EM CASES SUMMARY

Episode 124 Burn & Inhalation Injuries: ED Wound Care, Resuscitation and Airway Management

With Maria Ivankovic & Joel Fish
Prepared by Shaun Mehta, May 2019

Always Consider Non-accidental Trauma in The Pediatric Burn Injury Patient

For the pediatric patient presenting with burn and inhalation injuries, always consider **non-accidental injury** in your differential, particularly when:

- Delayed presentation to care
- Story and injury pattern mismatch
- Burns with well-demarcated lines (e.g. immersion burn)
- Patterned burns (feet, hands or buttocks)
- Burns in a certain shape (e.g. iron, cigarette)

First Aid for Burns

What *not* to do: ice causes severe vasoconstriction and can even deepen the burn. Toothpaste is also harmful given the effects of fluoride.
What *to* do: run cold water for *at least 20 minutes*. Evidence suggests that this can reduce pain and edema, reduce the depth of the burn, decrease the overall inflammatory response, improve the speed of wound healing, and minimize scarring.

Managing Burn-Associated Pain

Pain management should be a priority: Treating pain *early and aggressively* has been shown to prevent psychological trauma and even to improve healing. A multi-modal analgesic approach is recommended. Have a low threshold to include a narcotic given the severity of pain associated with burns. For pediatric burn patients, intranasal fentanyl and ketamine have similar analgesic effects, but fentanyl is preferred.

Acetaminophen, NSAIDs
⊕
Narcotic [1st line],
e.g. Fentanyl IN 1.5 mcg/kg divided into each nare (max 100 mcg)
or
Ketamine IN 1 mg/kg
[2nd line]

Burn Classification: Don't Use 1st, 2nd, 3rd Degree

The burn classification system has moved away from the traditional 1st, 2nd and 3rd degree nomenclature to a more physiologic classification: *superficial thickness, partial thickness* (superficial vs. deep) and *full thickness*.
There are three anatomic layers of the skin important for burns:

1. **Epidermis**: <1 mm in most areas, very thin layer of protection against bacteria and moisture loss.
2. **Dermis**: the "brains" of the skin containing most of the functional elements such as nerves, sweat glands, hair follicles and blood vessels.
3. **Subcutaneous tissue**

Many of the skin's structures are protein-based which coagulate upon heat exposure in a burn injury. As the heat penetrates deeper into the skin, more functional structures are affected.

A **superficial thickness** burn involves the epidermis only and looks like a sunburn. The skin is erythematous and mildly painful, with a brisk cap refill.

A **superficial partial thickness burn** goes beyond the epidermis to include the superficial dermis. These burns can have blisters, look wet, tend to be more painful but still have a fast cap refill time. Healing typically takes 2-4 weeks.

A **deep partial thickness burn** or deep dermal burn goes beyond the superficial dermis to include the deep dermis. These burns can look cherry red or pale and have sluggish cap refill. They may be less painful as more nerves have been destroyed. Healing may take 6 weeks and they generally require grafting to minimize scar and expedite healing.

A **full thickness burn** involves all layers of the skin and subcutaneous tissue, with involvement of underlying fascia, muscle and bone. They often look white or waxy or brown and leathery. There is no cap refill and they are usually painless in the immediate area. Treatment is always surgical.

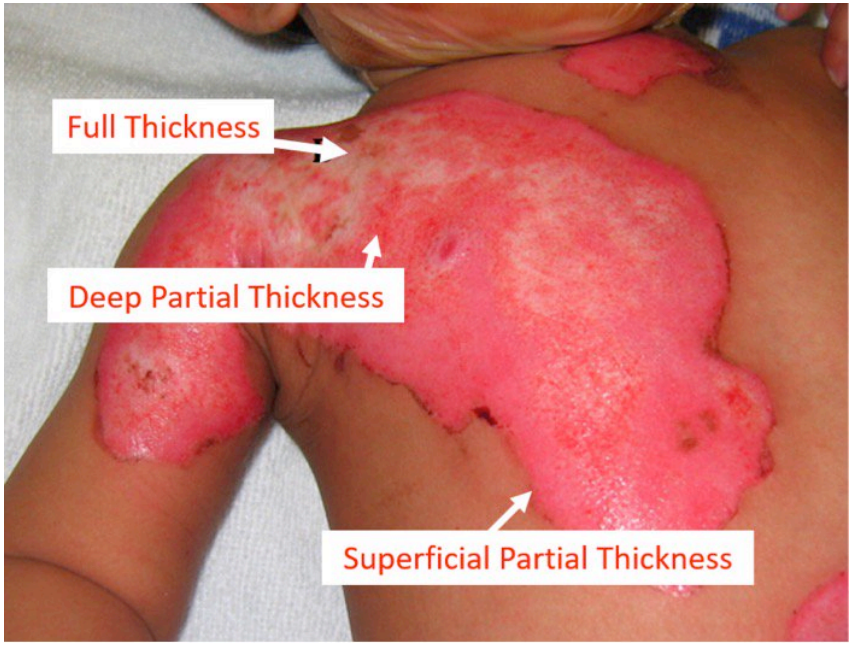
PEARL: A superficial thickness burn will often disappear 3-4 hours after the event. If it remains, this burn may be a superficial partial thickness burn.

BURN DESCRIPTION	APPEARANCE	CAP REFILL	SENSATION/ PAIN	HEALING	
1st SUPERFICIAL THICKNESS	ERYTHEMA	FAST	+	7-14D	
SUPERFICIAL PARTIAL THICKNESS 2nd	WET, PINK, BLISTERS,	FAST	++	2-4 WEEKS	
DEEP PARTIAL THICKNESS	LESS WET, RED, +/-BLISTERS,	SLUGGISH OR ABSENT	+/-	3-8WKS WITH SEVERE SCARRING; NEEDS GRAFTING	
3rd FULL THICKNESS	DRY, WHITE	ABSENT	ABSENT	NEEDS GRAFTING	

Burn Assessment Pitfalls

Do *not* use pain to *exclude* a full thickness burn. Burns are often mixed-depth and the edges of a full thickness burn can still be painful. **Both deep partial and full thickness burns may not blanch**.

Burns are *dynamic* wounds. Burns can deepen over the next few days, and so it is difficult to know the true depth of the wound for at least 48-72 hours. Even burn specialists are only correct about 60% of the time at accurately identifying the depth of the burn on initial assessment. Burns can deepen after the first few hours to days of assessment. This is particularly important when setting expectations with patients and families at the initial visit.



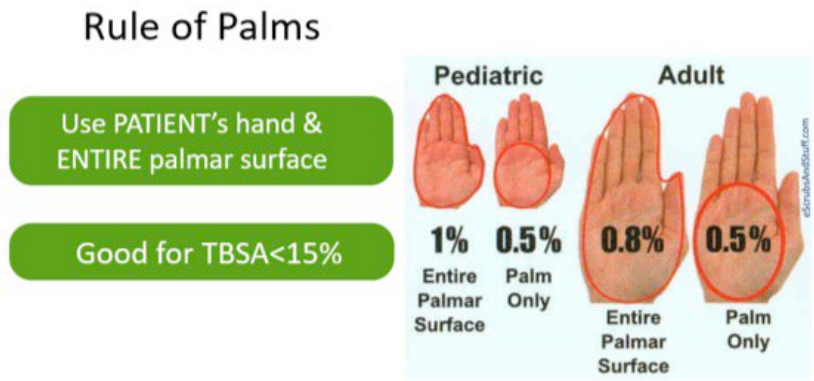
PEARL: *Burns in the ED are not easily classifiable on the initial assessment and they may convert to deeper burns over the next few days. Use caution when classifying burns and counseling patients and families about prognosis. Patients require close follow up of the wound for reassessment and ongoing care.*

Classic example of a burn converting to full thickness from day 2-5, courtesy of Dr. Joel Fish

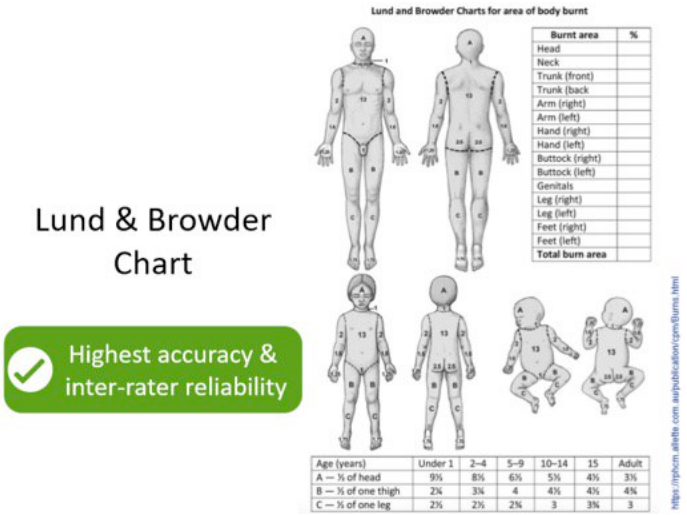
Burn Size Estimation

Calculating Total Body Surface Area (TBSA) is crucial in determining initial fluid resuscitation and potential disposition. The Rule of 9s is inaccurate and consistently overestimates TBSA by about 20% which can lead to over-resuscitation.

For TBSA <15% or >85%: The **Rule of Palms** is highly accurate and easy to teach. Use the size *of the patient's hand*(*including the fingers*) to estimate burn size.



For TBSA >15%: The **Lund & Browder Chart** is accurate and has excellent inter-rater reliability.



Beware: Do *not* include superficial thickness burns in TBSA estimation. Only include partial and full thickness burns.

Wound Care in Burn Injuries

Clinical Pearls

Keep wounds moist. A moist environment promotes re-epithelialization and prevents cellular dehydration.

Use a Non-adherent Dressing. Use a dressing such as Mepitel, Jelonet or Adaptic that will cause less pain upon removal. Apply a petrolatum-based antibiotic ointment to the dressing (rather than the wound itself), then place the dressing over the wound.

The daily dressing is dead. The patient does *not* need to return to the ED for daily dressing changes. The initial non-adherent dressing can be left on for 2-3 days until the patient has their follow up appointment. ***Don't* use silver sulfadiazine (Flamazine)**. Silver sulfadiazine may delay wound healing and requires more frequent dressing changes. Silver sulfadiazine creates a pseudoeschar around the wound that can also foster microbial colonization.

For burns that require cleaning use sterile water and a gentle soap. With a soapy washcloth very gently wipe but do not scrub the wound. For dirtier wounds use chlorhexidine. Avoid iodine as it is cytotoxic.

Burn Injuries Blisters – to debride or not to debride?

Blisters should be debrided for the following reasons:

- They can restrict function
- They prohibit proper assessment of the wound

- Blister skin is dead; non-viable tissue is a source of infection and should be removed
- Dressings need to be in contact with the viable tissue which is not possible with intact blisters
- Blister fluid may deepen the burn

Blisters <6mm in diameter may be left intact. To debride a blister snip the top with scissors to de-roof it then use tissue forceps to debride the devitalized tissue."

Resuscitation of the Burn and Inhalation Injuries Patient

One of the most important principles to remember with any burn patient is that they are a ***trauma*** **and** ***toxicology*****patient first**. Don't get distracted by the burns. Perform your primary and secondary survey as you normally would with a trauma patient and address the burns later.
Most common injuries associated with burns:

- Fractures (50-60%)
- Traumatic brain injury (20-25%)
- Thoracic or abdominal injuries (4-24%)

Carbon monoxide (CO) and cyanide poisoning are also associated with burn injuries. Apply 100% O2 to reduce the half-life of carboxyhemoglobin to all patients with a history of exposure to fire in an enclosed space.

PEARL: *All burn patients are trauma and toxicology patients until proven otherwise.*

Airway Considerations in the Burn and Inhalation Injuries Patient

The mortality of **inhalational injuries** is 10-30% and increases with greater TBSA burns. Be particularly suspicious of a significant inhalational injury if the patient or first responders report the patient was in an enclosed space for a minute or more.

While it is critical to anticipate impending airway compromise and consider securing an airway sooner rather than later, the systematic reviews suggests that **1/3 of burn patients are unnecessarily intubated in the ED**. Signs such as singed nasal hairs and facial burns alone are *not* indications for intubation. Mild inhalational injuries in patients with normal oxygen saturations and no signs of respiratory distress can be safely observed.

Indications for early intubation
Signs of respiratory distress, stridor, accessory muscle use
New onset of hoarseness
Blisters or edema of oropharynx
Deep burns to lower face or neck

Tip*: You can use a* ***nasopharyngoscope*** *to take a look at the airway. If the supraglottic area appears beefy red and sooty prepare for intubation soon but if it looks good that is reassuring. You could also use video laryngoscope to look for edema, charred mucosa or soot.*

When intubating choose an ET tube size 7.5 or larger as smaller sizes may prohibit passage of a bronchoscope for later assessment." Using a very large tube can worsen airway edema.

PEARL: *In the intubated burn patient, re-check the tube position frequently. Fluid resuscitation and edema can result in tube displacement.*

A note on awake intubation – Dr. George Kovacs

- The key is **meticulous topicalization**
- Warn the patient and your team that topicalization may cause a subjective feeling of respiratory distress when the cords are anesthetized
- Acknowledge the risk of laryngospasm and be prepared to manage
- Performing awake intubation successfully requires repeated simulated deliberate practice

Equipment:

- Tongue depressors x 2 + 5% lidocaine ointment
- Atomizer + 4% aqueous lidocaine
- Crash airway kit and RSI equipment
- +/- Anxiolytic medication (e.g. 0.5-1.0 mg midazolam)
- Flexible laryngoscope (or video laryngoscope)

Steps:

1. Trap the patient's tongue with gauze and spray inside the mouth with 10cc of 4% lidocaine for 3-4 seconds
2. Place tongue depressor with 5% lidocaine ointment smeared on the end on the posterior third of the tongue and let the lidocaine ointment melt onto the tissues; repeat 3 times for about 15-20 seconds for each application moving side to side to ensure the posterior third is well covered with the ointment
3. Attempt to perform laryngoscopy (ideally with flexible laryngoscope or with video laryngoscope)
4. If unable to do #3 due to patient gag, administer atomized lidocaine via nasal passage, 3 sprays x 3 times; repeat ointment administration as needed

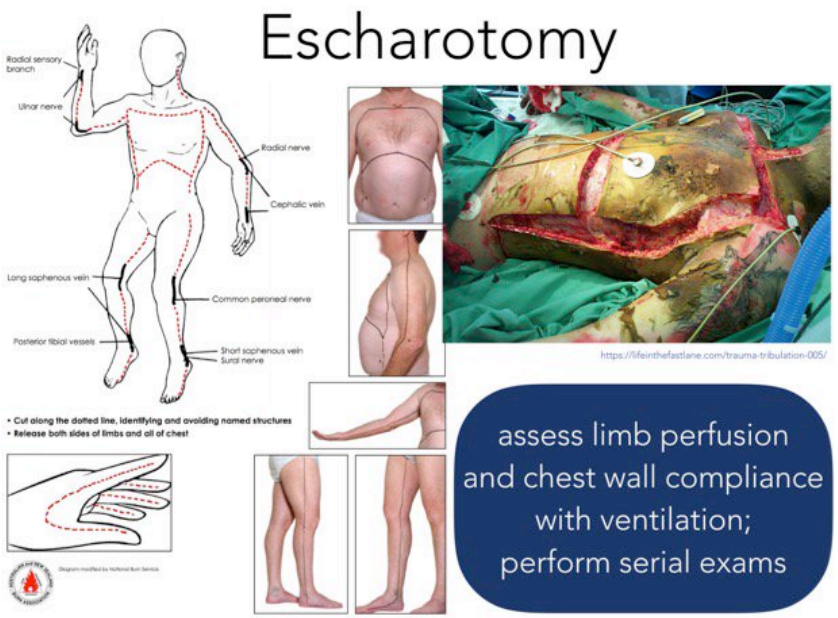
For videos and in depth discussion on awake intubation read ***Dr. Kovacs' free open access airway book (infinity edition)***

Indications for ED Escharotomy

Burns do *not* have to be circumferential to cause a compartment syndrome or restrict ventilation. Escharotomies are typically performed by a burn surgeon prophylactically to reduce the risk of compartment syndrome. If escharotomy is required immediately in the ED, call for help. Consider sending the burn surgeon a picture of the at-risk area and asking them to draw on a picture where to cut. The indications for ED escharotomy include:

- Inability to adequately ventilate due to restriction from chest eschar
- Absent or decreased pulses
- New neurologic deficits

In contrast to a fasciotomy that extends to deeper tissues, an escharotomy only includes the burned skin or eschar. It is ideally performed with cautery due to the risk of excessive bleeding with a scalpel. If using a scalpel, anesthetize using lidocaine *with epinephrine* to minimize bleeding. Do not extend the incision beyond the eschar. Incise mid-lateral and mid-medial areas of the limb to avoid neurovascular structures.



Cyanide Poisoning in Burn and Inhalation Injuries

Cyanide poisoning is a *clinical* diagnosis. Patients may present with non-specific symptoms similar to CO poisoning (nausea, headache, confusion). Suspect cyanide poisoning in patients exposed to a fire in an enclosed space and treat on speculation if:

- Altered mental status + soot in the mouth/nose (60% likelihood of CN poisoning)
- Altered mental status plus soot in the mouth/nose + hypotension/cardiac arrest (80% likelihood of CN poisoning)

Cyanide levels may take days to be resulted and is typically not recommended. Labs highly suspicious for CN poisoning include an anion gap metabolic acidosis or a lactate >8.
Consider treating cyanide poisoning on speculation if your burn patient has:

- Altered mental status (not attributed to head injury) + soot in the mouth or nose (portents about a 60% chance of cyanide poisoning)
- Altered mental status (not attributed to head injury) + soot in the mouth or nose + unexplained hypotension (portents about an 80% chance of cyanide poisoning)

Cyanide poisoning may present with non-specific symptoms similar to CO poisoning (nausea, vomiting, headache, confusion). Other features that should increase your suspicion of cyanide poisoning include burn in an enclosed space or with textiles/plastics, or an **unexplained anion gap metabolic acidosis** or **lactate > 8**.

Treatment of suspected cyanide poisoning

The antidote is hydroxocobalamin (Cyanokit) 5g given over 15min. Repeat the dose if the patient's GCS, hypotension or dysrhythmia is not improving in 15 minutes. Give sodium thiosulfate in addition to the hydroxocobalamin (cyanokit).

Hydroxocobalamin is generally safe. Side effects include red urine, red skin, hypertension, nausea, decreased lymphocytes, injection site reactions, and (rarely) acute renal failure. It may interfere with lab tests so consider drawing labs quickly as the antidote is being prepared (but do not delay treatment).

Older cyanide antidote kits contain sodium thiosulfate, amyl nitrite and sodium nitrite. Sodium nitrite works by forming methemoglobin which chelates CN. In fire victims that may already have carboxyhemoglobin

in their bloodstream from CO poisoning, the metHb *even further* reduces the O2 carrying capacity of blood. So *avoid* sodium nitrite in cases of both CO and CN poisoning. If you have a case of both CO and CN poisoning and you don't have access to hydroxocobalamin you can give the Sodium thiosulfate alone although slower and less effective than hydroxocobalamin.

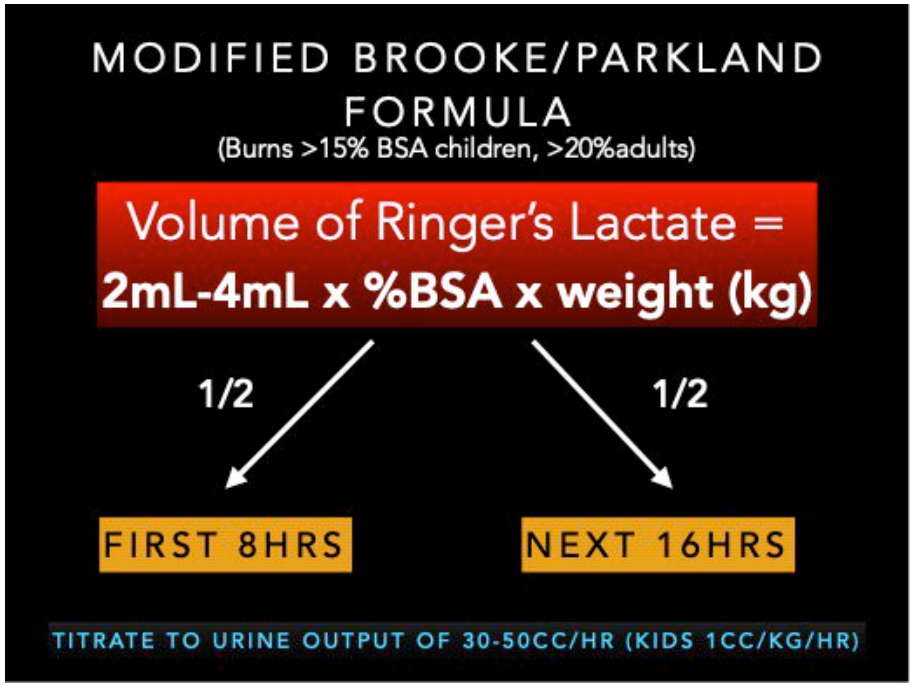
Fluid Resuscitation in Burn and Inhalation Injuries

Key Concepts

- Over-resuscitation is just as harmful as under-resuscitation
- Ringer's lactate is the preferred resuscitation fluid; children require maintenance (D5W+1/2NS) in addition to RL
- Formulas are just a starting point – titrate to urine output
- **Avoid boluses** whenever possible as they may increase the risk of compartment syndrome
- **Avoid vasopressors** whenever possible as vasoconstriction may devitalize burned tissue

The Parkland Formula is passé. Using the traditional Parkland formula of 4mL/kg tends to over-resuscitate most patients leading to complications such as abdominal compartment syndrome, orbital compartment syndrome, the need for escharotomies, impaired gas exchange and prolonged mechanical ventilation. Most experts now recommend a lower starting point. Check with your local burn center's practice guideline as practice varies by jurisdiction. Avoid boluses and increase or decrease resuscitation fluid rate by 30% if hourly target not reached.

Modified Brooke/Parkland Formula is recommended as a starting point for fluid resuscitation for burns >15% BSA in children and >20% BSA in adults. Patients with inhalation injuries generally require more fluid resuscitation (closer to 4mL x %BSA x kg) however the extent of injury is impossible to quantify accurately, so instead, end-organ perfusion should be monitored carefully to help guide management. Aim for an hourly urine output of 30-50cc/hr in adults and 0.5-1cc/kg/hr in children. Children <30kg require maintenance fluids in *addition* to their resuscitation fluids. Children <1 year of age require the addition of Dextrose.



Maintaining Normothermia in Burn and Inhalation Injuries

Burn patients are at high risk of hypothermia as they have impaired thermoregulation. Ensure the room is warm and cover patients with warm dry blankets. Avoid wet dressings which can contribute to

hypothermia. For transfer, the burns should be covered with dry sterile towels.

There is No Role for Prophylactic Antibiotics in Burn and Inhalation Injuries

There is no evidence to support the use of prophylactic antibiotics in burn and inhalation injuries patients. Administering antibiotics may increase the risk of resistant organisms and may increase the risk of fungal infections.

Indications for Consultation to a Burn Center

Burn Center Consultation Criteria

Full thickness burns

Partial thickness burns > 10%

Burns to hands, face, genitalia, perineum, major joints

Electrical (>600 V) or chemical burns

Inhalational injury

Special social, emotional or rehab needs

Key Take Home Points for Burn and Inhalation Injuries

- Think trauma and tox first; don't get distracted by the burns
- Debride blisters, cover burns with antibiotic ointment and nonadherent dressings with reassessment within 72 hours
- For fires in an enclosed space or involving plastics, consider cyanide toxicity in addition to carbon monoxide poisoning and consider treating on speculation
- Use the Palmar Method for burns <15% and Lund & Browder for burns>15% rather than the Rule of 9s to estimate TBSA
- Use modified Brooke/Parkland to guide fluid management
- Fluid formulas are starting points only; titrate to urine output and end organ perfusion to avoid over- and under-resuscitation

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