Initial Resuscitation of Major Burn Patients

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Family physicians living in rural areas must be familiar with the initial stages of resuscitation of the major burn patient, as they may often be the providers of first contact before the patient is transferred to a burn center. Correct initial resuscitation may have an impact on morbidity and mortality in the subsequent early recovery period. The mnemonic SAVE A PATIENT is useful in reminding one of each of the steps that must be considered in the initial resuscitation of such patient.

Injury and death by burns continue to be major concerns for health professionals. Burns are the second most common cause of accidental death, with a fatality rate of 3.5 per 100,000 population.[1] In 1985 there were an estimated 10,000 deaths resulting from burn injury in the United States.[2] An additional 21,000 people survived burns substantial enough to require admission to a major burn facility for treatment.[3]

Although there are no data available on the training of the physicians of first contact for these patients, in rural settings a family physician may often be the primary provider. Unfortunately, few family practice residency programs are able to provide trainees with experience in the initial resuscitation and management of major burn patients pending their transfer to burn centers. While accurate and helpful burn protocols are available, a narrative discussion with elaboration of some issues can be helpful to the primary provider.

There are four critical periods during which victims of major burns are likely to die: first, at the time of and within the first few hours after injury; second, at 24 to 48 hours after the injury; third, at four to seven days following the injury; and, fourth, at two to eight weeks after the injury. Each period has associated causes with anticipatory management implications.[4] During the first period death is primarily due to associated trauma and immediate respiratory and inhalation complications. During the second period increased mortality is related to fluid and electrolyte disturbances, while during the third and fourth periods patients die as a result of infective complications, which are responsible for the greatest mortality among burn patients surviving long enough to reach the hospital.[3,5] During each of the first three periods, the primary care provider can play a key role in lowering mortality by providing adequate resuscitation before transfer to a burn facility. The physician's role in lowering mortality is in addition to the importance of the initial resuscitation in minimizing tissue loss. A family physician practicing in a rural area should be familiar with the process of resuscitation of major burn patients.

Two patients recently seen in the 37-bed US Public Health Service Indian Hospital at Crownpoint, New Mexico, illustrate the problems faced, as well as the knowledge and skills needed, by primary providers in rural areas.

ILLUSTRATIVE CASES

Case 1

M.H., an 18-year-old man, was brought to the emergency room after having been burned in a house fire. At the scene he had been found lying on the ground outside the house. Sterile sheets and water were used by the emergency medical technicians to extinguish any burning, and he was transported to the emergency room. On arrival his pulse was 120 beats per minute, blood pressure 120/90 mmHg, and respirations 28/min. No other injuries were noted, and an initial estimate of his burns was that he had 65 percent second- and third-degree burns scattered over all areas of the body. Because of inability to visualize superficial veins through the burns, a right subclavian line was placed, and hydration with lactated Ringer's solution was begun at a rate to give 7 L in the first eight hours (recent weights had been 113 lb). Since the patient had perioral burns and carbonaceous material in the mouth, he was intubated by the endotracheal route. A nasogastric

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tube was placed. None of the burns was circumferential, so escharotomies were not performed, and topical therapy was not applied by the choice of the receiving burn center. The patient was given frequent 2- to 5-mg doses of intravenous morphine for analgesia and sedation during his resuscitation and transport to the burn center. He recovered after a prolonged hospitalization of seven months and was discharged for outpatient physical therapy of residual functional loss of his extremities.

Case 2

In an attempt at suicide, D.B., 50 years old, pitched himself into a bonfire he had built, sustaining burns of the upper two thirds of his body. He was transported in sterile sheets first by police, then by emergency medical technicians. He was not noted to have other injuries, and vital signs en route included pulse 88 beats per minute, blood pressure 96/74 mmHg, with respirations 36/min. He arrived in the emergency room three hours after the injury with essentially the same vital signs. No other injuries were noted. He was estimated to have 60 percent total body burns primarily of the upper two thirds of the body. Intravenous rehydration was begun through cutdowns at a rate sufficient to give 7 L of lactated Ringer's solution by eight hours after the injury (estimated weight 60 kg). Intraoral burns were noted, and although no respiratory stridor was heard, he was intubated by the endotracheal route. At the receiving burn center's request, 1 percent silver sulfadiazine cream was applied. In addition, a nasogastric suction tube and urethral catheter were placed. He was given small doses of intravenous meperidine for analgesia. Prior to transport, the circumferential burns of the hands were felt to be compromising the vascular flow of the extremities, as capillary refill in the nail beds was decreased. Since transport time to the burn center was anticipated to be two hours, escharotomies of the hands were performed following consultation with a surgeon at a referral center. The patient was then transported uneventfully. During an acute care hospitalization of six months, he recovered from the initial consequences of his burn and was discharged with follow-up planned of his residual deformities and psychiatric illness.

A COMPREHENSIVE APPROACH TO MANAGEMENT

The above two cases are useful in emphasizing the essentials of initial resuscitation of major burn patients. In every patient resuscitation should be an orderly sequence of steps with attention paid to each one of the steps, even though some may not be needed in every case. These steps can be summarized with the mnemonic SAVE A PATIENT (Figure 1).

S TOP THE BURNING PROCESS
A BCs OF BASIC LIFE SUPPORT
V ISUALIZE THE PATIENT FOR ALL INJURIES
E STIMATE BURN SIZE AND BEGIN FLUID RESUSCITATION

A IRWAY—INTUBATE IF INHALATION INJURY PRESENT

P ENICILLIN?
A NALGESIC
T OPICAL THERAPY
I NTOXICANTS/INHALANTS
E SCHAROTOMY
N ASOGASTRIC TUBE
T ETANUS

Figure 1. Essentials of initial resuscitation of major burn patients

Stop the Burning

The first step is to stop any ongoing burning and tissue loss. Ordinarily this step would have been taken at the scene by emergency personnel, but under some circumstances the agent causing the burn may still be in contact with tissue. Burn injury can result from exposure to thermal, electrical, chemical, or radiation sources.[1] In the case of thermal injury, the patient's clothes may act as a heat reservoir or may even still be smoldering inconspicuously when the patient arrives in the emergency room. The temperature at which synthetics burn is relatively high and can produce deep injury.[6] It is essential that the patient be completely disrobed upon arrival, not only as a first step in extinguishing any ongoing burning, but also to visualize fully the injuries. When the burn is from a chemical source, the correct management is copious irrigation with water until the chemical is clearly no longer in contact with the patient. Attempting chemical neutralization not only leads to wasted time in searching for the correct neutralizing agent, but also potentially adds thermal injury to the chemical one through the liberation of thermal energy in the neutralization reaction. Irrigation with water should also be used as an initial step when the causative agent of a thermal contact burn (eg, tar) remains in contact with the patient until such time as the agent has cooled completely. Removal of the contact agent can then be undertaken with specific emulsifiers at a later time. In the case of tar or asphalt, petroleum-based solvents have been recommended[7,8] as the preferred method of removal.

Some authors[9-11] also recommend 10 to 60 minutes of cool (10 to 20 °C) water lavage of burned areas to aid in heat removal (preventing deepening of the injury) and to offer some pain relief. It is critical, however, that this lavage not produce hypothermia. In fact, for large injuries cool water lavage should be avoided.[9,12] The burn patient is already prone to hypothermia, given the increased evaporative losses resulting from reduced skin surface and the exudate produced by the injured tissue. It is equally important that a cool water lavage not be allowed to interfere or delay further resuscitation of the patient.

ABCs of Basic Life Support

Coincident with efforts to stop the burning process, basic life support should be begun with the ABCs—airway, breathing, and circulation. Many burn patients will have other potentially life-threatening injuries. The provider must not let the dramatic presentation of the burn injuries distract her or him from attending to the basic principles of management of any major trauma victim.

Visualize the Patient for Associated Injuries

Although major burns require urgent management, rarely are they as emergently life-threatening as associated injuries can be. Patients suffering electrical burns may have fallen from substantial heights with resulting fractures, possibly including spinal ones. Patients burned in vehicular fires could have sustained hemorrhagic or neurologic injuries in the preceding accident. Injuries to the eyes should be evaluated early as subsequent burn-induced periorbital edema may make later examination difficult.[13] In every major burn-injured patient, regardless of the reported cause, a thorough review should be made of every major system to identify all associated injuries and to begin appropriate management of them.

Estimate Size of Burn and Begin Fluid Management

The most common method for burn size estimate is the Rule of Nines (Figure 2).[1,2,5,6,9,14] In an adult, this rule provides for a reasonable approximation of burn area by dividing the skin surface into areas of 9 percent of the total surface. In a child, because of the relatively increased contribution of the head and decreased contribution of the lower extremities to total surface area, the percentages are revised. For an infant, the head is estimated to be 18 percent (vs 9 percent in an adult), and the legs are 14 percent each. Age-related charts should be consulted for variations as the child grows older, but a rule of thumb is that starting at age 1 year, the head decreases by 1 percent, and the lower extremities each increase by 0.5 percent per year of age until the adult percentages are reached.[1] A useful guide in estimating smaller areas of burn is to consider the patient's palm as equal to 1 percent body surface area.

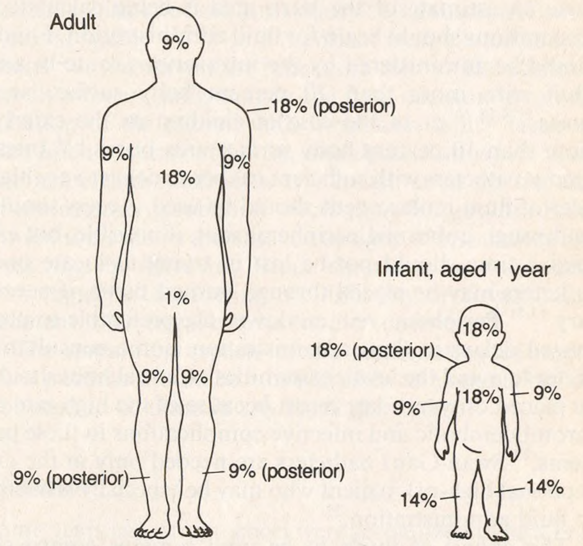

Figure 2. The Rule of Nines for estimating burn surface area

Charts are available[1,12,15,16] for more detailed assessment of burn surface area and should be kept in the emergency room. Recently, a computer-assisted method of burn estimation was developed.[17] For purposes of initial estimation, however, the Rule of Nines is adequate. Providers should bear in mind the tendency to overestimate burn size in the emergency setting.[18] The truism remains: "Burns are deeper than you think, and less extensive than you think."

In the initial calculation of burn size for use in fluid management, second- and third-degree burns should be added together (first-degree burns should not be included in size calculations). There is evidence that the proportions of partial-thickness and full-thickness burns affect ultimate mortality outcome,[19,20] but this appraisal has no relevance in the emergency setting, particularly since such initial estimates are often in error.[21]

As an estimate of the burn area is being calculated, preparations should begin for fluid administration. Fluids should be administered by the intravenous route in any adult with more than 20 percent body surface area burns,[9,14,18,22] or in the case of children or the elderly, more than 10 percent body surface area burns.[1,14] Intravenous catheters with sufficient caliber to deliver very high rates of fluid replacement should be used. Access should be through unburned peripheral sites, if possible, but excessive time should not be lost in trying to locate one; catheters may be placed through burned tissue, if necessary.[13,21] Peripheral vein cutdowns are preferable to prolonged delays in fluid administration (some consultants prefer to avoid the lower extremities). Central lines should be placed only as a last resort because of the high rate of thromboembolic and infective complications in these patients.[23] Swan-Ganz catheters are needed only in the exceptional high-risk patient who may be especially sensitive to fluid administration.[23]

The choice of fluids to be used remains controversial.[9,10,12,14,18,22,24-30] Nearly all authorities prefer to begin with crystalloid solutions alone. Colloids are added anywhere from 6 to 24 hours after the injury, but for purposes of emergency room management, should not be used, as they have no demonstrated beneficial effect on outcome when used in this setting.[3,18] The solution of choice is lactated Ringer's solution administered at a rate equal to 2 to 4 mL per percentage of body area burned per kilogram of body weight given over the first 24 hours after the injury.[1,5,9,18,28,31,32] One half of this total should be given in the first eight hours (after the burn episode) and the remaining one half given over the next 16 hours. Potassium should not be added to the initial solutions, as an early hyperkalemia may result from tissue destruction.[1,14] Hypokalemia is more commonly seen in the postresuscitation period.[22]

Several caveats related to this formula should be kept in mind. First and foremost is that this formula should be used only to initiate resuscitation and as a guideline. Therapy should be individualized in each patient, a point that has been emphasized repeatedly by many authors.[13,24,27,31] The pulse, blood pressure, sensorium, and urine output should all be monitored frequently. Though urine output in severely burned patients is an imperfect measure of volume status, because it is the best measure available in most clinical settings,[14,18,32] an indwelling urethral catheter should be placed. The aim of fluid management should be to maintain an hourly urine flow of 30 to 50 mL in the adult, and 1 mL/kg in children weighing less than 30 kg.[1,9,12,21,32,33] If urine flow exceeds this rate, the fluid administration rate should be decreased by 25 percent over the following hour.[32] If output continues to exceed the goal, further 25 percent decrements in the intravenous fluid rate should be made until the urine output is at the desired level. On the other hand, if the initial intravenous fluid rate is inadequate to produce the needed urine flow, the intravenous fluid rate should be rapidly increased until adequate urine output is established.

In several categories of patients, this suggested initial intravenous fluid rate may need to be modified. Patients with burns exceeding 40 percent of body surface area tend to need more fluids than those with lesser injuries, even out of proportion to the percentage burn.[28,30,31,34] Patients with inhalation injuries[25,26,28,30,33] or electrical burns[13,14,30] require greater fluid amounts than patients with comparable injuries without those risk factors. Patients with electrical burns require higher fluid rates to assure a higher urine output (75 to 100 mL/h) so as to clear myoglobin and hemoglobin loads created by their burns. A higher fluid rate should also be considered in patients with associated crush injury and muscle burns. Mannitol diuresis may be used if fluids alone do not produce adequate urine output, which will rarely be the case.[14,22,32] Despite the greater fluid requirements for patients with inhalation injuries, it has been suggested that because of the tendency for these patients to develop pulmonary edema as a result of the nature of their injury, a lower output of 0.3 to 0.5 $mL/(kg \cdot hr^{-1})$ should be considered acceptable[25]; so far, no studies have been conducted to support this recommendation.

Herndon et al[12] have made a case for using only body surface area calculations as a guide for fluid administration in children to avoid errors caused by extremes of patient or burn size. They suggest giving 5,000 mL/m^2 of burned area and 2,000 mL/m^2 of total body surface area over the first 24 hours, with one half delivered in the first eight hours.

As originally developed, the Parkland, or Baxter, formula (4 mL/kg per percentage of body surface area burned of lactated Ringer's solution in 24 hours following the injury, one half in the first eight hours) was derived as a method to deliver 0.52 mEq/kg per percentage of body surface area burned of sodium.[18] Sodium was determined to be the key factor in resuscitation of burn shock, as might be expected given the hypoproteinemic state induced by the burn, and 0.52 mEq/kg per percentage of body surface area burned was the determined mean amount required. The Brooke formula (2 mL/kg per percentage of body surface area burned in adults, 3 mL/kg per percentage of body surface area burned in children, both again to be delivered over the 24 hours following the injury, with one half in the first eight hours) was developed from clinical experience with the least amount of relatively isotonic solution to resuscitate adequately the majority of patients.

Recently several authors have suggested the use of hypertonic saline (250 mEq sodium per liter of water) as the primary, or backup, resuscitation fluid.[18,24,27,35] Its advocates say that this solution delivers less free water, acts to draw extravascular fluid into the vascular compartment, lessens edema away from the burn site, decreases the need for escharotomies, increases cardiac output, eliminates ileus, and decreases intrapulmonary water in patients with inhalation injury. Others say that such a solution is potentially dangerous because of the risk of severe electrolyte disturbances.[14,18,30,31] They point to a lack of proven benefit on clinical outcome.[1,21] Given the controversy about its use, the impracticalities of close electrolyte monitoring during transport, and its potential hazards, the use of hypertonic saline for initial resuscitation by the primary care physician is not advised.

A clear problem in deciding on a uniform approach to fluid administration is the lack of large controlled trials comparing the various solutions with reference to a variety of factors. Until such time as these studies are done, however, it is reasonable to begin with the guidelines suggested above: 2 to 4 mL of lactated Ringer's solution per kilogram of body weight per percentage of body surface area burned over 24 hours, one half given over the first eight hours. Patients with the risk factors cited above should be begun at the higher end of this range, children should be begun at the middle to upper end of the range, and other adults may be begun at the lower end. In all cases, continuing therapy should be individualized based on the clinical monitoring.

Blood products do not need to be administered in the emergency setting unless other injuries make it necessary or unless a sufficient degree of anemia before the injury is known.[1,10,14,18] Red cell mass loss at the time of injury is estimated to be 8 to 10 percent.[1,14,18]

At this point (following burn size estimate), where the patient should be managed once initial resuscitation is under way should be considered. In general, patients with the following injuries should be referred to regional burn centers: partial-thickness burns over 25 percent of body surface area; full-thickness burns over 10 percent of body surface area; inhalation injury; circumferential burns; facial, perineal, and hand burns; patients in the extremes of age with greater than 10 percent of body surface area burns.[1]

Airway

Once fluid resuscitation is begun, attention should be returned to the airway for further evaluation. It is estimated that 20 to 40 percent of patients admitted to burn centers have some degree of inhalation injury,[1,3,12,27,33] and its presence carries with it an associated increase in mortality for any given percentage of burn.[4,12,20,25,33] Signs of inhalation injury should be sought, and if found, tracheal intubation should be considered. Signs suggestive of inhalation injury include singed nasal vibrissae, carbonaceous sputum or material in the mouth, edema of the upper airway, circumoral burns, oropharyngeal burns, and hoarseness, stridor, or wheezing.[4,25,32] Some would also include a history of the burn injury being sustained inside a closed space,[4,25,27,32] and a patient with altered mental status[36] as risk factors for inhalation injury. The clinician should exercise judgment in the final decision about intubation of the patient with inhalation injury based in part upon severity of injury, anticipated transport time, and associated conditions. It is better to err on the side of unnecessary intubation where there is question. Early intubation even in the absence of signs of respiratory distress may be lifesaving (since deterioration may occur very rapidly), considering the difficulty of airway management if laryngeal edema should supervene.[4]

The remaining aspects of the resuscitation of major burn patients should be considered in all patients but do not need to be done in any particular order.

Penicillin

Some years ago, streptococci were recognized to be a major cause of mortality occurring in the first three to four days following the injury. As a result, it became standard in many centers to administer a course of prophylactic penicillin beginning at the time of initial resuscitation and extending for three to four days. Recently, this practice has fallen into disfavor with most authorities.[1,3,12,21] Studies have shown no beneficial effect of such prophylactic use; instead, use of antibiotics only in response to clinical infection is suggested.[37–41] Some workers continue to advocate its use, however.[10,34,42] In the emergency setting a final decision about the use of prophylactic penicillin is perhaps best made together with the receiving burn center.

Analgesia

Analgesia should be given intravenously in small doses once the blood pressure has been stabilized and urine output is established. The intramuscular or subcutaneous routes should be avoided because of uncertain absorption patterns. Analgesics are important not only for pain relief, but also to aid in slowing the tachycardia resulting from the pain and allow discrimination from tachycardia caused by recurrent hypovolemia.

Topical Therapy

The question of topical therapy should be discussed with the receiving burn center. If transport time to the burn center is relatively short, the center may prefer that no topical antibiotic be used so that the burn is not obscured and early management there is not made more difficult. If, however, the time since the burn or until receipt at the burn center is comparatively long, topical therapy should be applied. Topical antibiotic agents are responsible for a large decrease in burn mortality occurring since their introduction.[5,43] The agent of choice in the emergency room setting is 1 percent silver sulfadiazene.[5,10,12] Its spectrum is broad, its adverse reactions are minimal,[44,45] and its application easy and painless.[1,5] Other agents may have a role later in the patient's management,[32] but not in the emergency room. Regardless of whether topical antibiotics are used, clean sheets should be used to cover the patient during transport. Sterile dressings, such as gauze pads or wraps, may be used to cover specific burn areas, but only if they do not interfere with the monitoring of respiratory status or the vascular function of the involved part.

Intoxicants and Inhalants

Many major burn patients have some degree of alcohol or other drug intoxication at the time of their injury. Failure to consider the presence of one of these agents may lead to incorrect status assessment or management. Another intoxicant to be considered in the major burn patient is carbon monoxide. Since most major burns occurring now take place in residential fires,[1] carbon monoxide intoxication is a frequent accompaniment of the burn. The affinity of hemoglobin for carbon monoxide is well known and can produce severe hypoxemia and functional anemia. In any patient in whom carbon monoxide intoxication is a possibility (potentially anyone injured in a flame burn without regard to whether it was in a closed space), 100 percent oxygen should be administered until a carboxyhemoglobin level can be measured.[1] Arterial blood gases may not be useful, as the oxygen tension may continue to be high despite a toxic level of hemoglobin saturation by carbon monoxide.[36] A rapid qualitative test for a toxic level of carboxyhemoglobin can be done in almost any hospital even if a quantitative test is not readily available.[46] It calls for placing 10 mL of water in each of two test tubes. In one tube, 5 mL of normal blood is added; in the other, 5 mL of the patient's blood is added. Five drops of ammonium sulfide is then added to each, and they are both made faintly acid with acetic acid. Normal blood will turn a greenish brown color, while blood with 10 percent or greater carboxyhemoglobin saturation will turn a rose red color.

Along with the carbon monoxide, patients may have been exposed to a variety of toxic inhalants at the time of the burn. These toxins, capable of causing chemical pneumonitis, are responsible for the greatest part of inhalation injury in burn patients surviving to arrive at the hospital.[3,12,27,36] The nature of the specific toxin will usually be impossible to determine at the time of initial resuscitation, but management is supportive in any case. Arterial blood gases should be measured, and oxygen administered accordingly. Direct thermal injury of the lower respiratory tract is unusual unless steam is inhaled.[1,12,27,32,36] Prophylactic antibiotics and corticosteroids only act to increase the higher mortality rate in patients with inhalation injury.[1,2,12,21,27,32]

Escharotomy

Escharotomies may need to be performed on the patient before transport. Again the decision to perform an escharotomy is perhaps best made together with the receiving burn center personnel based at least in part upon the anticipated transport time. If signs of vascular compromise develop, however, there should be no delay. Whenever circumferential full-thickness burns exist on an extremity, particularly in association with crush or electrical injury, the potential for burn wound inelasticity and edema to inhibit blood flow to distal areas is great.[47] Frequent examination of the distal part for diminishing pulses or capillary refill or for paresthesias in unburned areas should be done throughout resuscitation and transport.[9,32,47] Circular jewelry should be removed without delay. If vascular compromise is suspected, it is considered better to do the escharotomy, perhaps unnecessarily, than to allow an insufficiency to go unattended.[47] Anesthesia is not required for the incisions through full-thickness burns, and the escharotomies can be done in the emergency room or during transport. Incisions should be made in medial and lateral axial planes along the involved areas and of sufficient depth to allow release of the subcutaneous tissue under pressure. The adequacy of the escharotomy can be determined by separation of the cut edges of the eschar and by return of vascular flow to distal parts of the extremities. Care should be taken to avoid making the incisions deeper than necessary thereby dividing viable structures, but involved joints should be crossed. In the leg all three compartments should be released.[47] When digits require escharotomies, they should be carried the length of the digit and across web spaces. For subsequent transport, the incisions may be covered with saline-soaked dressings.

It is possible for thoracic or neck circumferential or near-circumferential full-thickness burns to cause respiratory compromise. In this case escharotomies may prove lifesaving. On the thorax the incisions are made longitudinally in the anterior axillary lines. Further incisions may be needed anteriorly along the subcostal lines, longitudinally along the midsternal line, transversely at the level of the clavicles, and posteriorly along the midback, all depending upon the clinical status of the patient. In the neck, a vertical incision from the chin to the sternal notch is made.[1]

Nasogastric Tube

Nasogastric tube placement should be done before transport, especially if transport is to be by air.[13] A variety of factors act to produce an ileus in major burn patients during initial resuscitation. The stomach should be emptied to avoid the difficulty of emesis in a patient who may be obtunded because of injuries or analgesics. It has also been suggested that antacid be instilled in the nasogastric tube following insertion so that prophylaxis of the common Curling's gastric ulcer, which occurs in major burn patients, can be begun.[21,27,42]

Tetanus Immunization

Tetanus immunization status should not be neglected as part of the resuscitation. An update of the immunization should be provided as necessary.

COMMENT

The mnemonic SAVE A PATIENT provides a mechanism for assuring that the resuscitation of major burn patients is complete. What it does not do is provide an indication of the likely outcome of an individual patient. There are indices available to assist in making population-based predictions of severity and mortality likelihood.[19,20,48,49] There is no index, though, that can predict with accuracy the survival of an individual patient arriving in an emergency room, as patients with burns in excess of 90 percent may survive. Accordingly, all burn patients should receive maximal care until such time as they have been resuscitated and are in an appropriate facility where more deliberate decisions can be made about what course to pursue.[18]

Although the total number of deaths caused by burns has remained steady (as a result of population increase), over the last three decades there has been a decline in mortality of burn patients with any given size of burn.[32,43,48] Within the last few years, the incidence of burn injury has begun to decline.[3] Taken together, these facts give hope for even further improvement in burn morbidity and mortality. The provider of first contact with a major burn patient plays an important role in this regard and should be ready to perform a complete resuscitation so as to give the patient his or her best chance. It is especially crucial in rural areas that primary care providers be familiar with the aspects of resuscitation of major burn patients.

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