Pediatric Burn Management

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KEYWORDS

• Burn • Resuscitation • Total body surface area • Superficial partial thickness
• Deep partial thickness • Scald • Inhalation injury • Nonaccidental trauma

KEY POINTS

- The three major mechanisms of injury associated with burns are scald, contact, and flame injuries.
- Burn injuries can be further classified by their depth - superficial, superficial-partial thickness, deep-partial thickness, and/or full thickness.
- The extent of burn injury is expressed as a percentage of the child's total body surface area (%TBSA) and should only include partial and full thickness burns.
- Initial burn management should prioritize pain control and close airway assessment, with low threshold for definitive airway management.
- Management of straightforward burn injuries is within the purview pediatricians and emergency medicine physicians and involves pain control, debridement, and wound dressing.
- Children with extensive injuries, concern for airway compromise, or more complicated injuries should be transferred to a pediatric burn center.

INTRODUCTION

Although children with burn injuries are evaluated in various settings, including pediatricians' offices and urgent care clinics, the majority is seen in the emergency department (ED).[1] Burns are one of the leading causes of injury-induced mortality in children aged younger than 14 years.[2] The majority of children with burns are aged younger than 5 years, and the peak incidence occurs at 1 year of age.[2,3] Boys are more likely to present with burns than girls.[1,2,4] Most pediatric burns are accidental injuries that occur at home; however, adolescents are more likely to experience burn injuries outside the home.[1,2] The overall mortality rate is 0.4% to 2.8%.[1,2,5] Fortunately, the hospitalization rate and mortality rate for pediatric burns have decreased in the United

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Abbreviations	
%TBSA	percentage of the child's total body surface area
ATLS	Advanced Trauma Life Support
ED	emergency department
IM	intramuscular
IN	intranasal
IV	intravenous
PO	oral
PR	per rectum
Td	tetanus-diphtheria
TT	tetanus toxoid

States over the past 2 decades.[6–9] Although death is a rare complication of straightforward scald burns, there is increased mortality associated with fire-related injuries, full thickness burns, and abuse-related injuries.[3,10,11] There is also an increased risk of long-term mortality for children who have experienced burn injury compared to those who have not.[12] **Box 1** includes factors associated with increased mortality.

BURN BASICS

Mechanism of Injury

Scald burns

Scald burns are thermal burns caused by contact with hot liquids or steam.[13] Close to 60% of all pediatric burn injuries are scald-related,[2,14] and it is the most common mechanism of burn injury for children aged younger than 5 years.[2,3,13–15] Scald burns occur most often in the home,[16] and the resulting injuries range in depth and severity depending on the temperature of the substance, its viscosity, and duration of contact with the skin.[17,18] It would take 10 minutes of contact with 120°F (49°C) water for an adult to develop a full thickness burn, whereas 160°F (71°C) degree water would cause a full thickness burn in 1 second.[17,19] Increased viscosity is associated with a slower flow speed, and in turn, increased contact time with the skin in a child.[18]

Box 1 Factors associated with increased mortality in pediatric burns
Multiple involved body regions
Age >2 years old
Nonaccidental burns
Full thickness burns
Burns involving the neck
>40% TBSA
Associated inhalational injury
Associated sepsis
Delays in resuscitation
Residence in low-income or middle-income countries
From references.[2,5,7,9,10,24,72,114,115]

The majority of scald injuries involve plain water, followed by tea and coffee.[4] Among infants and toddlers, most of these injuries involve the child pulling the hot liquid down from a tabletop or cooktop.[4] Additionally, microwave-related burns result in scald injuries when the child accesses and spills the contents.[20,21] There is also an association between scald burns and running bathwater.[22] Legislation regulating maximum home water heater temperature settings has been associated with a decrease in scald injuries.[23] A common setting is 140°F (60°C), which takes 5 seconds in adults and 3 seconds in children to cause tissue destruction.[24]

Contact burns

Contact burns are common among children and, as the name suggests, involve direct contact with a hot surface.[17] These burns are usually not life-threatening, but they can cause considerable morbidity.[17,25] These injuries often involve the upper extremities as a result of the child touching or grabbing a hot surface while exploring their environment. Children have a propensity to "freeze" when they touch a hot object, which increases contact time with the hot object, leading to increased burn severity.[15] Children typically sustain contact burns from heated hair styling products, hot irons, oven doors, and glass-front fireplaces.[25–28]

Flame burns

Flames are the most common cause of burn in patients aged older than 5 years,[15] and fire and flame-induced burns account for most burn-related fatalities.[1,2,29] The injuries associated with these burns are deeper and wider and are associated with greater need for surgical interventions and longer hospitalization.[29–31] Most flame-related burns involve some sort of fire accelerant, and in most cases, it is another child who has thrown the accelerant in the fire.[4]

Classification of Injury

The American Burn Association characterizes burn injuries using a classification system based on the extent of injury (**Table 1**).[32–36] Superficial burns (formerly referred to as first-degree burns) are isolated to the epidermis and will appear erythematous, like a sunburn. Superficial burns do not have associated edema, blistering, or bullae formation.

Burns extending from the epidermis into the dermis are classified as partial thickness (formerly referred to as second-degree burns) and are further subdivided into superficial-partial thickness or deep-partial thickness. Most pediatric burns are partial thickness.[6] Superficial-partial thickness burns are pink or red in color, appear moist, and involve blistering and/or bullae, whereas deep-partial thickness burns involve more extensive injury to the dermis. Deep-partial thickness burns tend to appear paler and drier relative to superficial-partial thickness burns (**Fig. 1**). They also may be less painful than superficial-partial thickness burns due to the associated nerve damage.

Full thickness burns (formerly referred to as third-degree burns) involve damage to the epidermis and the entire dermis. These injuries are characterized by a pale or charred appearance and have a leather-like texture (**Fig. 2**). The extensive associated nerve damage often results in these burns being painless. Children aged younger than 2 years have thinner skin and are more susceptible to full thickness burns.[24] Burns that extend through the skin and into the subdermal fat are referred to as fourth-degree burns. They appear charred and can also involve muscles, tendons, and bones.[24,37]

EMERGENCY DEPARTMENT MANAGEMENT OF BURN INJURIES

Burn injuries are incredibly painful, and while the goal of initial first aid should be to reduce the child's pain, the principles of Advanced Trauma Life Support (ATLS)

Table 1
Burn classification

Classification	Depth	Examination Findings	Healing Time	Risk of Scarring
Superficial[a] (first degree)	Epidermis only	Erythematous, painful No blistering	4–5 d	Minimal
Superficial-partial (second degree)	Epidermis and upper dermis	Blisters that are painful if unroofed Exposed skin pink, moist, and blanchable with intact capillary refill	7–10 d	Minimal May be hypopigmented during healing due to loss of melanin
Deep-partial (second degree)	Epidermis through deeper dermis	Blisters are unroofed or easily unroofed Erythematous or yellow coloring, waxy to dry appearance, nonblanchable +/− painful depending on extent of nerve fiber involvement Hair follicles may be visible Capillary burst with red punctum of bleeding may be present	2–3 wk	Probable
Full-thickness (third degree)	Epidermis and full dermis	White, waxy, and leathery appearance Absence of hair follicles Painless/insensate	Weeks	Definite
Fourth degree	Extends to deep structures (music, bone, and tendons)	Visible deeper structures Charred appearance	Months	Definite

[a] Not included in *%TBSA* estimation.

Fig. 1. After emergency department (ED) debridement, a 12% TBSA bib pattern scald burn from a onesie on a toddler. Note the deeper (yellow) full-thickness burn in the center, a middle (white) deep partial-thickness burn, and an outer (red) superficial partial-thickness burn. (Ashley M. Strobel, Ryan Fey, Emergency Care of Pediatric Burns, Emergency Medicine Clinics of North America, 36 (2), 2018, 441-458, https://doi.org/10.1016/j.emc.2017.12.011.)

apply.[38] Pain management should be in concurrence with a thorough primary survey, with particular attention given to airway assessment and exposure so that burn injuries are accurately characterized and concomitant trauma and/or toxicity is identified. Adequate analgesia should be a priority, and pain should be reassessed and addressed prior to any wound manipulation. Most children with burns will receive initial management at a facility that is not associated with a burn center. After stabilization, those with extensive or potentially complicated injuries should promptly be transferred to a burn center for definitive management.

Advanced Trauma Life Support Assessment

Airway

The nuances of pediatric airway management are important to consider in the assessment of a child presenting with burn injuries. It is estimated that 4% to 5% of pediatric patients with scald burn will require mechanical ventilation. These children tend to be younger with more extensive burns.[39,40] Compared to adults, the small airway of a child is more susceptible to complete occlusion because of edema.[41–43] One millimeter of swelling in a pediatric airway can lead to a 50% reduction in airway diameter and a 16 fold increase in airway resistance[42] (**Fig. 3**). Early intubation is indicated to maintain a patent airway, as edema can become rapidly progressive once fluid

Fig. 2. A toddler with a lip full-thickness burn after biting an electrical cord. The electrocardiogram was normal. Burn consultation was obtained in the ED, and this family went home with good anticipatory guidance once pain control and the child's ability to tolerate oral fluids were achieved. (Ashley M. Strobel, Ryan Fey, Emergency Care of Pediatric Burns, Emergency Medicine Clinics of North America, 36 (2), 2018, 441-458, https://doi.org/10.1016/j.emc.2017.12.011.)

resuscitation is initiated.[24] Burn size is an important consideration in the decision to intubate. Children with extensive burns should be intubated in anticipation of the large volume of fluids they will ultimately receive, particularly those aged younger than 2 years with burns greater than 20% TBSA.[39,40]

Inhalational injuries should be considered in children who experienced flame burns in an enclosed space with smoke exposure. Singed facial hair and soot in the airway also suggest inhalational injury.[44] Although a historical teaching has equated nasal soot or singed nasal hairs with the need for immediate intubation, these findings are not consistently indicative of need for mechanical ventilation.[45,46] Not all inhalation injury requires intubation, but these patients should be monitored closely for signs of evolving airway compromise. Fiberoptic bronchoscopy can be used to directly visualize the airway and help identify extent of inhalational injury[47]; however, if there is concern for potential airway involvement, early intubation with a low pressure cuffed tube is indicated. Stridor and hoarseness are ominous signs and indicate the need for immediate intubation. Drooling, respiratory distress, significant facial burns, or altered mental status also indicate the need for definitive airway management in children.[38,44,48] Children with extensive burns requiring burn center or intensive care unit admission may also require intubation to achieve appropriate levels of pain control and sedation.

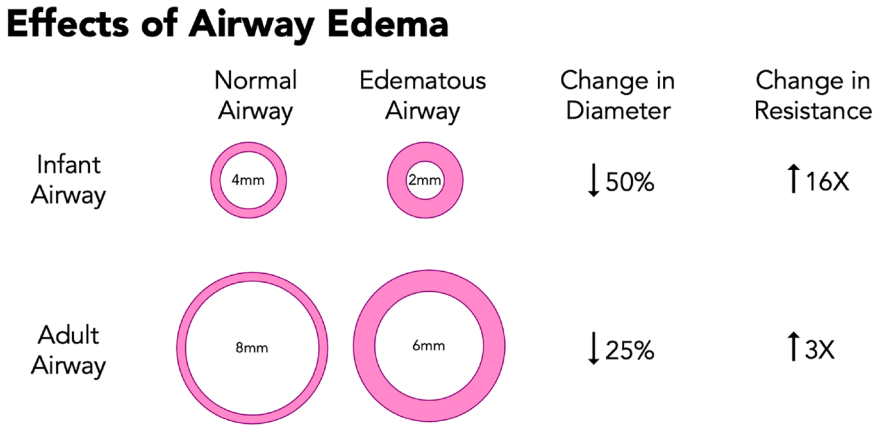


Fig. 3. Age-dependent effects of reduction in airway caliber on airway resistance and air flow to demonstrate the effect of airway edema, secondary to inhalation injury, on the respiratory mechanics in children compared with adults. A millimeter of circumferential edema will reduce the diameter of the airway by 2 mm, resulting in a 16 fold increase in airway resistance for the pediatric airway versus a 3 fold increase for the adult airway. It is even possible the resistance will increase by 32 fold when a child is crying in the resuscitation room. (*From* Wheeler DS, Spaeth JP, Mehta R, et al. Assessment and management of the pediatric airway. In: Wheeler DS, Wong HR, Shanley TP, editors. Resuscitation and stabilization of the critically ill child. New York: Springer; 2008. p. 224; with permission.)

Breathing, circulation, and disability

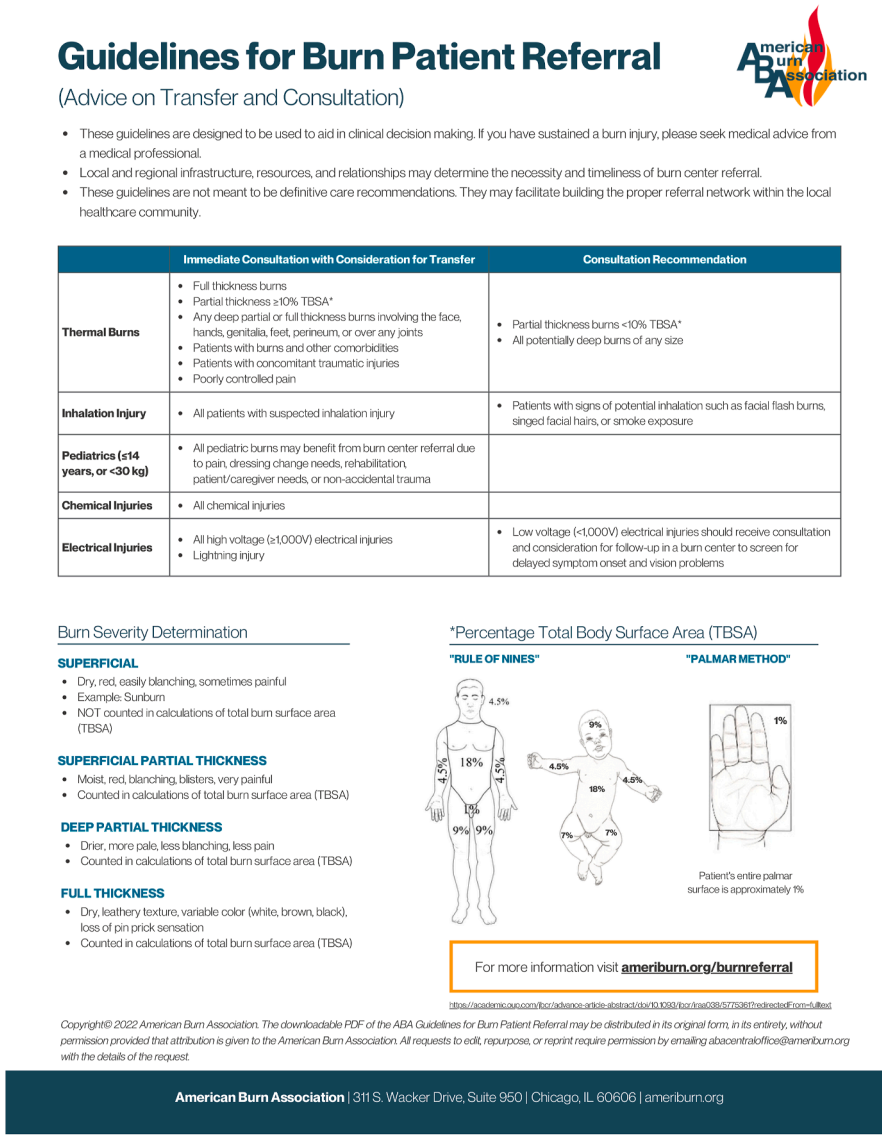
There are no specific special considerations for the respiratory, cardiovascular, or neurologic evaluation of children presenting with burn injuries. In most cases, the patient's breathing, circulation, Glasgow Coma Score, and pupillary response can be quickly assessed before proceeding to exposure. If the patient presents in hypovolemic shock or has extensive burns involving more than approximately 20% TBSA, initial fluid resuscitation with a 20 mL/kg bolus of crystalloid should be initiated. Ringer's lactate solution is preferred over 0.9% normal saline fluid in instances of burn injury resuscitation.

Exposure

All clothing should be removed, both to prevent further burn injury from continued exposure to the causative agent and to allow for full visual inspection of the child's body. Due to their increased surface area to mass ratio, children are at an increased risk of hypothermia, which should be minimized with active warming measures.[41]

Once the areas of burn injury are evaluated, they can be covered with clean sheets or gauze, both of which should be dry to prevent additional heat loss. Air convection against the damaged skin is also painful, and applying dressings has the additional benefit of improving the patient's comfort.[49] The dry dressings can be moistened later in order to ease removal.

The extent of the burn is best described by estimating the proportion of TBSA involved (%TBSA), and although there are several methods that can be used to calculate %TBSA, not all are suited for use in pediatric patients. While the Wallace "rule of nines" is a commonly used method to estimate %TBSA and can be used in adolescents and adults, it does not accurately represent the proportions of body surface



Guidelines for Burn Patient Referral

(Advice on Transfer and Consultation)

- These guidelines are designed to be used to aid in clinical decision making. If you have sustained a burn injury, please seek medical advice from a medical professional.
- Local and regional infrastructure, resources, and relationships may determine the necessity and timeliness of burn center referral.
- These guidelines are not meant to be definitive care recommendations. They may facilitate building the proper referral network within the local healthcare community.

	Immediate Consultation with Consideration for Transfer	Consultation Recommendation
Thermal Burns	• Full thickness burns • Partial thickness ≥10% TBSA* • Any deep partial or full thickness burns involving the face, hands, genitalia, feet, perineum, or over any joints • Patients with burns and other comorbidities • Patients with concomitant traumatic injuries • Poorly controlled pain	• Partial thickness burns <10% TBSA* • All potentially deep burns of any size
Inhalation Injury	• All patients with suspected inhalation injury	• Patients with signs of potential inhalation such as facial flash burns, singed facial hairs, or smoke exposure
Pediatrics (≤14 years, or <30 kg)	• All pediatric burns may benefit from burn center referral due to pain, dressing change needs, rehabilitation, patient/caregiver needs, or non-accidental trauma	
Chemical Injuries	• All chemical injuries	
Electrical Injuries	• All high voltage (≥1,000V) electrical injuries • Lightning injury	• Low voltage (<1,000V) electrical injuries should receive consultation and consideration for follow-up in a burn center to screen for delayed symptom onset and vision problems

Burn Severity Determination

SUPERFICIAL
- Dry, red, easily blanching, sometimes painful
- Example: Sunburn
- NOT counted in calculations of total burn surface area (TBSA)

SUPERFICIAL PARTIAL THICKNESS
- Moist, red, blanching, blisters, very painful
- Counted in calculations of total burn surface area (TBSA)

DEEP PARTIAL THICKNESS
- Drier, more pale, less blanching, less pain
- Counted in calculations of total burn surface area (TBSA)

FULL THICKNESS
- Dry, leathery texture, variable color (white, brown, black), loss of pin prick sensation
- Counted in calculations of total burn surface area (TBSA)

*Percentage Total Body Surface Area (TBSA)

"RULE OF NINES" "PALMAR METHOD"

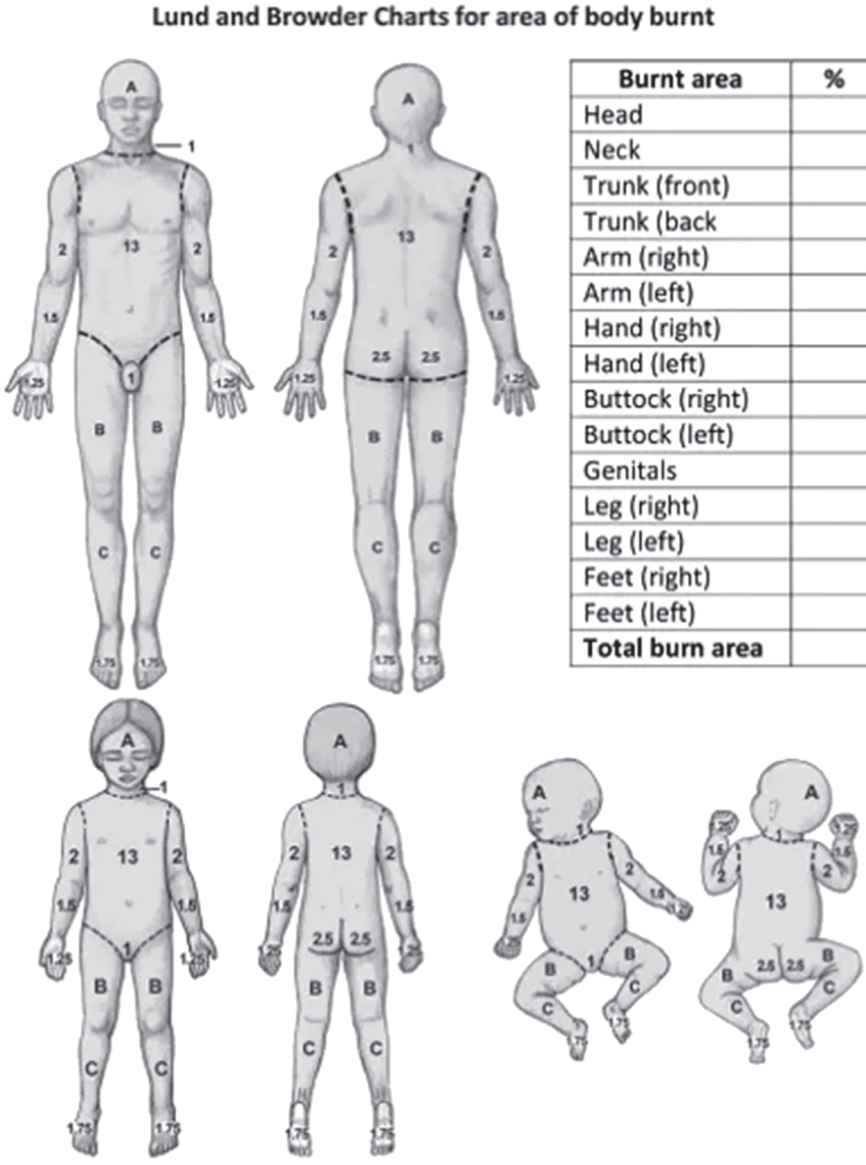
For more information visit **ameriburn.org/burnreferral**

https://academic.oup.com/jbcr/advance-article-abstract/doi/10.1093/jbcr/irac038/5775361?redirectedFrom=fulltext

American Burn Association | 311 S. Wacker Drive, Suite 950 | Chicago, IL 60606 | ameriburn.org

Fig. 4. American Burn Association guidelines for burn patient referral. (Copyright© 2022 American Burn Association.)

area in children. Pediatric adaptations of this method are available (Fig. 4).[37,50] The Lund and Browder chart (Fig. 5) includes adjustments for the patient's age; however, committing these adjustments to memory is not practical.[51] A fairly simple, and resource-free, method for estimating %TBSA uses the area of the patient's own palm, including the adducted fingers, to estimate the equivalent of 1% TBSA (see Fig. 4); however, this method can overestimate %TBSA in adults and underestimate %TBSA in children.[37,52] There are also several electronic applications available to estimate %TBSA.[37,53–56] One such application is the EasyTBSA app, which



Burnt area	%
Head	
Neck	
Trunk (front)	
Trunk (back	
Arm (right)	
Arm (left)	
Hand (right)	
Hand (left)	
Buttock (right)	
Buttock (left)	
Genitals	
Leg (right)	
Leg (left)	
Feet (right)	
Feet (left)	
Total burn area	

Age (years)	Under 1	2–4	5–9	10–14	15	Adult
A — ½ of head	9½	8½	6½	5½	4½	3½
B — ½ of one thigh	2¼	3¼	4	4½	4½	4¾
C — ½ of one leg	2½	2½	2¾	3	3¾	3

Fig. 5. Lund and Browder chart. (*From* the American Burn Association; and Reprinted from the Journal of the American College of Surgeons, formerly Surgery Gynecology & Obstetrics, with permission; and Nagel TR, Schunk JE. Using the hand to estimate the surface area of a burn in children. Pediatr Emerg Care 1997;13:254–5.)

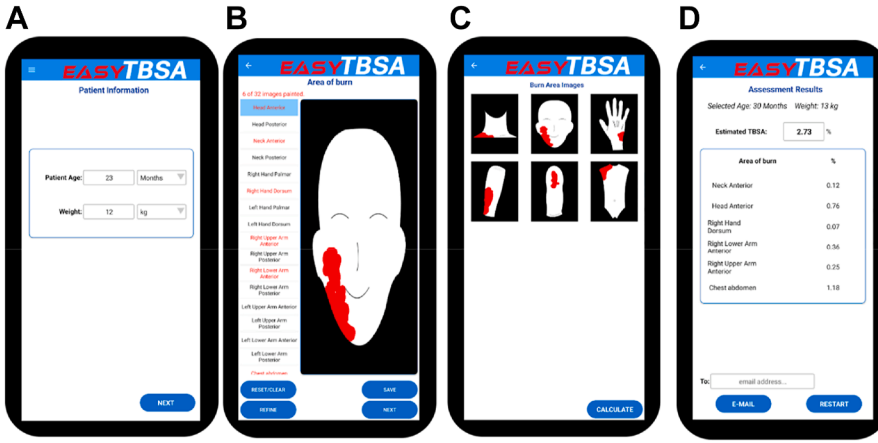


Fig. 6. EasyTBSA Application EasyTBSA is one of several publicly available application-based programs used to estimate %TBSA. The user enters the patient's age and weight (*A*), selects and highlights the areas of burn injury (*B*), confirms the areas of burn injury (*C*), and the application calculates the estimated TBSA (*D*).

involves the user indicating the areas of the patient's body with burns in order to generate a calculation of %TBSA involved (**Fig. 6**). In comparison to the previously mentioned methods, EasyTBSA provides a more accurate estimation of %TBSA.[53] Estimates of %TBSA should include partial and full thickness burns, while superficial burns should be excluded from the calculation. Despite the available resources for calculating %TBSA, patients transferred to burn centers are frequently found to have an overestimated %TBSA from the referring hospital, which can lead to unnecessary transfers and inappropriate fluid resuscitation.[57,58]

Resuscitation

The goal of any resuscitation is to optimize tissue perfusion and oxygenation. In the instance of burn injuries, optimization of resuscitation promotes wound healing. Adequate fluid resuscitation is imperative for the initial management of pediatric patients with burn to prevent shock and other injury complications.[8,49] In 2023, the American Burn Association released their Clinical Practice Guidelines on Burn Shock Resuscitation.[59] Although these guidelines focus on the management of adult burn patients with greater than 20% TBSA involvement, several of the principles apply to pediatric burn management.

Patients presenting with concern for hypovolemic shock should receive immediate fluid resuscitation during the primary survey with 20 mL/kg of either 0.9% normal saline or Ringer's lactate solution. Although, historically, there has been some debate over the value of crystalloid versus colloid fluid replacement, crystalloid is preferred as the initial resuscitative fluid. The potential benefit of intravascular fluid retention with colloid replacement early in resuscitation is limited since there is significant vascular permeability immediately following burn injuries.[24] Some experts propose including colloid fluids in subsequent fluid replacement, owing to its association with overall decreased fluid requirements, but there is limited evidence suggesting that this is a superior practice.[60]

Currently, there are no published clinical practice guidelines for fluid resuscitation in the management of pediatric burns; however, there are several formulas that can be

used to calculate a child's fluid deficit. In children with less than 15% TBSA burns, the risk of metabolic changes is low, and there is rarely significant capillary leak. These children generally do not require fluid resuscitation, and if intravenous (IV) fluids are administered, they can be limited to 1.5× maintenance IV rate of a crystalloid solution (0.9% normal saline or Ringer's lactate solution).

In children with greater than 10% to 15% TBSA burns, the American Burn Association recommends calculating a 24 hour total fluid volume deficit of 2 to 4 mL/kg/%TBSA. The most commonly used formulas are the Parkland (weight-based), Galveston (BSA-based), and Cincinnati (weight-based with BSA adjustment) formulas as well as recommendations from ATLS (weight-based,[60–64] **Table 2**). There is limited evidence suggesting whether weight-based or BSA-based estimations are superior, although weight-based estimates are easier to calculate in an emergency setting since height measurements are not routinely completed.[65] In addition to the fluid deficit replacement, children weighing less than 30 kg should also receive dextrose-containing maintenance fluids, as hypoglycemia is associated with increased mortality and should be avoided.[24,61,66]

Patients with burns greater than 20% to 25% TBSA require prompt fluid resuscitation due to the physiologic changes resulting in increased capillary permeability and decreased intravascular volume due to fluid shifts. These changes are typically most severe in the 24 hours following injury,[61] which, historically, has called for patients to receive aggressive fluid resuscitation. Recognition of a phenomenon termed "fluid creep," by which severely injured patients with burns experience increased morbidity and mortality following excessive fluid resuscitation, has created a conundrum for clinicians—resuscitation is needed to optimize tissue perfusion, oxygenation, and ultimately, wound healing, while the intervention to do so has the potential to cause harm.

The consequences of "fluid creep" manifest systemically and can present as facial swelling and airway edema, pulmonary edema, decreased chest wall compliance, congestive heart failure, extremity and abdominal compartment syndrome, cerebral edema, and anterior optic atrophy and blindness.[64,67,68] The %TBSA is frequently overestimated in children, which can contribute to excessive fluid resuscitation volumes.[58] Fluid management should ultimately be tailored to the patient's ongoing physiologic needs, and a urine output goal of 0.5 to 1 mL/kg/h can be used as an indicator of adequate resuscitation.[58–62,64,67]

Table 2
Fluid resuscitation estimation formulas

	Basis	Fluid Deficit Volume Calculation	Rate
Parkland	Weight	(4 mL/kg) × (weight in kg) × (%TBSA)	50% over 8 h then 50% over 16 h
Galveston	BSA	(5000 mL/m^2) × (burn BSA in m^2) PLUS (2000 mL/m^2) × (total BSA in m^2)	50% over 8 h then 50% over 16 h
Cincinnati	Weighted and BSA	(4 mL/kg) × (weight in kg) × (%TBSA) PLUs (1500 mL/m^2) × (burn BSA in m^2)	50% over 8 h then 50% over 16 h
ATLS	Weight	(4 mL/kg) × (weight) × (%TBSA)	50% over 8 h then 50% over 16 h

Secondary survey

AMPLE history and additional interventions. As part of the secondary survey, the child's allergies, medical history including immunization status, and current medications should be clarified. It is also important to clarify the events surrounding and leading to the injury. The history may raise concern for other associated injuries and prompt additional evaluation. If the events leading up to and causing the burn are inconsistent with the injury pattern, implausible based on the child's developmental level, or involve lack of adult supervision, the potential for nonaccidental trauma and neglect must be considered.

Children with "clean" burn injuries who have received the primary tetanus-diphtheria series (3 doses of vaccines with tetanus and diphtheria coverage, usually at ages 2, 4, and 6 months) and received a tetanus booster in the past 10 years generally do not require tetanus chemoprophylaxis. However, the need for tetanus immunization and, in some cases, tetanus immunoglobulin, should be evaluated for every patient presenting with burn injuries. The American Academy of Pediatrics' Red Book offers guidance for these decisions (**Fig. 7**).[69]

Laboratory studies should be completed based on the child's clinical presentation, and in most cases, a laboratory evaluation will not influence management decisions for straightforward burn injuries. In the case of house fires, special consideration should be given to the potential for both carbon monoxide exposure and cyanide exposure. Carbon monoxide poisoning should be considered for all patients presenting with fire injury or exposure. Pulse oximetry and Pa_{O_2} measurements cannot be relied upon to detect carbon monoxide exposure or poisoning. Serum carboxyhemoglobin levels can detect and stratify carbon monoxide poisoning and risk for serious side effects.[24,70] Cyanide poisoning should be considered, as certain burning products can release hydrogen cyanide gas. Elevated lactate levels are observed in cases of cyanide exposure due to the associated lactic acidosis, and serum cyanide levels can be confirmed. Treatment, however, should be initiated based on clinical suspicion and before quantitative confirmation is available.[24,71]

Burn injuries, particularly those involving motor vehicle crashes, house fires, explosions, or nonaccidental trauma, can involve other traumatic injuries. These patients should be evaluated with the appropriate radiographic studies, and if there is concern for associated crush injury, creatine kinase may be considered for the evaluation of associated rhabdomyolysis. If there is concern for nonaccidental trauma, liver enzymes and lipase help detect occult intra-abdominal injury.

Moderate and severe burn injuries activate a systemic inflammatory response, which can present similarly to infection and sepsis (fever, tachycardia, and interstitial fluid sequestration). Although sepsis is the leading cause of death for pediatric patients with burn injuries,[72] empiric systemic antibiotics are not routinely indicated in the initial management of burn injuries. Destruction of the epidermal layer and exposure of the dermis significantly alters an important barrier to infection. Debridement of dead skin tissue and application of topical antimicrobial dressings can help with infection prevention; however, if a child will be transferred to a burn center for definitive management, the injured areas can be covered with clean, dry dressings alone. Application of topical antimicrobial agents can be deferred to the accepting burn center. Children who develop fevers after the first few days following injury should receive special attention, and if there is suspicion for developing infection, appropriate antibiotic coverage, including coverage of multidrug-resistant organisms, should be considered. This is particularly important for children who have required prolonged hospitalization for management of their injuries.[72–74]

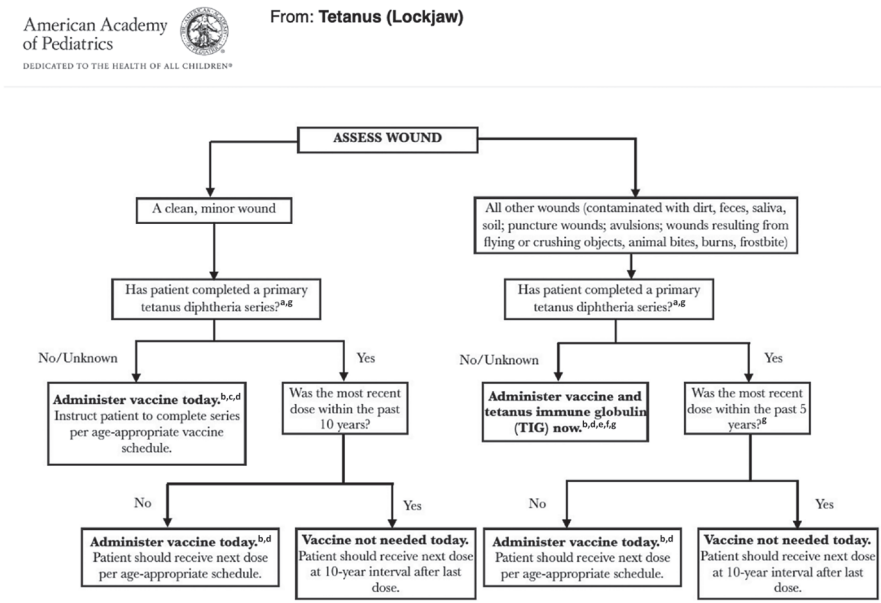


Fig. 7. Tetanus prophylaxis recommendations. [a]A primary series consists of a minimum of 3 doses of tetanus-containing and diphtheria-containing vaccine (DTaP/DTP/Tdap/DT/Td). [b]Age-appropriate vaccine:DTaP for infants and children aged 6 weeks up to 7 years. Tetanus-diphtheria (Td) toxoid for persons aged 7 through 9 years and 65 years and older. Tdap for persons aged 11 through 64 years if using Adacel* or 10 years and older if using Boostrix*, unless the person has received a prior dose of Tdap.* [c]No vaccine or TIG is recommended for infants aged younger than 6 weeks with clean, minor wounds. (And no vaccine is licensed for infants aged younger than 6 weeks.) [d]Tdap* is preferred for persons aged 11 through 64 years if using Adacel* or 10 years and older if using Boostrix* who have never received Tdap. Td is preferred to tetanus toxoid (TT) for persons aged 7 through 9 years, 65 years and older, or who have received a Tdap previously. If TT is administered, an adsorbed TT product is preferred to fluid TT. (All DTaP/DTP/Tdap/Td products contain adsorbed TT.) [e]Give TIG 250 U IM for all ages. It can and should be given simultaneously with the tetanus-containing vaccine. [f]For infants aged younger than 6 weeks, TIG (without vaccine) is recommended for "dirty" wounds (wounds other than clean, minor). [g]Persons who are human immunodeficiency virus positive should receive TIG regardless of tetanus immunization history. *Brand names are used for the purpose of clarifying product characteristics and are not an endorsement of either product. Tdap vaccines:Boostrix (GSK) is licensed for persons aged 10 years and older. Adacel (Sanofi) is licensed for persons aged 11 through 64 years. (Summary Guide to Tetanus Prophylaxis in Routine Wound Management, Minnesota Department of Health. Retrieved from: https://www.health.state.mn.us/diseases/tetanus/hcp/tetwdmgmt.html.)

Pain management. Early and continuous pain assessment is imperative for patients presenting to the ED with burns.[75] Burns can be incredibly painful, and untreated pain leads to an increased state of stress, anxiety, and fear.[76] Additionally, anxiety leads to a lowered threshold for pain.[77,78] Sadly, many patients do not receive adequate pain control during their prehospital and hospital care.[77,79,80] Although it is difficult for some young children to communicate their level of pain due to their developmental level, there are various pediatric pain assessment tools designed to evaluate a child's level of pain in an age-appropriate manner (**Fig. 8**).[76,81] Children presenting with burns should receive prompt interventions for pain relief. Oral

Fig. 8. The Wong Baker FACES pain scale is a commonly used pain scale for pediatric patients. (*From:* Wong-Baker FACES Foundation (2022). Wong-Baker FACES Pain Rating Scale. Retrieved [Date] with permission from http://www.WongBakerFACES.org. Originally published in Whaley & Wong's Nursing Care of Infants and Children. © Elsevier Inc.)

nonsteroidal anti-inflammatory drugs or acetaminophen may provide sufficient relief in cases of mild burns. More severe burns will likely require oral, intranasal, or IV opioids for optimal relief (**Table 3**).

It should be noted that fear and anxiety are difficult to distinguish from pain, particularly in the pediatric population.[82] Nonpharmacologic approaches, such as distraction, relaxation exercises, and virtual reality, can independently offer some relief and augment the effects of analgesic medications.[44,79,83] Child Life specialists can assist with nonpharmacologic approaches. Multimodal pain management—the use of multiple analgesic interventions to target different components of the pain pathway—should be considered when developing a plan for analgesia.[76]

In addition to the indisputable immediate short-term benefits of analgesia and anxiety reduction techniques, appropriate pain management supports the long-term well-being and recovery of a child.[76] Untreated and undertreated pain can have significant physical, emotional, and psychological consequences. Studies have shown the experience of being burned in childhood increases the risk of developing posttraumatic stress symptoms and posttraumatic stress disorder.[84] Untreated pain in childhood also leads to long-term changes to sensory and pain processing.[85]

Burn care. The goals of initial wound care in the ED are to minimize pain, curtail extension of the burn, and debride the wound without impeding future advanced wound care and management or inciting hypothermia. Younger children and children with higher %TBSA burns are more susceptible to hypothermia. Hypothermia is associated with increased risk of mortality and increased early sepsis.[86]

Cooling is an effective way to provide additional pain relief, reduce tissue damage, and promote wound healing.[75,79] Ice should not be used, as it can worsen tissue damage and hasten hypothermia.[44,75,76,83,87] In more extensive burns, the risk of hypothermia and delay in care may outweigh the benefits of cooling,[24] but in burns less than 5%TBSA, flushing the area with lukewarm tap water is the preferred cooling method and should be continued for 20 minutes or until pain relief is achieved.[24,87,88] The clinician should reassess the child's pain and administer appropriate analgesia, potentially including procedural sedation, before continuing to clean and debride the area.

If blisters are small (<1–2 cm), intact, and do not cross joints or otherwise limit activity, they do not require debridement. Thick-walled blisters of the palms and soles should also be left intact until consultation with a burn specialist.[89,90] In these cases, the intact blister minimizes potential contact with the injured dermis and exposed nerve endings, and subsequently helps reduce pain. The blister itself acts as a biological dressing and does not need to be covered with antibiotic ointment.[48] Larger partial

Table 3
Pediatric analgesia, anxiolysis, and sedation medications

	Route	Dose	Frequency	Comments
Nonopioid Analgesic Medications				
Acetaminophen	PO, IV, and PR	10–15 mg/kg	Every 4–6 h	Max dose 1000 mg
Ibuprofen	PO	10 mg/kg	Every 6 h	Max dose 600 mg
Ketorolac	IV	0.5 mg/kg	Every 6 h	
	IM	0.5 mg/kg	Every 6–8 h	
	PO	1 mg/kg	Every 4–6 h	Max dose 10 mg (40 mg/d)
Opioid Analgesic Medications				
Fentanyl	IN	1.5–2 mcg/kg	Every 1 h	≥10 kg, max dose 100 mcg/dose
	IV	0.5–1 mcg/kg	Every 1–2 h	Max dose 25–50 μg
Oxycodone	PO	0.1–0.2 mg/kg	Every 4–6 h	Max 5–10 mg every 4–6 h
	PO	0.025–0.05 mg/kg	Every 4–6 h	If ≤6 mo old
Morphine	PO	0.15–0.3 mg/kg	Every 3–4 h	If >50 kg, max 10–20 mg every 3–4 h
	PO	0.08–0.1 mg/kg	Every 3–4 h	If <6 mo
	IV	0.05–0.1 mg/kg	Every 2–4 h	If ≥50 kg, max 2–5 mg every 2–4 h
	IV	0.025–0.05 mg/kg	Every 2–4 h	If <6 mo
Sedation Medications				
Ketamine	IV	1–2 mg/kg	—	Infuse over 20–30 s
	IM	4–5 mg/kg		
Dexmedetomidine	IV	1–2 mg/kg	—	—
Propofol	IV	1–2 mg/kg	—	—

Abbreviations: IM, intramuscular; IN, intranasal; IV, intravenous; PO, oral; PR, per rectum.

thickness burns and blisters or bullae that have become unroofed should be debrided. The sloughing epidermis can be removed by wiping the area with gauze and sterile normal saline.[48] All loose or devitalized skin should be removed with tweezers, scissors, or friction. This dead skin serves as a medium for bacterial growth; its removal decreases potential bacterial load and controls the inflammatory response.[89]

Once the burn has been cleansed and debrided, the depth and extent of the burn should be reassessed for accuracy. Burns can continue to evolve with time, and areas that were initially concerning for superficial injuries may reveal extension to the dermis after the area is cleaned. The location and depth of the burn will contribute to the ultimate decision for wound dressing and ED disposition.[91] If a patient is being transferred to a burn center, simply covering the burns with gauze or a clean sheet is sufficient. The covering should be kept dry to prevent hypothermia during transport. It is not necessary to apply ointments or creams such as bacitracin or silver sulfadiazine to the wounds if the child is being transferred. In cases where the patient is not being transferred, silver-impregnated fabric and foam dressings can be used to cover the wound and should stay in place until the child is seen in follow-up clinic with their

pediatrician or, preferably, at a burn center. Silver sulfadiazine 1% cream is frequently used for deep-partial thickness and full thickness burns,[91,92] and these patients should have follow-up at a burn center.

DEFINITIVE MANAGEMENT OF BURNS

Burn Center Transfer Criteria

Once the patient has been stabilized in the ED, emergency clinicians must determine if the child can be discharged with outpatient follow-up or should be referred to a pediatric burn center for further evaluation. Children with small partial thickness burns can generally be discharged home from the ED with outpatient follow-up in a burn clinic for re-evaluation of wound healing. Those with larger, deeper, or more complicated burns should be transferred to a burn referral center. The American Burn Association publishes guidelines to aid in clinical decision-making, which are available at https://ameriburn.org/resources/burnreferral/ (see **Fig. 4**).[50] Broadly, all cases of inhalational injury, any full-thickness thermal burns or partial thickness thermal burns of greater than 10%TBSA, burns that could be complicated by their location, and burns associated with other injuries or medical complications should be transferred. Additionally, there are a few specific mechanisms of injury and anatomic areas that warrant special consideration and expert consultation.

SPECIAL CONSIDERATIONS

Treadmill Burns

Treadmill injuries have increased in frequency since the 1990s and primarily occur in children. They usually present as deep-partial and full thickness burns and most frequently occur on the upper extremities. Children are particularly susceptible, owing to their slow reflex time and thin skin. Children with treadmill injuries should be referred to a burn center as these injuries may ultimately require skin grafting.[93–95]

Chemical Burns

Most pediatric chemical burns occur in the home and involve accidental exposure to household items. Chemical burns can cause significant tissue damage, and the extent of injury depends on the chemical's properties, concentration, volume, and duration of contact with the skin.[96] These injuries often involve exposure of dermal or mucosal surfaces to acidic or alkaline agents.[48,96–98] Since the management of these injuries is specific to the type of agent involved, additional consultation with the local Poison Control Center (1-800-222-1222) should be considered for additional guidance on management.

Electrical Burns

Electrical burns are uncommon in children but can result in serious injuries with unique patterns.[24,99–102] Generally, electrical injuries and their management can be classified by whether the injury was the result of either a low-voltage or a high-voltage exposure.

Younger patients tend to sustain low-voltage electrical injuries after unintentional exposure to exposed wiring or as a consequence of biting on electrical cords (see **Fig. 2**).[101] These injuries result in oral mucosal burns that subsequently develop eschars, and these eschars have a high propensity for hemorrhage if debrided or when the scab separates 3 to 5 days after injury because of the circumoral artery's superficial location. These burns are often full thickness and require surgical evaluation.[24,101,102]

Older children and adolescents tend to experience high-voltage injuries from encounters with power lines, utility poles, and least frequently, lightning injuries.[101] While there may be minimal visible injury with high-voltage exposures, there can be serious deep tissue injury involving nerve and muscle damage with resultant rhabdomyolysis, cardiac arrhythmias, or altered mental status. These children should be evaluated with an electrocardiogram for cardiac injury, creatine kinase for muscle breakdown, and creatinine for renal disease.[24,100,101] All high-voltage injuries (≥1000 V) and lightning injuries should be transferred to a burn center for further evaluation and management.[24]

Anatomic Areas with Increased Associated Risks

The hands and fingers are the most frequent site of pediatric burns, accounting for over one-third of all burns.[1] Consultation with a burn specialist is recommended for palmar burns and burns crossing flexion joints of the fingers. Optimal healing is essential given the critical function of these areas.[11,103,104] Superficial burns of the palm usually heal well with daily cleansing, bismuth-impregnated petroleum gauze, or antimicrobial dressings.[11,105] Deep burns of the hands, however, should be closely monitored and may require skin grafting.[106–109] Similarly, burn injuries involving the feet require special consideration to optimize healing and minimize functional impairment.[110]

Head, neck, and facial burns also require special consideration. After hand injuries, this region is the second most commonly burned area, accounting for approximately 20% of pediatric burns. Chemical burns are 5.6 times more likely to occur in this area than in other areas of the body.[1] Burns to the head and face region warrant special attention because of the potential associated airway, ocular, and ear involvement. In addition to the potential for respiratory tract injury, there can be significant associated edema.[24] Subcutaneous and soft tissue edema may be rapidly progressive, leading to airway compromise as previously described.[43] The eyes and ears should be assessed before this quickly developing swelling makes examination, including evaluation for corneal injuries and tympanic membrane injuries, difficult.[24] The ears are also susceptible to cartilaginous injury due to the small amount of subcutaneous tissue present.

Special consideration should also be given to burns crossing joint lines. Contractures and pathologic scarring are a significant source of postburn morbidity, and approximately 25% of children with major burn injuries develop contractures at the time of hospital discharge. Unfortunately, contractures may occur despite early preventative interventions such as physical therapy and occupational therapy. Pediatric contractures occur most frequently in the shoulder and elbow followed but the wrist, knee, and ankle.[111,112]

Circumferential burns are associated with an increased risk of compromised vascular flow due to subsequent eschar formation. If vascular flow is compromised, which is signaled by absent or weakened Doppler signals in the extremity, escharotomy may be indicated. Alternatively, compartment syndrome may develop as a result of increased edema within the fascia and may be precipitated by copious fluid resuscitation, deep tissue damage from electrical injury, or delayed escharotomy. It should be noted that compartment syndrome, which is diagnosed with compartment pressure measurements, can also develop in areas without burns. Fasciotomy may be required for the management of compartment syndrome, but most cases of decreased vascular flow resolve with escharotomy alone.[24]

NONACCIDENTAL TRAUMA

The incidence of nonaccidental trauma for children presenting with burns is 9.7%,[113] and it is estimated that up to 20% of pediatric burns are related to abuse. The

likelihood of death because of burn injuries can be up to 4 times higher among those with suspected abuse.[103–105,113–115] Clinicians should have a high index of suspicion for abuse if injuries are extensive, the mechanism is unexplained, or the mechanism is inconsistent with the child's developmental level.[113] Unintentional burn injuries may also be associated with inappropriate supervision or neglect. Emergency department medical staff are mandated reporters, and if there is suspicion for abusive injuries or neglect, social work and child protective services should be consulted.

Scald burns are the most common nonaccidental burn in children and are often the result of forced submersion.[113–115] Burns that spare areas of flexion, involve bilateral lower extremities, and/or demonstrate sharply demarcated edges are suggestive of this mechanism. The buttocks may be spared with sharply demarcated borders as a result of direct contact with the bottom of the bathtub preventing contact between the skin and hot water. A "stocking and glove" distribution, where injuries are isolated to the hands and/or feet, also suggests that the child's extremities were forcefully held underwater, as the natural reflex to encountering hot water would create an irregular border. Deeper scald burns should also increase concern for abuse. A delay in presentation, lack of first aid, and inconsistent history also suggest abuse and/or neglect.[11,103–105,113,116] **Table 4** lists historical features and physical examination findings that should raise suspicion for potential abuse or neglect.

ANTICIPATORY GUIDANCE

The time to a recovery after a burn depends largely on the depth of the burn.[11,117] Superficial burns typically resolve after 4 to 5 days, while superficial-partial thickness burns can take 1 to 2 weeks to fully heal. Deep-partial thickness burns typically take longer than 2 weeks to heal, and full thickness burns may take weeks or months to heal.[15,17,117]

The degree of scarring associated with burn injury also largely depends on the depth of the burn.[112,118] Typically, superficial burns will not scar, and for deeper burns, the risk for scarring increases with depth. Deep-partial thickness burns are usually associated with some degree of scarring, and full thickness burns will almost certainly involve a significant scar. Hypertrophic scarring is a serious complication of burn injury,[112] with the prevalence ranging from 8% to 67% in adult patients. A portion of these patients requires reconstructive surgery. Surgical excision and laser therapy can be used in the management of pediatric hypertrophic scarring.[112,117]

Table 4
Characteristics of burns associated with abuse or neglect

Historical Features	Physical Examination Findings
Age <4 years old	Patterned injuries (eg, cigarette and iron)
Lack of explanation for injury	Stocking/glove distribution
Inconsistent explanation for injury	Sharply demarcated borders
Mechanism inconsistent with developmental stage	Injuries sparing the buttocks or flexion creases
Delayed presentation for medical care	Bilateral lower extremity involvement
Chronic medical conditions or developmental delay	Deeper burns
	Symmetric distribution of injuries

A source of discomfort for children after the ED evaluation is the pruritus that often occurs after burn injuries. It is an effect of the re-epithelialization associated with healing.[119] Pruritus can also occur after scar formation. In addition to the discomfort associated with pruritis, the scratching associated with pruritis can prolong the healing process.[120] Although there is limited evidence for interventions to address burn-associated pruritis in adults, oral antihistamines and analgesic creams such as lidocaine have been used for symptomatic relief of pruritus in the pediatric population.[119–121]

SUMMARY

Burn injuries are a common cause of morbidity and mortality in the pediatric population. All children presenting to the ED with burns should be promptly assessed for injury type and extent of injury. During the initial assessment, special attention should be paid to airway assessment, accurate classification of the extent of the injury and %TBSA, and prevention of hypothermia. Adequate pain control should be prioritized, and children with greater than 20% TBSA involvement should have prompt fluid resuscitation. Following stabilization, patients meeting criteria should be promptly transferred to regional pediatric burn center.

CLINICS CARE POINTS

- The initial evaluation of children with burn injuries should prioritize airway assessment and adequate pain control.
- The extent of pediatric burn injuries (depth and %TBSA) should be assessed using an age-appropriate estimation tool.
- Although most children with burn injuries do not require tranfer to a burn center, children with extensive injuries, potential airway compromise, and/or complicated burn injuries should be medically stabilized and transfered to a pediatric burn center.

DISCLOSURE

The authors have nothing to disclose.

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