

Pediatric Emergency Burn Care

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Burns and their sequelae are difficult topics, especially in pediatric patients. None of us wants to think about children being subjected to pain, graft surgeries, and physical and emotional scars that may last a lifetime. Children have special needs in the acute care setting, and it is important to be well informed and prepared to care for them.

Pathophysiology

A brief review of skin anatomy explains some concepts that are necessary to understand burn assessment findings and treatment strategies. The epidermis is the top layer of skin. Under the epidermis lie the dermis, subcutaneous tissue, muscle, and bone. Throughout the dermis are pain receptors. Infants and young children have a much thinner dermal layer than adults, resulting in a greater propensity for deeper burns. The dermis provides several important functions. Those that apply to emergency burn care are infection protection; prevention of fluid loss, temperature maintenance, appearance, and sensory functions (ie, pain).

Etiology of Pediatric Burns

The most common mechanism of burn injuries in children younger than 3 years old is thermal insults. Thermal burn injuries comprise an overwhelming majority of pediatric burn admissions to burn centers; the remainder consist of chemical,

electrical, and lightning injuries. The possibility of abuse must always be entertained in the pediatric population, especially with suspicious burn assessment findings as outlined in Table 1.

Burn Depth

In the past, burns often were classified as first, second, or third degree by EDs and burn centers. Now the depth of the burn is described as superficial, partial, or full thickness. Superficial burns are red and very painful, involving the epidermis only. Children with extensive superficial burns may need narcotic analgesia, but these burns are rarely life-threatening.

Partial thickness burns are characterized by blistering of the skin that involves not only the epidermis but also part of the dermis. The burned areas are reddened and have a shiny or moist appearance. As with superficial burns, the pain may be severe and should be treated appropriately. In addition, vascular permeability occurs, necessitating fluid resuscitation.

Full thickness burns involve the epidermis and dermis, possibly the subcutaneous tissue and muscle, and can present in various colors, such as black, brown, or white, with a leathery or charred appearance. Although pain receptors may be damaged in full thickness burns, analgesia still is required because most patients have varying depths of injury. Partial thickness burns often surround full thickness burns, so aggressive use of pain medication may be indicated. As with partial thickness burns, fluid replacement, temperature, and infection control become important issues in clinical management.

Assessment

When beginning to assess the patient's burn, also consider his or her underlying medical condition. When children have pre-existing diseases or other injuries associated with the burn, burn center care may be necessary, even with minor burns. When other trauma exists, life-threatening injuries must be treated first.

Airway. With any serious burn, consider the possibility of airway problems. Assessment signs and symptoms of inhalation injuries include:

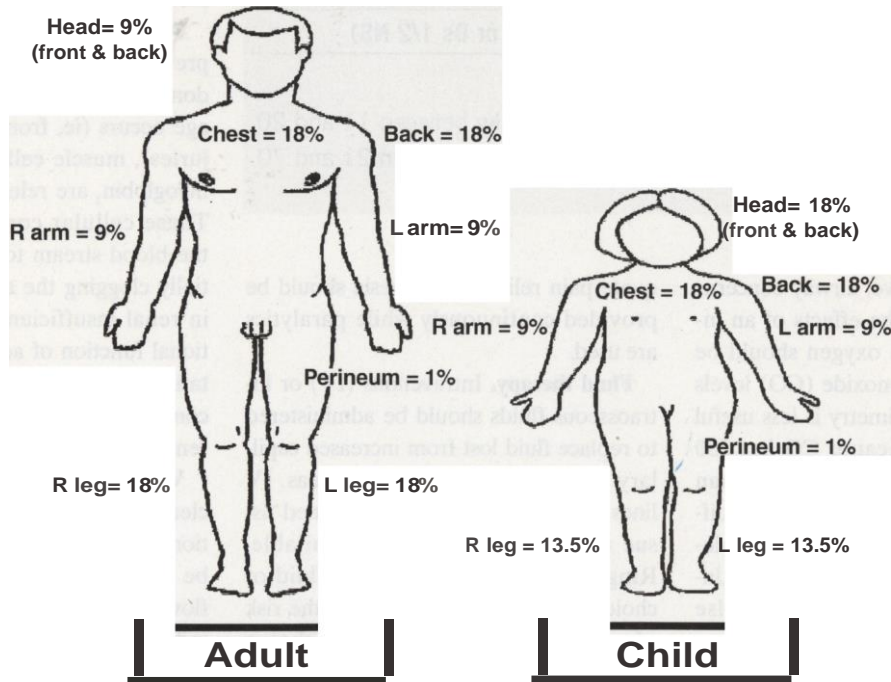
- Singed eyebrows or nasal hairs
- Black nasal discharge
- Hoarseness
- Carbonaceous oropharynx or sputum
- Facial burns

Table 1

SUSPICIOUS HISTORY AND ASSESSMENT FINDINGS

- Well demarcated burn of the perineum or buttocks
- Circumferential to the extremities burn
- Burn depicting the outline of an object
- Simultaneous soft tissue trauma
- Delayed medical treatment
- History of injury incompatible with burn or child's developmental stage
- Prior history of "accidents"
- Dysfunctional family unit

Figure 1. Body Surface Area Estimations



- History of enclosure in a smoke filled location

Smoke contains carbon monoxide and various other toxic gases that accompany superheated temperatures. These elements, combined with increased vascular permeability, can lead to edema. A high index of suspicion for airway complications as a result of edema must be maintained. Children, who have relatively smaller airways than adults, have an increased likelihood of complications related to edema.

Extent of the burn. Prehospital and emergency hospital personnel see a variety of burn injury severities:

- Minor burn patients who can be discharged home after treatment
- Minor burn patients who can be appropriately treated as inpatients at a community hospital
- Moderate and critical burn patients who should be transferred to a burn center

Regardless of the patient disposition, calculating the percentage of burn is crucial for proper assessment and treatment. The most commonly used emergency tool is the "Rule of 9s," a tool that applies body surface area (BSA) estimates in multiples of nine for easier clinical estimation. However, children have critical anatomic differences compared with

adults, as shown in Figure 1. When calculating percentages of burns in pediatric patients, the head is proportionately larger than an adult's and therefore given an 18% BSA instead of 9%. Some recommendations for burn assessment note that children also have smaller legs that should be calculated at 13.5% BSA each. When assessing noncontiguous or "patchy" burns, the "palm size" tool may be used, which states that the size of the patient's (not the provider's) palm is approximately 1% BSA.

Electrocardiogram (ECG) monitoring. ECG monitoring is necessary for serious burns, but the placement of ECG leads may be difficult when extensive areas are burned. ECG leads do not adhere to

burned tissues, so other areas must be identified.

Treatment

The child's clothing and jewelry must be removed when he or she is brought to the ED. If clothing has adhered to the burn, leave it in place and cool it-many fabrics can retain heat. The adherent material can be removed later during debridement. Jewelry removal is a priority because it typically is made of metal, which also retains heat and extends the depth of injury. Jewelry also may cause vascular compromise when not removed from edematous tissue (ie, rings on fingers).

ABCs. ABCs are the basis of all emergency algorithms, and burns are no dif-

Table 2

PARKLAND FORMULA*

Estimated fluid requirements for the first 24 hours after burn

- 4 mUkg/BSA burn
 - 4 ml of lactated Ringers or 0.9 normal saline
 - BSA burn (include partial and full thickness burns)
- Half of total amount administered during first 8 hours after burn occurs, not arrival in ED
- Remaining half of fluids administered during next 16 hours

**This is only a guide, not legal medical advice. The Parkland formula is predicated on the assumption that urine output is adequate and the patient is not in shock. Fluid requirements may be greater in these conditions.*

Table 3

MAINTENANCE FLUIDS

Weight	Amount of fluid (Ds 114 NS or Ds 1/2 NS)
0-10 kg	100 mUkg/24 hrs
11-20 kg	1000 ml + 50 mUkg/24 hrs for each kg between 11 and 20
21-70 kg	1500 ml + 20 mUkg/24 hrs for each kg between 21 and 70
> 70 kg	2500 mU24 hrs

ferent. As noted above, airway concerns include edema and the effects of an inhalation injury. Pure oxygen should be given and carbon monoxide (CO) levels determined. Pulse oximetry is less useful in CO poisonings because CO has 230 times the affinity for hemoglobin than oxygen. Most pulse oximeters do not differentiate between a hemoglobin molecule that is bound by oxygen or CO. Unless the CO level is known, the pulse oximetry reading may not accurately reflect patient oxygenation. Therefore, 100% oxygen should be administered to all burn patients until CO poisoning is ruled out.

When concern about airway edema exists, the child should be intubated rapidly. When considering an appropriate rapid onset paralytic, anectine (succinylcholine) can be used safely in burned children 12 to 24 hours after injury. After 24 hours, hyperkalemia concerns may make non-depolarizing paralytics more appropriate. Longer acting paralytic medications, such as vecuronium (Norcuron), pancuronium (Pavulon), and atracurium (Tracrium), may inhibit the ability to assess for ade-

quate pain relief, so analgesia should be provided continuously while paralytics are used.

Fluid therapy. Intravenous (IV) or intraosseous fluids should be administered to replace fluid lost from increased capillary permeability and burned areas. IV lines should not be placed in burned tissue unless no alternative is available. Ringers lactate is the isotonic fluid of choice for resuscitation to avoid the risk of unnecessary sodium loading that is possible with normal saline.

The Parkland formula, based on the Parkland Medical Center Burn Criteria, commonly is used as a guide to determine the amount of fluids required. This formula, outlined in Table 2, stipulates that 4 mL/kg/BSA of fluids be given in the first 24 hours. The 24-hour period is calculated from the time of the injury, not the time care is initiated. Most fluid loss will occur during the first 8 hours after the burn, so half of this total amount should be administered in that window. Urine output should be measured in the ED to better assess fluid requirements. A urinary catheter must be placed properly

to measure output. Urine output of 1 or 2 mL/kg/hr is the goal of fluid resuscitation therapy in children.

A major concern in burn care is the prevention of complications from rhabdomyolysis. When extensive muscle damage occurs (ie, from burns/electrical injuries), muscle cell contents, including myoglobin, are released into circulation. These cellular contents flow through the blood stream to the kidneys, potentially clogging the tubules and resulting in renal insufficiency/failure. An additional function of adequate fluid resuscitation in burn patients is to prevent this complication by continuously flushing the renal tubules.

With severe myoglobunuria not cleared by fluid resuscitation, the addition of a diuretic, such as mannitol, may be necessary to increase tubular fluid flow. The routine use of diuretics is not indicated in acute burn care because of the potential for severe intravascular volume depletion and compounding electrolyte disturbances. Pediatric patients undergoing fluid resuscitation also require additional maintenance IV fluids to prevent complications from hypoglycemia and potential electrolyte imbalances. Maintenance fluid guidelines are presented in Table 3.

Temperature maintenance. Maintaining a normal temperature is especially important for pediatric patients, who can become hypothermic rapidly. Infants and small children lose significant amounts of heat from their large heads, so a small stocking cap can be made from stockinet or other material. Burn areas should be wrapped in dry clean sheets to minimize heat loss. Moist dressings should be avoided. Keeping the room warmer than usual and cautiously using a radiant warmer and warming blankets can help prevent heat loss. Additionally, warmed IV fluids can be an important adjunct in maintaining normothermia.

Wound care. Burned areas should be loosely covered for transport. Put clean, dry sheets under and over the child and a blanket on top to prevent heat loss (even in summer). Antimicrobial ointment should not be placed on the burn if the patient is being transferred without first consulting the receiving burn facility. If a burn center transfer is not warranted, burns, after cleaning and debridement are performed, should be dressed with dry

Table 4

CRITERIA FOR TRANSFER OF BURN PATIENTS

- Partial and full thickness burns greater than 10% of total body surface area (BSA) in patients younger than 10 or older than 50
- Partial and full thickness burns greater than 20% of BSA in any age group
- Partial and full thickness burns involving the face, ears, eyes, hands, feet, genitalia, or perineum or burns that involve skin overlying major joints
- Full thickness burns greater than 5% BSA in any age group
- Significant electrical burns, including lightning injury
- Significant chemical burns
- Inhalation injury
- Burn injury in patients with pre-existing illness

Additional notes: Any burn patient in whom concomitant trauma poses an increased risk of morbidity or mortality may be treated initially in a trauma center until stabilized before transfer to a burn center.

Children with burns seen in hospitals without qualified personnel or equipment for their care should be transferred to a burn center with such capabilities.

Adapted from Advanced Trauma Life Support, 6th edition, 1997

gauze and topical antimicrobials, such as silver sulfadiazine (Silvadene). Repeated assessments and dressing changes then can be accomplished at home, by the primary physician, or in the hospital setting.

Pain management. Pain from bum injuries can be severe and often requires an aggressive use of analgesia. With minor burns, oral analgesics, such as acetaminophen or ibuprofen, are appropriate and effective. IV narcotics are the drug and route of choice for more severe burns. Intramuscular analgesia is inappropriate in extensive burns for a variety of reasons, including hypovolemia, inadequate absorption/distribution, and increased muscle damage.

Emergency care providers should serve as patient advocates in ensuring adequate pain relief for pediatric patients. Sufficient medication should be given to keep the child comfortable. While administering pain medications to the nonintubated patient, clinicians must be continually aware of the potential for respiratory depression and be prepared to act emergently. A pediatric bag/valve/mask device and naloxone should be kept at the bedside. Naloxone can be used to reverse narcotic-induced respiratory depression, if needed.

Emotional support. With any bum, regardless of severity, the importance of parental or family support should not be underestimated. Calming measures from the family members and distraction therapies, such as music or videos, can reduce anxiety and pain in the child. This tranquility in tum can reduce the anxiety felt by the providers caring for the pediatric bum patient. Parents should be included in all aspects of the care of their child. Additionally, the presence of parents during dressing changes and other therapeutic procedures will be advantageous for two reasons. First and foremost, the support and calming effect on the child will be invaluable. Second, by actively participating in their burned child's care, parents will

feel more comfortable continuing care when their child returns home.

Fasciotomies/escharotomies. A circumferential bum (one encompassing the entire circumference of the body part) can impair circulation. When the entire thorax is involved, respiration can be impaired. This situation results from the inflexibility of the eschar (full thickness burned tissue), which does not stretch and accommodate the rapid progression of swelling.

When circumferential burns of the extremities occur, circulatory, motor, and sensory functions may be compromised as edema compresses the arteries, nerves, and veins. Although rarely needed, escharotomies of the chest and/or extremities may be indicated before transport.

Nonthermal Burns

Burns also can be caused by chemicals and electricity, which are special cases not discussed in this article. Burns to specific areas, such as hands, feet, joints, face, and genitalia, require very careful assessment and specialized treatment. These types of burns often require transfer to a burn unit; criteria for such a transfer are listed in Table 4.

Summary

As difficult as it may be to imagine the physical and emotional pain a severely burned child may experience, we, as acute care providers, must be constantly aware of the physiological changes that may occur as the result of an acute burn injury. Remembering the functions of the body while in homeostasis will facilitate a better understanding of the insult that occurs to every body system. Emergency care of pediatric burns must continually focus on aggressive control of the airway, fluid resuscitation, temperature maintenance, pain control, and emotional support of the patient and family. By focusing on these issues, emergency providers will have managed their role in the long road of recovery that awaits burn patients. r.!

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