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Prehospital and emergency department burn care

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> If all that changes slowly is explained by life –
> All that changes quickly is explained by fire!
>
> G. Bachelard (1884–1962)

When paramedics and emergency department nurses are asked what kind of patients they most fear caring for, the answer typically involves critically ill children and burn victims. No one wants to think about a child, or even an adult, being subjected to pain, multiple debridements and surgeries for grafting, and physical and emotional scars associated with burn injuries that may last a lifetime. Burn-injured patients have special needs in the prehospital and emergency department settings. This article addresses the nursing priorities in prehospital and emergency department care.

Skin anatomy

A brief review of skin anatomy provides concepts necessary to understand emergency burn assessment findings and later treatment strategies. The epidermis is the outermost layer of skin; under the epidermis are the dermis, subcutaneous tissue, muscle, and bone; throughout the epidermis and dermis are pain receptors. Infants, young children, and elderly adults have a much thinner dermal layer with a resulting greater propensity for deeper burns. The skin provides several important functions, but four essential functions that apply to emergency burn care are protection against infection, prevention of fluid loss, temperature maintenance, and sensation (eg, pain perception) [1–3]. Fig. 1 provides a schematic view of the skin and depth of burn injuries.

Degree of burn versus burn thickness

Burns have been historically classified as first degree, second degree, or third degree by prehospital emergency medical services (EMS) and emergency department personnel. More recently, especially in burn centers, the depth of the burn is described as being partial or full-thickness; however, most EMS and emergency department staff still use the first- to third-degree classification, probably because they infrequently encounter critically ill burn patients. First-degree (superficial) burns are most commonly seen with sunburns and brief heat exposures. They are red, exquisitely painful, and involve only the epidermis. Patients with extensive first-degree burns may need narcotic analgesia and mild fluid resuscitation, but these burns are rarely life threatening and do not require debridement or grafting [1,2]. Second-degree (partial-thickness) burns are classified as either being superficial or deep partial-thickness. Superficial partial-thickness burns involve the epidermis and the superficial dermis. Blistering of the skin is commonly seen either on initial presentation or several hours later, along with severe pain. Deep partial-thickness

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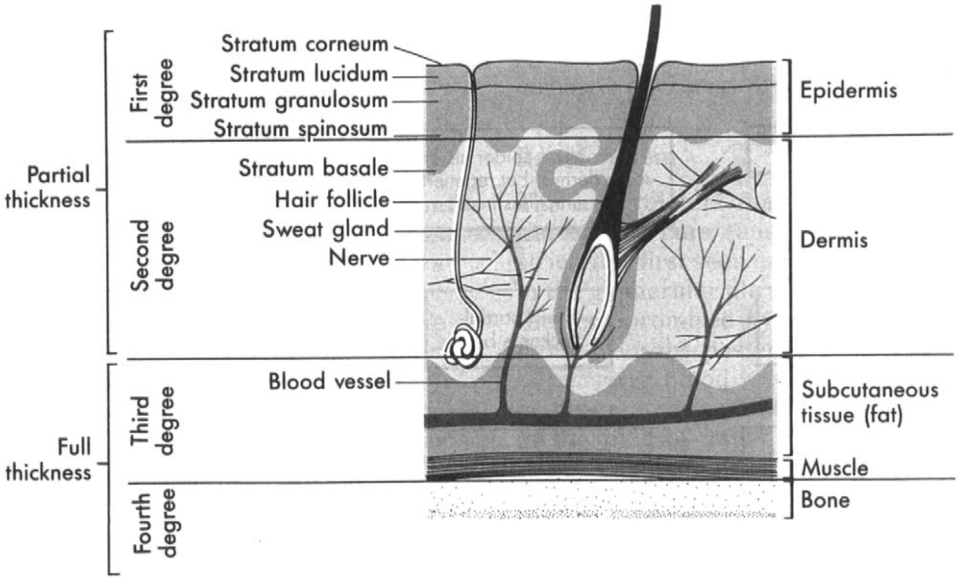

Fig. 1. Layers of the skin involved in burn injury. *From* Ogden B. Nursing management of adults with burns. In: Beare P, Myers J, editors. Principles and practice of adult health nursing. 2nd edition. St. Louis (MO): Mosby; 1994. p. 2119; with permission.

burns are deeper than superficial partial-thickness burns, resulting in more destruction of the dermal layer. A clinical guide to differentiating between partial and full-thickness burns is the presence of pain at the burn site in partial-thickness burns and the absence of pain in full-thickness burns. It is important to remember that the severity of a burn may not be apparent for 24 to 48 hours. An injury that may initially present as a partial-thickness burn may extend into a full-thickness burn. Also, burn patterns are frequently mixed, so it may be difficult to differentiate clearly between a partial-thickness wound and a full-thickness injury [1,2]. Third-degree (full-thickness) burns involve the epidermis, dermis, and possibly subcutaneous tissue. In appearance, full-thickness burns can be black, brown, or white, and leathery, dry, or charred. Third-degree burns may not be painful because the pain receptors have been destroyed. A clinical caveat is that third-degree burns commonly occur in a bull's-eye pattern with third-degree burns surrounded by second-degree injury, so the patient will have areas that are painful and other areas that are insensate. These more superficial burn areas are the ones that can cause intense pain for the patient [1,2]. There is some disagreement about the use of the term "fourth-degree burn." Fourth-degree burns can be classified as deep full-thickness burns. Most references agree that a fourth-degree injury involves all skin layers, subcutaneous tissue, muscle, and possibly bone. These burns commonly result in a nonviable extremity or, if very extensive, in patient mortality [1,2].

EMS and emergency department assessment overview

What makes a not-bad burn bad and a bad burn really bad?

Several factors can negatively affect a burn patient's prognosis. One factor is associated trauma, but the most important factor is the patient's health status before the burn injury. Coexisting medical conditions such as diabetes, chronic obstructive pulmonary disease, asthma, and cardiac disease, among others, are the primary reasons for poor patient outcomes following burn injury. Comorbidities increase the risk of complications such as pneumonia, sepsis, multisystem organ dysfunction, and poor healing [1,2]. Box 1 presents the American Burn Association (ABA) criteria for burn center transfer and referral. The ABA recommends transfer to a burn center for significant thermal, electrical, or chemical burns as well as for a "burn injury in patients with pre-existing medical disorders which could complicate management, prolong recovery, or affect mortality" [1,4].

Box 1. American Burn Association criteria for major burn injuries [1,4]

- Any patient with partial-thickness burns greater than 10% total body surface area
- Any patient with burns that involve the face, hands, feet, genitalia, perineum, or major joints
- Any patient with third-degree burns
- Any patient with electrical burns, including lightning injury
- Any patient with chemical burns
- Any patient with inhalation injury
- Burn injury in patients with pre-existing medical disorders that could complicate management, prolong recovery, or affect mortality
- Any patient with burns and concomitant trauma in which the burn injury poses the greatest risk
- Burned children in hospitals without qualified personnel or equipment for their care
- Any patient with burns who requires special social, emotional, or long-term rehabilitative intervention

For prehospital caregivers, the first priority, even before assessing and managing any patient, is always scene safety. Burn injury may involve trauma such as that resulting from an explosion or fall. It is important to discover from the patient or family members and on-scene EMS personnel the mechanism of injury involved. Questions to ask that may assist in assessing mechanism of injury and presence of potential or associated injuries are

Where was the patient found (eg, in bed versus at the foot of the stairs)?
Was an explosion involved?
Did the victim jump from a window to avoid the fire?

Asking questions that can shed light on other potential or actual associated injuries is important in early burn patient management [2]. Trauma patients with burns are exactly that, trauma patients first and foremost. They should be evaluated for life-threatening injuries first at an emergency department or trauma center as protocols and facilities allow. Once traumatic injuries requiring immediate treatment (eg, spinal cord injury, epidural hematoma, ruptured spleen) have been ruled out, the focus should be on the management of the burn injury [5]. Health care workers instinctively want to address the burns first because burn injuries are so dramatic in appearance, and the patients are appropriately very vocal about their burn pain. In the first few hours after injury, however, the burn tissue injury is not usually lethal, and emergent care involves correcting airway compromise and providing fluid resuscitation. Fig. 2 demonstrates the time of exposure required for tissue destruction at a known temperature. The higher the temperature and longer the duration of exposure, the greater the tissue damage [6]. Priorities for EMS, however, are the immediate treatment of associated traumatic injuries and airway and fluid resuscitation management.

Last, a comparison of the alleged mechanism of injury with the injury itself is essential when the possibility of abuse, intentional injury, or even suicide is being considered [1,7]. Box 2 presents assessment findings that may suggest the health care team should investigate more closely for possible intentional injury.

Where is the patient burned? Inhalation injuries

Patients can be burned in one of two areas – internally and externally. An internal burn injury involves an inhalation injury or burns to the upper airway. Emergency personnel should remember that a patient who is burned on the outside is probably burned on the inside. More importantly, a patient who is swollen on the outside is probably is swollen on the inside. This consideration is crucial with regards to airway management: especially in children, who have proportionately smaller airways, a little edema significantly compromises the airway (Fig. 3) [1]. Establishing and maintaining a patent airway is a primary function of both the EMS and emergency department personnel in any burn victim. Airway tissue edema from the heat injury and chemical burns, compounded by the intravenous (IV) fluids required for resuscitation, can quickly lead to airway compromise. Edema is an equal opportunity killer [2]. Thus establishing and maintaining an airway for burn-injured patients is a life-saving procedure.

For a victim of a house fire, anxiety, fear, and hypoxia all lead to tachypneic breathing of inhaled smoke with carbon monoxide and the various other toxic gases that accompany the superheated temperatures. Carbon monoxide poisoning should be presumed to be present in all thermal-burn patients when smoke inhalation is involved. One hundred

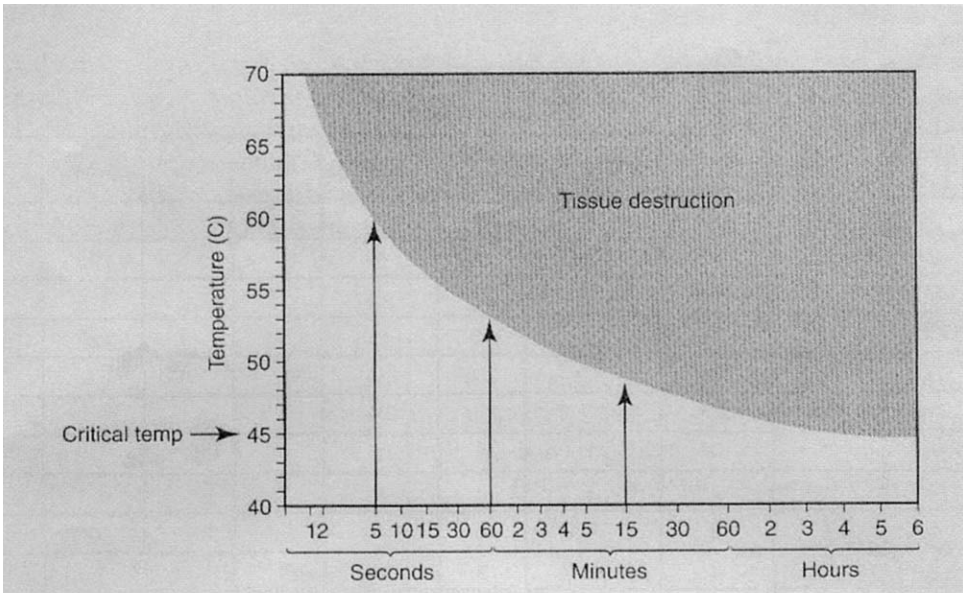

Fig. 2. Temperature duration curve. *From* Flynn M. Burn injuries. In: McQuillan K, VonRueden K, Hartsock R, Flynn M, Whalen E, editors. Trauma nursing: from resuscitation through rehabilitation. 3rd edition. Philadelphia: WB Saunders; 2002. p. 788–809; with permission.

percent oxygen should be given until venous or arterial carbon monoxide levels have been determined. Pulse oximetry is useful but can be misleading when smoke inhalation is involved. Carbon monoxide has 250 times more affinity for hemoglobin than does oxygen. Most pulse oximeters cannot differentiate between a hemoglobin molecule that is bound by oxygen or carbon monoxide. Although an oxygen saturation reading of 100% is normally a reassuring reading, the pulse oximetry reading cannot be considered accurate unless the carbon monoxide level is known. The actual oxygen saturation is derived by subtracting the carbon monoxide level from the pulse oximeter saturation. As an example, a pulse oximetry reading of 100% with a carbon monoxide level of 50% means that the patient's actual oxygen saturation is only 50%. Symptoms of carbon monoxide toxicity are variable and nonspecific, ranging from headache and nausea to coma and death. The classic symptom of cherry-red coloration of the skin and mucous membranes is inconsistently found, and its presence or absence should not be considered diagnostic. Management remains controversial, with administration of 100% oxygen by facemask or endotracheal tube continuing to be standard treatment, with hyperbaric oxygen therapy as an additional possible therapy [2,5,8,9]. With any burn-injured patient, the possibility of airway involvement is a primary consideration that must be assessed. Box 3 outlines commonly encountered signs and symptoms that would lead one to suspect an inhalation injury.

Where is the patient burned? Exterior injuries

How badly is the patient burned?

Prehospital and emergency department personnel see three kinds of burn patients: (1) patients who can be sent home; (2) burn patients who can be appropriately treated as an inpatient in a community hospital setting (an option that should be used only if all those involved in the care of the patient have the skills and

Box 2. Suspicious burns [3]

- Any burn involving a child
- History of tap water immersion
- Multiple burns of same or different ages
- Presence or absence of splash marks, spared regions, bilateral symmetry (stocking/glove distribution)
- Burns on the soles of the feet
- Non–burn-associated trauma

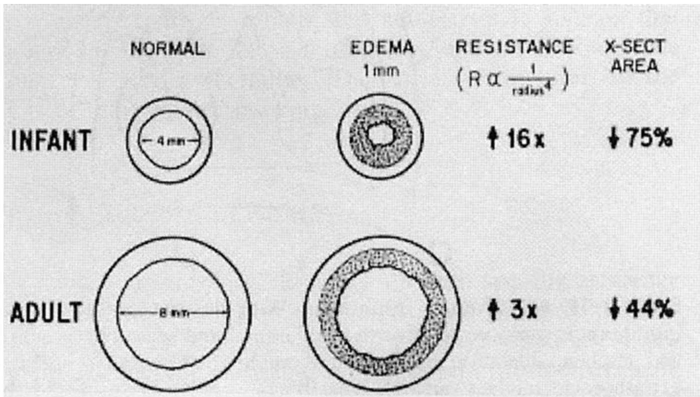

Fig. 3. Airway diameter/edema. *From* Wheeler M, Cole C, Todres I. Pediatric airway. In: Cote C, Todres I, Ryan J, Goudsouzian N, editors. A practice of anesthesia for infants and children. 3rd edition. Philadelphia: WB Saunders; 2001. p. 85; with permission.

experience needed to provide the required assessments and interventions); and (3) burn patients who should be transferred for treatment in a burn center. The ABA has established criteria that should be used to determine admission versus transfer to a burn center (see Box 1). The University of Chicago Burn Center and the University of Chicago Aeromedical Network (UCAN Transport Team) actively urge paramedics and emergency departments to use the "call before they hit the door" protocol. The EMS providers inform the emergency department that they will be receiving a severely burned patient in "x" minutes and asks the emergency department to contact the burn center even before the patient arrives. This initial notification of a possible burn admission or transfer serves to determine burn center bed availability and transport team readiness and allows the burn center to assist with the initial telephone resuscitation guidelines and burn treatment suggestions given to the EMS personnel in the field.

Regardless of the patient disposition, calculating the percentage of burn is crucial for proper assessment of severity of injury and subsequent treatments. The most commonly used prehospital and emergency tool used to assess the extent of burn tissue injury is the Rule of 9s. To understand this rule, the mnemonic of "little parts and big parts" is helpful. "Little parts" represent 9% of total body surface area (TBSA), and "big parts" represent 18% (Box 4). Children have a critical anatomic difference: the head is disproportionately bigger than the body (Fig. 4). Remembering that children have "big heads" is crucial, because it makes a difference in calculating burn percentage, evaluating heat loss, and determining proper positioning if a spinal injury is suspected. When calculating percentage of burns in pediatric patients, the head is a "big part" and therefore represents 18% of the TBSA, not 9% as in with adults.

Box 3. Signs of inhalation injury [2]

- Singed eyebrows or nasal hairs
- Black nasal or oral discharge
- Grossly swollen lips
- Hoarse voice
- Carbonaceous oropharynx or sputum
- Facial burns
- Abnormal oxygenation
- History of enclosure in a smoke-filled location

Box 4. Real-life reminders for the Rule of 9s [1]

The body is divided into big parts and little parts:
- Big parts represent 18% of total body surface area
- Little parts represent 9% of total body surface area (hence the Rule of 9s)

Remember children have
- Big head, little body syndrome: the head is a big part (18% TBSA, not 9% as in adults)
- Short and stubby leg syndrome: legs in children represent 14% TBSA (not 18% as in adults)

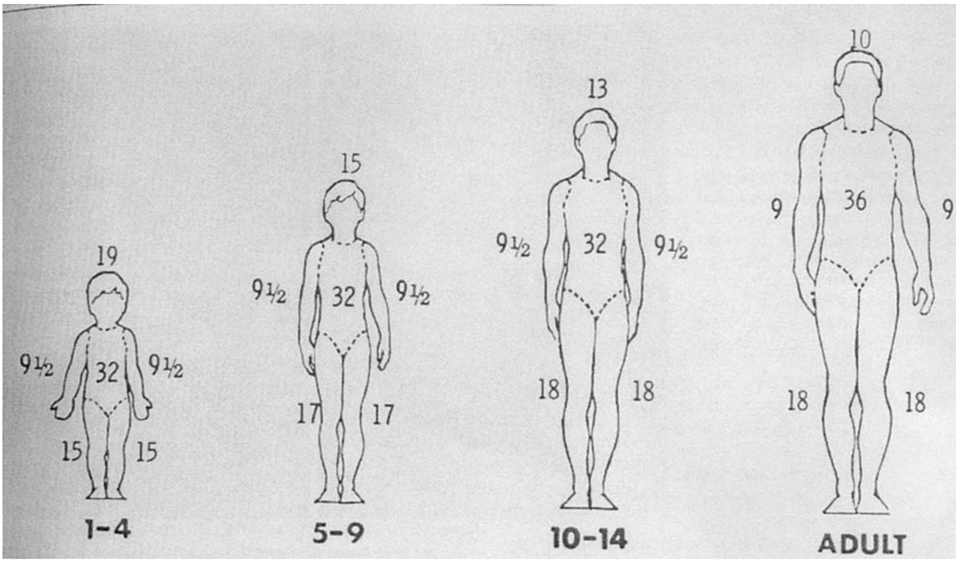

Fig. 4. Rule of 9s from infants to adults. *From* Syzfelbein S, Martyn J, Sheridan R, Cote C. Anesthesia for children with burn injuries. In: Cote C, Todres I, Ryan J, Goudsouzian N, editors. A practice of anesthesia for infants and children. 3rd edition. Philadelphia: WB Saunders; 2001. p. 522–43; with permission.

Some guides as to burn severity note that children have short, stubby legs that should be calculated as 14% of TBSA, not 18% as with adults [1,8]. For prehospital and emergency department personnel who do not treat extensive burns every day, however, the simpler "big parts/little parts" mnemonic can be easier to remember during these stressful situations.

Once a burn patient is stabilized, the Lund-Browder chart is frequently used and is more accurate than the Rule of 9s, which can overestimate burn severity [1,2]. Although the Rule of 9s is used for extensive burns, the whole-hand equivalent may be used to assess patchy burns (eg, a burn to the elbow rather than to the entire arm). Until recently, the palm was considered to be 1% of the TBSA. Studies have now shown that the palm without digits is only 0.4% to 0.5% TBSA; however, when the fingers are included in the measurement, the hand represents 0.7% to 0.8% TBSA (simplified as 1%) [10]. In summary, a burn to the entire arm is a "little part" and therefore approximately 9% TBSA; however a burn only to the elbow is about the size of a patient's whole hand and consequently only 1% TBSA.

ECG monitoring

ECG monitoring is appropriate for serious thermal and all electrical burns, but the placement of ECG leads may be difficult when there are extensively burned areas [2]. ECG leads do not adhere to burned tissues, so the leads must be placed in nontraditional areas (eg, anywhere not burned, such as the back or legs). If there are no unburned areas of the body, in the prehospital setting, ECG leads can be placed in the customary positions and held in place with a wrap of gauze around the chest. In the emergency department and burn center settings, a more invasive technique, such as stapling ECG leads in place, may be used. Appropriate systemic analgesics should be administered before this procedure. In thermally injured patients, arrhythmias are most commonly related to stress, hypovolemia, and acidosis. With electrical injury victims, ventricular arrhythmias such as fibrillation can occur, and ECG monitoring should continue for at least 24 hours after the injury [2].

Overview of EMS and emergency department management

With any significant burn injury, all clothing and jewelry should be removed, preferably by the EMS personnel, before the patient arrives at the emergency department. The early removal of jewelry avoids the need for cutting it off later. Jewelry removal is a priority because it is typically made of metal, which can retain heat and continue to cause thermal damage and because it may become a tourniquet as the surrounding tissues become edematous. All jewelry must be removed quickly even from unburned areas, because patients can later exhibit enormous amounts of generalized swelling. Burned clothing should be wet to extinguish heat and then removed if possible by EMS personnel. In the emergency department, remaining clothing should be removed, and appropriate dressings should be placed on the burned areas. Clothing that adheres to the burn should be left in place. When the burn is later debrided, any remaining clothing will be removed with the burned tissue [11]. Special considerations to prevent hypothermia must be addressed when the patient's clothing is removed.

Airway, breathing, and circulation

Airway, breathing, and circulation (the ABCs) are the basis of all emergency algorithms, and burns are no different. Airway compromise caused by edema is secondary to the effects of breathing superheated air or an inhalation injury. Not all burn patients must be intubated. A conscious patient with no respiratory distress, normal oxygenation by arterial blood gases, and no visible airway injury is highly unlikely to require urgent intubation. When there are concerns about airway edema, patients, especially children, should be intubated soon after arrival, before the airway is compromised by edema [2]. How long does it take an airway to swell, and how much will it swell? The answers to these two questions are unknown. Think about what happens when a finger is slammed in a car door. It swells immediately but continues to swell for hours after the injury. The same process occurs with a burned airway. An initial management principle for potential airway compromise is that it is better to intubate and secure an airway early, because it may not be possible to secure the airway later as edema develops. Invasive airways, such as needle or surgical cricothyroidotomy can be done, but these techniques are challenging in most patients and are significantly more difficult to perform in children [12].

The decision to intubate the patient at the scene depends on EMS protocols and assessment of the burn victim. If the patient is unconscious or in an arrest state, paramedics should immediately intubate the patient. If the patient is unconscious but still has a gag reflex or remains conscious even with severe facial burns, intubation in the EMS environment using rapid sequence intubation (RSI) techniques should be considered. If RSI is not an option, then 100% oxygen should be administered by facemask until the airway is definitively secured in the emergency department [1,2,11]. Last, once an endotracheal tube (ETT) has been placed, securing placement can be quite difficult in patients with severe facial burns. Traditional methods of taping ETTs simply do not work; therefore, use of either umbilical or twill tape or a commercially prepared ETT fixation device should be considered [1].

RSI using adequate sedation and analgesia and short-acting neuromuscular blocking agents (NMBA) has become the airway management technique of choice in the emergency department and operating room arenas. Succinylcholine (Anectine) is a fast-acting agent (30–60 seconds) with a short duration (8–10 minutes in most patients) and is commonly used with RSI [13]. Although the problem is unlikely arise in the initial few hours after the burn (eg, in the EMS or emergency department settings), succinylcholine should still be used with extreme caution because severe hyperkalemia may result [13]. Dr. Madelyn Kahana from the University of Chicago Hospitals departments of pediatric critical care and anesthesia teaches the "1 day–to–1 year rule" regarding succinylcholine and burns: "Succinylcholine is safe on the day of the burn and 1 year after the burn, but never between the two" [13]. This rule is needed to avoid unnecessary life-threatening complications that may result from hyperkalemia. Longer-acting NMBAs, such as vecuronium (Norcuron), pancuronium (Pavulon), rocuronium (Zemuron), and cisatracrium (Nimbex) may be used to assist with intubation or for muscle relaxation after intubation has been successfully accomplished. Although these nondepolarizing NMBA do not cause the hyperkalemia associated with succinylcholine, the duration of these medications (20–60 minutes) can be worrisome if they are used to aid in intubation, especially if intubation cannot immediately performed [13]. The practitioner must remember that NMBAs do not provide analgesia or sedation. Their administration must be accompanied by adequate amounts of IV sedatives and analgesics [13]. Dr. Kahana frequently poses the following questions to surgical residents and to emergency department, critical care, and transport nurses:

1. How can you tell if the patient is sedated enough? Vital signs are not a reliable indicator, especially for patients in shock; NMBAs make the patient lie still and not voice concerns, but if unless concurrently sedated, the patient is awake and able to hear and feel everything.
2. Why are you using NMBAs with the patient in the first place? If the answer is because the patient is moving or agitated, the patient is not sedated adequately. If you give the patient enough sedatives and analgesics, he will act as though he has received a NMBA.

Neuromuscular blocking agents do have a role with intubation, surgical procedures, and with difficulties with ventilation, but in many cases liberal doses of sedatives and analgesics can achieve the same effect.

Intravenous fluids

IV fluids are administered to re-establish intravascular volume that was lost as a result of tissue destruction from the burn and fluid shifts associated with tissue edema. Establishing and securing an IV line can be challenging. Nonburned areas and large veins are the IV sites of choice. If there is unburned area, an IV line can be placed in burned tissue. If peripheral IV access cannot be quickly obtained, an intraosseous line may be placed in children and adults even if this area is burned. The tibia should be used in children; in adults, the sternum (F.A.S.T.1 (Pyng Technologies, Richmond, B.C., Canada), tibia, or arm (Bone Injection Gun, WaisMed, Caesarea, Israel) may be used for intraosseous cannulation [1,2].

Two common concerns are involved in the placement of an IV line through a burned area. The first concern is securing an IV line placed in burn tissue. For prehospital caregivers, wrapping the IV site snugly with gauze will hold the line in place temporarily; as with ECG leads, tape does not stick to burned tissue. Once the patient arrives in the emergency department, the IV line may be sutured with one or two simple sutures. The second concern is the risk of infection. IV lines should not be placed in a burned area, unless there is no alternative, because infection is always an issue; the rapid administration of fluid is of overriding importance, however [1,2].

Lactated Ringers (LR) or normal saline (0.9 NS) solution may be administered depending on burn center preference and protocols. Both are both isotonic fluids that allow maximum fluid to remain in the intravascular space and re-establish perfusion. In addition to resuscitation fluids, children should also receive maintenance fluids containing dextrose, such as D5LR, to avoid hypoglycemia. The consensus formula, formerly known as the Parkland formula, is commonly used as a guideline for initial fluid resuscitation. Fluid resuscitation formulas are only guides. Other assessment parameters such as hemodynamic status, acid base balance, and urine output should be evaluated for each patient. Some patients need more volume replacement than the formula recommends, and certainly some patients need less. The consensus formula calculates the amount of fluid to be given in the first 24 hours after the burn, not after arrival for treatment [11]. Most fluid loss occurs in the first 8 hours postburn, so half the total amount should be administered in the first 8 hours after the burn in an effort to re-establish tissue perfusion quickly. Box 5 summarizes the consensus formula.

An easy way to remember the components of this formula is the following: 4 cc's × "big kid or a little kid" ("big kids," ie, adults, get more fluids than "little kids") × "bad burn versus not bad burn" ("bad burns" get more fluid than "not bad" burns). For example, based on the consensus formula, a healthy 100-kg, 20-year-old patient with a 50% TBSA burn would receive 20,000 cc's in 24 hours; 10,000 cc's, or 10 L of fluids, would be administered in the first 8 hours after the burn. It can be challenging for paramedics to use the consensus formula because in the EMS arena, weight, and percent of TBSA burned are only estimated. In addition, IV infusion pumps are not commonly available in the field, and IV fluids are simply infused and adjusted based on hemodynamic response. For a burn-injured child, as with any pediatric trauma patient, a 20-cc's/kg fluid bolus should be administered, by which point one hopes the patient will be at the emergency department [1]. In adults with severe burns, the Advanced Burn Life Support (ABLS) course recommends that adults receive a 500-cc's fluid bolus, although many centers recommend that EMS personnel simply administer wide-open fluids because it is difficult to give the severely burned adult

Box 5. Consensus/Parkland formula for estimating fluid requirements for the first 24 hours postburn [1]

4 cc's/kg/BSA burn
- 4 cc's of lactated Ringers or 0.9 normal saline
- Big kid versus little kid (kg)
- Bad burn versus not bad burn (BSA burn)

One half of total amount administered over first 8 hours after burn (not timed from arrival in emergency department)

Remaining one half of fluids administered over next 16 hours

Remember: This formula is only a guide. This formula is based on the assumptions that urine output is adequate and the patient is not in shock. Fluid requirements may be greater in these conditions.

patient enough fluids in the prehospital setting. In areas with prolonged prehospital transport times, these guides must certainly be adapted. Accurate estimation of the volume of fluid given during transport by EMS is then figured into the total sum of fluids that the burn patient should receive according to the consensus formula [2,4,11].

Urine output

Urine output should be measured in the emergency department to assess fluid requirements better. Two categories of patients should have urinary catheters placed before transport to a burn center. First are those with burns to the genitalia. Burns in this area can cause extensive edema, and if a catheter is not placed early in the resuscitation, later transurethral insertion may be impossible, requiring placement of a suprapubic catheter. The second category of patients requiring urinary catheterization is patients with serious burns (> 10% TBSA) requiring hospitalization and extensive fluid resuscitation. The accepting burn center can also provide guidance if referring staff are unsure whether a urinary catheter should be placed [1,11].

A major concern in the emergency department and later burn center settings is to prevent or treat myoglobinuria. If the Foley bag contains very dark urine ("Pepsi pee"), significant myoglobinuria is present. When extensive muscle damage occurs (eg, in electrical burns), myoglobin is released and flows through the blood stream to the kidneys, potentially clogging the tubules and resulting in kidney damage or failure. If significant myoglobinuria is grossly visible or found to be present by urinalysis, the treatment is simply to increase hourly fluid administration to flush the kidneys. Other concurrent therapies, such as administration of a diuretic such as mannitol or alkalization of urine by administering sodium bicarbonate, can be recommended by the burn center [5,11].

Temperature

Hypothermia can quickly ensue because of the physical loss of skin, environmental factors such as cold, wet clothing, and ambulance and emergency department ambient temperatures. In addition to maintaining a warm environment, one should remember that wet skin gets colder 30 times faster than dry skin [1,14]. Hypothermia can compromise perfusion and the hemodynamic stability of the patient. Hypothermia may result in prolonged clotting times, hemodynamic instability, and even apnea in infants and children. Infants and small children lose significant amounts of heat from their large heads, so a small stocking cap can be made from stockinet or other material and applied to the head in an attempt to minimize heat loss. If available, warmed IV fluids should be used, because fluids at room temperature (68°F) can quickly result in disastrous hypothermia. Interventions such as keeping the ambulance or treatment room as warm as tolerable and using a convection forced-air warmer (Bair Hugger, Arizant Health Care, Eden Prarie, MN) or warming blankets can help prevent heat loss in these patients [1,14].

EMS and emergency department wound care

In the prehospital and emergency department environments, the priorities of major burn management are to stop the burning process, address the ABCs, provide analgesia, cover the wound with dressings, and transport the patient. For transport, serious burns should be loosely covered with dry or Water Jel (Water Jel Medical Technologies, Carlstadt, NJ) dressings, per burn center preference. Clean (sterile if available), dry sheets should be placed under and over the patient, with a blanket to prevent heat loss (even in summer). Silver sulfadiazine (Silvadene) although commonly used for burns in the outpatient and inpatient settings, should not be placed on the burn if the patient is being transferred to another facility, because the receiving staff will have to remove the dressings and the silver sulfadiazine to assess the burn [2,11].

Small burns can be covered initially with gauze and saline or Water Jel. As described earlier, although wet dressings feel better, they can result in a worsening of hypothermia. Wounds in patients with minor burn injuries who may be sent home or admitted to a hospital facility (but not transferred to a burn center) should be lightly covered with topical antimicrobial agents such as silver sulfadiazine or neomycin and gently wrapped with dry gauze or synthetic occlusive dressings such as Biobrane (Bertek Pharmaceuticals, Morgantown, West Virginia), DuoDerm (ConvaTec, Princeton, New Jersey), or Opsite (Smith & Nephew, Largo, Florida) [1,2,11]. Repeated assessments and dressing changes can then be accomplished at home by the patient or family members, in the office by the primary physician, or in the outpatient hospital settings.

There are three schools of thought regarding burn blisters. Some believe the blister should be left intact because the top layer acts as a biologic barrier to infection. Some centers aspirate blister fluid with a syringe, because the fluid is thought to impair leukocyte activity, but leave the blister covering intact.

Some centers advocate the complete removal of all blister fluid and the epithelial covering because of concerns about impaired wound healing [11]. Whatever method of blister management is chosen, the wound should be covered with a topical antimicrobial agent (if the patient is not going to be transferred) and close follow-up ensured [2,11].

In the emergency department setting, if the patient is to be discharged home or admitted, gentle cleansing with warm water and mild soap is appropriate. Again, if the patient is going to be transferred to a burn center, clean and dry dressings (or Water Jel, per burn center preference) are appropriate; the burn center will later clean the wounds with the agents of its choice. Last, both in pediatric and adult burn patients, immunization status should be assessed, and subsequent tetanus prophylaxis should be administered as needed [2].

Pain management

> The wise person looks not for pleasure, but merely freedom from pain (Aristotle 384-322 BCE)

> Disease can destroy the body, but pain can destroy the soul (E. Lisson 1989)

Burn pain is unlike any other pain and can require amounts of analgesia that in other patients would be considered unsafe. With minor superficial burns, topical anesthetics (Solarcaine, aloe vera) or oral medications, such as acetaminophen with or without codeine or ibuprofen, can often provide acceptable pain relief. Topical anesthetics should be used with caution in children with larger body surface areas, because absorption of the anesthetic may cause seizures.

IV analgesia should be used with more severe burns. IV morphine or fentanyl can be used for systemic analgesia in conjunction with aggressive fluid resuscitation [5,11,14]. If the patient is in shock, blood is preferentially shunted to the heart, lungs, and brain. Therefore, administration of intramuscular or oral medications is not advisable in these patients. Nurses should serve as patient advocates in assuring adequate pain relief for all patients [5]. Sufficient medication should be given to keep the patient calm, conscious, or at least easily awakened. A bag-valve-mask device with oxygen and an appropriate-sized mask should be always kept at the bedside in case of severe respiratory depression. In pediatric patients 0.1 mg/kg IV morphine and in adults 5 to 10 mg IV morphine every 5 minutes may be necessary to provide adequate pain relief [2]. These amounts are in stark contrast with the 1 to 2 mg IV of morphine that is cautiously administered to adult patients with chest pain. If necessary, naloxone (Narcan) can be used to reverse opiate-induced respiratory depression. Paramedics with adult overdose patients teach the concept of "B without B" – "breathing without beatings!" Administration of naloxone can result in excruciating pain as the naloxone reverses the analgesic agent. The same is true for opiate-induced respiratory depression in burn patients. Small, repeated doses (0.1 mg/kg in children under 12 months of age and 1.0 mg in older children and adults) of IV naloxone should be administered for respiratory depression or apnea, in addition to assisted ventilation as needed [15]. If the patient who has received appropriate amounts of analgesics and finally is comfortable also stops breathing, intubation to allow adequate pain control should be seriously considered.

A relatively new innovation in pediatric burn pain management in the hospital setting is the fentanyl Oralet (Abbott Laboratories, Abbott Park, Illinois). Fentanyl is a synthetic opiate that is 100 times more powerful than morphine and, in addition to the commonly administered IV route, can also be given in orally, as an Oralet or in lollipop form. This option works well if IV access is not in place; the major drawback is a 30% incidence of nausea or vomiting, especially in the opiate-naïve patient. For treatment of pain in children during dressing changes, the University of Chicago Burn Center has had good success with this medication because it provides pain relief and moderate sedation, but only for short periods of time; the half-life of fentanyl is much shorter than that of morphine [16]. With any burn, regardless of severity, the importance of parental or family support cannot be overstated. Calming measures from the family members and distraction therapies such as music or videos can reduce anxiety and pain in the child, which in turn reduces the pain and anxiety felt by the emergency department staff caring for the pediatric burn patient [14].

Fasciotomies and escharotomies

A full-thickness circumferential burn, that is, a burn that goes all the way around a body part, can impair circulation because of excessive pressure within the tissue compartment. When the entire thorax is involved, respiration can be impaired. Compartment compression is the result of the inflexibility of the eschar (dead tissue), which does not stretch, to accommodate the rapid progression of swelling. Circulatory, motor, and sensory functions may be compromised as edema compresses the veins, nerves, and arteries. In the emergency department setting, in patients with circumferential burns, extremity escharotomies or fasciotomies are rarely needed if expedient transport to a burn center can be arranged, unless neurovascular compromise is present. If the chest is circumferentially burned, and ventilation cannot occur despite mechanical ventilation with an endotracheal tube, a chest escharotomy may be indicated before transport to a burn center [2,11].

In summary, EMS and emergency department personnel provide essential assessment and management of the burn-injured patient through aggressive fluid resuscitation, airway and pain management, application of burn wound dressings, and treatment of compartment compression requiring escharotomies. Frequent contact with the receiving burn center is essential for guidance, support, and optimization of patient survival.

Overview of special burns

Electrical injuries

For prehospital caregivers, the first priority before assessing and managing any patient is always scene safety. Three differences must be remembered when confronted with a high-voltage (> 500–1000 volts) or low-voltage (< 500–1000 volts) electrical burn injury. First, electricity follows nerves and fluid. Nerves are attached to muscles and contract when stimulated, possibly resulting in spinal injuries caused by the muscular contraction or subsequent falls from a height. Therefore, in these patients spinal injury precautions involving rigid cervical collars and spinal boards are appropriate in the prehospital setting, until physical examination or radiography rule out a spinal cord injury [1,17–19]. Second, the on-site caregiver should remember, "Electricity loves nerves." Nerves are located deeper in the tissues, so electrical burns cause thermal injury from deep tissue progressing outward. Electrical burns are otherwise characterized by statements such as "what you see on the outside is not always what's on the inside" or the "tip of the iceberg syndrome." The visible burns may not appear severe, but the internal injuries can be more severe because of the thermal damage to deep tissues as the electricity moved through the body. In toddlers, the most common type of electrical burn is a mouth burn from chewing on electrical cords. Though these burns can initially seem minimal, the real risk with this injury comes 3 to 5 days after the burn, when delayed hemorrhage from the labial artery can occur [1]. Fluid resuscitation formulas may not be accurate, because internal thermal damage is not easily assessed; thus, with electrical burns, fluids are given to achieve hemodynamic stability and urine output of at least 1 cc/kg/hour in children and 100 cc/hour in adults [1,17]. Third, one must consider electricity's effect on major muscle groups, and the much higher risk for associated myoglobinuria, and admitting all patients sustaining high-voltage burns for at least 24 hours of cardiac enzyme and ECG monitoring for potentially lethal arrhythmias [1,2,17].

Lightning injuries

The amount of energy that accompanies a lightning strike can be beyond the imagination. Only 110 to 220 volts is encountered with biting through an electrical cord or putting a finger or a fork in a socket. If a person grasps a power line, several thousand volts can be involved. Lightning has been measured ranging from 2000 to 2 billion volts, an unimaginable amount of energy [20]. The same concerns apply to lightning injuries as to any electrical burn. Spinal injuries may occur from muscle contractions, from being thrown, or from blunt or penetrating trauma from nearby debris. The most common cause of death in lightning victims is cardiac arrest caused by a massive countershock to the myocardium and paralysis of the medullary respiratory center [20]. Almost all victims of lightning strikes who do not suffer cardiac arrest do survive, but long-term cardiac, neurologic, and ophthalmologic sequelae are common [20]. Because of the short duration of the lightning exposure, the current tends to flash over the body with resulting deep entrance and exit wounds; myoglobinuria rarely occurs. Patients struck by lightning should be admitted for at least 24 to 36 hours of observation and continuous cardiac monitoring, with follow-up cardiac, neurologic, and ophthalmologic examinations [17,20].

Chemical burns

Treatment of chemical burns, whatever the chemical, essentially consists of flushing the skin with copious amounts of water. The only notable exceptions to this rule are burns from alkali metals such as sodium, potassium, and lithium. These metals burn and can even explode when placed in contact with water and therefore should be covered in oil and then carefully removed. There are specific antidotes for certain chemical exposures, such as hydrofluoric acid and white phosphorous, but they are exceptions to the rule. If the patient has a chemical burn, flush the skin with water first, then consider finding and administering the antidotes [2].

Hot tar burns

Tar is sticky and hot. Tar is heated to 120°C to 135°C (275°–300°F) for paving roads and to 218°C to

245°C (450°F–500°F) for roofing projects. The priority for EMS and emergency department personnel is not to get the tar off but to cool the tar down. Well-meaning health care workers focus on trying to get the tar off, while thermal energy from the tar continues to penetrate the underlying tissue. Copious amounts of cool water or Water Jel dressings should be used to cool the tar. Signs and symptoms of hypothermia need to be assessed during the cooling of the tar. Once the tar is cooled, it can be removed. Emollient ointments such as petroleum jelly, neosporin, or even mayonnaise will help separate the tar from the skin and make removal easier. Once the tar is removed, the depth of the tissue injury can be assessed [2].

Nonaccidental burns

If the reported mechanism of injury does not fit the injury, abuse is assumed until proven otherwise. Whether based on conflicting or changing history or on suspicious findings, the possibility of abuse must be entertained with burn-injured children and elderly persons. If the injury is thought to have been caused by abuse, it must be reported to the appropriate authorities, because of legal mandates and because of the associated ethical implications. EMS personnel should inform the emergency department of their suspicions and document the initial on-scene findings, verbal history, and findings from the physical assessment of the patient. Whether the child is going to be discharged home, admitted, or transferred to a burn center, the ER should call and report their suspicions of abuse. Even if the burn center will also call, it is recommended that both the transferring and the receiving centers notify the appropriate contacts. Health care providers have an obligation to help protect those who cannot protect themselves [1,7].

Prehospital and emergency burn care priorities can be summarized as assessment of the ABCs and transportation of the patient to an ABA burn center for definitive treatment. The primary survey focuses on the mechanism of burn injury, assessment of associated trauma, establishment of a patent airway, and initiation of fluid resuscitation. The secondary survey expands the primary survey to include aggressive pain management and initial burn treatment. EMS and emergency department personnel who are knowledgeable about burn patient resuscitation and management can improve patient survival.

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