**Chapter 33  
Thermal and chemical burns**

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**Introduction**

A contemporary understanding of burn injuries is essential for all out-of-hospital providers. Burn injuries carry high morbidity and mortality, resulting in severe pain, scarring, and permanent disability. Additionally, specialized resources such as burn centers are required for care and recovery.

Deaths from fires and burns are the third leading cause of fatal home injury. The US burn mortality rate ranks eighth among the 25 developed countries [1]. According to the American Burn Association National Burn Repository 2012 statistics, over 450,000 victims received medical treatment for burns in the US in the last decade [1]. The majority of these burns result from fire and/or flame injuries and contact with hot objects. Chemical burns account for approximately 3% of burns and 7% of burn admissions annually. Approximately 3,400 deaths occurred (most from smoke inhalation), including 2,550 deaths from residential fires (most from cooking), 300 from vehicle crash fires, and 550 from other sources (approximately 150 deaths from flame burns or smoke inhalation in non-residential fires, 400 from contact with electricity, scalding liquids, or hot objects). Although the number of fatalities and injuries from residential fires has declined gradually, many residential fire-related deaths remain preventable and pose a significant public health problem. Over 60% of US acute burn hospitalizations were admitted to 127 burn centers [1]. Such centers each average over 200 annual admissions for burn injury and skin disorders requiring similar treatment. The other 4,500 US acute care hospitals average fewer than three burn admissions each per year [1–4]. Fire and burn injuries represent 1% of the incidence of injuries and 2% of the total costs of injuries, or $7.5 billion each year [5]. Risk factors for burn injuries include extreme age groups (<4 years and >65 years), poverty, African and Native American descent, and rural area dwellers.

**Pathophysiology**

Most adults have sustained burns during their lives. The skin is the largest organ in the body and serves as a barrier to outside insults and injuries. The skin protects against water loss, entrance of undesirable substances (microorganisms, toxins), mechanical shock and forces, extreme environmental temperatures, and ultraviolet light damage to keratin and melanin. Furthermore, the skin is involved in sensory perception, temperature regulation, and biochemical activities (e.g. vitamin D synthesis).

The skin is made up of three basic layers. The outer layer, the epidermis, is the thin outer layer of the skin which consists of the stratum corneum containing fully mature keratinocytes which produce fibrous proteins (keratins) that are continuously shed (prevents the entry of most foreign substances as well as the loss of fluid from the body), the keratinocyte layer containing living keratinocytes (squamous cells), and the basal layer, the deepest layer of the epidermis, containing basal cells (continually dividing and forming new keratinocytes). The middle layer of the skin, the dermis, contains blood vessels, lymph vessels, hair follicles, sweat glands, fibroblasts, and nerves. The dermis is held together by collagen, made by fibroblasts, and gives skin flexibility and strength. The dermis also contains pain and touch receptors. The subcutis is the deepest layer of skin and consists of a network of collagen and fat cells that aid in conserving the body's heat and protect the body from injury by acting as a “shock absorber.”

**Severity**

Accurate assessment of the burn patient and appropriate institution of early care are critical to optimal outcomes. Although burn size and depth are obvious factors in determining burn severity, the location (body part) of the burn, age of the patient, preexisting disease, and presence of trauma, including inhalation injury, may complicate treatment. Specific anatomical locations of burns often result in significant morbidity and mortality disproportionate to burn size (i.e. head, neck, hands, feet, perineum, and genitalia).

Furthermore, patients <2 years or >50 years old are at higher risk of complications and death than the remaining population [1]. In infants, thin skin, limited reserves, and high surface area-to-mass ratios contribute to this risk, whereas thinning skin and medical problems commonly associated with aging are major factors in older individuals. Young children are also at risk for burns caused by abuse. These injuries are most often scald burns from tap water, are deeper than those seen in the general pediatric burn population, and commonly involve the lower extremities, buttocks, and genitalia. Pediatric and elderly burns may often be an initial presentation of abuse and should be considered in the differential diagnosis.

There are several ways to classify burns (depth, severity, and surface area).

**Depth**

Burn depth is a product of temperature, duration of exposure, and skin thickness, with depth being described in its relationship to total skin thickness. Most burns have areas that are of mixed depth, with deeper burns often occurring in areas of thinner skin. The older classification of describing “degrees” of burn is not often used any more. Rather, the American Burn Association now uses the total body surface area and the severity (partial verses full thickness) of injury as a modern descriptor ([Tables 33.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-tbl-0001), [33.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-tbl-0002)). The old descriptive terms are paired with the newer classification system in order to understand the changes.

[**Table 33.1**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#R_c33-tbl-0001) Classification of burns based on depth

Source: Data from US Army Institute of Surgical Research.

| **Classification** | **Cause** | **Appearance** | **Sensation** | **Healing time** | **Scarring** |
| --- | --- | --- | --- | --- | --- |
| Superficial burn | Ultraviolet light, very short flash (flame exposure) | Dry and red; blanches with pressure | Painful | 3–6 days | None |
| Superficial partial-thickness burn | Scald (spill or splash), short flash | Blisters; moist, red and weeping; blanches with pressure | Painful to air and temperature | 7–20 days | Unusual; potential pigmentary changes |
| Deep partial-thickness burn | Scald (spill), flame, oil, grease | Blisters (easily unroofed); wet or waxy dry; variable color (patchy to cheesy white to red); does not blanch with pressure | Perceptive of pressure only | More than 21 days | Severe (hypertrophic) risk of contracture |
| Full-thickness burn | Scald (immersion), flame, steam, oil, grease, chemical, high-voltage electricity | Waxy white to leathery gray to charred and black; dry and inelastic; does not blanch with pressure | Deep pressure only | Never (if the burn affects more than 2% of the total surface area of the body) | Very severe risk of contracture |

[**Table 33.2**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#R_c33-tbl-0002) American Burn Association classification of burns by total body surface area (TBSA)

Source: Data from US Army Institute of Surgical Research and American Burn Association.

| **Type of burn** | **Minor** | **Moderate** | **Major** |
| --- | --- | --- | --- |
| Criteria | <10% TBSA burn in adult | 10–20% TBSA burn in adult | >20% TBSA burn in adult |
| <5% TBSA burn in young or old | 5–10% TBSA burn in young or old | > 10% TBSA burn in young or old |
| <2% full-thickness burn | 2–5% full-thickness burn | > 5% full-thickness burn |
| High-voltage injury | High-voltage burn |
| Suspected inhalation injury | Known inhalation injury Any significant |
| Circumferential burn | burn to face, eyes, ears, genitalia or joints |
| Concomitant medical problem predisposing the patient to infection (e.g. diabetes, sickle cell disease) | Significant associated injuries (e.g. fracture, other major trauma) |
| Disposition | Outpatient management | Hospital admission | Referral to burn center |

First-degree (superficial) burn injuries involve only the epidermis or topmost layer of skin and are recognized by their erythematous appearance and lack of blisters or skin separation. The classic first-degree injury is the sunburn or superficial scald burn from spills. These burns usually have morbidity restricted only to pain, and are therefore not classified into burn size.

Second-degree (superficial or deep partial thickness) burn injuries involve the epidermis and part way through the dermis. Epithelial elements remain in the undestroyed dermal appendages and spontaneous healing usually occurs in 7–28 days. Second-degree burns are very painful and are usually blistered.

Third-degree (full-thickness) burn injuries are those that extend through the dermis, destroying all epidermal and dermal elements. They may initially have blisters containing hemorrhagic fluid and/or dead tissue (eschar). The presence or absence of pain is an unreliable indicator of depth and severity.

**Burn size**

Accurate initial assessment of burn size is essential for optimal patient care. Burn size is expressed as total body surface area (TBSA) or body surface area (BSA), where approximately 1% of a patient’s surface area is equal to the palmar surface of the patient’s hand with the fingers closed. This measurement is most useful for small (<5% TBSA) or spotty burns. For larger areas, the rule of nines ([Figure 33.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fig-0001)) for adults provides a simple and rapid estimation of burn size in the adult.

[**Figure 33.1**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#R_c33-fig-0001) Rule of nines.

Source: *Dorland's Illustrated Medical Dictionary*, 32nd edn. Philadelphia: Elsevier Saunders, 2011. Reproduced with permission of Elsevier.

When calculating burn size using any method, first-degree burns are not counted and only the proportion of area with at least a partial-thickness burn is calculated. Thus, for an upper extremity to be considered 9% TBSA, the entire extremity from the shoulder to the finger tips must be burned at least to the blistering level. If only the posterior half of the upper extremity is burned, then burn size is considered to be 4.5% TBSA.

Calculating pediatric burns is often challenging and can be inaccurate if the provider is not appropriately trained. The rule of nines (see [Figure 33.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fig-0001)) has also been used for pediatric patients. However, the Lund and Browder classification can also be used to more precisely calculate the percentage of BSA burned by mapping the injured areas of the body on charts detailing age-appropriate measurements. This method identifies the different body proportions according to the age of the patient (with children having larger heads and smaller lower extremities than adults) and through dividing the body into smaller units, such as dividing the upper extremity into the upper arm, lower arm, and hand. Computer programs are now being used to estimate surface area calculations.

**Inhalation injury**

Inhalation injury is a complex set of pathophysiological reactions that occur from exposure to smoke and/or chemical products. Systemic and respiratory damage can result in significant morbidity and mortality as well as permanent dysfunction [6,7]. When combined with thermal injury, inhalation injury increases pulmonary compliance and fluid requirements, and doubles mortality. Technically, injury is a misnomer, and inhalation injury is really the result of fluid shifts caused by external burns. These conditions do not necessarily imply pulmonary injury, because they also occur with scald and chemical burns. Edema formation in the posterior pharynx and glottic and subglottic areas associated with deep burns of the upper chest, neck, and lower face has the potential to occlude the upper airway. Tachypnea and stridor are often late signs and when absent are unreliable in ruling out airway injury.

Airway injury is diagnosed by fiberoptic bronchoscopy [8]. Early grading of inhalation injury severity is often inaccurate. The injury is basically a chemical burn from which resulting edema of the small airways creates distal microatelectasis and a clinical picture identical to acute respiratory distress syndrome. Lower airway or “smoke inhalation” injury is caused by the patient inhaling the products of combustion, often as a result of being in a confined space. Specific injuries resulting from specific toxins, cyanide and carbon monoxide, are discussed elsewhere in this text.

**Chemical burn**

A caustic or corrosive agent is a chemical capable of causing tissue and mucous membrane injury upon contact. These agents are generally made up of extreme pH values (<3 or >11). The American Burn Association National Burn Repository reported in 2012 that over a 10-year period, chemicals represented 3.3% of all burns in the US [1]. The majority of these burns resulted from accidental exposure at work. Chemical burns have higher complication rates in the very young and old populations with the most common complications being cellulitis, pneumonia, and respiratory failure. Common household and industrial products that result in burns include hydrochloric acid, potassium hydroxide, sodium hydroxide, sulfuric and phosphoric acids, and many others. Hydrofluoric acid (HF) is a weak acid and requires special consideration and specific antidotes that are addressed in Volume 1, [Chapter 46](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c46.xhtml). Although the most commonly affected body areas are the face, eyes, and extremities, almost all fatalities are as a result of ingestion [9].

## Specific training requirements

The central concepts for prehospital providers and EMS physicians caring for burn patients include the following.

1. Thorough training on a consistent, organized patient assessment algorithm that can be applied to all burn patients, regardless of injury severity, is foundational. It should provide hierarchical management that focuses on life threats, yet incorporates full, sequenced evaluation and integrated management options for actual and potential injuries. Frequent reassessments and ability to integrate information and recognize trends that require urgent intervention are essential.
2. Efficient, appropriate use of local resources (air evacuation, hazardous materials teams, specialized rescue units), and knowledge of hospital capabilities and destination policies (e.g. specialty burn care center) can improve patient outcomes in patients with significant injuries where time is of the essence. EMS systems should have policies and procedures to identify such patients and promote primary transport to the appropriate facility when available. This concept, pioneered by trauma systems, is now being extended effectively to non-trauma disease processes (see Volume 1, [Chapter 26](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c26.xhtml) and [39](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c39.xhtml)).
3. Proper use of spinal motion restriction, splinting, fluid resuscitation, and pain management to limit additional morbidity. Knowing how and when to properly use infrequent invasive procedures such as cricothyrotomy, needle thoracostomy, and escharotomy is essential for patient safety and care.
4. Recognition of a chemical exposure and proper use of protective equipment is essential in limiting exposure to bystander and health care personnel.

## Burn-specific patient assessment and care

The mechanism of injury, while not entirely predictive of actual injury sustained, often alerts the astute clinician to potential injuries that may be encountered during the assessment and management of burn patients. The importance of integration of local EMS and hospital resources, and tailoring guidelines to optimize patient care within these parameters, cannot be overemphasized. Newer telemedicine applications that allow concurrent assessment by EMS and receiving emergency physicians may facilitate triage and continuity of and expedited care at the receiving facility for a number of time-sensitive medical complaints, certainly including burn injuries.

Burn management differs significantly from routine trauma care. Traumatic injuries occur in 5–15% of admitted burn patients [1]. Evaluation and treatment of traumatic injuries take precedence over treatment of the burn, with the caveat that maintenance of body temperature, airway protection, and appropriate burn fluid resuscitation must be achieved.

Distance to the destination burn or trauma center should influence the plan for airway management. If transport time is short (e.g. <10 minutes) and if able to achieve adequate oxygenation and ventilation with basic measures such as a face mask or bag-valve-mask ventilation, time should generally not be taken at the scene for endotracheal intubation (ETI), including pharmacologically assisted intubation. However, in patients with suspected inhalation injury or impending obstruction, prehospital personnel should consider immediate ETI. ETI can be particularly challenging in the burn victim due to altered mental status and/or combativeness, airway secretions or debris, and potential swelling and distortion of anatomy.

The EMS provider must decide if the delay in transport due to placing an advanced airway in a specific patient and situation is clinically beneficial, specifically if it outweighs the potential risk to the patient from either deterioration due to the injuries or due to secondary complications that could occur if the airway cannot be secured in a timely manner [10]. While orotracheal intubation is the preferred route, edema and debris in a burn patient’s airway may require a cricothyrotomy to be performed as a last resort. Training EMS personnel in alternative airway techniques may be extremely useful for complicated airway management [11].

Secure the tube with cotton umbilical ribbon. Do not use adhesive tape on the endotracheal tube or any other important device or tube in the burn patient. The patient will become very edematous, the skin will fall off, and the endotracheal tube will fall out if secured only with tape. If this happens, it is very difficult to reestablish the airway due to extensive airway edema. If the patient is not intubated, closely observe for early indicators of impending airway obstruction such as facial or tongue swelling or hoarseness, and intubate the patient if these signs appear.

Careful monitoring of respiratory parameters including pulse oximetry, end-tidal carbon dioxide, ventilatory compliance, and circulation will provide trending that can alert the provider to developing complications in a critical patient [10]. High-flow oxygen should be used in all patients who show signs of respiratory distress and/or hypoxia. Beta-agonists have been used in cases of inhalation injury resulting in increased oxygen delivery and decreased bronchospasm [7]. Outcome prediction metrics based on currently available high-level non-invasive monitoring may help refine destination choices and in-hospital trauma management. Burn eschar on the chest may interfere with ventilation and if this is the case, chest escharotomy should be performed during this assessment.

Those with burn injuries have higher fluid requirements than other trauma patients [7,8,12]. However, prehospital personnel must avoid excessive fluid resuscitation that could paradoxically lead to worsening hemorrhage and/or pulmonary function. Fluid resuscitation is the cornerstone of early burn care. The microvascular structures beneath a burn wound develop increased permeability immediately after injury, resulting in capillary leakage. Capillary leak is roughly proportional to burn size and becomes hemodynamically significant in burns larger than 20% TBSA (10% TBSA in young children or elderly patients). The objective of resuscitation is to replace lost intravascular fluid with the minimal amount of fluid required to maintain normal bodily function [12].

Guidelines in the current literature instruct providers to calculate predicted 24-hour fluid requirements and initial fluid rate based on formulas ([Box 33.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fea-0001)) [12]. Although there are multiple formulas for predicting the first 24 hours of fluid required in burn patients, two of the most advocated formulas are as follows.

* **Modified Brooke**. Initial 24 hours: no colloids. Ringer’s lactated (RL) solution 2 mL/kg/% burn in adults and 3 mL/kg/% burn in children.
* **Parkland Formula**. Initial 24 hours: RL solution 4 mL/kg/% burn for adults and 3 mL/kg/% burn for children. RL solution is added for maintenance for children:
  + 4 mL/kg/hour for children weighing 0–10 kg
  + 40 mL/hour + 2 mL/hour for children weighing 10–20 kg
  + 60 mL/hour + 1 mL/kg/hour for children weighing 20 kg or higher.

## Box 33.1 Basic fluid guidelines for burn injuries

* Fluid guidelines should be used in all adults and children with burns >20% total body surface area (TBSA)
* Common formulas used to initiate resuscitation estimate a crystalloid need for 2–4 mL/kg body weight/% TBSA during the first 24 hours
* Fluid resuscitation, regardless of solution type or estimated need, should be titrated to maintain a urine output of approximately 0.5–1.0 mL/kg/hour in adults and 1.0–1.5 mL/kg/hour in children
* Maintenance fluids should be administered to children in addition to their calculated fluid requirements caused by injury
* Increased volume requirements can be anticipated in patients with full-thickness injuries, inhalation injury, and a delay in resuscitation

Source: Data from US Army Institute of Surgical Research.

A randomized study of adult, military burn patients comparing these two formulas demonstrated that the modified Brooke formula was successful in lowering fluid requirements without increased mortality [12]. Another burn formula to simplify fluid delivery was also advocated in prehospital patients, labeled “the rule of 10 [13].”

* Estimate burn size (using the rule of nines) to the nearest 10% TBSA.
* Multiply that by 10 to calculate the initial fluid rate for patients weighing 40–80 kg.
* Increase fluid rate by 100 cc/hour for every 10 kg of body weight above 80 kg.

Underresuscitation may result in renal failure, hypotension, and multiple organ dysfunction, whereas overresuscitation results in pulmonary and cardiac overload and excessive edema formation [7,9]. The extremes of age are especially sensitive to misestimation of fluid needs. Resuscitation requires an accurate estimation of the time of burn, burn size, and measurement of patient weight. Factors that increase fluid requirements include inhalation injury, late initiation of resuscitation, deep burns, acute intoxication, and preexisting malnutrition [1].

All burn formulas are only starting points in resuscitation. Individual changes to fluid administration rates must be made hourly (or half-hourly in infants and small children) based on urine output and vital signs. The best formula is the one used by the burn center to which the patient is being transferred [13].

Regardless of the type and volume of fluid used in resuscitation of burn patients, awareness and prevention of hypothermia are essential in maintaining circulation. Hypothermia increases burn mortality. Administration of significant volumes of IV fluids at or below room temperature can exacerbate the problem. Preventing heat loss and providing warm fluids to a patient in need of volume resuscitation or rewarming can diminish this potential effect [14–16]. Several commercially available fluid warmers have been studied [17].

All wounds should be exposed for evaluation. In patients with extensive burns, overlying clothes and jewelry should be removed. These items may have melted onto the skin. If this is the case, the burn team may need to excise these items along with the burned skin. Jewelry may have to be cut off with wire cutters or similar devices. Decontamination from toxins and chemicals should also begin during this phase of assessment. Saturated clothing should be removed, powdered chemicals should be brushed off the skin, and the contaminated area(s) irrigated with copious amounts of water until the patient experiences a decrease in pain in the wound. The use of neutralizing solutions in treatment of chemical burns is not routinely recommended except for burns involving hydrogen fluoride. However, control of amount of strong neutralizing solution is the key difficulty. Chemical injuries to the eye are treated by forcing the eyelid open and flushing the eye with water or saline.

## Special considerations

### Compartment syndrome

Formation of edema beneath full-thickness (usually circumferential) burn eschar has the potential to occlude arterial inflow to the extremity or restrict chest motion and hence ventilation, resulting in respiratory failure [18]. If available, Doppler signals should be followed; if not, check pulses, skin temperature, and capillary refill at regular intervals. Diminution of the signal or a change in its character may suggest compartment syndrome. Patients receiving massive amounts of fluid may also develop compartment syndrome. This results from an increase in the tissue pressure of an inexpansible compartment of the body. If compartment syndrome is suspected, decompression of the involved compartments with appropriate escharotomy and fasciotomy is indicated as soon as possible [18]. Treatment with escharotomy may be performed in the prehospital setting with either local anesthesia or conscious sedation. Incisions are placed midaxially on the medial and lateral portions of affected extremities and on the midaxillary lines of the trunk connected by an inverted “V” (chevron) incision along the costal margins ([Figure 33.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fig-0002)). Escharotomies of the fingers are seldom, if ever, required.

[**Figure 33.2**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#R_c33-fig-0002) Location of escharotomy incisions.

Source: US Army Institute of Surgical Research. Reproduced with permission.

### Pain management

The prehospital environment exacerbates the typical challenges found in treatment of acute pain and has the additional obstacles of a lack of supplies and equipment, delayed or prolonged evacuation times and distances, devastating injuries, provider inexperience, and dangerous tactical situations [19,20]. Studies have shown an increase in the incidence of chronic pain and posttraumatic stress disorder (PTSD) with failure to recognize and treat acute pain appropriately, as well as a reduction in PTSD incidence when pain is adequately managed, particularly with early use of ketamine [21,22].

### Hydrofluoric acid burn

Hydrofluoric acid is an aqueous solution of the inorganic acid of elemental fluorine and will dissolve anything that has glass or silica content. HF and related products may cause dermal, ocular, pulmonary, gastrointestinal, and systemic injury [1]. When in contact with skin, HF dissociates into hydrogen ions and free fluoride ions. There may be a latent period before a clinically evident burn is apparent, dependent on the concentration of the acid and the length of time it is in contact with the skin. Fluoride ions penetrate tissues deeply, causing tissue damage and the potential for systemic toxicity depending on the HF concentration. In general, exposure to HF solutions of greater than 50% concentration results in immediate pain and tissue destruction. The skin appears blanched, and within 1–2 hours the dermal lines are obliterated by edema. Dermal contact with concentrations of 20–50% HF usually results in burns that develop within a few hours [8,23].

Concentrations greater than 20% HF have a potential for serious toxicity regardless of the degree of surface area involved [23]. Contact with solutions of less than 20% HF concentration results in dermal injury that usually develops within about 24 hours [24]. The clinical presentation of exposure to strong HF solutions of greater than 20% begins with pain at the site that is characteristically intense [24] and often described by patients as “burning,” “deep,” “throbbing,” or “exquisite.” Local erythema and edema may or may not be present initially, but later a pale, blanched appearance of the skin is apparent in more severe burns from concentrated HF (e.g. >50%) [8,23,24]. Extensive bullae and maceration of tissue may be seen. Gray areas may develop and progress to frank necrosis and deep ulceration within 6–24 hours.

## Guidelines for out-of-hospital management

Guidelines for management of the burn patient should be focused on providing necessary interventions, together with rapid transport to the closest appropriate facility Triage guidelines should also address burn/trauma patients who need different types of specialty care by identifying regional facilities with special capabilities such as pediatric trauma, burn care, hyperbaric therapy, and extremity replantation. Scene time should not be delayed while the provider waits for direct medical oversight. Patient outcomes are significantly better at burn centers than non-burn centers [25]. Burn centers have teams of professionals dedicated to optimal burn care. The American Burn Association has established criteria for transfer of a patient to one of these centers ([Box 33.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fea-0002)).

## Box 33.2 American Burn Association burn center referral criteria

1. Partial thickness burns >10% total body surface area
2. Burns that involve the face, hands, feet, genitalia, perineum, or major joints
3. Third-degree burns in any age group
4. Electrical burns, including lightning injury
5. Chemical burns
6. Inhalation injury
7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
8. Any patients with burns and concomitant trauma, in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit
9. Burned children in hospitals without qualified personnel or equipment for the care of children
10. Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention

Source: Adapted from *Guidelines for the Operation of Burn Centers*. *Resources for Optimal Care of the Injured Patient*. Chicago: Committee on Trauma, American College of Surgeons, 2006, pp.79–86.

### Requirements for transfer

Patients with major burns (>20% TBSA) require IV access, preferably two large-bore peripheral lines. Catheters may be placed through the burned tissue. Central venous access should be avoided because of its high complication rate in the early postburn period when vasospasm, low flow, and a hypercoagulable state contribute to complications. A urinary catheter and a nasogastric tube are recommended for long or delayed transport. Use of ice on a burn wound is absolutely contraindicated because of the risk of a cold injury superposed on the burn. Continual efforts must be made to keep the patient warm. No burn debridement is required before transfer, and the burns should be wrapped in dry sterile or clean sheets or burn-specific water-based gel dressings, and further covered with warm blankets.

**Prevention**

The prehospital environment offers a unique “teachable moment” for clinicians to educate patients and their families about preventing burns in the future. Prevention programs and safety legislation have made substantial contributions to decreasing the incidence and severity of burn injury, especially for parents and school-age children.

In addition, several initiatives are targeting vulnerable segments of the population for prevention efforts. Mothers with less than high school education who are younger than 20 years and have more than two children are at a much higher risk for fatal fire events [1]. Although prevention initiatives are reaching increasing numbers of people, there is still the need for further education of the public and in particular those subsegments of the population at high risk for burn injury. Specific preventive recommendations are listed in [Box 33.3](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c33.xhtml?favre=brett#c33-fea-0003).

**Box 33.3 Burn injury prevention**

|  |  |
| --- | --- |
| Flame burn prevention | Test smoke detectors regularly |
| Create an escape plan for the home, and practice it |
| Safety device around fireplace and stoves |
| Keep matches, lighters away from children |
| Scald prevention | Use splash guards on stove |
| Lower hot water heater maximum temperature to <54 °C |
| Use thermometer for bath water |

Source: Data from US Army Institute of Surgical Research.

**References**

1. 1 American Burn Association. 2012 National Burn Repository Report of Data from 2002–2011. Available at: [www.ameriburn.org/2012NBRAnnualReport.pdf](http://www.ameriburn.org/2012NBRAnnualReport.pdf)
2. 2 Ahrens M. *Home Structure Fires*. Quincy, MA: National Fire Protection Association, 2011.
3. 3 Karter MJ. *Fire Loss in the United States During 2010*. Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, 2011.
4. 4 Centers for Disease Control. *Fire Deaths and Injuries Fact Sheet*. Available at: [www.cdc.gov/homeandrecreationalsafety/fire-prevention/fires-factsheet.html](http://www.cdc.gov/homeandrecreationalsafety/fire-prevention/fires-factsheet.html)
5. 5 Corso P, Finkelstein E, Miller T, Fiebelkorn I, Zaloshnja E. Incidence and lifetime costs of injuries in the United States. *Inj Prev* 2006;12(4):212–18.
6. 6 Palmieri TL. Inhalation injury: research progress and needs. *J Burn Care Res* 2007;28:549–54.
7. 7 Colohan SM. Predicting prognosis in thermal burns with associated inhalational injury: a systematic review of prognostic factors in adult burn victims. *J Burn Care Res* 2010;31:529–39.
8. 8 Shirani KZ, Pruitt BA Jr, Mason AD Jr. The influence of inhalation injury and pneumonia on burn mortality. *Ann Surg* 1987;205:82–7.
9. 9 Stuke LE, Arnoldo BD, Hunt JL, Purdue GF. Hydrofluoric acid burns: a 15-year experience. *J Burn Care Res* 2008;29:893–6.
10. 10 Wang HE, Kupas DF, Hostler D, Cooney R, Yealy DM, Lave JR. Procedural experience with out-of-hospital endotracheal intubation. *Crit Care Med* 2005;33:1718–21.
11. 11 Kurola JO, Turunen MJ, Laakso J, et al. A comparison of the laryngeal tube and bag-valve mask ventilation by emergency medical technicians: a feasibility study in anesthetized patients. *Anesth Analg* 2005;101:1477–81.
12. 12 Chung KK, Wolf SE, Cancio LC, et al. Resuscitation of severely burned military casualties: fluid begets more fluid. *J Trauma* 2009;67:231–7.
13. 13 Chung KK, Salinas J, Renz EM, et al. Simple derivation of the initial fluid rate for the resuscitation of severely burned adult combat casualties: in silico validation of the rule of 10. *J Trauma* 2010;69:S49–54.
14. 14 Hildebrand F, Giannoudis PV, van Griensven M, Chawda M, Pape HC. Pathophysiologic changes and effects of hypothermia on outcome in elective surgery and trauma patients. *Am J Surg* 2004;187:363–71.
15. 15 Mizushima Y, Wang P, Cioffi WG, Bland KI, Chaudry IH. Should normothermia be restored and maintained during resuscitation after trauma and hemorrhage? *J Trauma* 2000;48:58–65.
16. 16 Segers MJ, Diephuis JC, van Kesteren RG, van der Werken C. Hypothermia in trauma patients. *Unfallchirurg* 1998;101(10):742–9.
17. 17 Dubick MA, Brooks DE, Macaitis JM, Bice TG, Moreau AR, Holcomb JB. Evaluation of commercially available fluid-warming devices for use in forward surgical and combat areas. *Mil Med* 2005;170:76–82.
18. 18 Kupas DF, Miller DD. Out-of-hospital chest escharotomy: a case series and procedure review. *Prehosp Emerg Care* 2010;14:349–54.
19. 19 Black I, McManus JG. Pain management in current combat operations. *Prehosp Emerg Care* 2009;13:223–7.
20. 20 Wedmore IS, Johnson T, Czarnik J, Hendrix S. Pain management in the wilderness and operational setting. *Emerg Med Clin North Am* 2005;23:585–601.
21. 21 Otis JD, Keane TM, Kerns RD. An examination of the relationship between chronic pain and post-traumatic stress disorder. *J Rehabil Res Dev* 2003;40:397–405.
22. 22 McGhee LL, Maani CV, Garza TH, Gaylord KM, Black IH. The correlation between ketamine and posttraumatic stress disorder in burned service members. *J Trauma* 2008;64:S195–8.
23. 23 Seyb ST, Noordhoek L, Botens S, Mani MM. A study to determine the efficacy of treatments for hydrofluoric acid burns. *J Burn Care Rehabil* 1995;16:253–7.
24. 24 Centers for Disease Control and Prevention. *Hydrogen Fluoride Systemic Agent*. Available at: [www.cdc.gov/niosh/ershdb/Emergency ResponseCard\_29750030.html](http://www.cdc.gov/niosh/ershdb/EmergencyResponseCard_29750030.html)
25. 25 Holmes JH 4th, Carter JE, Neff LP, et al. The effectiveness of regionalized burn care: an analysis of 6,873 burn admissions in North Carolina from 2000 to 2007. *J Am Coll Surg* 2011;212:487–93.