INITIAL CARE OF THE BURN PATIENT

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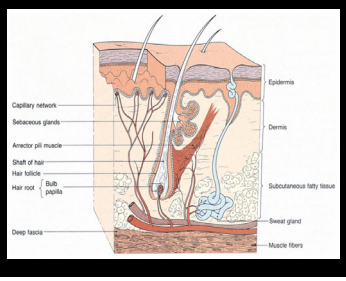
FUNCTIONS OF SKIN

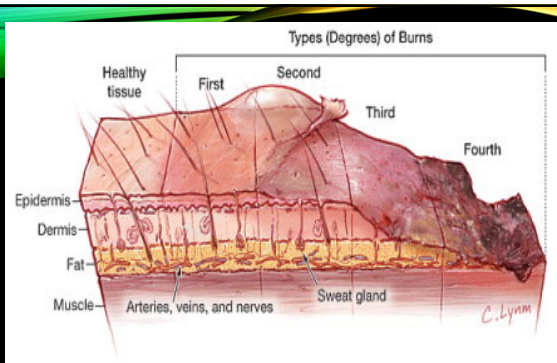
- **Epidermis**
  - **Barrier against the environment**
  - **Thermal and fluid regulation**
- **Dermis**
  - **Principal cell is fibroblast**
  - **Durability and elasticity**
  - **Epidermal appendages**
    - **Hair follicles, sweat glands**



BURN TRAUMA

- Skin damage
  - Direct injury from heat or caustic chemicals
  - Inflammatory response
- Sources

Flame	Chemical
Contact	Electric
Scald	Radiation



FIRST DEGREE BURN

- Only epidermis has been damaged
- Erythematous, blanches, painful to touch, hypersensitivity, uncomfortable
- Heals with minimal effort, symptomatic relief (NSAIDS), soothing topical
- Usually heals within a week
- **NOT** used in the calculation of the TBSA percentage!

SECOND DEGREE/PARTIAL THICKNESS (SUPERFICIAL)

- Epidermis and superficial (papillary dermis) are damaged
- Erythematous, wet and often blistering occur. Extreme pain
- Usually heals in 7-14 days. Requires coverage with topical antimicrobials or artificial skin covering

SUPERFICIAL PARTIAL THICKNESS

SECOND DEGREE/PARTIAL THICKNESS (DEEP)

- Epidermis, papillary dermis and varying depths of deep dermis have been damaged
- Pale, pink-white, or cherry red. Dry appearance common. Does not blanch
- Can convert to full thickness (third degree)
- Remains painful to pinprick but presents with less pain than superficial 2nd degree

DEEP PARTIAL THICKNESS

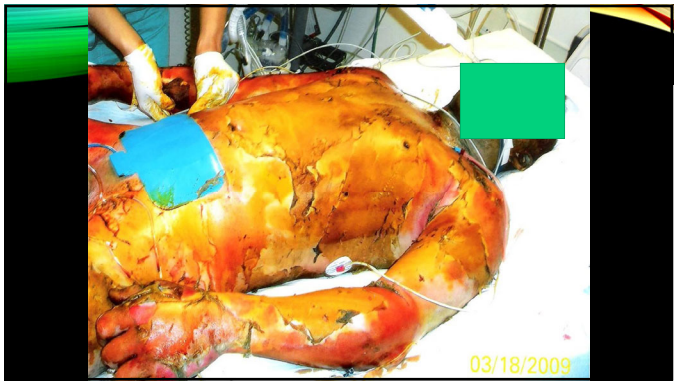
- Can heal but may take 3-4 weeks
- Excisional debridement with temporary or permanent skin coverage may be required
- Would likely benefit from admission to a burn center.

THIRD DEGREE (FULL THICKNESS)

- Epidermis, papillary and deep dermis, and different depths of SQ tissue have been damaged
- Sensory terminations to skin destroyed (painless)
- Hard leathery eschar that is white, black, or tan in color. May appear charred

THIRD DEGREE (FULL THICKNESS)

- High potential for infection
- Cannot heal spontaneously
- Treatment involves excision of all injured tissue
- Will need to be grafted



FOURTH DEGREE

- Extensive damage to deep structures (muscle or bone)
- Will not heal- amputation or muscle flap coverage

BURN DEPTH

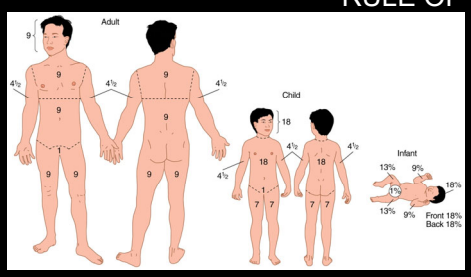
- Progression
  - Inflammatory response
    - Severe fluid loss (hours or days)
    - Extends damage and depth (1–2 days)
    - Sepsis (days to weeks)
  - Reduced circulation extends depth
  - Edema extends depth

BURN SEVERITY

- Burn Depth
AND
- Burn Size

Goal is to limit progression of burn depth

RULE OF NINES



HAND RULE

- The PATIENT'S hand—palm and fingers = 1% TBSA

LUND AND BROWDER CHART

Lund and Browder Chart

Area	Age (Years) 0–1	1–4	5–9	10–15	Adults	% 2°	% 3°	% Total
Head	19	17	13	10	7			
Neck	2	2	2	2	2			
Ant. Trunk	13	17	13	13	13			
Post. Trunk	13	13	13	13	13			
R. Buttock	2 ½	2 ½	2 ½	2 ½	2 ½			
L. Buttock	2 ½	2 ½	2 ½	2 ½	2 ½			
Genitalia	1	1	1	1	1			
R.U. Arm	4	4	4	4	4			
L.U. Arm	4	4	4	4	4			
R.L. Arm	3	3	3	3	3			
L.L. Arm	3	3	3	3	3			
R. Hand	2 ½	2 ½	2 ½	2 ½	2 ½			
L. Hand	2 ½	2 ½	2 ½	2 ½	2 ½			
R. Thigh	5 ½	6 ½	8 ½	8 ½	9 ½			
L. Thigh	5 ½	6 ½	8 ½	8 ½	9 ½			
R. Leg	5	5	5 ½	6	7			
L. Leg	5	5	5 ½	6	7			
R. Foot	3 ½	3 ½	3 ½	3 ½	3 ½			
L. Foot	3 ½	3 ½	3 ½	3 ½	3 ½			
					Total			

Weight _____
Height _____

BURN MANAGEMENT

- Limit burn progression
  - Cool skin, clothing with clean water 1–2 minutes
    - Longer induces hypothermia
  - **Maintain body temperature**
    - Prevent hypothermia
    - Remove wet clothing and items
  - Clean, dry sheets, blankets
    - Sterile sheets not necessary

INITIAL ASSESSMENT

- Primary Survey
  - A - Airway
  - B - Breathing
  - C - Circulation
  - D - Disability, Neurologic Deficit
  - E - Exposure/Environmental Controls
- Secondary Survey
  - Estimate TBSA %

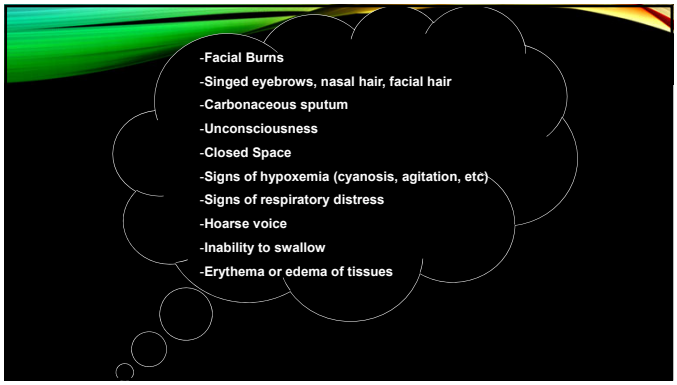
FLUID RESUSCITATION

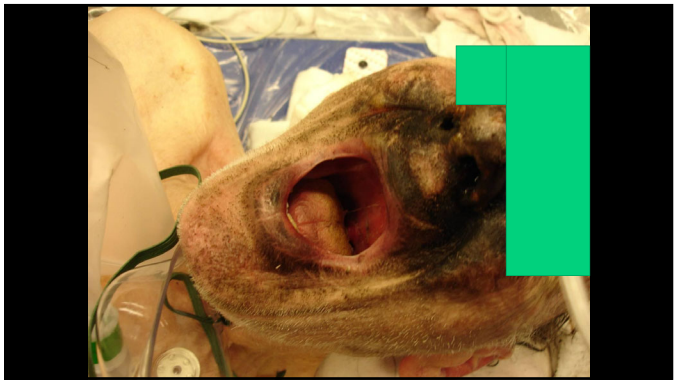
- IVF should be started **immediately** when >20% TBSA is suspected
- Prehospital and Pre-assessment fluid rates:
  - 5 years old and younger–LR @ 125ml/hr
  - 6-14 years old – LR @ 250ml/hr
  - 15 years and older – LR @ 500ml/hr

INHALATION INJURY

- Inhalational injuries complicate nearly one third of all major burns
- Doubles the mortality of cutaneous burns
- Accounts for 50-70% of burn mortality

When do you suspect an inhalation injury??





INHALATION INJURY

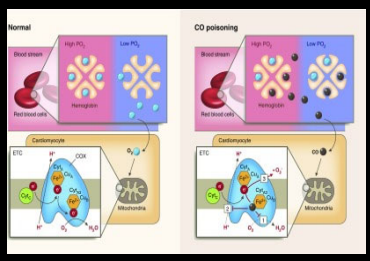
- Three distinct components
  - Carbon monoxide poisoning
  - Upper airway thermal burns
  - Lower airway chemical injuries

CARBON MONOXIDE POISONING

- Produced by the combustion of organic material
- Systemic poison
  - Inhibits transport and mitochondrial use of oxygen
  - Causes inefficient cellular respiration
- Pulse oximeter gives spuriously high reading for O2 saturation and is not reliable

CARBON MONOXIDE POISONING

- Binds to Hgb- 200 to 250 times greater affinity than O2
- Appear normal to unresponsive
- COHgb assessment should be made by lab test



Am J Respir Crit Care Med. 2017 Mar 1; 195(5): 596–606.
Published online 2017 Mar 1. doi: 10.1164/rccm.201606-1275CI

CARBON MONOXIDE POISONING

- 0% - 5% = Normal value
- 15% - 20% = Headache, confusion
- 20% - 40% = Visual changes, nausea
- 40% - 60% = Hallucinations, combativeness, coma
- > 60% = Mortality rate > 50%

CARBON MONOXIDE POISONING

- Treatment
  - 1/2 life on room air = 4-8 hours
  - 1/2 life at 100% FIO2 = 1-2 hours
  - HBO (O2 at 3 atm.) = 30 min
    - Several randomized, controlled trials have failed to consistently demonstrate a significant benefit over 100% O2.
    - Should be reserved for severe cases: LOC, neurologic deficits, ischemic cardiac changes, significant metabolic acidosis, or COHb level >25.

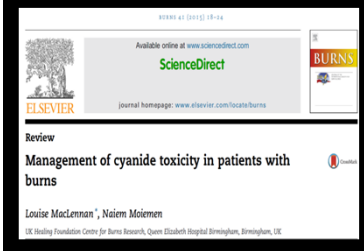
CYANIDE

- Cyanide compounds are used in the production of acrylic, rubber and plastics.
- Inhalation injury can result from the combustion of cyanide containing synthetic substances.
- Blocks aerobic respiration by inhibiting the electron transport chain in mitochondria.

CYANIDE

- Whole blood levels of 0.5-1.0 mg/L are regarded as toxic. 2.5-3 mg/L are fatal
- Half-life 1-3 hours
- Symptoms:
  - Tachycardia, hypertension, palpitations, tachypnea, anxiety, nausea, vomiting
  - Confusion drowsiness, seizures, bradycardia, decreased respiratory rate, hypotension
  - Loss of consciousness, fixed pupils, cardiovascular collapse.

CYANIDE



- Diagnosis:
  - Lab values are not useful
  - Clinical diagnosis
- Management:
  - Supportive measures: 100% FiO2, circulatory support, mechanical ventilation
  - Antidotes: hydroxycobalamin, sodium thiosulphate, sodium nitrite, amyl nitrite, dicobalt edetate

CYANIDE

- Hydroxycobalamin:
  - Binds to cyanide
  - Excreted by the kidneys
  - Given 5g IV over 15 min—found in commercial product CyanoKit

CYANOKIT

- **Treat Empirically:**
  - **Patients with decreased mental status/loss of consciousness and hypotension**
  - **Lactate >10**
  - **Persistent acidosis.**


Critical Care

RESEARCH Open Access

Association between hydroxocobalamin administration and acute kidney injury after smoke inhalation: a multicenter retrospective study

CYANOKIT

Side effects:

- Renal failure from oxalate crystals
  - Depret *et al*, demonstrated out of 739 patients 39% patients developed AKI and 25% developed severe AKI.
  - Odds ratio of AKI 1.597 (95% confidence interval 1.055, 2.419) and 1.772 (95% confidence interval 1.137, 2.762) for severe AKI.
  - Survival after administration was 1.114 (95% confidence interval 0.691, 1.797)
- Transient hypertension
- Bradycardia
- Headache
- Skin and urine discoloration

UPPER AIRWAY THERMAL INJURIES

- Occur due to hot air or chemical toxins
- Diagnose by direct laryngoscopy
  - Swelling, sloughing, carbonaceous sputum above vocal cords
- Severe edema develops quickly
- Indication for prophylactic intubation
- Maximal swelling 12 – 24 hrs

LOWER AIRWAY THERMAL INJURIES

- Injury to tracheobronchial tree and lung parenchyma
- Due to combustion products in smoke and inhaled steam. More chemical than thermal.
  - Atelectasis
  - Decreased ciliary action
  - Pooling of secretions
  - Bronchorrhea
  - Bronchospasm
  - Pulmonary Edema

MANAGEMENT OF INHALATION INJURY

- Airway assessment
- Endotracheal intubation
- Mechanical ventilation
- High flow - 100% oxygen
- Serial ABGs
- Serial CO Hgb
- Potentially daily bronchoscopies until sufficient healing
- Inhaled heparin/mucomyst with albuterol

FLUID RESUSCITATION

- Prehospital/PreAssessment: When suspect >20% TBSA
  - 5 years old and younger–LR @ 125ml/hr
  - 6-14 years old – LR @ 250ml/hr
  - 15 years and older – LR @ 500ml/hr

FLUID RESUSCITATION

- **Required for burns > 20% TBSA**
- Thermal and chemical burns:
  - *Adults and children >14 years old: 2 cc x Kg x %TBSA*
  - *Children <14 years old: 3 cc x Kg x %TBSA*
  - *Children </= 30 kg: 3 cc x Kg x %TBSA **plus** D5LR at maintenance rate*
- Electrical burns:
  4 cc x Kg x %TBSA

Use Lactated Ringers if available.

FLUID RESUSCITATION

- ½ of total in first 8 hours, 2nd ½ in next 16 hours
  - 8 hours from the time of injury!!
  - Must include all fluids given prior to arrival and subtract them from the total

DO YOU STICK TO THE FORMULA?

No!

Monitor urine output

Adults: ½-1cc per kg per hour

Children <40kg: 1-1.5 cc per kg per hour

Foley catheter placement is a must!

RESUSCITATION

- If UOP is low increase IVF rate.
- Do NOT bolus (unless profoundly hypotensive)
- Add albumin about 6-8 hours post burn at ¼ previous total rate.
- Vasopressin is the 1st pressor of choice, next norepinephrine

FLUID RESUSCITATION

- No single perfect formula
- Adverse consequences
  - Poor tissue perfusion
  - Abdominal compartment syndrome
  - Extremity compartment syndrome
  - Pulmonary edema
  - Pleural effusion

SEVERE BURNS

- Circumferential full-thickness burns
  - As edema progresses, may have tourniquet effect
    - Escharotomy
- Management
  - Monitor respiration and chest expansion
  - Monitor distal circulation
  - Extremity elevation

ESCHAROTOMIES & FASCIOTOMIES

- Circumferential Trunk Burns
  - Difficulty breathing
  - Unable to ventilate
- Circumferential Extremity Burns
  - Cyanosis of distal unburned skin on limb
  - Unrelenting deep tissue pain
  - Progressive paresthesias
  - Decrease or absence of pulse
- Fasciotomy in OR

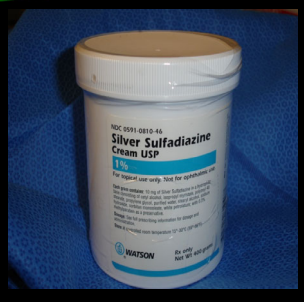
WOUND MANAGEMENT

- Thermal injury disrupts protective barrier function of skin
- Dressings protect against environmental flora and evaporative heat loss
- Usually daily dressing changes
- No need for systemic antibiotics unless cellulitis is present.

WOUND MANAGEMENT

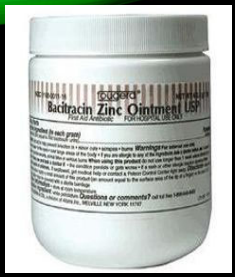
- Topical antimicrobials
  - Eschar is devitalized and avascular – systemic antibiotics do not reach
  - Topicals delay wound colonization and infection
  - Promote spontaneous wound healing
  - Early excision and grafting still key

SILVER SULFADIAZINE AKA: SILVADENE



- Most widely used
- Broad spectrum
- Soothing
- Does not penetrate eschar
- Test patch with sulfa allergy
- Leaves a thick pseudoeschar if used long term.
- Can use on any type of burn.
- Cover with dry gauze, wrap with rolled gauze.
- Change Twice Daily—wash with soap and water each time.

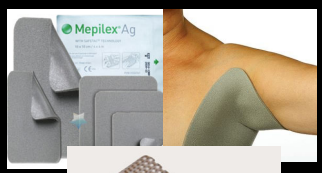
BACITRACIN/POLYSPORIN



- Both gram negative and gram positive coverage.
- Inexpensive
- Can get an allergy if used long term.
- Use on partial thickness burns—mostly superficial partial
- Cover with xeroform or dry gauze, wrap with rolled gauze.
- Change Daily—wash with soap and water each time.
- For faces; wash with soap and water and apply bacitracin 4 times per day

MEPILEX/MEPITEL AG

- Silver product
- Self adhesive, but need to secure well, usually with kerlix and coban.
- Good for superficial partial thickness wounds.
  - Wounds need to be wet for the mepilex to stick!!
- Left in place for 5-7 days.



AQUACEL AG

- Silver hydrofiber dressing
- Higher silver content than mepitel AG
- Broad Spectrum
- Needs to be fixed in place with a adhesive dressing (duoderm)
- Use on superficial or deep partial thickness. Small full thickness.
- Changed every 48-72 hours

MAFENIDE ACETATE AKA: SULFAMYLON


- Antimicrobial solution
  - Excellent GN coverage, particularly pseudomonas
  - Not for staph, fungus
- Penetrates eschar
- Used to prevent or treat common burn wound infections
- Cream or solution
- Inhibits carbonic anhydrase-metabolic acidosis
- Use on deep partial and full thickness burns. Used postoperatively.
- Cover cream with dry gauze and rolled gauze
  - Change daily—wash with soap and water.

BURN EXCISION AND GRAFTING

- Excision usually begins as early as post-burn day 3
- Extensive burns - serial operations placed several days apart
- Temporarily cover with biologic dressing, xenograft, cadaveric allograft until autograft available or wound bed is ready for autograft.

PEDIATRIC BURNS

- Greater severity
  - Thinner skin, larger surface area to body mass ratio
- Mechanism
  - Accidental
  - Child neglect or abuse

PEDIATRIC BURNS

- Most commonly due to scald burns from hot liquids.
- Scald burns = 65% of all hospitalized burn injuries in children age 4 and under.

PATHOPHYSIOLOGY
BODY SURFACE AREA

Relatively greater BSA/kg of body weight

EXAMPLE – 7 kg child

Wt = 10% of average 70kg adult

BSA = 33% of the adult BSA

PATHOPHYSIOLOGY
TEMPERATURE REGULATION

- Small muscle mass hampers ability to shiver
- Infants < 6 months old rely on metabolic temperature controls
- Monitor core temperature
- External protection, i.e., blankets, warm room

PATHOPHYSIOLOGY
DEPTH OF BURN

Thinner skin leads to deeper burns

SCALD

Water Temperature		*Time for a third degree burn to occur*
100° F	**37° C**	**Safe temperature for bathing**
120° F	48°C	5 minutes
124° F	51° C	3 minutes
127° F	52° C	1 minute
133° F	56° C	15 seconds
140° F	60° C	5 seconds
148° F	64° C	2 seconds
155° F	**68° C**	**1 second**

SCALD

- Approximate temperatures for frequently encountered hot liquids:
  - Spa/Jacuzzi: 102–104°F
  - Recommended water heater setting: 120°F (5 mins)
  - Holding temperatures for fast food and coffee: 175–185°F (1 second)
  - Boiling water: 212°F (<1 second)
  - Grease – frying: 300–500°F (<1 second)

SCALD

SCALD

CHILD ABUSE

- Consider during initial evaluation:
  - Delays in seeking treatment.
  - Alterations in the history surrounding the event.
  - Pattern of burn inconsistent with the history.
  - Presence of old healed fractures.
  - Match object shapes
  - Clear lines without splatter or splash
- Parents, siblings and childcare givers have all been reported.
- Occurs at any socioeconomic level.

CHILD ABUSE

- Factors suspicious for child abuse:
  - Retinal damage.
  - Healed old burn injuries.
  - Skull fractures
  - Children are typically withdrawn, poor hygiene.
  - Malnourished.
  - Often allow medical personnel to perform invasive procedures with minimal resistance.

CHILD ABUSE

- Common abuse burns:
  - Cigarette burns.
  - Some scald burns.
  - Hot iron contact burns.
- If doubt exists, complete radiological series should be obtained.
- Social Work Consult should be obtained

PEDIATRIC BURNS

- Fluid resuscitation (>20% TBSA)
  - Initially (before TBSA calculated):
    - Start LR at 125 cc/hr for <5 years of age
    - Start LR at 250 cc/hr for 6-14 years of age
    - Start LR at 500 cc/hr for greater than 15 years of age
  - Thermal injury:
    Children <14 years old: LR 3cc x Kg x % TBSA
    Children </= 30 kg: LR 3cc x Kg x % TBSA ***plus*** *D5LR at maintenance rate*
  - Electrical injury: 4cc x Kg x % TBSA burn

PEDIATRIC BURNS

- Fluid Resuscitation
  - Urinary catheter (mainly with burns 20% TBSA or greater).
  - Hourly urinary output (U/O): 1-1.5 cc/kg/hr

PEDIATRIC BURNS

- Monitor GLUCOSE LEVEL in children < 2 years of age as they have smaller glycogen stores .
- Children < 30 Kg add D5LR maintenance rate.

SUMMARY OF PEDIATRIC BURNS

- Thin skin plays a role in severity
- Impaired capacity for thermal regulation
- Limited glycogen stores
- Possibility of neglect or abuse

CHEMICAL BURNS

- Personal protection is key! Wear protective gear.
- Concentration, amount, manner, duration of contact, mechanism of chemical action
  - Initial skin changes minimal even when severe
  - Can have systemic onset.
- Can be absorbed, ingested, inhaled, or any combination of the former.
- Remove source:
  - Put clothes in plastic bags
  - Brush off dry chemicals
  - Irrigate with copious water 20-30 min. (will be difficult to maintain normothermia)
  - Remove contact lenses or foreign bodies.
  - Treat burn as you would any other burn once irrigated
    - Except for a few instances…

CHEMICAL BURNS—SPECIAL SUBSTANCES

- Hydrofluoric Acid:
  - Used to etch glass, make Teflon, tan leather, rust remover, clean conductors
  - Irrigate with water for 20-30 min, Topical Calcium gel for pain relief, if no relief– Arterial Calcium
  - Monitor EKG, Monitor Ca++ level.
- Phenol:
  - Poor solubility in water
  - Irrigate with water immediately. Then use 50% PEG (polyethyleneglycol) or ethyl alcohol to remove completely
- Petroleum:
  - Thurough assessment of skin. Can cause cutaneous burns
  - Possible multisystem toxicity 6-24 hrs after exposure.

ELECTRICAL INJURY

- Heat generated by passage of current.
- Extremities greater risk of injury
- Mechanism:
  - Type and amount of current (AC, DC, voltage), path of current through body, duration of contact with current source
- Cardiac arrhythmia
  - PVCs, ventricular tachycardia, ventricular fibrillation
- Contact Points
  - Impossible to determine extent
- Other associated injuries:
  - Flame burns, fractures, dislocations, internal injuries

ELECTRICAL INJURY

- Assess extremities for compartment syndrome
  - May need fasciotomies
- Monitor for rhabdomyolysis
- Resuscitation: 4 cc/kg/%TBSA for all ages!
- UOP goal: 75-100 cc/hr for adults, 2 cc/kg/hr for kids

BURN CENTER GUIDELINES

Table 16-4 Injuries That Benefit from Care at a Burn Center

- Partial-thickness burns greater than 10% total body surface area (TBSA)
- Burns that involve the face, hands, feet, genitalia, perineum, or major joints
- Third-degree burns in any age group
- Electrical burns, including lightning injury
- Chemical burns
- Inhalation injury
- Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
- Any patients with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
- Burned children in hospitals without qualified personnel or equipment for the care of children
- Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention

Source: American College of Surgeons, Committee on Trauma. 2006. *Guidelines for the operations of burn units; Resources for optimal care of the injured patient.*

SUMMARY

- Limit progression of depth and extent
- Careful, systematic approach:
  - Identify and manage critical life-threatening problems
- Start fluid resuscitation early, no boluses, adjust fluid rate, monitor UOP.
- Keep patients warm
- High index of suspicion for child abuse
- Thin skin of children make burns worse, they get cold faster, and have low glycogen stores.
- Irrigate chemical burns for 20-30 min
- Calcium gluconate for hydrofluoric acid. 50% PEG solution for phenols.
- Monitor for compartment syndrome in electrical injury
- Remember the Burn Center Referral Criteria

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THE CLARK BURN CENTER
CBC
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