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 DO_2
- 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 TXA_2
  - 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

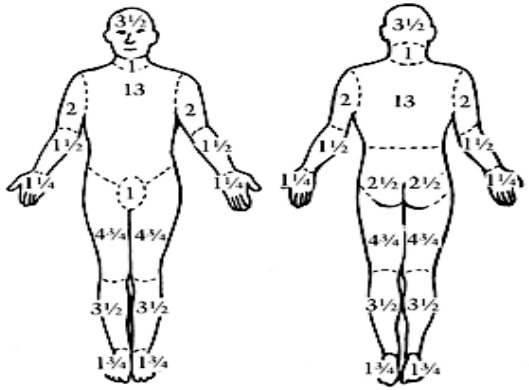
- Jackson's Zones of Injury
  - Central zone of coagulation (necrosis)
  - Middle zone of stasis
  - Outer zone of hyperemia
- Middle zone "at risk"
- With optimal resuscitation, zone can recover and heal
- Sub-optimal resuscitation increases necrosis


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^{nd} and 3^{rd} degree)
    - Need Lund Browder Chart for children
  - Patient's dry weight (in kg)

E – How much?—Lund Browder



Age: _____
Sex: _____
Weight: _____

Area	Birth–1 yr	1–4 yr	5–9 yr	10–14 yr	15 yr	Adult	Partial thickness 2°	Full thickness 3°	Total
Head	19	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	2½	2½	2½	2½	2½	2½			
Left buttock	2½	2½	2½	2½	2½	2½			
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	2½	2½	2½	2½	2½	2½			
Left hand	2½	2½	2½	2½	2½	2½			
Right thigh	5½	6½	8	8½	9	9½			
Left thigh	5½	6½	8	8½	9	9½			
Right leg	5	5	5½	6	6½	7			
Left leg	5	5	5½	6	6½	8			
Right foot	3½	3½	3½	3½	3½	3½			
Left foot	3½	3½	3½	3½	3½	3½			
						Total			

Resuscitation—Exceptions

- Inhalation injuries
- Electrical injuries
- Polytrauma
- Electrical injury - Rhabdomyolysis
  - Sodium bicarbonate
  - Mannitol

Resuscitation Formulae—Peds

Table 1. Formulae for estimating fluid requirements in burned patients

Authors/ reference	Formula for estimating fluid needs	Hydrating solution	Rate of fluid administration and special instructions
Cope and Moore (1947) [6]	150 ml/% BSA burned per 24 h + (maintenance fluids)	½ plasma and ½ crystalloid, 5% dextrose in water	Half during first 8 h and half during subsequent 16 h; ceiling: 10%–12% of body weight in liters
Evans et al. (1952) [8]	2 ml/kg/% BSA burned per 24 h + 2,000 ml/24 h (maintenance fluids)	½plasma and ½ crystalloid, 5% dextrose in water	Half during first 8 h and half during subsequent 16 h; ceiling: 50% burn
Gelin (1952) [10]	<30% burn = 2 ml/kg/% BSA burned per 48 h[a] 30%–60% burn = 2.5 ml/kg/% BSA burned per 48 h[a] >60% burn = 3 ml/kg/% BSA burned per 48 h[a]	Dextran (low molecular weight)	
Reiss et al. (1953) [9]	2 ml/kg/% BSA burned per 24 h + 2,000 ml/24 h (maintenance fluids)	¼ plasma and ¾ crystalloid, 5% dextrose in water	Half during first 8 h and half during subsequent 16 h; ceiling: 50% burn
Eagle (1956) [13]	30 ml/% BSA burned per 48 h + 10% of body weight in kg/48 h + 4,000 ml/m² BSA per 48 h	Dextrose 5%, 0.66 N saline containing 20 g of human serum albumin/l	Ceiling: 50% burn; burns <15% do not administer the fluid equivalent to 10% of the body weight
Batchelor et al. (1961) [15]	Mean (children) 3 ml/kg/% BSA burned per 24 h[a] Range (children) 1–5 ml/kg/% BSA burned per 24 h[a]	Plasma and blood only	In children there is too wide a variation to rely on a single-figure formula
Welch (1962) [17]	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	a. Plasma b. Normal saline c. Dextrose 5% in water	Rate: ⅓ first 8 h, ⅓ second 16 h, ⅓ 2nd day
Baxter and Shires (1968) [11]	4 ml/kg/% BSA burned per 24 h[a]	Crystalloids only (isotonic salt solutions)	Half during first 8 h and half during subsequent 16 h; no ceiling
Carvajal (1975) [21]	5,000 ml/m² BSA burned per 24 h + 2,000 ml/m² total body surface per 24 h	Dextrose 5% lactated Ringer's solution containing 12.5 g of human-serum albumin/l	Half during first 8 h and half during subsequent 16 h; no ceiling
Pruitt (1978) [12]	3 ml/kg/% BSA burned per 24 h[a]	Crystalloids only (isotonic salt solutions)	Half during first 8 h and half during subsequent 16 h; no ceiling
Bowser and Caldwell (1983) [51]	2 ml/kg/% BSA burned per 24 h	Hypertonic lactated saline	Ceiling: 50% burn

BSA, Body surface area

[a] Total fluid intake – no separate allowance for maintenance fluids

Resuscitation peds—Galvaston

- Estimated fluid requirements in first 24 hours
  - 5000mL/m^2 TBSA burn plus 2000mL/m^2 TBSA maintenance
    - 50% infused in the first 8 hours post burn
    - 50% infused in the next 16 hours
- In 2nd 24hrs, 3750ml/m^2 plus 1500ml/m^2 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% O_2 decreases $t_{½}$ 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

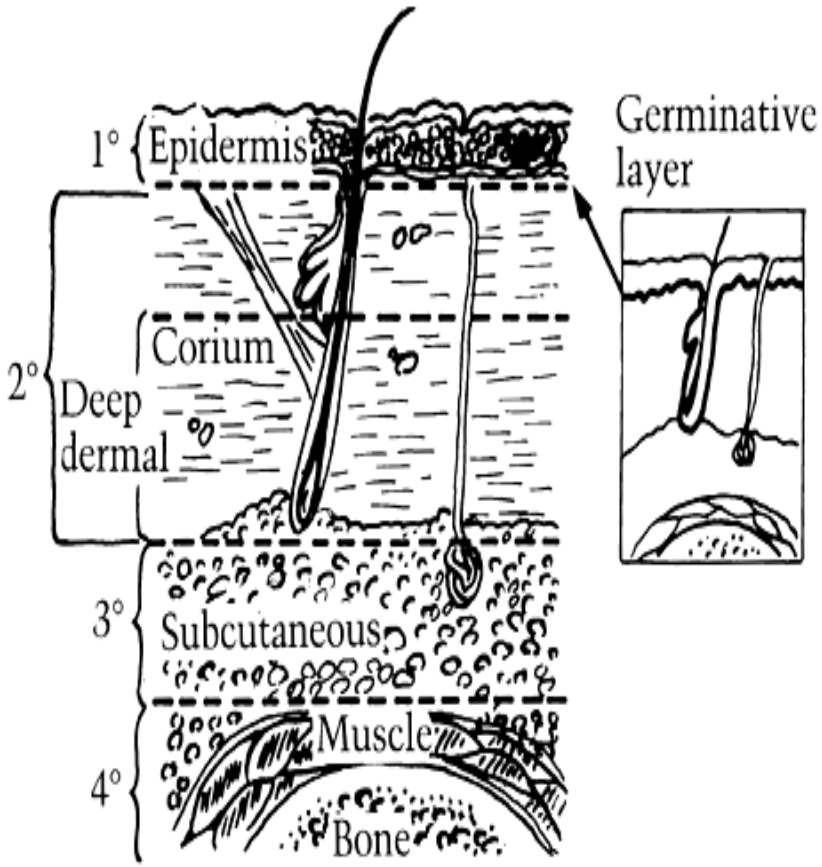
D - Disability

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

E - Exposure

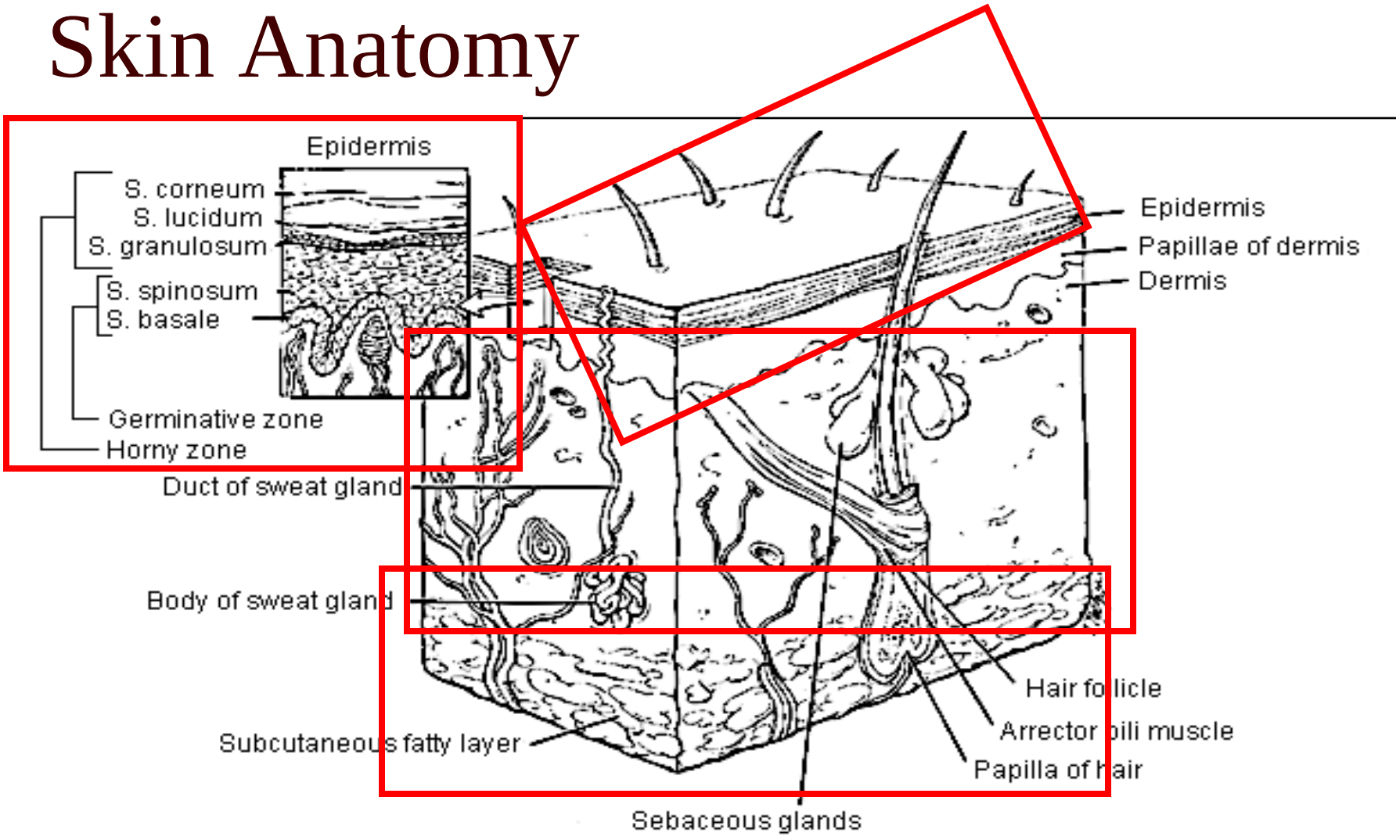
- Remove all hot/burning clothing
- Sweep away any caustic materials
  - Irrigate until you think you're irrigated enough…then irrigate some more
- Judge your burn BSA
- Judge your depth

Burn Depth



- 1st degree
  - Sunburn
- Superficial 2nd degree
  - Papillary dermis
- Deep 2nd degree
  - Reticular dermis
- 3rd degree
  - Subcutaneous tissue
- 4th degree
  - Muscle and bone

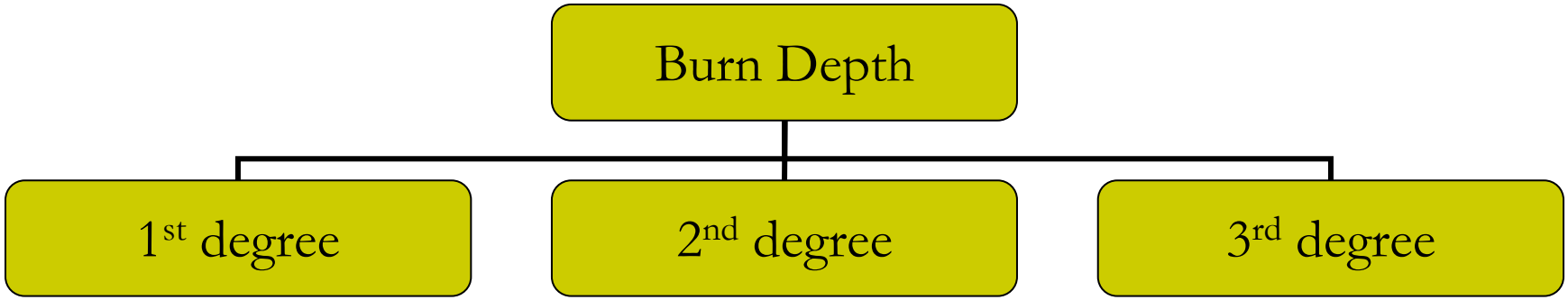
Skin Anatomy



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



Clinically Oriented Burn Classification

Superficial dermal ⇔ Deep dermal

	Superficial	Deep
Blisters	Yes	Yes
Anatomical depth	Papillary dermis	Reticular Dermis
Early analgesia	No	Yes
Color	Pink	White, mottled
Capillary refill	Yes	No
Reepithel'n time	<21 days	>21 days
Hypertrophic scar	Rare	Frequent
Wound contract'n	Minimal	Potentially sig.

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

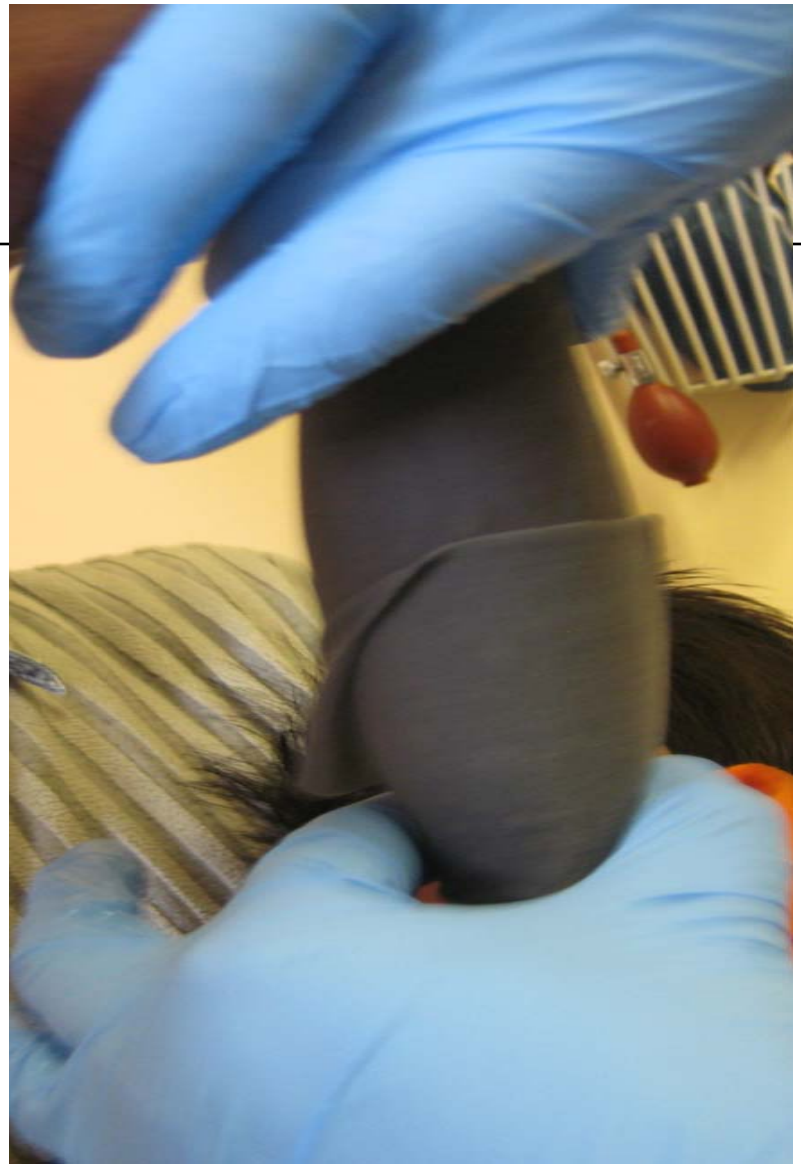
- Deep
  - Involves deep dermis
  - White with punctate hemorrhages
  - Non-blanching
  - Decreased/absent sens.
  - Dry
  - Hair pulls out easily
  - Will require >3wks to heal and will scar poorly without debrid't + STSG

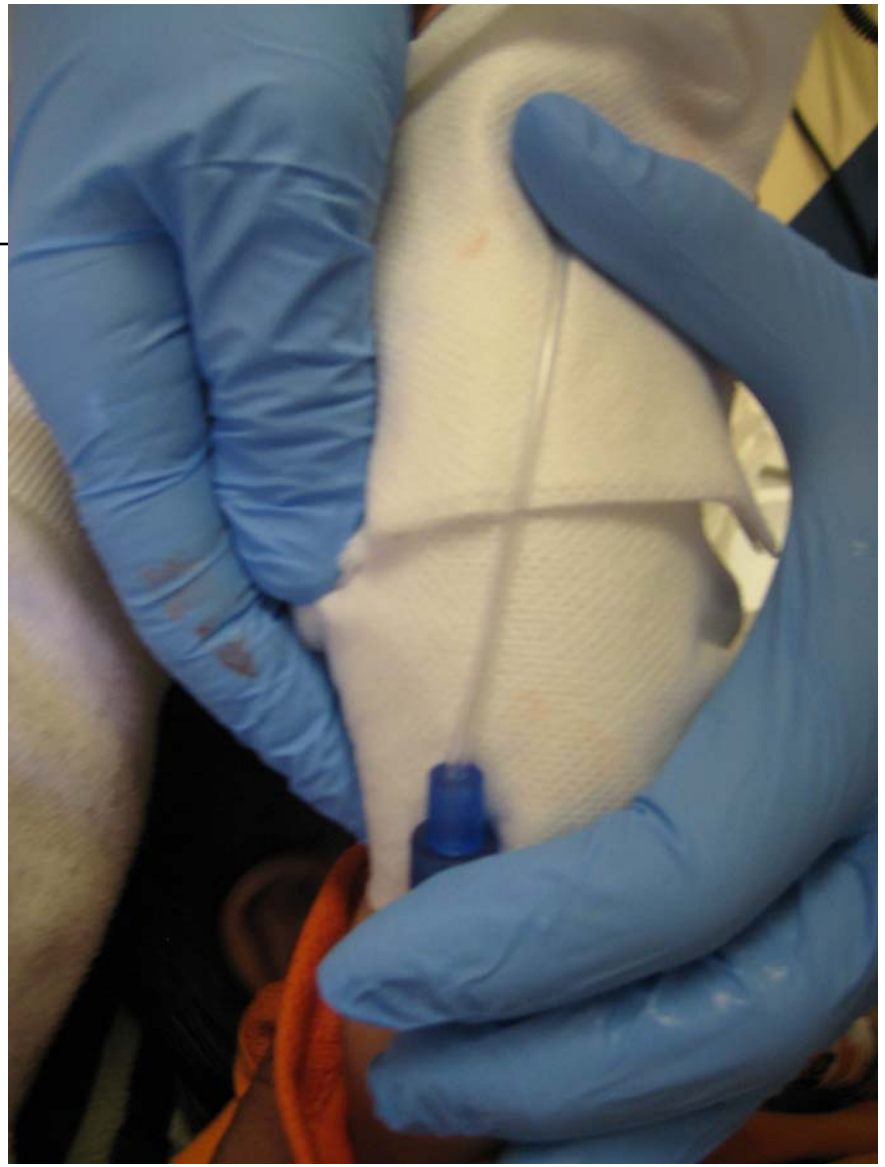
Who gets admitted?

- Any infant <1yr with >8% BSA
- 2nd degree of >10% BSA
- 3rd 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 oinment usually sufficient
- F/U in Plastic Surgery clinic





Don’t forget…..

- Address tetanus status
- Analgesia

Do I give Antibiotics or Narcotics?

- No and Yes

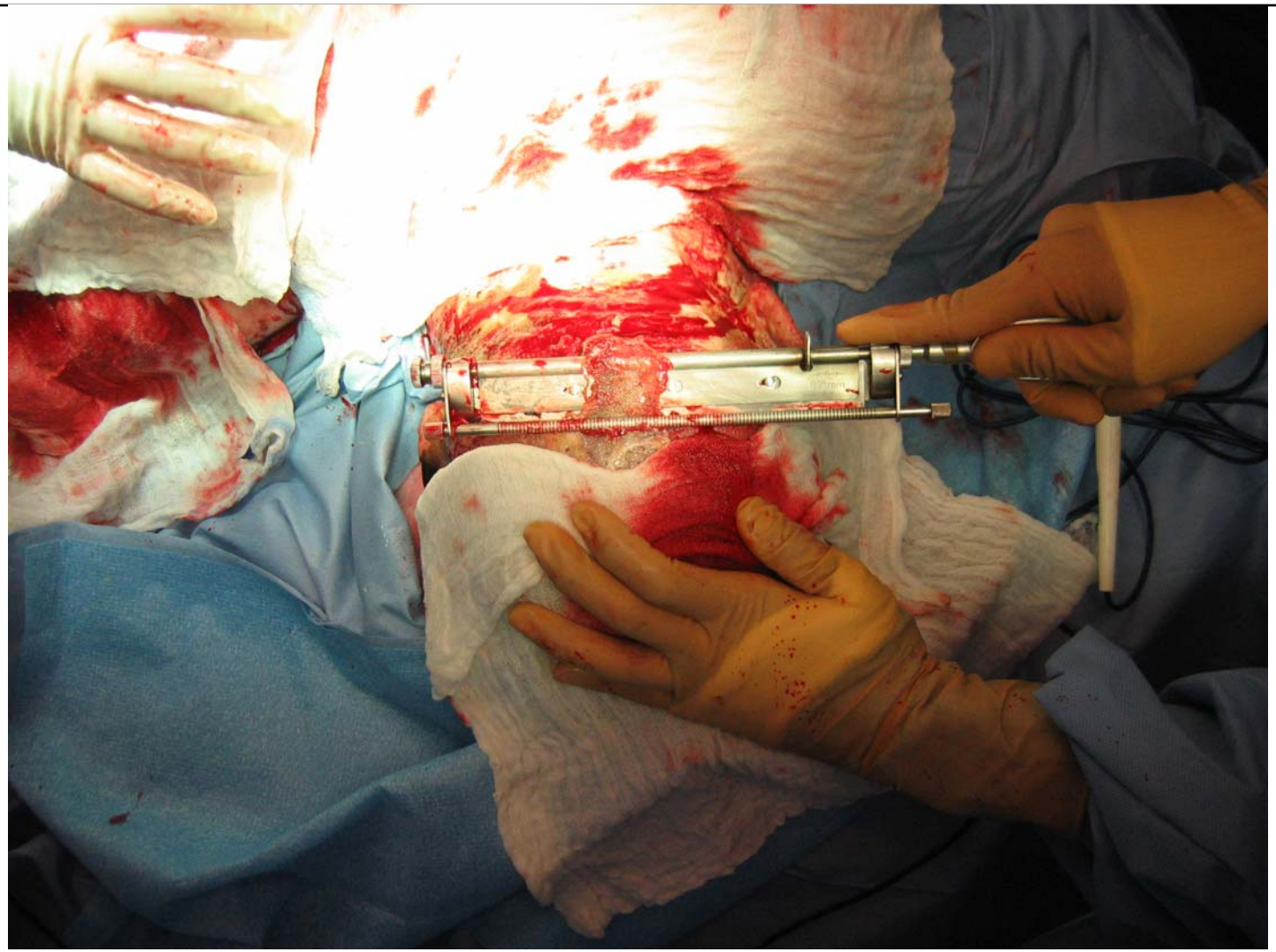
Why/how do I do an escharotomy?

- Circumferential burns
- Respiratory embarrasment
- Cautery or knife
- Through eschar (not fascia)

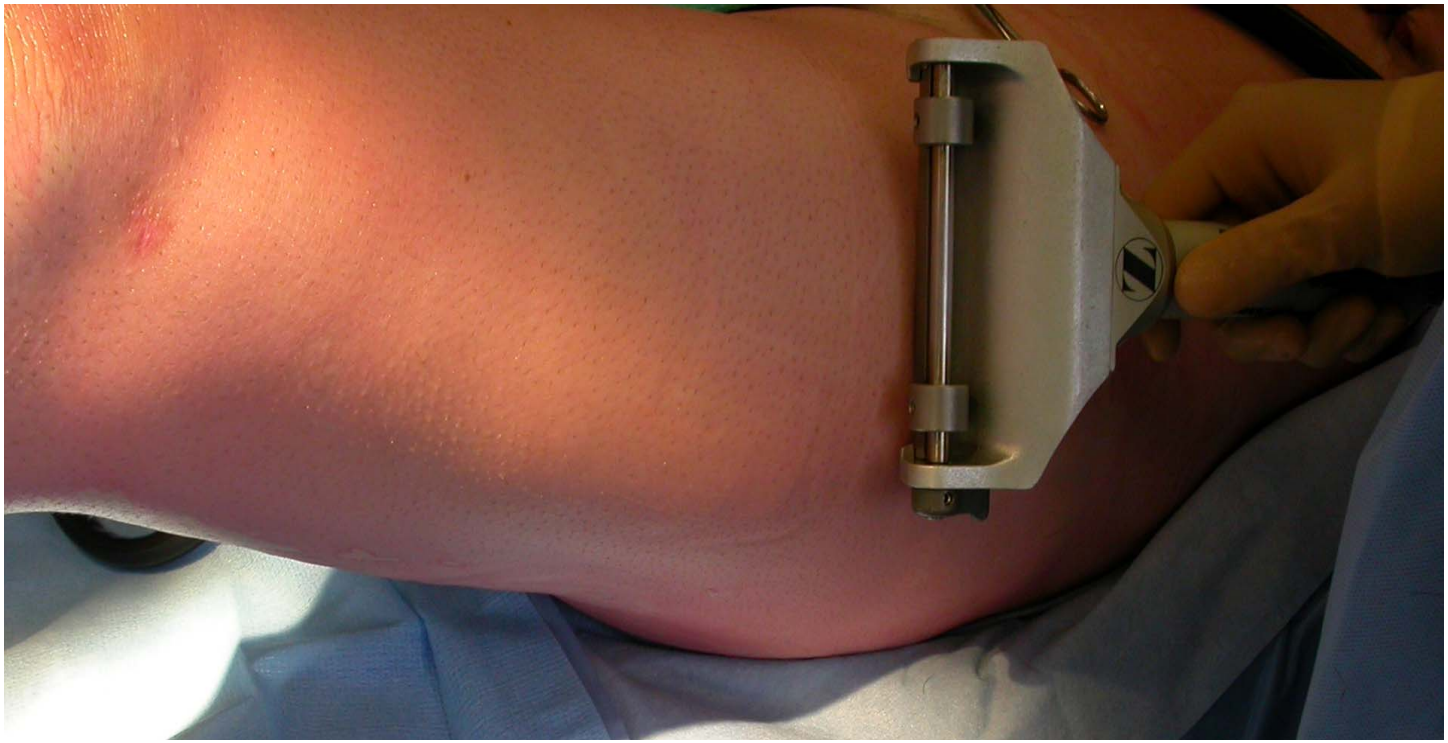
Surgical management

- 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