, using 4,2,1 rule. Do not titrate maint. IVF.
5. If weight is <10kg or age is less than 2 years old, use D5 LR instead of LR, add maint. rate with D5 LR as in #3. Do not titrate maint. IVF
6. Calculate expected UOP as in box below. Titrate IVF hourly based on UOP until maint. IVF rate is reached



Start post-pyloric TF in <3 hours, advance to goal within the next 4 hours
Decompress stomach with NGT and feed postpyloric if gastric dilitation or >40% TBSA

*This is not part of the Medical Record, place in "Resuscitation" Folder at end of 24 hour period

Notes about fluid administration in burns

- Avoid over-rescuscitation
- After about 12-15 hours post burn, the capillary leak is usually starting to seal.
  - If oliguric despite fluid admin → consider FFP
- If the patient still appears to be intravascularly depleted, you have steadily been increasing your fluid rate and you still are having a difficult time maintaining urine output, consider hematocrit or echo!

Electrolyte imbalances

- Early resuscitation phase (0-36 hours)
  - Hyponatremia (usually replaced through resuscitation fluids
  - Hyperkalemia
  - Hypophosphatemia
    - Major burns can have severe hypophosphatemia. Must be replaced to keep >3.0
  - Late phase
    - Hypernatremia (replace free water deficit)

IV Access

1st choice	peripheral vein	non-burn area
2nd choice	central vein	non-burn area
3rd choice	peripheral vein	burn area
4th choice	central vein	burn area

Emergency short term access- can use an IO needle

1. To secure a line in a burned area, suture is often needed. Tape simply will not stick to a slippery, weeping wound.
2. It will be difficult to identify veins in a burned area. Ultrasound can help.
3. As the wound swells, there is a tendency for the catheter to pull out of the vein
4. Using a circumferential bandage to try to secure a line can become a tourniquet as swelling occurs

Special Situations

- Inhalational injury
  - Most deaths now are due to smoke inhalation
  - A significant burn wound combined with an inhalation injury doubles the mortality rate for all individuals
  - Commonly seen in house fire injuries

- Three criteria are helpful in assessing for inhalation injury:
  1. History of a closed space fire
  2. Carbonaceous sputum (out of lungs, not spit in mouth)
  3. Carboxyhemoglobin level greater than 10%

Special Situations - Inhalational injury

- **Carboxyhemoglobin** (COHb), which normally comprises less than 1-2 % of total hemoglobin, is the product of reaction between carbon monoxide and hemoglobin

- The half-life of CO on room air is approximately 4 hours. On 100% FIO2 - ~ 1 hour

  - Thus, the treatment for CO toxicity is 100% inspired oxygen until the CO level is less than 10%

- Most patients with smoke inhalation and CO poisoning will be intubated by the time they get to the ER

- Hyperbaric oxygen has been used

Special Situations - Inhalational injury

- **Cyanide Poisoning**
  - Burning of synthetics, such as polyurethane, produces hydrogen cyanide gas
  - Impairs mitochondrial function and ATP
    - Metabolic acidosis and neurologic impairment
  - Think about it if they have been fire involving camper or trailer
  - If high suspicion – give Cyanokit (contains hydroxycobalamin)

Electrical Injury

- Electrical burns only account for 3-6% of burn center admissions
- **LOW VOLTAGE- 110-220 VOLTS** (HOUSEHOLD CURRENT)
  - Usually the contact points will be trivial. These burns are usually small and superficial, If the patient has no persistent symptoms and has a normal EKG, he can go home.
- **HIGH VOLTAGE - >1000 VOLTS**
  - These usually are industrial injuries and power line injuries, and voltage amount may vary.
  - Serum CK levels are often drawn at time of admission
  - Think compartment syndrome!!!

Electrical Injury – Low voltage

Electrical Injury – High Voltage

- **>1000 VOLTS**
- These usually are industrial injuries and power line injuries, and voltage amount may vary.
- Serum CK levels are often drawn at time of admission
- Need to check EKG/Echo
- Think compartment syndrome!!!

Surgical management of burns

- Treatment of choice for deeper burns – ***early excision and grafting (STSG)***
- Sharp debridement with tangential excision of dead tissue & burn eschar performed in the OR
- Advantages of early excision/grafting:
  - Decreases infection, fluid loss, and pain
  - Earlier mobilization and return of function
  - Better cosmetic result

Zora Janzekovic

18 mo with scald burn to chest (soup)

- Mostly deep partial thickness, punctate areas of full thickness
- Penumbra of superficial partial thickness surrounding central, deeper areas
- 1.5% TBSA

2 weeks post injury

Why we excise/graft

4 weeks post injury

3 months post injury

Surgical management of burns

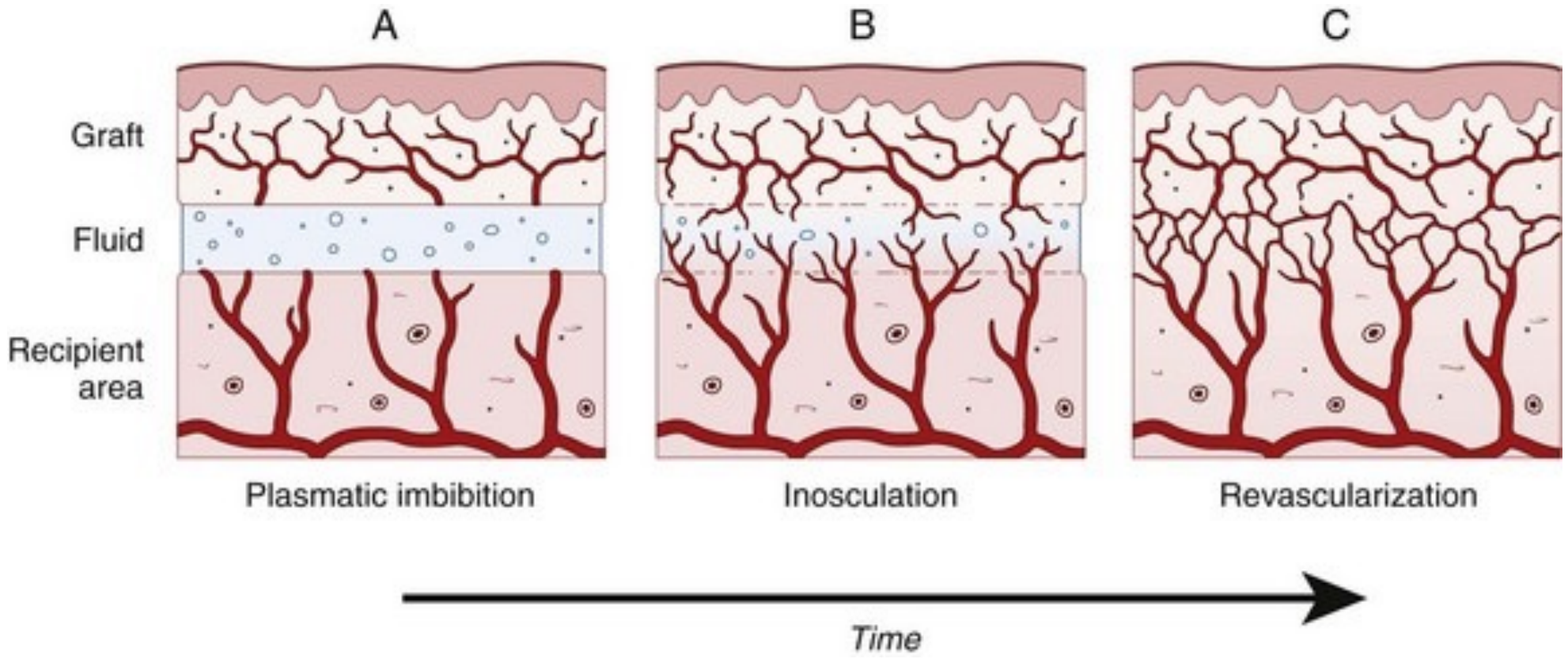
- Dressing changes
  - Polysporin + xeroform dressing changes daily until burn wound conversion has finished
  - Early excision and skin grafting planned within 3-5 days of injury

Skin substitutes

- Allograft/homograft (cadaver skin)
- Xenograft (pigskin)
- Used as temporary coverings until autografting can take place
- Usually requires daily dressing change with antimicrobial solution

Skin Graft : Autografting (meshed)

STSG graft survival/healing



Autografting: Donor Site

- Heal quickly—do not need daily dressing changes

Spray-on skin cells

RECELL®

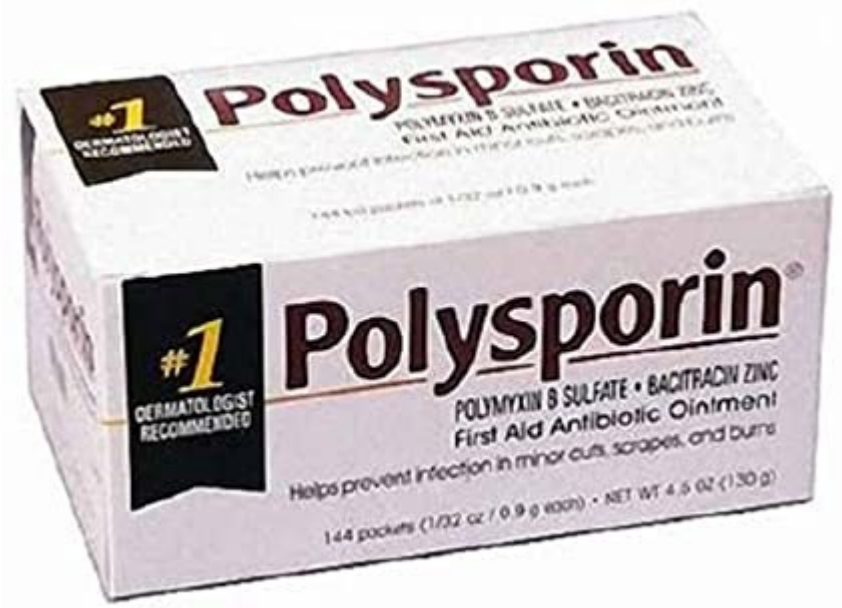
2 yo with thermal burn from touching fireplace screen

- Needs to be debrided in ED under sedation

Daily dressing changes with polysporin/xeroform

Pediatric Wound care

- Daily wound care
  - Xeroform and polysporin
- Advanced dressings
  - Mepilex AG
  - Mepitel AG
  - Silverlon



4 yo scald burn to right shoulder from hot tea

Debridement under sedation in ED

Dressing Change – post burn day 4

Post burn day 12

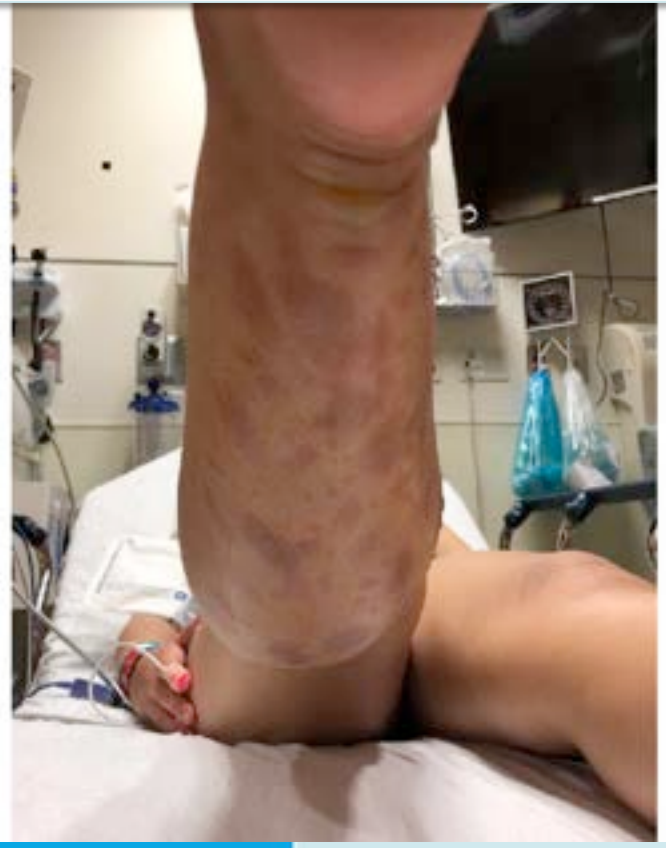
6 yo scald burn – Ramen noodle soup

6 yo scald burn – Ramen noodle soup

Post Burn day 12

1 month from injury, 2 weeks from grafting

12 yo with 10% TBSA grease burn to bilateral lower extremities



Partial Thickness – Mepitel Ag

Transfer Criteria

Guidelines for Burn Patient Referral

(Advice on Transfer and Consultation)

- These guidelines are designed to be used to aid in clinical decision making. If you have sustained a burn injury, please seek medical advice from a medical professional.
- Local and regional infrastructure, resources, and relationships may determine the necessity and timeliness of burn center referral.
- These guidelines are not meant to be definitive care recommendations. They may facilitate building the proper referral network within the local healthcare community.

	Immediate Consultation with Consideration for Transfer	Consultation Recommendation
Thermal Burns	• Full thickness burns • Partial thickness ≥10% TBSA* • Any deep partial or full thickness burns involving the face, hands, genitalia, feet, perineum, or over any joints • Patients with burns and other comorbidities • Patients with concomitant traumatic injuries • Poorly controlled pain	• Partial thickness burns <10% TBSA* • All potentially deep burns of any size
Inhalation Injury	• All patients with suspected inhalation injury	• Patients with signs of potential inhalation such as facial flash burns, singed facial hairs, or smoke exposure
Pediatrics (≤14 years, or <30 kg)	• All pediatric burns may benefit from burn center referral due to pain, dressing change needs, rehabilitation, patient/caregiver needs, or non-accidental trauma	
Chemical Injuries	• All chemical injuries	
Electrical Injuries	• All high voltage (≥1,000V) electrical injuries • Lightning injury	• Low voltage (<1,000V) electrical injuries should receive consultation and consideration for follow-up in a burn center to screen for delayed symptom onset and vision problems

Other Considerations for Transfer

- Extent of injury
- Concern for non-accidental trauma
- Pain management
- Social situation/ability for follow up
- Most importantly – YOUR JUDGMENT

Burn Camp