Burns: Post-Injury Assessment and Initial Care

Andrew Nordin, MD
Trauma Medical Director, Oishei Children's Hospital
Clinical Assistant Professor, University at Buffalo Department of Surgery
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Disclosures

- No financial disclosures
- Pediatric Surgeon ≠ burn surgeon
- Not ABA-verified burn center

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Overview

- Burn Epidemiology
- Common Burn Mechanisms
- (Patho)physiology
- Evaluating Burn Depth
- Evaluating Burn Size
- Initial Burn Management
  - Fluid Management
  - Dressings and management
- Summary

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Objectives

- Describe common burn mechanisms and patterns of burns
- Understand the differences in burn wound depth and its assessment
- Be able to accurately calculate initial fluid resuscitation requirements

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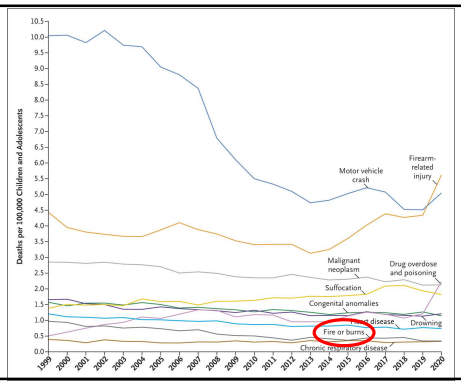

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Burn Epidemiology

- Currently 9th overall cause of mortality in children and adolescents
  - Mortality decreases with increasing age
  - Significant morbidity based on location, depth, mechanism

Epidemiology and trend of US pediatric burn hospitalizations, 2003–2016

- Decreasing burn admissions and mortality in US
  - 2003: 13.4 admissions/100,000
  - 2016: 11.1 admissions/100,000
  - 48% decrease in mortality
  - Decrease in LOS from 2.6 to 1.9 days

Global trends in pediatric burn injuries and care capacity from the World Health Organization Global Burn Registry

- Majority of pediatric burns are <5 years old
  - 80% scald burns
- ~50% of burns were "major" (>15% TBSA)
- ~50% required an operation at index hospitalization

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Burn Epidemiology

Published in final edited form as:
Burns. 2017 March ; 43(2): 249–257. doi:10.1016/j.burns.2016.08.013.

Recent Trends in Burn Epidemiology Worldwide: A Systematic Review

Christian Smolle[a,*], Janos Cambiaso-Daniel[b], Abigail A. Forbes[b], Paul Wurzer[a,c,d], Gabriel Hundeshagen[c,d], Ludwik K. Branski[b,c,d], Fredrik Huss[e,f], and Lars-Peter Kamolz[a]
[a]Division of Plastic, Aesthetic and Reconstructive Surgery, Department of Surgery, Medical University of Graz, Auenbruggerplatz 29, 8036 Graz, Austria

- Review of studies from 2001-2016
- In general, burns have decreased in:
  - Incidence
  - Severity
    - ?Maybe? At least not increasing
  - Inpatient LOS
  - Mortality
- Limited data from less developed countries

J Burn Care Res. 2009 ; 30(1): 30–36. doi:10.1097/BCR.0b013e3181921e8c.

Epidemiology and Outcomes of Older Adults With Burn Injury: An Analysis of the National Burn Repository

Tam N. Pham, MD[*], C. Bradley Kramer, MPA[*], Jin Wang, PhD[†], Frederick P. Rivara, MD, MPH[†], David M. Heimbach, MD[*], Nicole S. Gibran, MD[*], and Matthew B. Klein, MD[*,†]
[*] Department of Surgery, University of Washington, Seattle
[†] Harborview Injury Prevention and Research Center, University of Washington, Seattle

- 15 year review of NBR for patients >55 years of age
  - Males > females
    - Differences decrease with increasing age
  - Flame burns most common
  - Mortality increased with age
  - Proportion of burn survivors discharging home decreased with age

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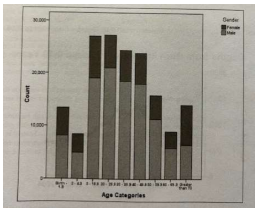
Burn Epidemiology

- Risk factors for burns:
  - Male sex
  - Lower socioeconomic status
    - Higher mortality
    - Higher risk of flame burns, including house fire
  - Single parent household
  - Lower parental education
    - Higher maternal education is protective
  - Type of housing- 42% of burns occur in the house
    - Mobile homes, apartment complexes
    - Presence of smoke detector
    - Living room is protective



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Burn Mechanisms: Scald

- Most commonly encountered burns in children (up up to 50%)
  - More common in younger children, decreasing incidence with age
- Occur with pulling down hot liquids, spills/splashes, tub or sink bathing, etc
  - Can be large – up to 40% of scald burns are 25% TBSA or more
  - Often of varying depth
- Type of liquid matters!
  - Grease/oil burns often deeper

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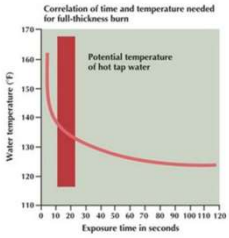
Burn Mechanisms: Scald

What is the maximum water temperature at which a water heater should be set?

- A. 100 F
- B. 120 F
- C. 40 C
- D. 130 F
- E. 100 C

Temp (F)	Time to Full Thickness
120	10 min
124	3 min
127	1 min
133	15 sec
140	5 sec
149	2 sec
156	1 sec



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Burn Mechanisms: Contact

- Second most common mechanism of burns
  - Also more common in younger children
  - Children 1-2 years old at highest risk
    - Exploratory years
- TBSA generally smaller (average size ~2%)
  - Commonly affect face, hands
- ~1/3 require surgical intervention

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Burn Mechanisms: Fire/Flame

- House fires = third leading cause household mortality
  - Risks for children double those of adults
  - Highest mortality of all burn etiologies
- Risk increases with increasing age
  - Consider presence of accelerants
- Most common cause in older adults
- Fireworks result in hand, face, eye burns

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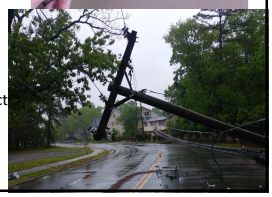
Burn Mechanisms: Electrical

- Less common- only account for 1-5% of burn injuries
- Low voltage (<1000 V) injuries
  - Electrical cords, outlets
- High voltage (>1000 V) injuries
  - Power lines, lightning strikes
- Smaller TBSA, deeper burn
  - Commonly affects head, hands, feet, mouth
  - High skin resistance → deeper burns at contact and grounding points
  - Up to 60% need grafting
  - Can cause dysrhythmias, rhabdomyolysis, compartment syndrome, cataracts, etc



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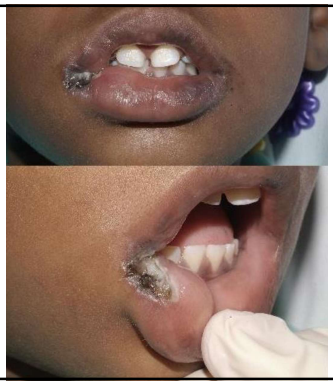

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Burn Mechanisms: NAT

Intentional burns more likely:

- Higher TBSA
- Deeper (deep partial or full thickness)
- Uniform thickness
- Location
  - Posterior > anterior trunk
  - Buttocks, genitals
  - Lower extremities
  - Bilateral, symmetric burns
  - Sharply demarcated
- All mechanisms seen
  - Scalds still most common; more likely with tap water
  - No sweeping associations with any specific mechanism
- Look for associated injuries
- Usual “red flags” still present
  - Need to look for burn patterns inconsistent with history

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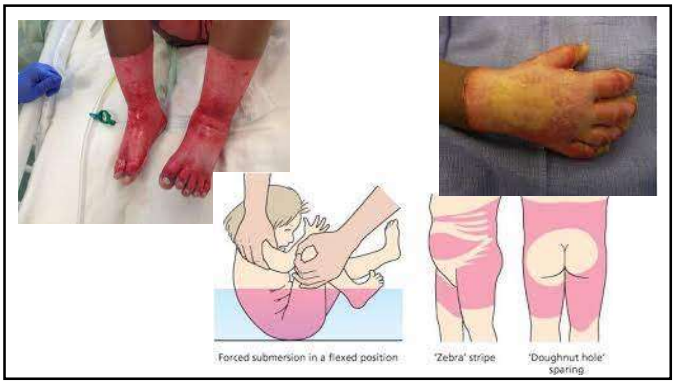

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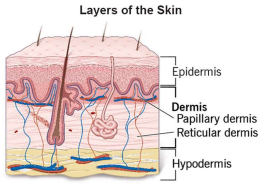
Skin Physiology

- Skin is the largest organ in the human body, with several functions:
  - Thermoregulation
  - Protection from infection, environment, UV radiation, etc
  - Assists in vitamin D metabolism
  - Sensation
  - Fluid retention
- Skin layers
  - Epidermis
  - Dermis
    - Papillary dermis
    - Reticular dermis
  - (subcutaneous tissue/hypodermis)



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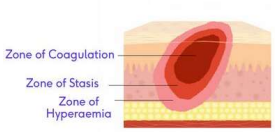
Burn Pathophysiology

- Burns cause coagulative necrosis
- Burn depth depends on:
  - Temperature of substance
  - Specific heat of the substance
  - Duration of contact
  - Local skin thickness and conductance
- 3 zones of burn injury
  - Zone of coagulation- maximal damage; irreversible tissue loss
  - Zone of stasis- capillary construction and thrombosis → decreased tissue perfusion
    - POTENTIALLY SALVAGEABLE; mix of viable and nonviable cells
  - Zone of hyperemia- vasodilation, inflammatory mediators → increased tissue perfusion and edema
    - Typically recovers unless additional insults occur



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Burn Pathophysiology

- Local inflammation mediated by TXA_2, histamine, and pro-inflammatory cytokines
- Not just local phenomenon!
  - Deep burns and burns >15% can precipitate systemic inflammatory response
  - Immediately after burn, NF-kB → TNF-a induction
  - Results in surge of pro-inflammatory molecules: IL-6, IL-1, ROS, RNS, prostaglandins, bradykinin, etc ("ebb phase")
    - Increased capillary permeability → decreased plasma volume, third-spaced fluids
    - Pulmonary and splanchnic vasoconstriction
      - Decreased intestinal perfusion → villi atrophy → intestinal permeability and translocation
    - Cardiac, renal dysfunction; ARDS
    - Global immune function depression ("flow phase")
    - Prolonged catabolism/hypermetabolism

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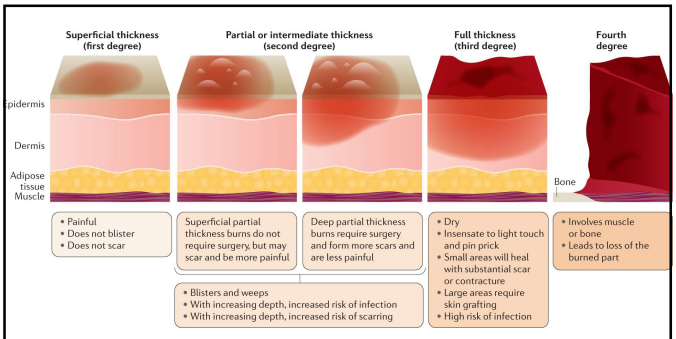

"Degrees" not considered official/standard nomenclature

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Burn Depth

- Superficial (first degree)
  - Involves only epidermis
  - Redness, mild swelling, pain
    - Often limited to first 48-72 hrs
  - Generally heals within 3-7 days
    - Epidermis may peel
  - No lasting wounds/scarring
  - No specific medical attention required

  - DO NOT INCLUDE in TBSA calculations

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Burn Depth

- Partial thickness (second degree)
  - Involves destruction of epidermis and variable depth of dermis
    - Separation of epidermis → blistering
    - Blistering burn = partial thickness
  - Superficial partial thickness = papillary/upper dermis
    - Red, weepy, blanch with pressure
    - Exquisitely painful
      - Exposed nerve endings
    - Generally heal in 7-14 days
      - Minimal scarring

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Burn Depth

- Partial thickness (second degree)
  - Deep partial thickness = reticular/deeper dermis
    - May be dark red or yellow/white
    - Delayed blanching, less painful
    - Will still heal
      - Takes several weeks to months
      - Increased contracture + scarring
    - Often require surgical excision and grafting

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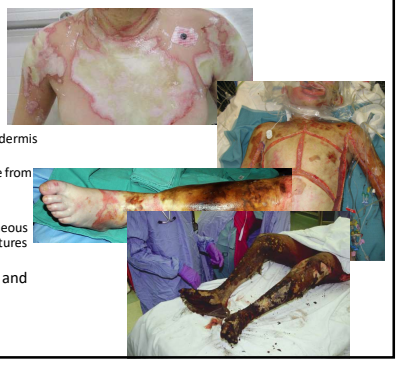
Burn Depth

- Full thickness
  - Third degree
    - Complete destruction of epidermis and dermis
    - Can only heal by contracture from wound edges
  - Fourth degree
    - Epidermis, dermis, subcutaneous tissues and underlying structures (muscle, bone, etc)
  - All require surgical excision and grafting +/- reconstruction



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Burn Depth – how to determine

- Clinical evaluation: most common, least expensive, most expedient
  - Early post-burn assessment
  - May only be accurate 2/3 – 3/4 of the time overall
- Skin biopsy: "gold standard" for assessing depth of burn injury
  - Potential for sampling error, fixation errors, lag time, need for pathologist, etc
  - Also not necessary for non-operative burns (i.e. most pediatric burns)
- Thermography (measurement burn wound temperature)
  - Inversely correlates with depth; multiple confounders → not clinical yet
- Indocyanine green (ICG) videography
  - May be impaired by dressings
- Laser Doppler Imaging: 90-97% accurate
- Others: NIRS, ultrasound, nuclear imaging, etc

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Calculating Burn Size

- Multiple reasons to obtain accurate TBSA (and early)
  - Calculate accurate fluid resuscitation
    - More to come on this soon- hang tight
  - Determine nutritional requirements
  - Approximate degree of physiologic derangement
  - Determine need for burn center referral
- Accurate TBSA is super important… and we're really bad at it
- Superficial burns don't count! Do not include!
  - Only include partial and full thickness burn injuries

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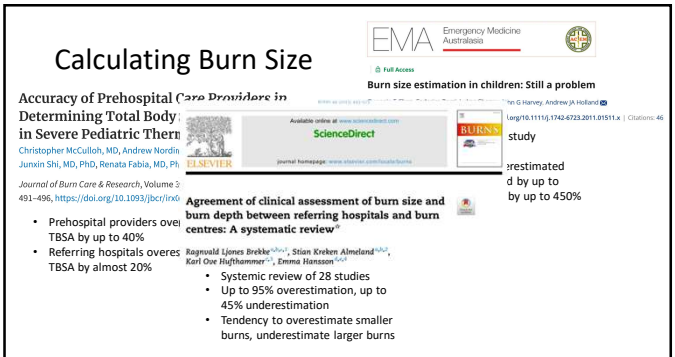
Calculating Burn Size



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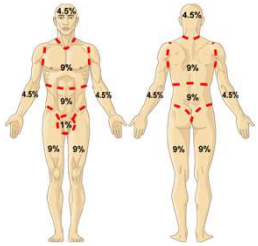
Calculating Burn Size

- ONLY count 2nd and 3rd degree!
- Rule of 9s used in adults
- Not accurate in children; less accurate with decreasing age
  - Head proportionally larger
  - Legs relatively smaller
  - Both continue to change in size until ~14 years old
- How then should pediatric TBSA be calculated?



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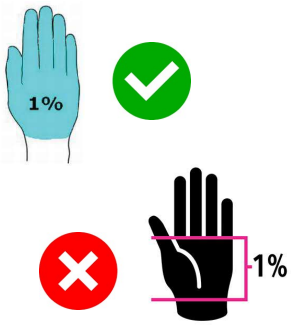
Calculating Burn Size

- Palmar method
  - Surface area of palm approximates ~1% TBSA
    - Wrist crease to finger tip; INCLUDES DIGITS!
    - Palm by itself is closer to 0.5-0.6% TBSA
  - Especially helpful for smaller area, scattered burns
  - Pro tip: use the patient's hand, not the examiners



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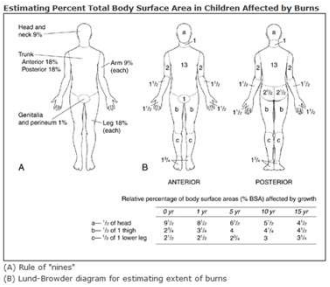
Calculating Burn Size

- Lund-Browder Charts
  - Created in 1944 in Boston
  - Accounts for patient age, relative differences in body size
  - → more accurate for children at different ages
  - Drawback: more complicated to calculate TBSA



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LUND AND BROWDER CHART

Commonly used in burn centers

Estimate of % Total Body Surface Area (TBSA) Burn by sum of individual areas

Area	Birth–1	1–4 Years	5–9 Years	10–14 Years	15 Years	Adult	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	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	
Total							

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Fluid Resuscitation

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Fluid Resuscitation

- True fluid resuscitation only starts ABOVE 20% TBSA
  - Below this point, oral intake +/- IV fluids sufficient to maintain hydration
- Fluid of choice = Lactated Ringer's
- Fluid volume requirements EITHER weight-based or body surface area-based
  - One of these is a little easier to obtain
  - To calculate BSA
  - BSA-based fluid volume calculations may be more accurate in children
- Examples of BSA-based resuscitation formulas = Cincinnati, Galveston

TABLE 26-2

Calculation Formulas for Body Surface Area

Dubois formula	BSA (m^2) = height $(cm)^{0.725}$ × weight $(kg)^{0.425}$ × 0.007184
Jacobson formula	BSA (m^2) = [height (cm) + weight (kg) − 60]/100

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Fluid Resuscitation

- Weight-based resuscitation formulas
  - Parkland

Total 24 hr fluid volume = 4 ml/kg x weight(in kg) x % TBSA

½ in first 8 hours ½ in second 16 hours

  - Modified Brooks

Total 24 hr fluid volume = 2 ml/kg x weight(in kg) x % TBSA

½ in first 8 hours ½ in second 16 hours

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Fluid Resuscitation

- Fluid volume formulas depend on weight, height, BSA, TBSA, etc
  - i.e. information that may NOT be available early on post-injury
- **IF** obviously >20% TBSA:
  - Patients ≤ 5 yrs → LR @ 125 ml/hr
  - Patients 6-12 yrs → LR @ 250 ml/hr
  - Patients ≥ 13 yrs → LR @ 500 ml/hr
- This volume will NEED to be considered in total 24 hour fluid volumes

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Fluid Resuscitation

- ABLS Guidelines
  - Adults: 2 ml/kg x weight(kg) x TBSA
  - Children (under 13 years): 3ml/kg x weight(kg) x TBSA
    - Include D5LR at maintenance rate for children under 30 kg
  - Electrical Injuries: 4 ml/kg x weight(kg) x TBSA
- These volumes are NOT fixed
  - Adjust fluid rates based on hourly urine output
  - Target urine output = 1 ml/kg/hr (younger children); 0.5-1 ml/kg/hr (older children); 30-50 ml/hr (adults; or 0.5 ml/kg/hr)
    - Higher for electrical injury/myoglobinuria
- Many burn centers incorporate colloids into resuscitation early (but not upfront)
  - Albumin vs FFP

ONLY COUNT SECOND AND THIRD DEGREE BURNS!

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Fluid Resuscitation

- Anticipate patients with challenging fluid resuscitation:
  - Associated traumatic injuries
  - Electrical injuries
  - Obviously deep burns

  } Consider rhabdomyolysis
  - (Suspected) inhalational injury
  - Delayed fluid resuscitation
  - Comorbidities
    - CHF, CKD/ESRD, ESLD, etc

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Initial Wound Care/Bandaging

- Cooling with tap water may be appropriate in smaller burns (< 5% TBSA)
  - Risk for causing hypothermia in larger burns
- If not at burn center or not equipped to manage, transfer vs consult with burn team
  - Priority = address life-threatening injuries, stabilize patient
  - Cover patient with clean, dry blanket; can cover/dress burns with dry gauze
  - Elevate affected extremities
- Otherwise:
  - Cleanse the affected areas
  - Gently debride and dress burn wounds
  - Premedication often critical

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Putting It All Together

- All burn patients are trauma patients first- think of them similarly!
  - Primary survey
  - Secondary survey
  - Any adjuncts, if needed
  - Stabilize and transfer to burn center as warranted
- Just as in trauma, key details of the incident can help anticipate expected injuries and physiology
  - Type of burn, timing of injury
  - Location and circumstances of burn
  - Estimated TBSA (may or may not be helpful)

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Putting It All Together: Primary Survey

- A: assess airway while protecting C-spine
  - Examine for signs of potential airway injury (i.e. consider intubation):
    - Hoarseness, stridor, accessory muscle use, and retractions
    - Extensive DEEP facial burns
    - Intraoral burns
    - Dysphagia
    - Intraoral/submental edema (lip/facial edema does not inherently indicate upper airway edema)
    - Decreased mentation
    - Singed hairs/soot
  - In appropriate patients, intubation may facilitate pulmonary toileting and bronchial clearance
  - Consider securing airway with >30-40% TBSA or circumferential torso burns

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Putting It All Together: Primary Survey

- B: listen for breath sounds
  - Consider smoke inhalational injury **in the appropriate clinical setting**
    - i.e. facial housefire burns >> facial scald burns
    - Lower airway injury; chemically and NOT heat-mediated
  - CO toxicity → 100% O_2 via NRB
    - Displaces O_2 from Hgb, resulting in cellular hypoxia
  - CN toxicity → hydroxocobalamin
    - Blocks mitochondrial O_2 use, resulting in anaerobic metabolism, lactic acidosis
    - Consider with persistent/refractory hypoxemia, lactic acidosis, neurologic or cardiac dysfunction

CN Toxicity Symptoms	CN Toxicity Signs
Headache	Altered mental status
Confusion	Tachypnea (early); bradypnea/apnea (late)
Dyspnea	Hypertension (early); hypotension/ cardiovascular collapse (late)
Nausea	Vomiting
	Serum lactate >8 mmol/L
	Seizures
	Coma

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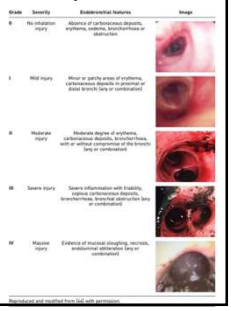
Putting It All Together: Primary Survey

- B (continued)
  - Intubation is only the first step in management of inhalational injury
  - Pulmonary toileting
    - Chest physiotherapy
    - Frequent suctioning, early mobility
    - Nebulizers
      - Bronchodilators, racemic epinephrine
      - Heparin
      - 20% N-acetylcysteine
  - Inhalational injuries require additional fluids
  - Diagnostic/therapeutic bronchoscopy



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Putting It All Together: Primary Survey

- C: burns >15% TBSA need resuscitative fluids
  - NO ROLE FOR EMPIRIC CRYSTALLOID FLUID BOLUS
  - Fluid administration as previously described
    - Take pre-hospital fluids into account!
    - Accurate weight and TBSA calculations are critical
    - Can use ABLS-dictated empiric fluid rates/volumes until TBSA calculated
  - Need vascular access like any trauma patient
    - CAN be placed through burned skin if necessary
      - Suture in place; will not be able to adhere dressing
    - Place IOs if vascular access challenging
    - Consider central venous catheter placement for larger burns
      - …but don't wait for central line to establish access
      - Patient still needs fluids, pain medications, etc
  - Check distal pulses and perfusion
    - Circumferential full thickness burns → escharotomy

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Putting It All Together: Primary Survey

- D: obtain GCS, examine pupils
  - Consider CO, CN toxicities
  - Consider any associated/related trauma and need for imaging
- E: stop any ongoing burning process
  - Remove ALL clothing, jewelry, diaper, shoes, etc
    - Includes getting clothes out from under the patient when rolling
      - Source of either ongoing burning OR temperature dysregulation
  - Cover patient with warm blankets
  - Cover burns with clean dry gauze (until more definitive wound care can be performed)
  - Warm the room

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Putting It All Together: Secondary Survey and Beyond

- Complete head to toe exam
  - Assess and identify all burned areas
  - Look for any other traumatic injuries
- Additional studies
  - CBC, BMP, UA, type/screen
  - ABG (with associated trauma, inhalational injuries, flame burns, etc)
  - CXR (if intubated; low specificity for inhalational injury)
  - EKG (if electrical burns)
- AMPLE history
- Tetanus
- NO ROLE FOR EMPIRIC ANTIBIOTICS

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ABA Burn Center Referral Criteria

1. Partial thickness burns >10% TBSA
2. Burns involving: face, hands, feet, genitalia, perineum, major joints
3. Any full thickness burns
4. Electrical burns
5. Inhalational injuries
6. Chemical burns
7. Burns in patients with pre-existing medical disorders that complicate management
8. Burns with associated traumatic injuries
9. Pediatric burns in hospitals without qualified personnel or equipment
10. Burns in patients requiring special social, emotional, rehab interventions

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Questions?
anordin@kaleidahealth.org
512.695.2900
Children's Hospital

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