A 63-year-old man is rescued from a house fire and brought to the emergency department. According to paramedics responding to a three-alarm fire, the victim was found unconscious in an upstairs bedroom of a house. The patient’s past medical problems are unknown. His pulse is 112 beats/min, blood pressure 150/85 mm Hg, and respiratory rate 30 breaths/min. A pulse oximeter registers 92% O2 saturation with a face mask. His face and the exposed portions of his body are covered with a carbonaceous deposit. The patient has blistering and open burn wounds involving the circumference of his left arm and left leg and more than 80% of his back and buttocks. He does not respond verbally to questions and reacts to painful stimulation with occasional moans.

**Q/What is the most appropriate next step?**

**Q/ What are the immediate and late complications associated with thermal injuries?**

**Thermal Injury**

Summary: A 63-year-old man presents with an approximately 40% total body surface area (TBSA) burn injury and inhalation injuries. • Next step: Definitive airway management by intubation is appropriate in this patient with possible inhalation injuries and carbon monoxide (CO) poisoning. • Immediate and late complications: Airway compromise and tissue hypoperfusion are common early complications, and sepsis and functional loss are possible late complications.

**ANALYSIS Objectives**

1. Learn the initial assessment and treatment of patients with thermal injuries. 2. Learn the assessment and management of burn wounds. 3. Be familiar with the prognosis associated with thermal injuries.

Considerations: Given the circumstances surrounding the injury (a house fire), the size of the burn, and the age of patient, all of which indicate a high likelihood of pulmonary complications, immediate intubation is clearly indicated. Persons at risk for upper airway thermal damage include this particular patient because he was found unconscious in a closed-space fire. Fluid resuscitation with lactated Ringer solution should be initiated based on 2 to 4 mL/kg/% burn. Unless the patient is already at a facility that specializes in burn care, immediate arrangements should be made for a transfer after initial stabilization.

**APPROACH TO: Thermal Injury**

In the United States each year, burn injuries contribute to over 500,000 emergency department visits, 45,000 hospital admissions, and 4500 deaths. More than 60% of all US hospitalizations for burns are made to 125 hospitals with specialized burn centers. The skin is the largest organ of the body. It allows the body to maintain fluid balance, temperature regulation, and protein regulation, and provides a barrier against bacteria and fungi. It is a necessary organ for living. Knowledge of the initial resuscitation and treatment, along with the late complications, can help minimize the morbidity and mortality of these injuries.

**CLINICAL APPROACH**

Initial Assessment The initial assessment of a burn patient is the same as for any trauma patient (attention to the airway, breathing, and circulation—the ABCs), with additional considerations. Along with their burns, patients can acquire thoracic and abdominal trauma, fractures, or head injuries from associated falls or crashes. Overall, concomitant injuries are seen in approximately 10% of the burn victims.

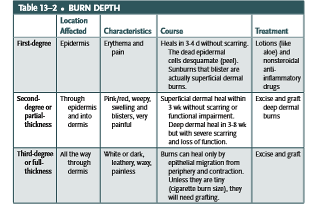
Airway As for other traumas, airway assessment is the initial consideration. Although patients do not receive “pulmonary burns” (unless they inhale live steam or explosive gases), the upper airway can be burned as it cools the hot gases from a fire. Additional signs of potential airway involvement include facial and upper torso burns and carbonaceous sputum. If the oropharynx is dry, red, or blistered, the patient will probably require intubation. When indicated, endotracheal intubation should be performed early, before a surgical airway is required secondary to pharyngeal and laryngeal edema. Smoke inhalation can also cause tracheobronchitis and edema from exposure to the incomplete combustion of carbon particles and other toxic fumes. CO poisoning can cause hypoxia because CO has a 240-fold greater affinity for hemoglobin than O2, thus shifting the oxyhemoglobin curve to the left. All patients injured in closed-space fires should have their carboxyhemoglobin (COHgb) level determined. A COHgb level of greater than 30% may indicate significant central nervous system dysfunction that may also be permanent. A COHgb level of greater than 60% may portend coma and death. It is important to bear in mind that one can develop a 30% COHgb level within 3 minutes in a moderately smoky enclosed space fire. When associated with cutaneous burns, smoke inhalation doubles the risk of mortality. Patients with a COHgb greater than 10% with carbonaceous sputum from a closed-space fire have a greater than 90% chance of needing ventilator support if they have associated burns of more than 20% TBSA. The half-life of CO in the blood on room air is 250 minutes. If the patient is receiving 100% O2, the half-life is reduced to approximately 40 to 60 minutes. Therefore, the patient’s initial COHgb level is estimated by knowing the transport time and the time prior to the arterial blood draw, as well as the oxygen concentration the patient is receiving. A request for the COHgb level can be sent to the laboratory along with the request for a baseline arterial blood gas analysis. In the scenario described here, where the patient is found unconscious in a building with 40% TBSA burns, carbonaceous sputum, signs of hypoxia (abnormal oxygen saturation), and neurologic deficits (responding only to painful stimuli), intubation is needed. The presence of inhalation injury increases patient mortality by a factor of 9.

Resuscitation Cutaneous burns produce accelerated fluid loss into the interstitial tissues in the burned and nonburned areas. Mediators such as prostaglandins, thromboxane A2, and reactive oxygen radicals are released from injured tissue, which cause localedema, increased capillary permeability, decreased perfusion, and end-organ dysfunction. Burn sizes exceeding 20% TBSA can result in a systemic response, with significant interstitial edema in distant soft tissues. With these large burns, an initial decrease in cardiac output is seen, followed by a hypermetabolic response. These fluid losses make resuscitation an important part of burn management. Organs, including skin, can progress from a hypoperfused state to more permanent end-organ damage if resuscitation is not accomplished in a timely fashion.

Calculating Resuscitation Fluid Requirements Most patients with burns involving less than 15% TBSA can be resuscitated with oral fluids. For larger burns, isotonic intravenous fluids such as lactated Ringer solution should be used (large volumes of normal saline can cause hyperchloremic metabolic acidosis). Fluid needs are estimated by the Parkland or other formulas such as the Modified Brooke formula. Based on the Parkland formula, for adults and children weighing more than 10 kg, the total 24-hour volume is calculated using 4 mL/kg/% burn. Half of this amount is given in the first 8 hours and the remainder in the next 16 hours. The Modified Brooke formula is calculated to give lactated Ringers at 2 mL/kg/% TBSA burn, where one-half is given in the first 8 hours and the remainder in the subsequent 16 hours. During the second 24 hours colloids are given at 0.3 to 0.5 mL/kg/% + D5W (dextrose 5% water) to maintain adequate urine output. Intravenous fluid hydration given by the paramedics en route should be considered part of this volume. Children weighing less than 10 kg should be given 2 to 3 mL/kg/% burn divided similarly over the next 24 hours. In addition, they should receive a maintenance fluid that includes 5% dextrose. Because of the increased capillary permeability, colloids such as albumin are generally avoided for the first 12 to 18 hours but can be used subsequently if resuscitation is not being achieved with the crystalloid regimen. Inhalational injuries, extensive and/or deep burns, and delayed resuscitation usually result in larger fluid requirements than initially calculated. Care must be taken to observe the amount of fluid the patient receives. Fluid creep or excess fluid administration is a serious problem in burn patients.

Assessing the Adequacy of Resuscitation Measuring urine output (UOP) is a helpful way of assessing the adequacy of the resuscitation. Adults should achieve 0.5 mL/kg/h of UOP, children should produce 0.5 to 1 mL/kg/h, and infants should produce 1 to 2 mL/kg/h because they have a higher volume-to-surface-area ratio. Generally, UOP is averaged over 2 to 3 hours before changes are made. Excess UOP should also be avoided unless one is treating myoglobinuria. Patients should not be massively fluid overloaded during the resuscitative period.

Calculating the Burn Area The “rule of nines” is a useful guide in assessing the extent of a person’s burns (Table 13–1). The body can be fairly accurately divided into anatomic regions that represent 9% or multiples of 9% of the total body surface. In estimating irregular outlines or distributions, note that the palm of a patient’s hand (not including the fingers) represents approximately 1% of the patient’s total body surface.



Burn Depth When calculating the total percentage of burn involvement in a patient with more serious burns, first-degree burns are not included. Different burn depths (Table 13–2) should be noted on a burn diagram form. As burns marginate, the assessment of depth may change from the value calculated initially, particularly in the case of scald burns, where the initial depth may not appear as severe. Fourth-degree burns are those that extend through skin and subcutaneous fat, even involving deep structures.

Temporary Wound Coverings Because the skin serves in temperature regulation and as a barrier against bacterial and fungal organisms, attention must be given to the prevention of hypothermia and monitoring for infection. Because a burn site can become infected and allow microbes systemic access, steroids should not be used for any burn greater than 10% TBSA. Prophylactic intravenous antibiotics are usually not recommended because they select for resistant organisms. The different creams commonly used topically have local broad antimicrobial activity that can resist colonization. Silver sulfadiazine (SS) does not penetrate the eschar and so is not helpful in an infected burn. It can rarely cause leukopenia, requiring cessation of use. Patients who are allergic to sulfa are usually not affected by SS because the silver molecule is attached to the antigenic portion of the sulfadiazine molecule; however, if this cream is chosen, it is prudent to try a test patch for patients with a sulfa allergy. A rash or pain (rather than the usual soothing) will ensue if they are truly allergic to SS. Sulfamylon (mafenide) is less commonly used because it is painful on application. Furthermore, it can cause severe systemic metabolic acidosis through carbonic anhydrase inhibition. It penetrates the eschar and is therefore useful for full-thickness infected burns (there is less pain on application) and for unexcised burns with colonization. Silver nitrate does not penetrate the eschar and turns the burn area black. Usage can result in severe leaching of sodium and chloride, which can lead to profound hyponatremia and hypochloremia, particularly when used on large areas on children. Pigskin can be used on flat, clean wounds. Its growth factors can encourage epithelialization in partial-thickness burns.

BURN COMPLICATIONS Systemic: Burns larger than 20% TBSA are associated with systemic hypermetabolic responses. These responses include the activation of the complement and coagulation pathways producing microvascular thromboses, capillary leak, and interstitial edema. The systemic activation of the proinflammatory cascade also triggers subsequent counter-regulatory anti-inflammatory reactions that produce subsequent immune suppression and increased susceptibility to nosocomial infections and sepsis. Neurologic: Transient delirium commonly occurs, but an altered mental status requires evaluation to identify other etiologies such as anoxia and metabolic abnormalities. Pulmonary: Pneumonias and respiratory failure requiring mechanical ventilation are frequently seen. Cardiovascular: Myocardial depression occurs transiently following major burns, and this is mediated by vasoactive and inflammatory mediators released by the injured tissues. In selective patients, inotropic agents to support end-organ perfusion are indicated during the early postinjury period (initial 24-48 hours). Venous thrombosis can occur. Suppurative thrombophlebitis can lead to bacteremia, which may cause endocarditis along with the local venous abscess. Gastrointestinal: Stomach and duodenal ulcers can develop secondary to decreased mucosal defenses resulting from the decrease in splanchnic blood flow. Early gastric tube feedings before atony occurs may help improve nutrition or prevent stress ulcers. Early feeding may prevent the development of nosocomial pneumonias by inhibiting bacterial overgrowth. As the result of regional hypoperfusion, critically ill burn patients are at risk for the development of acalculous cholecystitis, pancreatitis, and hepatic dysfunction.

Renal: Acute kidney injury is reported in up to 20% of patients with severe burns. Early on, acute tubular necrosis can develop because of inadequate resuscitation or myoglobinuria (commonly associated with deep burns and electrical injuries), and late onset of acute kidney injury can be caused by sepsis, worsening of preexisting renal dysfunction, and nephrotoxic agents (eg, medications and contrast media). Infection: Burn size and increased age are contributors of host immune suppression and increased susceptibility to infections following major burns. Infections can arise from the burns themselves or from treatments used in critical care, such as urinary tract infections from Foley catheters and sinusitis or otitis from feeding or nasogastric tubes. Ophthalmic: Corneal abrasions or ulcerations may be seen, resulting either from the initial injury or from exposure. Patients with potential eye injuries, particularly those caused by explosions, should be examined early in the emergency department using fluorescein for corneal abrasions, which should be treated with antibiotic lubrication. Early examination is important before edema makes the examination difficult. Eyelid problems also may require treatment. Musculoskeletal and soft tissue: Scarring can cause functional or cosmetic defects. Physical and occupational therapy, scar releases, regrafting, and silicone prostheses can help. Psychological: Burns can be very traumatic as well as defacing. Adequate support should be provided. Because of the specialized care required and the multidisciplinary aspects of burn treatment, the American Burn Association recommends that certain patients receive their care at burn centers (Table 13–3).

OUTPATIENT MANAGEENT OF BURNS Patients with minor burn injuries may be appropriately managed as outpatients. Candidates for outpatient treatments include some adults with partial-thickness burns of less than 10% TBSA, children and elderly adults with less than 5% TBSA burns, and adults with less than 2% full-thickness burns. In order to qualify for outpatient treatments, the outpatient situations need to be sufficient to address the patients’ wound pain, limit contamination, and provide sufficient care and resources for optimal wound healing and functional recovery. In most cases, these goals can be accomplished with appropriate home care, outpatient physical therapy, and frequent outpatient follow-ups.

Table