Thermal Burns: Rapid Assessment And Treatment

While the incidence of burns has steadily declined over the last few decades,1,2 thermal injuries are still responsible for nearly 12,000 deaths each year. They are also the second leading cause of accidental deaths, a mortality rate surpassed only by motor vehicle collisions. The number of productive years lost from burns is greater than that from cancer deaths each year. They are also the second leading cause of accidental burns.8 A recent report estimated that approximately 1.25 million people are treated in the multidisciplinary approach to the burned patient. Indeed, a review of 791 medical records of patients treated at three EDs in 1991 demonstrated that there was suboptimal documentation of diagnosis, treatment, and follow-up care of the thermally injured patients.7 This article will hopefully improve the situation. (Chemical burns and those resulting from electrical current are not addressed in depth.)

Epidemiology

Each year, approximately 1.0%-1.5% of the population sees a physician for a burn. A recent report estimated that approximately 1.25 million people are treated for burns in hospitals throughout the United States each year. This
includes over 50,000 hospitalizations and nearly 5,000 deaths. Of those hospitalized, three-quarters have burns involving less than 10% of the body surface area.4

While building fires are responsible for only 5% of all admissions, they are responsible for nearly half of burn fatalities.9 There are many causes of burns, including smoking, cooking, electrical sources, heating, and arson. In children, most burns are the result of scalds, whereas flammable liquids are responsible for more burns in adults and adolescents. Water at temperatures of 44°C (110°F) will not injure the skin until hours after contact, but water at 51°C (123°F) can burn in seconds. Water at 70°C (160°F) or greater can produce nearly instantaneous full-thickness burns.10 Immersion burns typically produce deeper injury, as the contact time is greater than with splash exposures.

Electric burns account for 10% of burn injuries.11 The resistance of body tissues to the flow of electrical current generates heat; temperature varies with amperage and duration of contact. Individual tissue susceptibility is an important aspect of electrical injury. The extent of electrical injury is often under-appreciated. A small entry or exit wound may hide devastating internal damage, especially to the muscles.

Mortality
Most fire-related deaths occur at home, and nearly half are in children.12 While the majority of burns occur in young adults, deaths are more common in the very young and old. In the past, hypovolemic shock was responsible for most deaths associated with major burns. Currently, smoke inhalation, which occurs in nearly 30% of all major burns, is the most common cause of early death. Wound infection, sepsis, and pneumonia cause most late deaths.12

Physicians have long known that the elderly are especially likely to die of burns. Geriatric burn mortality may be calculated by the Baux formula—age plus percent body surface area (BSA) burned equals mortality. The formula is less accurate at extremes of age, and a significant number of patients survive despite Baux scores greater than 100.13-15 However, when more than 70% of the body surface area is burned in an elderly patient, or if the Baux score is greater than 130, mortality is close to 100%.16

One large study used a multivariate analysis to predict burn outcome. The most important factor in predicting mortality was %TBSA burn (accuracy = 92.8%) or a combination of %TBSA burn and patient age (accuracy = 93.0%). While inhalation injury was significantly associated with mortality after thermal injury, it added little to the prediction of mortality using %TBSA and age alone.17

Another recent study identified three risk factors for death: age greater than 60 years, more than 40% of body-surface area burned, and inhalation injury. The mortality formula predicted 0.3%, 3%, 33%, or approximately 90% mortality, depending on whether zero, one, two, or three risk factors were present.18

Pathophysiology
Burns are dynamic injuries that result in both local and systemic effects. The extent of the initial injury depends on both the offending temperature and the duration of exposure.19 Cellular damage and protein denaturation usually occur with exposure to temperatures of 45°C and greater. Full-thickness injuries develop with prolonged exposures at temperatures greater than 55°C.

In his classic paper from 1953, Jackson noted that every burn wound consists of three distinct areas.20 The central “zone of coagulation” results from direct thermal injury at the time of exposure. Surrounding this area is a “zone of stasis” that demonstrates a prominent inflammatory response and vascular reactivity that reduces blood flow. This reduction in flow may extend and deepen the wound over the first 24-48 hours after injury. The third and outermost area of the burn is the “zone of hyperemia,” characterized by intense yet reversible vasodilatation and increased blood flow.

Thermal injuries trigger an intense local and systemic inflammatory response. Much burn research and many of the newest therapies focus on reducing this inflammatory response, intending to limit the progression of burns. Initial release of histamine with venodilatation is followed by release of bradykinin that results in arteriolar vasodilatation. Capillary permeability increases secondary to the direct thermal injury as well as the release of vasoactive substances. Thus fluids and proteins leak from the vascular spaces to the interstitial compartment.21 This massive “third spacing” can decrease cardiac output and cause hypovolemic shock if not treated by aggressive fluid replacement. Polymorphonuclear leukocytes (PMNs) adhere to the small vessel walls, leading to progressive vascular thrombosis and occlusion.22 This process may result from the up-regulation of the endothelial and leukocyte adhesion molecules ICAM 1 and CD18. Indeed, early treatment of burns with antibodies against these two adherent molecules prevents vascular occlusion and reduces the amount of subsequent necrosis in the area surrounding the central zone.23

Dying PMNs in the wound area release toxic oxygen radicals, which in turn cause peroxidation of cell membrane fatty acids.24 This is followed by the discharge of cytotoxic proteinases, such as thromboxane A2, from the cyclooxygenase pathway and leukotrienes from the lipoxygenase pathway. These compounds, found in great amounts within burned tissue, cause vasoconstriction and platelet aggregation, further reducing the microcirculatory blood flow in the wound.25 The thermal injury may also result in the release of a variety of cellular proteases that inactivate growth factors, which, in combination with bacterial proteinases, results in destruction of the newly formed tissues.

With major burns, the many inflammatory mediators cause multisystem organ failure, cardiovascular collapse, and disrupt gastrointestinal mucosal integrity. Antioxidants such as glutathione and xanthine oxidase inhibitors
as well as the free radical scavengers vitamin C and vitamin E have been used to treat burns in both animals and humans.\textsuperscript{26,27} Researchers have also used topical and systemic treatments using anti-inflammatory agents such as heparin, ibuprofen, and corticosteroids with variable success.\textsuperscript{22} Unfortunately, none of these treatments has resulted in consistent and clinically significant improvements in the outcome of either major or minor burns. Because a short course of ibuprofen is relatively benign, inexpensive, and useful for pain control as well, it is often prescribed or advised in burns. However, the empiric data is weak. At present, none of these interventions can be routinely recommended based upon available information.

“Some say the world will end in fire,
Some say in ice.
From what I’ve tasted of desire
I hold with those who favor fire.”

**Burn Classification**

One of the most important aspects of burn care is determination of the extent and depth of the injury, since these determine both subsequent management and prognosis. Classification of burns into minor and major injuries depends on their location as well as the depth and extent of injury.\textsuperscript{26} Patient age, the presence of associated trauma, and comorbid illnesses also contribute to burn severity. (See Table 1.)

**The Importance Of Burn Location**

Significant burns located on the hands or feet are problematic and often require admission and excision because of their complexity and the crucial function of these areas. Perineal burns are also difficult to manage since they are in areas subject to pressure and soiling by urine and feces. Burns that encircle a limb, the neck, or the chest also deserve special attention. In circumferential third-degree burns, the presence of an eschar (dead, coagulated skin) may cause vascular or respiratory compromise.

**Determining The Depth Of Injury**

The depth of injury is one of the most important determinants of outcome. Most superficial burns heal within one to two weeks with minimal or no scarring. Deeper burns usually take more than three weeks to heal, cause unsightly hypertrophic scarring, and provide a fragile epithelial cover that may cause significant functional impairment.\textsuperscript{29} Traditionally, burns are classified into first-, second-, and third-degree injury. (See Table 2.)

*First-degree burns* involve the epidermal layer only and present with pain and erythema that blanches to pressure. They do not blister. Since all dermal elements are preserved, these burns heal completely within several days with minimal or no systemic response. First-degree burns are usually caused by sun (ultraviolet) exposure or mild scalds.

*Second-degree (partial-thickness) burns* involve the epidermis and only part of the dermis. They are subdivided into superficial and deep partial-thickness burns. Superficial partial-thickness burns involve the epidermis and the superficial dermis. These burns are very painful, and blister formation is common. If the blisters rupture, the wound is moist and erythematous. After applying pressure, these burns blanch and sensation remains intact. These burns heal by reepithelialization from adjacent unburned skin and intact epidermal skin appendages (hair follicles, sebaceous and sweat glands) in two to three weeks with minimal scarring. Scalds, flash burns, or brief contact with hot objects usually causes superficial second-degree burns.

Flame, scalds, or hot grease commonly produce deep second-degree burns. They involve the epidermis and most parts of the dermis, leaving few intact skin appendages and nerve endings. These burns often appear waxy white with red elements representing coagulated dermal elements. Spontaneous healing may require up to six weeks and is often associated with hypertrophic scarring and joint contractures. Initially it is often difficult to


<table>
<thead>
<tr>
<th>Table 1. Classification of Burn Severity.</th>
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<tr>
<td><strong>Burn Severity/Age</strong></td>
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<tr>
<td>Minor</td>
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<tr>
<td>Moderate</td>
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<td></td>
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<td>Severe</td>
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* Critical areas include face, hands, feet, perineum
** Complications include inhalation injury, high-voltage electrical burns, associated major trauma, infants, elderly, and comorbid medical problems (e.g., diabetes mellitus)
distinguish deep second-degree burns from full-thickness third-degree burns. Two or three days may be required before the depth of injury is evident.

Th**ird-degree (full-thickness)** burns involve all of the epidermal and dermal layers, with varying amounts of the sub-cutaneous layer. As a result, these burns cannot heal spontaneously unless extremely small, thus requiring excision and subsequent grafting. These burns appear white, tan, gray, brown, or red, and thrombosed vessels are often seen. Due to loss of elasticity, the burn wound has a leathery texture, and the wound is anesthetic. Full-thickness (third-degree) burns are usually caused by flame, electricity, chemicals, or prolonged exposure to the heat source.

Burns that involve deep structures such as tendon, muscle, and bone are often referred to as fourth-degree burns. Molten metal, electrical injury, or prolonged contact with flames may cause fourth-degree burns. Because of muscle damage, myoglobinuria and subsequent renal failure may occur.

Currently, the most common method used to determine burn depth is clinical evaluation by visual and tactile assessment by an experienced burn specialist. However, clinical estimation of burn depth is inaccurate. For example, the clinical accuracy of an experienced surgeon at predicting which burns will heal in three weeks was only 50%. Numerous investigational methods have been developed to help define the depth of injury, including vital dyes, fluorescein fluorometry, ultrasonography, thermography, light reflectance, laser Doppler flowmetry, and MRI. These methods take advantage of the ability to detect dead cells or denatured collagen (ultrasound, vital dyes); the changes in blood flow (fluorescein, laser Doppler, thermography); the color of the wound (light reflectance); and the presence of edema (nuclear magnetic resonance imaging). However, these methods have also suffered from inconsistent reliability. While invasive and requiring an experienced histopathologist, histologic sections of burns remain the standard for determining burn depth.

### Initial Management

**In The Prehospital Setting And ED**

Initial management of the burned patient should follow the general principles and guidelines with attention to airway, breathing, and circulation. Identification and treatment of associated injuries is of paramount importance, since burned patients may have other life- or limb-threatening injuries in addition to their burns. This is especially true in explosions and when burning structures collapse.

At the scene, quickly removing the patient from the source of injury can control the burning process. For flame burns, the patient should be dropped to the ground and either rolled over or covered with a fire-resistant material.

**Airway And Breathing**

As with all injuries, airway management is crucial. In cases of possible smoke inhalation, medics should administer 100% oxygen by face mask. Smoke inhalation should be suspected in the presence of facial burns, singed nasal hairs, carbonaceous sputum, persistent cough, or a history of fire in a closed space. If there is any indication of impending airway obstruction (such as the presence of hoarseness or stridor), orotracheal intubation should be performed early—certainly prior to massive edema formation. When severe facial or oropharyngeal swelling prohibit orotracheal intubation, emergent cricothyroidotomy may be necessary. After arrival in the ED, direct fiberoptic laryngoscopy can be performed in questionable cases. Repeated laryngoscopy may be performed as indicated in the ED or critical care setting.

**Circulation**

After confirming or establishing a secure airway, intravenous fluid therapy is indicated in all but minor burns. Infusion of a balanced crystalloid solution is best achieved via a peripheral large-bore intravenous catheter. Intravenous fluid therapy can be initiated during transport to avoid associated delays.

### Table 2. Burn Depth Classification.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Histology</th>
<th>Appearance</th>
<th>Sensation</th>
<th>Healing</th>
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<tbody>
<tr>
<td><strong>First-degree</strong>:</td>
<td>Epidermis only</td>
<td>Erythema; blanches with pressure</td>
<td>Intact; mild to moderate pain</td>
<td>3-6 days without scarring</td>
</tr>
<tr>
<td><strong>Second-degree</strong>:</td>
<td>Epidermis and superficial dermis; skin appendages intact</td>
<td>Erythema, blister, moist, elastic; blanches with pressure</td>
<td>Intact; severe pain</td>
<td>1-3 weeks; scarring unusual</td>
</tr>
<tr>
<td><em>Superficial</em></td>
<td>Epidermis and most dermis; most skin appendages destroyed</td>
<td>White appearing with erythematous areas, dry, waxy, less elastic; reduced blanching to pressure</td>
<td>Decreased; may be less painful</td>
<td>&gt;3 weeks; often with scarring and contractures</td>
</tr>
<tr>
<td><em>Deep</em></td>
<td>Epidermis and all of dermis; destruction of all skin appendages</td>
<td>White, charred, tan, thrombosed vessels; dry and leathery; does not blanch</td>
<td>Anesthetic; not painful (although surrounding areas of second-degree burns are painful)</td>
<td>Does not heal; severe scarring and contractures</td>
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Cervical spine injuries and need for immobilization with a rigid cervical collar and backboard should be considered when there is a history of an explosion, fall, or blunt trauma, especially in patients with spinal tenderness or altered mental status.

**First Aid**

Cooling may decrease the depth of the burn if applied up to 60 minutes post injury.\(^9\) Because it may improve outcome and reduce pain, emergency care providers should cool the burn wound with cold saline or tap water.\(^10\) The evidence would indicate that it is safe to cool even large burns in this manner; however, avoid the use of ice or ice water. Cooling is also important with cases of adherent hot tar or melted plastics that may continue to injure tissues with its residual heat.

*Copious irrigation and decontamination with large volumes of saline or water are essential for all chemical burns.* However, any obvious pieces of metal or powder should be brushed away prior to irrigation. A summary of treatment measures for specific chemical burns is presented in Table 3.

Using topical mineral oil or petroleum-based ointments (e.g., Bacitracin) can facilitate removal of hot tar. Even butter may be used to remove tar from the skin.\(^41\) Tar should not be pulled off as this could result in further damage to the important skin appendages (sweat glands, hair follicles) from which new skin will grow.

Blisters should be left intact and any non-adherent garments should be carefully removed, since continued transfer of heat and progression of injury have been demonstrated when burned garments were not immediately removed. The burned areas should then be covered with a clean dressing.

**Further ED Management**

**History**

Obtain a history of the events surrounding the burn and determine the potential for occult trauma and inhalation injury. A history of injury within a closed space, exposure to toxic smoke (e.g., burning upholstery with release of large quantities of toxic substances) should raise concern for inhalation injury. Determine the details of how the burn was sustained, especially in children. Be alert to an implausible or inconsistent story. As many as 16% of pediatric burn injuries are non-accidental, and approximately half of these are ultimately proven to be abuse.\(^42\)

Past medical history can to some extent predict the risk of complications and help determine whether transfer is needed for a high-risk patient. Determine whether the patient is allergic to sulfa, which precludes transfer of heat and progression of injury have been demonstrated when burned garments were not immediately removed. The burned areas should then be covered with a clean dressing.

**Physical Examination**

Patients with inhalation injury may present with signs suggestive of direct thermal injury to their airway, such as singed nasal hair or carbonaceous sputum, or with symptoms secondary to mucosal irritation, such as cough, hoarseness, and lacrimation. Dyspnea or an altered mental status may be the result of hypoxemia. The presence of facial burns is also associated with an increased risk of inhalation injury. Unfortunately, “classic” clinical signs such as stridor or hoarseness are infrequently present.\(^43\)

**Determining The Extent Of Injury**

The accuracy of burn size estimation and subsequent fluid administration is frequently miscalculated by referring physicians. One study showed that burns around 20% body surface area were most accurately assessed; smaller burns were overestimated and larger burns underestimated. Inaccuracies in fluid resuscitation resulted in many patients receiving twice the appropriate volume of fluid for the burn size.\(^44\) Errors in estimation of burn size are especially likely when the physician uses guesswork to “eyeball” the size of the wound. In 24 of 132 transfers to a burn center, the extent of injury was overestimated by the transferring emergency room by 100% or more.\(^45\)

The extent of injury is best described using the percentage of the total body surface area (TBSA) that is burned. *When calculating the TBSA, only second- and third-degree burns are included.* For patients older than 10, the “rule of nines” may be used to estimate the TBSA. (See Figure 1.) For small or patchy burns, it is helpful to remember that in the adult, the patient’s palm (not counting the fingers) covers approximately 1% of the TBSA.

For children younger than 10 years old, the proportions of the different body areas vary. As a result, the Lund-Browder chart should be used to calculate TBSA for these ages.\(^46\) (See Figure 2.) When evaluating smaller burns in children, the size of the child’s palm including the fingers approximates 1% of their body surface area.\(^47\) In 91 children, the entire palmar surface (including fingers) represented 0.94% of body surface area while the palm alone covered only 0.52%.

<table>
<thead>
<tr>
<th>Table 3. Summary Of Treatment Measures For Specific Chemical Burns.</th>
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<tbody>
<tr>
<td><strong>Irrigation with water</strong></td>
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<tr>
<td>Most acids and alkali</td>
</tr>
<tr>
<td>Hydrocarbons</td>
</tr>
<tr>
<td><strong>Topical or injectable calcium or magnesium salts</strong></td>
</tr>
<tr>
<td>Hydrofluoric acid</td>
</tr>
<tr>
<td><strong>Cover burn with oil</strong></td>
</tr>
<tr>
<td>Sodium metal</td>
</tr>
<tr>
<td>Lithium metal</td>
</tr>
<tr>
<td><strong>Special measures</strong></td>
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<tr>
<td>Sodium and lithium metals: brush away or excise pieces of metal</td>
</tr>
<tr>
<td>Phenol: polyethylene glycol wipe</td>
</tr>
<tr>
<td>White phosphorus: copper sulfate irrigation</td>
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<tr>
<td>Alkyl mercury agents: debride and remove blister fluid</td>
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</table>
Determine the presence of circumferential burns early in the evaluation. Circumferential burns to the chest, neck, and extremities are life or limb threatening.

When assessing the adequacy of peripheral perfusion, remember that the loss of distal pulses is a late sign of inadequate perfusion. Assess extremities for warmth, softness, and normal range of motion; all are important signs of adequate perfusion. Doppler examination of the palmar arch and digital vessels may be helpful. As flow to the hand drops, it will become firm, cool, and will assume a clawed position.

The physical examination may also provide clues to abuse. Assess the pattern of burns for possible immersion injury in children or dependent adults. These burns are well circumscribed and are often found on the feet, ankles, and buttocks. Other stigmata of burn abuse include pattern burns from cigarette butts or other hot objects.

**Laboratory Studies**

Patients who suffer major burns usually have blood drawn for laboratory analysis in the ED. Tests such as the complete blood count, electrolytes, and occasionally coagulation parameters are frequently measured. The clinical utility of such tests remains unknown.

If the burned patient demonstrates altered mental status, a bedside glucose test is indicated. Carbon monoxide should be measured in those who were burned in an enclosed area if they have headache, chest pain, or altered mental status. Pulse oximetry will yield a falsely elevated value in such patients since it measures carboxyhemoglobin as oxyhemoglobin. In such patients, a blood gas will be especially valuable.

Apart from the issue of carbon monoxide, the blood gas (or other measure of acidosis) may provide important information regarding the burn victim. Acidosis, measured as either base deficit or as lactate, may correlate with volume status. In one study, successful resuscitation was associated with declining serum lactate levels. A wide-gap metabolic acidosis is also seen in victims of cyanide inhalation. This diagnosis is especially likely in a burn victim who was trapped in an enclosed space who is acidotic patient despite a low CO level.

Patients with fourth-degree burns are at risk for myoglobin-induced renal failure. A creatinine kinase (CK) level may be helpful if muscle injury is suspected. A urine dip for blood (myoglobin) is insensitive for rhabdomyolysis.

**Radiographic Studies**

A chest film (CXR) is routine for severely burned patients and those at risk for inhalational injury. Findings of inhalation injury may include nodules, consolidations, interstitial edema, and atelectasis. Do not be surprised, however, by a normal film despite strong clinical suspi-

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**Figure 1. Estimating the percent total body surface area of burns in adults.**

Used with permission: Clayton MC, Solem LD. No ice, no butter. Advice on management of burns for primary care physicians. Postgrad Med 1995;97(5):151-165, Fig. 5.

**Figure 2. Estimating the percent total body surface area of burns in children.**

Used with permission: Clayton MC, Solem LD. No ice, no butter. Advice on management of burns for primary care physicians. Postgrad Med 1995;97(5):151-165, Fig. 6; adapted, with permission, from Lund and Browder.
cation of inhalation injury. As many as half of patients intubated for inhalation injury may have normal admission chest films; radiographic findings may lag hours behind clinical signs.

**Treatment**

General treatment principles and priorities should follow the ABCs and guidelines, as noted in the prior section. Early involvement of a local burn specialist or transfer to a dedicated burn center should be considered after initial stabilization in all but minor burns. The major goals of initial ED management include identification and treatment of any airway compromise, inhalation injury, or associated major trauma; initiation of fluid therapy; and pain management. Intravenous fluid resuscitation should be initiated in most second- or third-degree burns involving greater than 20% TBSA in adults or greater than 10% TBSA in children. The intraosseous route or central line may be necessary in young children with extensive burns and no peripheral access. Insertion of a urethral catheter that permits continuous monitoring of urinary output is indicated in moderately and severely burned patients. Since burns involving greater than 20% TBSA are often associated with gastric atony and paralytic ileus, consider placing a nasogastric tube in these patients.

Patients with burns who have received adequate prior tetanus immunoprophylaxis should receive a tetanus toxoid if more than five years have elapsed since the last booster administration. Patients without adequate prior tetanus immunization should receive tetanus toxoid as well as 250 units of intramuscular tetanus immune globulin. *Systemic antibiotics are not routinely indicated in patients with burns.* "**Prophylactic**" antibiotics may result in the patient being colonized or infected with resistant organisms.

Deep or circumferential burns involving the limbs, neck, or chest may result in impaired circulation or ventilation. In these patients, an emergent escharotomy may be a life- or limb-saving procedure. This is achieved by incising the eschar with a scalpel along the lateral aspects of the limbs or chest down to the level of the subcutaneous fat. (See Figure 3.) Care should be taken to avoid damage to any major neurovascular structures. Some advocate use of electrocautery in order to minimize bleeding. Since deep burns are insensate, no anesthetic is required.

Many patients with burns experience significant amounts of pain. Intravenous narcotic agents are recommended due to poor or erratic intramuscular absorption in the presence of shock. *Repeated small intravenous boluses of a narcotic agent (e.g., morphine sulfate 2-4 mg every 5-10 minutes) should be used and titrated to pain control.* Patients who are intubated may also experience significant amounts of pain and require intravenous narcotic agents with or without sedatives (benzodiazepines). Elevation of a patient’s blood pressure and/or pulse may signify increasing levels of agitation and pain. Patients who are dependent upon narcotics on a daily basis (chronic opioid users including those on methadone maintenance) may require astounding amounts of intravenous morphine—50-70 mg or more of intravenous morphine during the ED stay.

**Smoke Inhalation Injury**

Currently, smoke inhalation is responsible for many of the early deaths associated with major burns, and the incidence increases with larger burns. Often, clinical evolution of inhalation injury may require several days. Most inhalation injuries are caused by exposure of the airways and lungs to toxic chemicals during fires and are

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**Figure 3. Performance of escharotomies.**

not the result of direct thermal injury. Exposure to smoke and toxic inhalants (such as aldehydes and acids) results in a tracheobronchitis and formation of epithelial and fibrin casts within the airways, contributing to upper airway obstruction. Margination of PMNs within the pulmonary capillaries with release of inflammatory mediators (such as oxygen radicals and proteases) increases microvascular permeability, further contributing to airway obstruction and pulmonary edema, which usually occurs within 2-3 days from injury.56 Pulmonary edema may be delayed, especially with exposure to phosgene or chloramine. Burning plastics are likely to generate these toxic substances. In some patients with inhalation injury, pneumonia develops 7 to 14 days later, further increasing morbidity and mortality.

While not consistently present, patients with inhalation injury may also present with hypoxemia or elevated levels of carbon monoxide and/or lactic acid. Unfortunately, plain chest radiography is not very sensitive to inhalation injury, although computed tomography (CT scan) of the chest is more sensitive.43 While physical examination findings can raise suspicion for inhalation injury, findings such as singed nasal hairs (and, to a lesser extent, carbonaceous sputum) can occur without inhalation injury. The diagnosis is best established with bronchoscopy that allows direct visualization of the major airways, combined with xenon-133 lung scan, which detects ventilation perfusion defects.57 Indeed, an accuracy of up to 93% has been reported in a group of patients, 40% of whom had inhalation injury. Fiberoptic bronchoscopy can be performed at the patient’s bedside after hemodynamic stabilization, allowing direct bronchoalveolar lavage of toxic particles. Because small smoke particles are deposited in the distal bronchoalveolar tree, it is possible to have normal findings on bronchoscopy despite significant inhalation injury. If a patient has normal findings on bronchoscopy and inhalation injury is still suspected, the admitting physician can order a xenon ventilation scan.

Treatment Of Inhalation Injury
For many years, clinicians believed that aggressive fluid resuscitation was detrimental to patients with inhalation injury. However, a recent prospective study clearly demonstrated that patients with both burns and smoke inhalation required 2 mL/ %TBSA burn/kg more fluid than those with burn injuries alone in order to maintain adequate cardiac and urinary output.58 Do not withhold resuscitation fluids in the mistaken notion that they will worsen inhalation injury.

The treatment of inhalation injury begins with 100% supplemental oxygen. Patients with upper airway compromise or impending respiratory failure need endotracheal intubation and institution of mechanical ventilation. (See Table 4.) Rapid sequence induction is recommended for most burned patients who require endotracheal intubation. While use of a depolarizing paralytic agent may cause significant hyperkalemia in patients who have sustained burns 3 to 10 days prior to its administration, succinylcholine is not contraindicated in burn patients who present within several days of injury. Some authorities encourage the use of non-depolarizing agents in children. (See the May 2000 issue of Emergency Medicine Practice.) Consider awake intubation using topical anesthetic agents in patients with massive airway edema who are breathing spontaneously. If such patients are paralyzed without opening a cricothyroidotomy tray beforehand, and they cannot be intubated, the notorious airway flail ensues.

Use of standard volume-controlled mechanical ventilation may lead to barotrauma secondary to air-trapping in small airways obstructed by casts. High-frequency percussive jet ventilation, in which small subtidal volumes are given at very high frequencies, can reduce airway pressures and improve survival compared to historical controls.59,60 Free radical scavengers like nebulized dimethylsulphoxide or n-acetyl-cysteine reduce the degree of bronchoalveolar damage after smoke inhalation.60,61 Addition of heparin to this regimen further reduces pulmonary injury.62 In an animal study, ibuprofen decreased pulmonary artery pressures and lung lymph flow changes usually associated with lung injury.63 However, these therapies have not been the subject of rigorous clinical trials and cannot be routinely encouraged. In contrast, clinical trials show corticosteroids and prophylactic antibiotics to be ineffective in the treatment of inhalation injury.

Acute carbon monoxide and cyanide poisoning are other features of inhalation injury. CO-poisoned patients may benefit from supplemental oxygen therapy that accelerates CO elimination several-fold.65 Traditionally, hyperbaric oxygen therapy has been recommended for severe CO poisonings. (See Table 5.) However, a recent prospective study from Australia questions the clinical utility of hyperbaric therapy even in the most severely poisoned patients.66 Suspect cyanide poisoning in comatose patients with severe metabolic acidosis with normal levels of CO. If cyanide poisoning is likely, consider the use of amyl nitrite, sodium nitrite, and sodium thiosulfate (Lilly Cyanide kit).

“It is not necessary to imagine the world ending in fire or ice. There are two other possibilities: one is paperwork, and the other is nostalgia.”
—Frank Zappa

Table 4. Indications For Endotracheal Intubation And Mechanical Ventilation.

- Significant or rapidly progressive upper airway edema
- Tachypnea with use of accessory muscles of respiration
- Arterial hypoxemia ≤ 70 mmHg despite oxygen therapy
- Ratio of partial pressure of arterial oxygen to fraction of inspired oxygen less than 200
 Fluid Resuscitation

For many years the major cause of burn-associated mortality was hypovolemic shock. Burn shock is the result of large transvascular fluid shifts secondary to a generalized increase in capillary permeability. With most small burns, edema is maximal within 8 to 12 hours. However, with major burns, edema may increase up to 24 to 48 hours after injury. The major goal of fluid resuscitation during the initial 24 hours after injury is to preserve organ perfusion and urine output. This may be achieved by using one of a variety of fluid resuscitation formulas. (See Table 6.)

One study suggests that rapid resuscitation in burned children may be given as one-half volume over four hours or less, followed by the remainder given over 20 hours. Researchers compared vital signs, urine output, urine specific gravity, blood gases (acidosis), ventilator needs, morbidity, and mortality between traditional and rapid resuscitation groups. The rapid resuscitation group did better in all measured parameters.

While some favor the use of fluids containing colloids or hypertonic saline because of their tendency to limit the total volume infused, controlled trials have not consistently demonstrated any advantage to their use. In one small study, complications were lower in patients receiving hypertonic lactated saline when compared to those who received a lactated Ringer’s solution. However, in another series, hypertonic sodium resuscitation for burned patients was associated with an increased incidence of renal failure and death. While several animal studies demonstrate a beneficial effect using hypertonic saline, good human data on the topic is thin.

Although the evidence to support their use is scarce, crystalloids such as lactated Ringer’s solution at a rate of 2-4 mL/%TBSA burn/kg are most commonly used. The Parkland formula (the most popular fluid resuscitation regimen) was developed based on a single retrospective study that demonstrated that most burn patients required lactated Ringer’s solution at a rate of 4 mL/%TBSA burn/kg to maintain adequate urinary output and optimal central venous pressures. When using the Parkland formula, one half of the calculated fluid requirement should be given within the first eight hours after injury, with the remainder given over the next 16 hours. A frequent mistake involves calculating fluid needs over the first eight hours based not upon the time of the burn but on time of arrival in the ED. However, in some patients this delay may encompass several hours. If the fluid resuscitation begins three hours after injury, one half of the calculated fluid requirements must be given over the ensuing five hours.

Fluid resuscitation formulas provide only a rough guideline. Fluids require monitoring and then adjustment based on the clinical response. In most patients, a urinary output of 0.5-1.0 mL/kg/hr in adults and 1.0-1.5 mL/kg/hr in children is considered the best indicator of adequate resuscitation and organ perfusion. The evidence to support these traditional parameters is not especially robust. A recent study showed that patients with “adequate” urinary parameters had persistently high serum lactate and base deficits.

In patients with severe burns or underlying cardiorespiratory illnesses, invasive cardiac monitoring may be required to ensure optimal resuscitation. In some centers, use of invasive monitoring to produce hyperdynamic circulatory endpoints resulted in a significant decrease in overall mortality, especially in the elderly.

Fluid requirements may be increased in children with large burns, in patients with smoke inhalation, and in patients in whom resuscitation was delayed. Formulas based on body surface area as opposed to weight-based calculations may be more effective in children. At the Shriners Burn Institute in Galveston, fluid is administered at 5,000 mL/m² body surface area plus 2,000 mL/m² for maintenance. Since infants lack adequate carbohydrate stores, crystalloid solutions containing 5% dextrose should be used. For all formulas, first-degree burns should not be included in the calculation of burn size.

Table 5. Proposed Indications For Hyperbaric Therapy In CO Poisoning.

- CO level >25% (or >15% for pregnant women and young children)
- Myocardial ischemia
- Cardiac dysrhythmias
- Neuropsychiatric abnormalities or history of coma

Table 6. Fluid Resuscitation Formulas.

**Crystallloid Formulas**

**Parkland**
- Lactated Ringer’s 4 mL/%TBSA burn/kg
- Give half of calculated needs in first eight hours, the rest over 16 hours

**Modified Brooke**
- Lactated Ringer's 2 mL/%TBSA burn/kg

**Hypertonic Saline**
- Saline solution containing sodium 250 meq/L 0.6 mL/%TBSA burn/kg plus one-third isotonic salt solution orally up to 3,500 mL limit

**Colloid Formulas (under recent question: see reference 83)**

**Brooke**
- Lactated Ringer's 1.5 mL/%burn/kg + 0.5 mL/kg Colloid + 2,000 mL D₅W

**Evans**
- Normal saline 1.0 mL/%burn/kg + 1.0 mL/%burn/kg Colloid + 2,000 mL D₅W

**Slater**
- Lactated Ringer’s 2,000 mL/24 hr + Fresh frozen plasma 75 mL/kg/24 hr

Emergency Medicine Practice
Clinical Pathway: Management of Major Burns

Respiratory distress? Significant or progressive airway edema?

- Yes → Intubate (Class IIa)
- No

• Oxygen (Class IIb)
• Intravenous access and initial fluid resuscitation (Class IIa)
• Cardiac monitor (Class IIb)
• Pulse oximetry (Class IIb)
• Automated BP monitoring (Class IIb)

Patient in pain?

- Yes → Pain control
  • Titrate intravenous opioid to pain and blood pressure (Class IIb)
  • Use pain scale (verbal or visual scoring system) to monitor response (Class IIb)
  • Continually reassess opioid needs (Class IIb)
- No

History and physical potential for:
1. Inhalation injury?
2. Multiple trauma?
3. CO poisoning?
4. Non-accidental trauma?

- Yes →
  1. Consider fiberoptic examination of airway (Class IIb)
  2. Protect neck as indicated. Search for occult hemorrhage (Class IIb)
  3. CO level, ABG (Class IIb)
  4. Appropriate police and social service consult (Class IIb)
- No

• Calculate depth and extent of burns (Class IIb)
• Adjust fluids to burn formula (Class IIb)
• Order CXR (Class IIb)
• Place NG and Foley catheter for large burns (Class IIb)

Go to top of next page

The evidence for recommendations is graded using the following scale. For complete definitions, see back page. Class I: Definitely recommended. Definitive, excellent evidence provides support. Class IIa: Acceptable and useful. Very good evidence provides support. Class IIb: Acceptable and useful. Fair-to-good evidence provides support. Class III: Not acceptable, not useful, may be harmful. Indeterminate: Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute, professional judgment and may be changed depending upon a patient's individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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**Clinical Pathway: Management of Major Burns** (continued)

Deep circumferential burns to neck, chest, or extremity?

- Yes
  - Emergency escharotomy (Class IIb)

- No
  - Administer tetanus and tetanus immune globulin as needed (Class IIb)
  - Reassess pain control (Class IIb)
  - Reassess response to fluids (urine output, vital signs, possible lactate or base deficit) (Class IIb)
  - Consider PO ibuprofen (or parenteral ketorolac if unable to take PO) (Class IIb)

Patient meets criteria for transfer to burn center*?

- Yes
  - Arrange for expeditious transfer (Class IIb)
    - Contact accepting center
    - Follow applicable federal law
    - Send all appropriate documents
    - Ensure airway intact
    - Calculate fluids for transport
    - Instruct medics on parameters for pain control during transport

- No
  - *Some larger non-burn center hospitals have appropriate resources to manage significant burns

Wound care

- Leave blisters intact (Class IIa)
- Clean burns with soap and water (Class IIb)
- Apply topical antimicrobial or occlusive/semi-occlusive dressing (Class I)
- Arrange for admission/follow-up (Class IIb)

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The evidence for recommendations is graded using the following scale. For complete definitions, see back page. **Class I**: Definitely recommended. Definitive, excellent evidence provides support. **Class IIa**: Acceptable and useful. Very good evidence provides support. **Class IIb**: Acceptable and useful. Fair-to-good evidence provides support. **Class III**: Not acceptable, not useful, may be harmful. **Indeterminate**: Continuing area of research.

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agent to fluid replacements after the first day of therapy. This was done in the hopes of reducing the amount of third spacing and total fluid requirements. A recent meta-analysis showed that the use of albumin or plasma protein fraction does not reduce death in critically ill burn patients and may even be associated with increased mortality.\(^8^3\) A prospective randomized trial showed that routine administration of albumin does not improve outcome in severely burned children.\(^8^4\)

There are a number of new therapies now entering clinical trials. In one small study, administration of high-dose ascorbic acid during the first 24 hours after thermal injury significantly reduced resuscitation fluid volume requirements, body weight gain, and wound edema. The severity of respiratory dysfunction was also decreased in these patients.\(^8^5\)

### Local Burn Wound Care

For most burns treated in the ED, local care of the wound is all that is required. All burns should be cleaned with a mild soap and saline or water. This may require administration of a narcotic analgesic such as morphine sulfate. Careful debridement of ruptured blisters and any devitalized tissues should be performed. The depth and location of burns drive local management. Systemic antibiotics should not be routinely administered except when prophylaxis for bacterial endocarditis is required. However, all burns should be closely monitored for signs of infection.

Most burns will require some form of a dressing that should serve three primary functions. First, it should protect the wound from further damage. Second, it should reduce evaporative fluid losses and minimize heat dissipation. Finally, the dressing should provide patient comfort. Dressings should be continued until complete reepithelialization occurs. After this period, skin moisturizers can be applied to reduce dryness and itching, and the patients should be instructed to keep the burned area out of the sun for at least one year.

### First-Degree Burns

First-degree burns do not require any dressings or topical therapies. Use of systemic or topical non-steroidal anti-inflammatory agents have theoretical appeal and reduce the pain associated with these burns.

### Second-Degree Burns

The large number of therapies used to treat second-degree burns attests to the lack of consensus regarding optimal management. Considerable controversy revolves around whether to leave burn blisters intact or not. Some burn centers insist that every blister be debrided while others are equally vehement that they remain intact. While blisters contain several substances that inhibit wound healing,\(^8^6\),\(^8^7\) the preponderance of evidence (mostly animal data) suggests leaving blisters intact speeds healing and reduces infection.\(^8^8\)-\(^9^1\) One human trial showed that leaving blisters intact significantly decreases bacterial colonization.\(^8^2\) Some suggest that blisters caused by chemicals be debrided as they may contain toxic material that will further delay healing. While seemingly reasonable, the empirical support for this recommendation ranges from limited to non-existent.

---

**Ten Excuses That Don't Work In Court**

1. **“He had a distal pulse, so I didn’t perform an escharotomy. How was I supposed to know that he would develop a compartment syndrome?”**

   Perform an escharotomy in deep circumferential burns of the extremities, neck, or chest. Complete loss of the distal pulse is a “too-late” sign of impaired perfusion.

2. **“There was no stridor when I first saw her, so I figured she could go to a regular floor.”**

   Stridor and hoarseness are infrequent or belated signs of airway injury. Intubate early if there are other signs of respiratory distress, or significant swelling of the nose and lower face. Consider fiberoptic laryngoscopy to exclude airway edema.

3. **“It looked superficial when he came in right after the burn. I didn’t think the patient needed any further follow-up.”**

   Remember that burn injuries will progress; superficial burns may develop into deep or, if infection sets in, full-thickness injuries. Burn patients should follow up with a practitioner who has experience treating burns. A recheck in the first 24 hours may prompt additional interventions.

4. **“He lived in the United States for over 20 years, so I didn’t worry about tetanus.”**

   Many immigrants as well as elderly patients have not received adequate primary immunization against tetanus. Obtain an accurate history of prior immunizations and give tetanus immune globulin to patients without adequate immunoprophylaxis.

5. **“He only had burns to his face. How was I supposed to know that he broke his neck?”**

   Well, the house did collapse in the blaze. Consider other traumatic injuries in burn patients, especially those with an altered mental status or those involved in explosions. Immobilize such patients until cervical injuries can be excluded.

6. **“Her parents were so well dressed—besides, they live in our**

   Continued on page 13
In general, there are two basic methods of managing second-degree burns. In the first, the burns are covered with a topical antimicrobial agent (see Table 7) followed by a non-adherent dressing. The purpose of topical antimicrobial agents is to minimize bacterial proliferation and fungal colonization that may cause burn wound contamination and sepsis. Indeed, the routine use of antimicrobial agents has resulted in a substantial decrease in burn mortality. Because of its relatively low toxicity and ease of use, silver sulfadiazine is the most widely used topical antimicrobial agent presently. There are no good studies directly comparing silver sulfadiazine to other topical agents such as bacitracin. Silver sulfadiazine can cause bone marrow suppression, resulting in transient leukopenia, although for the most part, this phenomenon appears to be self-limited and of little clinical consequence. Hemolytic anemia has been reported as well as rashes, especially in sun-exposed skin.

Burns of the face or neck can be treated with a topical antimicrobial agent such as bacitracin without any additional dressing. While silver sulfadiazine may be used on the face, it is cosmetically jarring and some believe that sunlight can precipitate the silver granules. Since their effect is limited to 6-24 hours, most topical antimicrobial agents should be applied twice daily as a thin layer after gently washing off the burn wound with a mild soap under running water. Soaking the dressing in water may facilitate its removal.

### Table 7. Topical Antimicrobial Agents.

<table>
<thead>
<tr>
<th>Agent</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver sulfadiazine</td>
<td>• Good eschar penetration&lt;br&gt;• Comfortable application</td>
<td>• Transient leukopenia&lt;br&gt;• Allergy to sulfa&lt;br&gt;• Risk of kernicterus (avoid in pregnant women and newborns)&lt;br&gt;• Retarded healing in vitro</td>
</tr>
<tr>
<td>Silver nitrate</td>
<td>• Hypotonic solution may cause leaching of electrolytes; &lt;br&gt;• Painful application; &lt;br&gt;• Stains skin; &lt;br&gt;• Poor eschar penetration (not for established infections)</td>
<td></td>
</tr>
<tr>
<td>Mafenide acetate</td>
<td>• Best eschar penetration</td>
<td>• Allergy to sulfa (frequent rashes)&lt;br&gt;• Metabolic acidosis&lt;br&gt;• Painful application</td>
</tr>
<tr>
<td>Bacitracin</td>
<td>• Easy application&lt;br&gt;• Good for superficial and facial burns</td>
<td>• Rare allergies</td>
</tr>
</tbody>
</table>

### Ten Excuses That Don't Work In Court (continued)

**part of town!**

Consider child abuse in cases of pediatric burns. A young infant who cannot walk is unlikely to knock over a pot of boiling water. Completely undress the burned child and look for immersion injury and "branding" patterns consistent with cigarettes or other hot objects.

7. “I thought he had a concussion from hitting his head in the explosion.”

Suspect carbon monoxide poisoning (and hypoglycemia) in all burn patients with altered mental status. Patients should be placed on 100% oxygen and undergo testing for carbon monoxide. Pulse oximetry alone is inadequate and gives a false reading in carbon monoxide poisoning.

8. “Cyanide levels were not available for three weeks, and I was afraid to administer nitrites without being sure of the diagnosis.”

You certainly can’t wait three weeks to be sure. Combustion of nitrogen-containing polymers, found in both industrial and house fires, may release large amounts of cyanide. Loss of consciousness with or without seizures is common in cyanide poisonings. Patients may present with a severe lactic acidosis. Treatment of cyanide poisoning with the commercially available Lilly Cyanide Antidote Kit is a decision that must be made on a clinical, not laboratory, basis.

9. “But I followed the Parkland formula!”

Sort of. But you forgot to take into account that appropriate fluid resuscitation did not begin at the transferring hospital. This patient came to you six hours "behind" in fluid needs. More importantly, you slavishly adhered to the Parkland “numbers” and did not increase fluids in response to falling urine output and a rising base deficit.

10. “How was I to know that Silvadene contains a sulfa moiety?”

Silver sulfadiazine is contraindicated in patients with a known allergy to sulfa-containing agents. It may cause severe allergic reactions in these individuals.
In the second method, second-degree burns are covered with a biological or synthetic occlusive dressing (see Table 8) without topical application of an antimicrobial agent. Proponents of this method argue that the ability of occlusive dressings to speed wound healing has been well established.\textsuperscript{98-104} This may be the result of creation of a moist environment that enhances re-epithelialization,\textsuperscript{98,99} angiogenesis,\textsuperscript{100} or collagen synthesis under the occlusive dressings.\textsuperscript{101} The protection afforded by the occlusive dressing may also avoid damage to the newly formed epithelium at the time of dressing changes. Additional benefits of occlusive therapy include pain reduction and a possible improvement in cosmetic outcome.\textsuperscript{102-104} If the occlusive dressing remains dry and intact, it may be left to complete reepithelialization. Leakage of fluid under the occlusive dressing necessitates its aspiration or removal of the dressing.

While there has been considerable concern that occlusive therapy would increase the risk of infection, an extensive review by Hutchinson demonstrated that infection rates were reduced under occlusion.\textsuperscript{105} Despite these studies, clinical trials have failed to demonstrate a consistent advantage of occlusive dressing over standard topical antimicrobial therapy for the management of most partial-thickness burns. Due to the tendency for fluid to accumulate under occlusive dressings, necessitating their early removal, they should probably be limited to small burns with minor blistering. Large exuding burns, which are more prone to infection, are best treated with a topical antimicrobial agent.\textsuperscript{106}

### Table 8. Occlusive Dressings.

<table>
<thead>
<tr>
<th>Dressing</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyurethane films (Tegaderm, OpSite)</td>
<td>Easy and frequent wound assessment</td>
<td>Possible retention of fluid</td>
</tr>
<tr>
<td>Hydrocolloids (DuoDerm)</td>
<td>Greater absorption of fluids</td>
<td>Expensive</td>
</tr>
<tr>
<td>Semi-open dressings (Biobrane)</td>
<td>Good wound adherence, tolerates external wetting</td>
<td>May increase infection rates</td>
</tr>
</tbody>
</table>

### Table 9. Skin Substitutes.

<table>
<thead>
<tr>
<th>Type of skin substitute and brand name*</th>
<th>Components</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidermal</td>
<td>Cultured autologous epidermal cells</td>
<td>Wide and permanent skin coverage</td>
<td>2- to 3-week delay, high cost, fragility, labor-intensive use</td>
</tr>
<tr>
<td></td>
<td>Cultured allogeneic epidermal cells</td>
<td>Ready availability, no need for biopsy</td>
<td>Temporary superficial coverage</td>
</tr>
<tr>
<td>Dermal</td>
<td>Cryopreserved allogeneic skin</td>
<td>Ready availability, use as base for cultured epidermal cells</td>
<td>Need for procurement, potential disease transmission</td>
</tr>
<tr>
<td>• Alloderm</td>
<td>Decellularized allogeneic human skin</td>
<td>Ready availability, inert nature, use as base for epidermal grafts</td>
<td>Need for procurement, potential disease transmission</td>
</tr>
<tr>
<td>• Integra</td>
<td>Bovine collagen with chondroitin 6-sulfate</td>
<td>Ready availability, possible use of thin autograft, reduced scarring</td>
<td>Need to excise wounds, risk of infection, high cost</td>
</tr>
<tr>
<td>• Dermagraft-TC</td>
<td>Fibroblasts on nylon mesh</td>
<td>Ready availability, low recurrence of ulcers</td>
<td>Possible need for multiple applications</td>
</tr>
<tr>
<td>Combined epidermal and dermal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Apligraf</td>
<td>Bovine collagen, allogeneic fibroblasts, and epidermal cells</td>
<td>Ready availability, no need for subsequent autografting</td>
<td>Limited viability</td>
</tr>
<tr>
<td>• Composite Cultured Skin</td>
<td>Collagen matrix substrate with fibroblasts and epidermal cells</td>
<td>Ready availability, no need for subsequent autografting</td>
<td>Limited quantity</td>
</tr>
</tbody>
</table>

* The manufacturers are as follows: Alloderm, Life Cell, Woodlands, Tex.; Integra, Integra Life Sciences, Plainsboro, N.J.; Dermagraft-TC, Advanced Tissue Sciences, La Jolla, Calif.; Apligraf, Organogenesis, Canton, Mass.; and Composite Cultured Skin, Ortec International, New York.

Alternative Agents
Aloe vera has long been used as an alternative therapy in the management of minor burns. Studies show that aloe vera has anti-inflammatory properties and promotes wound healing when applied to a second-degree burn wound.\textsuperscript{107,108} In a study of 27 patients with partial-thickness burns, aloe vera gel was compared with Vaseline gauze. The lesions treated with aloe vera gel healed nearly six days faster than the Vaseline gauze areas (\( P < 0.002 \)).\textsuperscript{109}

Some burn therapies appear distant and indistinct on the therapeutic horizon (at least to American-trained physicians). In one prospective, randomized study, topical application of unprocessed honey proved more effective than silver sulfadiazine-impregnated gauze in patients with burn wounds.\textsuperscript{110} Other studies confirm the fact that honey is beneficial in burn care.\textsuperscript{111,112} It has significant antibacterial properties due only in part to its high osmolarity.\textsuperscript{113} Honey is also significantly more available and less expensive than silver sulfadiazine (and flies do not seem to be a problem in clinical practice.)

Third-Degree Burns
Third-degree burns do not heal spontaneously, and all but the smallest of these will require early excision and grafting by an experienced burn specialist. As such, early consultation or referral to a burn specialist should be performed for all full-thickness burns. Ideally, after excision, the wound should be closed with an autograft of the patient’s own skin. With extensive or recalcitrant wounds, one of a variety of skin substitutes may be required.\textsuperscript{114} (See Table 9.) Except for cultured autologous epidermal grafts, most skin substitutes do not survive. However, they accelerate wound healing by stimulating the host to produce a variety of wound-healing mediators. The advantages and disadvantages of the various skin substitutes currently available are summarized in Table 9. Their use is generally restricted to burn specialists.

Indications For Admission Or Transfer
Determine the need for transfer to specialized care early. The emergency physician can make the decision to transfer a patient to a burn center within minutes of the patient’s arrival, based upon the patient’s age, characteristics of the burns (size, depth, and location), and the presence of associated injuries and co-morbidities. Unnecessary delay in transfer can hinder needed specialty care and result in clinical deterioration. Criteria for patient referral to a specialized burn unit are presented in

<table>
<thead>
<tr>
<th>Table 10. Burn Unit Referral Criteria.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Partial-thickness burns greater than 10% TBSA</td>
</tr>
<tr>
<td>2. Burns that involve the face, hands, feet, genitalia, perineum, or major joints</td>
</tr>
<tr>
<td>3. Third-degree burns in any age group</td>
</tr>
<tr>
<td>4. Electrical burns, including lightning injury</td>
</tr>
<tr>
<td>5. Chemical burns</td>
</tr>
<tr>
<td>6. Inhalation injury</td>
</tr>
<tr>
<td>7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality</td>
</tr>
<tr>
<td>8. Any patients with burns and concomitant trauma (such as fractures) in which the burn injury poses the greatest risk of morbidity or mortality</td>
</tr>
<tr>
<td>9. Burned children in hospitals without qualified personnel or equipment for the care of children</td>
</tr>
<tr>
<td>10. Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention</td>
</tr>
</tbody>
</table>

Tool 1. Sample Discharge Instructions For Burn Patients.

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- Gently cleanse your burn twice daily with a mild soap and dry with a clean cloth or gauze.
- Apply antibacterial cream twice daily to the affected areas and cover with bulky gauze dressing and wrap.
- Elevate all burned extremities.
- Report to your doctor or go to an emergency department if you develop increasing pain, redness, swelling, or a foul-smelling discharge from your burn or if you develop a fever and/or chills.
- You may take acetaminophen 500–1000 mg every 4-6 hours or ibuprofen 400-800 mg every 6-8 hours by mouth with food for pain.

Remember that the emergency department is open 24 hours a day, every day, and we are always glad to see you.
**Table 10.** These criteria are not universally accepted, and tertiary centers often treat many of the conditions listed, despite lack of a formal burn center designation.

Still, the American Burn Association’s grading system is a useful guide to determine the need for admission or transfer. Adults with second-degree burns of greater than 15% TBSA or greater than 10% in children, and third-degree burns greater than 2% TBSA in either, should be admitted. Patients with burns over critical areas (hands, feet, face, and perineum) as well as those with serious underlying systemic illnesses may also require admission. Special social considerations (such as homelessness, psychiatric illness, or suspected child abuse) should also be taken into account when arranging disposition.

**Follow-up Care**

Sample discharge instructions for patients with minor burns are presented in Tool 1 on page 15.

**Summary**

Burns are one of the most common injuries encountered in the ED. Associated trauma should be considered and excluded in all patients. Early management of impending airway compromise and ventilatory support may be required in patients with inhalation injury or those with massive burns. Patients with large burns will need aggressive fluid resuscitation; fluid resuscitation is guided by established formulas and largely by physiologic response. While the emergency physician can manage most burns, early consultation with a specialist is required for all deep and extensive burns. Further research and understanding of the pathophysiology of burns will likely be followed by the development of improved treatments to limit burn progression, enhance wound healing, and limit scarring.

**References**

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report. To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available. In addition, the most informative references cited in the paper, as determined by the authors, will be noted by an asterisk (*) next to the number of the reference.

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Physician CME Questions

33. The most accurate way to determine burn depth is:
   a. visual and tactile assessment.
   b. analysis of histologic sections of burns by an experienced histopathologist.
   c. ultrasonography.
   d. MRI.

34. The top priority in the initial management of the burned patient is:
   a. obtaining a patient history.
   b. irrigation and decontamination.
   c. securing the patient’s airway, if necessary.
   d. obtaining a bedside glucose test.

35. When calculating the extent of burn injury:
   a. only second- and third-degree burns are included.
   b. it’s rare for physicians to over- or underestimate.
   c. the “rule of nines” applies to both adults and children.
   d. a child’s palm (not counting the fingers) is approximately 1% of the TBSA.

36. Radiographic findings of inhalation injury include:
   a. nodules.
   b. consolidations.
   c. interstitial edema.
   d. a normal x-ray, since findings may lag behind clinical signs.
   e. all of the above.

37. Inhalation injury:
   a. is more common when a fire has occurred in a confined space or toxic chemicals are involved.
   b. may take several days to evolve.
   c. can occur in spite of a normal chest x-ray in about half of cases.
   d. is best diagnosed by bronchoscopy and xenon ventilation scan.
   e. all of the above.

38. All of the following are true of treatment of inhalation injuries except:
   a. It should begin with 100% supplemental oxygen.
   b. RSI is recommended for most patients who require endotracheal intubation.
   c. High-frequency percussive jet ventilation is more effective than standard volume controlled mechanical ventilation.
   d. Resuscitation fluids will worsen inhalation injuries.

39. In children, most burns are the result of:
   a. scalds.
   b. arson.
   c. flammable liquids.
   d. electrical current.

40. The highest risk of death occurs in patients:
   a. who are older than 60.
   b. with more than 40% TBSA burned.
   c. with inhalation injuries.
   d. when all three risk factors are combined.

41. Which of the following is false concerning deep or circumferential burns involving the limbs, neck, or chest?
   a. They may result in impaired circulation or ventilation.
   b. They require emergent escharotomy.
   c. They require prophylactic antibiotics.
   d. They can lead to compartment syndrome even if the distal pulse is present.

42. Concerning the cooling of burns, all of the following are true except:
   a. It may reduce the depth and extent of the burn if done promptly after injury.
   b. Ice or ice water are recommended.
   c. It can improve outcomes and reduce pain.
   d. It is important with cases of hot tar or melted plastics.

43. Pain control:
   a. is best achieved with repeated small boluses of a narcotic titrated to pain control.
   b. is unnecessary in intubated patients.
   c. is unnecessary in heroin addicts.
   d. is unnecessary in patients with third-degree burns, since these burns are anesthetic.

44. Fluid resuscitation formulas:
   a. should include first-degree burns in the calculation of burn size.
   b. should be implemented based on the time of presentation to the ED.
   c. are guidelines; fluids require monitoring and adjustment based on clinical response.
   d. shouldn’t be mediated by the presence of smoke inhalation or delay in resuscitation.

45. The primary function(s) of burn wound dressings is/are:
   a. to protect the wound from further damage.
   b. to reduce evaporative fluid losses and minimize heat dissipation.
   c. to provide patient comfort.
   d. all of the above.

46. Second-degree burn management should include all of the following except:
   a. cleansing with mild soap and saline or water.
   b. careful debridement of ruptured blisters and any devitalized tissues.
   c. administration of systemic antibiotics.
   d. covering the burns with a topical antimicrobial agent followed by a non-adherent dressing or covering the burns with a biological or synthetic occlusive agent without topical application of an antimicrobial agent.
47. Studies have shown that effective topical therapies for burns include:
   a. silver sulfadiazine.
   b. aloe vera.
   c. unprocessed honey.
   d. all of the above.

48. Candidates for hospital admission include:
   a. patients with third-degree burns covering more than 2% TBSA.
   b. adults with second-degree burns covering more than 15% TBSA or children with second-degree burns covering more than 10% TBSA.
   c. patients with burns over the hands, feet, face, or perineum.
   d. patients with underlying systemic disease or special social considerations.
   e. all of the above.

### Class Of Evidence Definitions

Each action in the clinical pathways section of Emergency Medicine Practice receives an alpha-numerical score based on the following definitions.

**Class I**
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness
- Must be used in the intended manner for proper clinical indications

**Level of Evidence:**
- One or more large prospective studies are present (with rare exceptions)
- Study results consistently positive and compelling

**Class IIa**
- Safe, acceptable
- Clinically useful
- Considered treatments of choice

**Level of Evidence:**
- Generally higher levels of evidence
- Results are consistently positive

**Class IIb**
- Safe, acceptable
- Clinically useful
- Considered optional or alternative treatments

**Level of Evidence:**
- Generally lower or intermediate levels of evidence
- Generally, but not consistently, positive results

**Class III:**
- Unacceptable
- Not useful clinically
- May be harmful

**Level of Evidence:**
- No positive high-level data
- Some studies suggest or confirm harm

**Indeterminate**
- Continuing area of research
- No recommendations until further research

**Level of Evidence:**
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Adapted from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. JAMA 1992;268(16):2289-2295.

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**Needs Assessment:** The need for this educational activity was determined by a survey of medical staff, including the editorial board of this publication; review of mortality and morbidity data from the CDC, AHA, NCHS, and ACEP; and evaluation of prior activities for emergency physicians.

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