BURNS

Burns are one of the most common forms of accidental injury with approximately 2 million per year in the U.S. alone. Of those, about 100,000 are classified as major; 6,000 will end in death. The disability incurred by these injuries is dependent upon the severity, which encompasses many factors to be discussed. As anyone who has worked with burn patients will know, these can be some of the most devastating of injuries. The goal of the Medical Officer is to have a basic understanding of burn classification, estimating severity, how to treat minor burns, and how to approach the victim of a major burn in the field in order to optimize that patients opportunities for recovery and rehabilitation. Always keep in mind that burns are trauma and your ATLS training will give you an excellent foundation when faced with one of these injuries.

Classifying burns

It is often difficult to clinically classify a burn in the first few hours. Serial examinations over a several day period may be required to accurately assess a burn. Nonetheless, it is important to know these definitions as they play a key role in the determination of which type of facility a burn patient will require.

A first degree burn involves only the epidermis. Clinically, the skin will appear red, is very painful to touch, and will not be blistered (acutely). An example of this would be sunburn.

Second degree burns, also known as partial thickness burns, involve all layers of the epidermis and extend to a variable depth into the dermis. If the superficial half of the dermis, known as the papillary dermis, or less is involved, the burn is termed superficial second degree or superficial partial thickness. Clinically, the skin appears moist and mottled, pink to red in color, with blisters present. Hairs will remain and the skin will blanch with pressure. The patient will experience severe pain and be very tender to light touch.

If the deep dermal layer, the reticular dermis, is involved, this is a deep second degree or deep partial thickness wound. Clinically, these wounds may be highly variable. The skin may be dry, white, without blisters and without tenderness or may be moist, red, and blistered, with exquisite pain and tenderness. The common denominator is the absence of blanching and ease with which hairs may be removed.

Third degree burns, the equivalent of full thickness burns, destroy all epidermal and dermal elements, extending into the subcutaneous tissue. They may appear white, pearly, or charred. They are not painful and are insensate. Hair follicles and sweat glands have been destroyed (these are the foci for re-epithelization) so that reformation of skin elements is impossible.

Another, more recent, class has been added; the fourth degree burn which is used when structures such as muscle, fascia, and bone are involved. This is of importance in electrical injuries as the skin wound may be deceptively small compared to a substantial and life threatening burn in the deep tissues which may be missed if a high index of suspicion is not maintained.

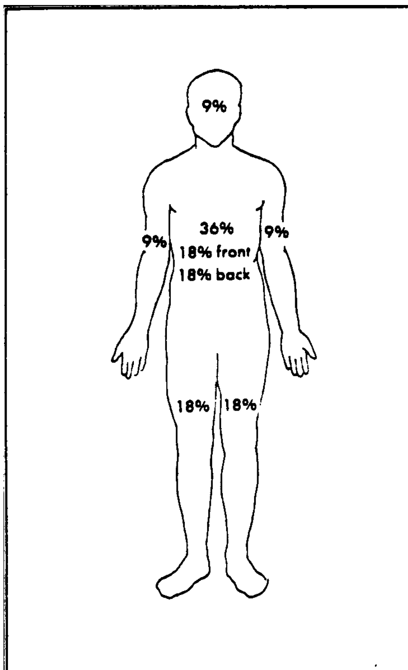
Categorizing burns and burn severity

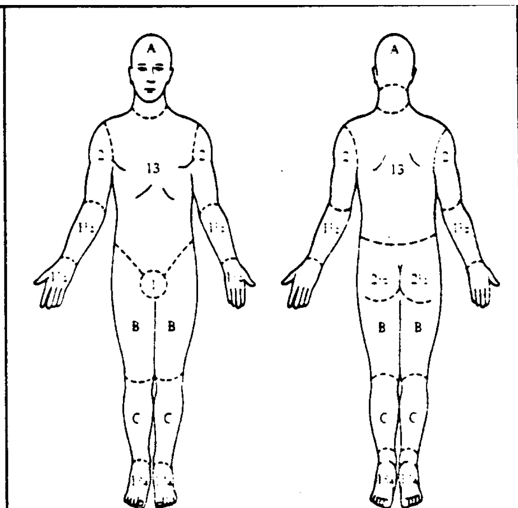
There are three categories utilized in determining the severity or seriousness of a burn: minor, moderate, and major or critical. There are dependant on six factors:

- The class of the burn, i.e. what degree.
- The percentage of body surface involved.
- Involvement of critical areas such as hands, face, ears, eyes, feet, or perineum.
- The presence of associated traumatic injuries.
- The age of the patient - the very young and the elderly have significantly less reserve.
- Pre-existing health problems may adversely affect the patient's ability to recover, i.e. heart disease, pulmonary disease, renal disease, etc.

There are several means by which the percentage of body surface area (BSA) involved may be estimated. For small burns, it is easiest to assume that one surface of the patient's hand is 1% of the BSA, and then estimate how many hands the burn wound is in size. For larger burns, the rule of nines is easy to remember and use. It is based on dividing the body into zones representing 9% segments.

For children, this is not accurate, so the rule of 19 is utilized. In children, the head and neck represent a greater percentage of the BSA at 19%. The rule of 19 states that 1% is subtracted from the starting 19% for the head and neck and added to the legs for each year of life until age 10.





Relative Percentages of Areas Affected by Growth (Age in Years)

	0	1	5	10	15	Adult
A: half of head	9½	8½	6½	5½	4½	3½
B: half of thigh	2¾	3¼	4	4¼	4½	4¾
C: half of leg	2½	2½	2¾	3	3¼	3½

After age 10, the rule of 9's is applicable. There are more accurate systems for calculating the extent of a burn which utilize charts for various body parts taking into account age, growth and development (Lund-Browder charts), however, this is not practical for the initial assessment of a burn victim.

It would be useful to have this memorized during your career because you may be the primary physician at the scene of an accident involving severe burns.

Burn types and pathophysiology
There are four general mechanisms by which burns are caused: thermal, electrical, chemical, and radiation. Determining the mechanism of a burn is important for many reasons. It is used when extricating the patient, when assessing severity of the wound, and in both the acute and long term management of the injury.
Thermal injury is dependant upon temperature, duration of exposure, nature of agent, and region of the body affected. Obviously, the higher the temperature and longer the exposure, the greater the severity of the injury. Similarly, if the affected skin is thinner, as in children and the elderly, the severity will be greater. The agent delivering the heat to the skin is also a factor as flame usually causes 3rd degree burns. Molten metals and synthetics which cling to the skin also generally cause 3rd degree burns. Liquids usually cause 2nd degree burns, but grease can readily cause 3rd degree injury. Another factor affecting the disabled or children is prolonged exposure to liquids in a lesser heat range which would not cause a burn to an adult due to reflex withdrawal from the liquid, i.e. running bath water may feel O.K. when tested by an adult but could cause significant burns to a small child who might be immersed for a period of several minutes.

Electrical burns are caused by current flow through tissues and the extent is dependant upon several factors. These include the duration, frequency, and magnitude of the current as well as the volume and resistance of the tissue traversed. Injury occurs when kinetic energy from the electrons is converted to heat energy during collision of moving electrons with stationary particles within the traversed tissues. The amount of heat generated is directly proportional to tissue resistance and increases as the square of the current magnitude. According to Ohm's law, the magnitude of the current is proportional to the magnitude of the voltage, and can be made equal if the current is multiplied by the resistance (V=IR). The currents generated from high voltage sources tend to produce a depressed entry wound and a blown out appearing exit wound. The associated deep tissue injury is usually extensive and may involve any and all tissue (muscle, nerve, vasculature, viscera, bone, etc.). Any electrical injury may cause cardiac arrhythmias including ventricular fibrillation and asystole. These arrhythmias may be the only injury with lower voltage sources (> 40 volt) and can occur without any sign of thermal injury. As the current travels through the body, it is somewhat dispersed and produces less damage to tissue due to the lower current density. However, as the current converges to proceed through the exit site, the current density increases once again and so does the severity of the injury in this locale.

Chemical burns are usually caused by strong acids or alkali. The extent and severity of injury is dependant upon the strength, concentration, quantity, and mechanism of action of the offending agent, as well as the duration and location of contact and extent of penetration. Acids cause coagulation necrosis by denaturation and precipitation of proteins. Acids are sometimes absorbed through the integument and, if in large quantities, may cause acidemia/acidosis which could lead to significant disruption of the clotting cascade. Alkalis induce liquefaction necrosis and generally penetrate much deeper than acids. They may continue to cause injury for several hours after exposure.

Radiation injuries are produced by ionizing radiation such as ultra violet light from the sun and emissions from nuclear reactions. Injury is caused by damage to molecular structure by the radiant energy. Severity and extent depend upon radiation type, dose received (includes level and rate), area of body exposed, and cell sensitivity. High energy burns from nuclear sources may appear to only involve the skin initially, but usually involve the cells of the deeper tissues to varying degrees. They may initially appear as hyperemic segments of skin, but can progress to the appearance of a 3rd degree burn over a few hours to days with sloughing of all skin layers.

Assessment and treatment of minor burns

According to the American Burn Association, a burn may be considered minor if it involves less than 10% of an adult's BSA or 5% of a child's BSA, involves no more than 2% 3rd degree injury, and spares the critical areas (face, hands, perineum, etc.). If these criteria are met with no other complicating health issues, the patient may be treated as an outpatient. Close follow-up and monitoring is imperative for optimal recovery.

Goals in treating minor burns are 1) to remove dead tissue, 2) prevent further cell death, and 3) protect remaining tissue while healing occurs. On a more clinical level, the goals can be thought of as 1) pain relief, 2) preventing infection and further trauma, and 3) minimizing scarring and contracture. Rapid healing is the key to optimal recovery.

The initial care of the burn wound is focused on halting the burning process. This is accomplished by application of cold, wet compresses or immersion in ice water (do not use ice directly on the wound as this may cause frostbite). Care must be taken, especially in children, not to lower the body temperature during this procedure as this may result in cardiac arrest. This cooling of the wound prevents the release of oxygen free radicals and arachidonate metabolites which can lead to further tissue injury through instigation of local ischemia.

Examination is usually performed after cold compresses or ice water has been applied as this affords adequate initial analgesia. For more definitive cleaning and debridement of loose tissue and foreign material, intravenous narcotics are generally appropriate. For the outpatient management of pain, an oral agent such as Tylenol with codeine or hydroxycodone are usually appropriate. The patient should be instructed to take analgesics approximately one half hour prior to dressing changes.

Prophylaxis with tetanus toxoid is recommended for burn patients who have not received a booster in the past five years. Tetanus antiserum is appropriate for the unimmunized patient only when the injury occurred in a tetanus prone environment, or the patient is elderly or debilitated. Antibiotic prophylaxis is recommended for the first three days after injury. Penicillin is the drug of choice as the primary hazard is streptococcal cellulitis. If this should occur, the patient would require hospitalization and parenteral antibiotics.

For a first degree burn, treatment is aimed at limiting pain and edema. This can be accomplished with topical application of a mild emollient, such as Dermaide, containing aloe. This limits inflammation, pain, and prevents desiccation until the injured skin is able to produce its own sebum again.

The second degree burn is initially cleansed with either mild soap and water or with quarter strength iodine solution and normal saline. If blisters exist, they should be sterilely drained as they contain arachidonate metabolites which may harm viable tissue as well as providing a bacterial growth medium. The skin should be left intact as it acts as an excellent dressing.

A third degree burn will have a tough eschar. This may be left in place until natural separation occurs. As with any wound, continued attention to keeping the burn area clean is imperative.

Once the wound has been cleansed and debrided, if necessary, it must be protected so that healing may proceed. This is achieved by use of a dressing. Occlusive dressings are not recommended as they allow accumulation of serum on the wound which promotes bacterial growth.

The best choice to dress a fresh, clean, superficial second degree burn is a biosynthetic bilaminar membrane, such as Biobrane. This prevents desiccation as well as collection of serum. It is placed tightly over the burn and then covered with compressive gauze. It may be difficult to attain a tight seal and the use of liquid adhesives around the perimeter of the wound may be necessary, in addition to sterile adhesive tapes. The pores in its silicone layer allow passage of serum from the wound out into the gauze. The collagen surface adheres to the wound and prevents excessive water loss. The dressing may be removed after the underlying skin has re-epithelialized. If the membrane has difficulty adhering to the wound (this occurs in the first two days), infection should be closely inspected for as it is the leading cause of membrane failure. Disadvantages of membrane dressings are that they are only useful for partial thickness wounds and may require splinting for the first two days if the wound is in a mobile location.

If a membrane dressing is not available or the wound is not suited to such a dressing, a nonadherent gauze, such as Scarlet Red, Xeroform, and Xeroflo may be used. These will not stick to the wound but often contain grease which leads to an occlusive dressing unless removed. This can be done by placing the gauze between two sterile towels and wringing it out. Another potential problem with some of these dressings is their use of bismuth as an antimicrobial agent. Bismuth is also somewhat cytotoxic and may impede re-epithelization. If available, a gauze without bismuth, such as Scarlet Red, is preferable.
An alternative to adherent gauze dressings is the application of topical antibacterial agents, such

as 1% silver sulfadiazine, followed by a soft, absorbent, and bulky gauze dressing. The application of 1% silver sulfadiazine usually confers immediate pain control, but may exacerbate pain if the patient is allergic. This dressing technique produces a soothing, soft, and pliant dressing which is effective in controlling bacterial proliferation. It must be removed at least daily, the wound washed with saline, and the cream and dressing reapplied.
Deep partial thickness and full thickness (3rd degree) burns should be treated with topical antimicrobial agents and referred to a specialist for elective excision and grafting.

Nonthermal burns require special attention. Chemical burns may require specific neutralizing agents but are initially appropriately treated with copious water irrigation; acid burns for 30 minutes and alkaline burns for 1 to 2 hours. Consultation with a burn center for specific treatment may be pursued during this time. Electrical burns are cleaned in the same manner as thermal burns but a penetrating antibacterial agent such as mafenide acetate should be used. Tar burns are most effectively treated with rapid cooling of the tar, gently cleaning the area, and then application of a petrolatum base antibacterial agent which will dissolve the tar over 24 hours. The tar may then be easily washed away and the wound handled as a thermal burn.

Special consideration should be given to burns of deep partial thickness severity or deeper when they involve joints. Due to the nature of these injuries and the length of time required to heal, (16 days) a degree of scarring will be present and may lead to loss of range of motion if early physical therapy is not instituted. Of particular importance are burns involving the hands. Specialist consultation should be considered early in order to maximize residual and recuperative function.

Assessment and treatment of major burns

IN THE FIELD: As an operational FMF physician there is a strong possibility that you may be in charge of handling a disaster with many multiply injured patients, including those with major burns. If the needs of the injured are greater than the available resources, then you must triage casualties, as you learned in ATLS. Many factors must be considered: on-site medical personnel and their training, supplies, difficulty of evacuation, time to evacuation, tactical situation, and receiving facilities. Since burn injuries are trauma, these patients may be treated as per ATLS protocols with a few extra considerations.

Before any treatment may be instituted, the patient must be removed to a safe environment and the burning process halted. It is of prime importance for the rescuing team to use caution and avoid injury to themselves during extraction of the victim. It is useful, if time and the situation permit, to perform a rapid primary survey prior to removing the patient in order to assess for associated traumatic injuries, such as cervical spine injuries, which may necessitate extra caution. If this is not practical, assume c-spine injuries and place the patient in c-spine precautions if the circumstances imply a mechanism. Removing a patient from the site of an electrical or nuclear accident may prove especially hazardous to the rescuing team. When approaching an electrical accident, ensure that the current is off and have electrical specialists discharge capacitors if possible. Then use dry nonconducting materials as insulators while removing the victim to a safe locale. The rescue of a nuclear accident requires special equipment and specially trained rescue personnel and is beyond the scope of this chapter.

As the patient is removed from the scene, hot or contaminated garments should be cooled with water and then removed. Flaming or smoldering garments should be extinguished with water-gel blankets or fire blankets prior to removal. If clothing is adherent or imbedded into the wound, do not try and remove it, but cut off as much as possible. Chemical burns should be copiously diluted with water as soon as the patient is in a safe location. Never attempt to use neutralizing agents in the field.

While your assistants are halting the burning process and removing all garments, you must assess the ABC's. Inhalation injury must be kept in mind as you assess the airway and breathing as carbon monoxide poisoning is the leading cause of death from fire. Diagnostic clues are impaired mentation, closed space fire, change in voice, singed facial hair, carbon deposits or burns in the oropharynx, carbonaceous sputum (pathognomonic), and wheezing or air hunger. Intubation should be performed early if the patient shows progressive signs or symptoms of respiratory difficulty as it may quickly become impossible due to oropharyngeal edema. The early treatment of carbon monoxide poisoning is 100% oxygen by non-rebreather mask or endotracheal tube, if indicated.

Circulatory support consists of intravenous infusion of lactated ringer's solution at 200 ml/hr for most major burns without other major injuries. If other injuries are present which lead to hypotension or shock, these should be treated as per ATLS. If the patient's vital signs are stable and within normal limits, a field IV may not be necessary provided transportation to a hospital is available in under 30 minutes.

As with all major trauma victims, frequent monitoring of the vital signs and neurological status are imperative.

Estimating the severity of the burn is important in selecting the facility to which the patient is to be transferred which in turn determines the necessary means of conveyance. This depends on several factors discussed previously: depth of burn, percentage of BSA, involvement of critical areas, patient's age, and pre-injury health.

After the ABC's have been addressed, the burning process stopped, and an estimation of the burn severity has been made, a secondary survey should be carried out. It may turn up an injury of greater long term import than the more obvious burn injury. This also will be important when making your evacuation decisions.

The treatment of burns in the field is very simple; wrap the patient up in water-jel blankets or clean (sterile if possible) sheets. This will help control pain as well as reassure the patient.

While third degree burns are initially painless, other burns are exquisitely painful and anxiety provoking for both the patient and most health care professionals. There are several avenues of pain management which are useful for the burn patient, the easiest and quickest is the application of cold compresses. If oral intake is possible, aspirin or codeine are useful for mild to moderate pain. For severe pain, intravenous morphine, 2-8 mg every 2 to 4 hours is effective. It is important to note that narcotics should ONLY be given intravenously due to the tremendous fluid shifts that take place in the burned patient. Subcutaneous administration may result in poor initial absorption, only to be later rapidly absorbed at an inopportune time (right after a subsequent narcotic dose) resulting in respiratory arrest. Due to the anxiety associated with these injuries, it is frequently useful to give an anxiolytic, such as diazepam 2-10 mg every 4-6 hours, intravenously in order to get more complete pain relief. It is important to ensure that anxiety is not secondary to hypoxia or hypovolemia prior to treating with an anxiolytic.

All aspects of the accident should be clearly and concisely recorded. This should include all known history, mechanism, vitals, exams, assessments, and interventions. This will be of enormous help to the receiving facility when they take charge of the patient's care.

Evacuation of the burn patient will depend on the facilities available, the various means of conveyance available, and the stability of the patient. If the patient is categorized as a major burn then he will require a burn center unless the time to transport the patient is excessive compared with the patient's stability. You may have to transport the patient to a less sophisticated facility in order to stabilize the patient prior to later transfer to a burn center. For most situations, ground transport will be readily available and appropriate. Water transport may be necessary, depending on the circumstances. If the distance from the burn center and the accident site is 30 to 150 miles, then helicopter evacuation may be the most appropriate. For distances greater than 150 miles, fixed wing transport is most appropriate. Whichever mode is utilized, it should be completely outfitted with a full complement of equipment (ventilatory support may be necessary), thermal control, and trained medical personnel.

IN THE EMERGENCY ROOM: If you are in a locale where evacuation to a burn center will be delayed, it will be important to embark upon a well thought out management plan to ensure maximal recovery of your patient.

When the major burn patient is brought to you (or by you) in the emergency room, you must start at the beginning by reassessing the ABC's to ensure that nothing has changed during transport. A secondary survey may be able to be performed with more attention to detail. A nasogastric tube and Foley catheter should be placed. Blood should be drawn for baseline studies including ABG, CBC, chemistry panel, and type and screen. Urine should be sent for urinalysis. Pertinent x-rays are obtained. A baseline ECG is obtained; this is particularly important in electrical injuries. Tetanus prophylaxis is obtained with toxoid if the patient has not had a booster in five years.

Pain is managed with intravenous narcotics as previously outlined, titrated in small doses over frequent intervals. An adjunct, as previously mentioned is the application of cool wet compresses. Care should be taken, especially with large burns, that the body temperature is not lowered as this may cause reflex vasoconstriction leading to progressive ischemia in the marginal tissue of the burn wound. A more comprehensive history with allergies is obtained.

An estimation of the fluid losses must be made in order that they may be replaced. The Parkland formula is easy to remember and is useful for the institution of therapy. It calls for 4 ml of Ringer's lactate per kg body weight times the percent BSA burned be given over the first 24 hours. Half of this should be given over the first 8 hours with the remaining half given over the subsequent 16 hours. The rate is adjusted to so that urine output remain at 50 to 100 ml per hour. The second 24 hour period calls for salt free solution containing only glucose and water be given at a rate to maintain urinary output. It is critical to closely monitor serum electrolytes, vital signs, capillary refill, neurological status, peripheral pulses, strict ins and outs, and to make changes in therapy as indicated. Keep in mind that fluid requirements from associated injuries must be calculated separately, the various burn formulae only address fluid losses due to the burn injury.

The gastric pH should be maintained greater than or equal to 7 with antacids per the NGT on a 4 hour schedule in order to reduce the risk of Curling's ulcers. The nasogastric tube will alert the care givers immediately if gastric bleeding occurs and allows rapid treatment with ice water lavage. The nasogastric tube is also useful for decompressing the upper gastrointestinal tract when a paralytic ileus occurs, as is often the case with major burns.
The elderly are at risk for silent myocardial ischemia due to decreased coronary perfusion with burn shock; they should be closely monitored for this. They are also prone to suffer from bradycardia; this may be treated with atropine or electrical pacing if ineffective. It is critical to maintain a reasonable cardiac output to prevent other organ system damage and failure.

The initial management of the burn wound is very similar to that of a minor burn but on a larger scale. The precepts are cleaning, debriding, and the prevention of infection. The wound should be gently cleaned with sterile saline and an antiseptic soap. Sterile scissors and forceps are then used to remove loose and necrotic tissue as well as debris. Carefully shave hair from the wound and its periphery. Rinse thoroughly with normal saline. Strict aseptic technique should be used during the entire process. The wound may then be coated with a topical antibacterial cream, such as 1% silver sulfadiazine and covered with a nonocclusive gauze dressing. As effort should be made to record the presumed depth of the wound and recalculate the surface area using a Lund-Browder chart so that fluid calculations may be rechecked with a more accurate burn fraction.

Systemic antibiotics are only given prophylactically prior to wound debridement as this is thought to be associated with a transient bacteremia. Afterwards, the wound is followed closely for signs of cellulitis and treated with specific antibiotics based on culture results.
When transportation is available and the patient is stable for transfer (best done with in the first few days post injury), all details of the transfer should be discussed by the transferring and the receiving physicians and agreed upon based on the clinical situation. As always, complete and accurate documentation is important both for your protection and optimal patient care during the

transfer.

References:

Artz, M.D., Moncrief, M.D., Pruitt, M.D., Burns: A Team Approach, W. B. Saunders Company, Philadelphia, PA, 1979.

Phillips, M.D., Robson, M.D., Heggers, M.D., Treating Minor Burns, Postgraduate Medicine. Vol 85, No 1, January 1989, pp. 219-231.

Wachtel, Thomas L., M.D., Initial Care of Major Burns, Postgraduate Medicine. Vol 85, No 1, January 1989, pp. 178-196.

Baxter, M.D., Waeckerle, M.D., Emergency Treatment of Burn Injury, Annals of Emergency Medicine. Vol 17, No 12, December 1989, pp. 1305-1315.

American College of Surgeons, Advanced Trauma Life Support Manual, The American College of Surgeons, Chicago, IL, 1989.