



Chapter 20

BURNS

KEY FIGURES:

Rule of 9's adult, child

Burns can be serious injuries and are a major cause of morbidity and disability worldwide. This chapter describes techniques that give the best chance of survival and reduce the risk of long-term disability. When treating patients with a severe burn, you must be prepared to provide extensive care over many days or even weeks. If you cannot meet this commitment, consider transferring the patient to a facility that specializes in the care of burns.

Important Functions of Skin

Intact, uninjured skin plays a vital role in maintaining health. A burn causes significant damage that compromises the ability of the skin to perform its key functions (see table below).

Table 1. The Physiologic Consequences of Burn injury

Skin Function	Consequence of Burn Injury and Required Intervention
Contributes to temperature regulation by preventing heat loss	Patient is prone to lose body heat. You must keep patient covered and warm at all times to prevent hypothermia.
Keeps bacteria and microorganisms from invading body	Patient is at high risk for infection. Antibiotic ointments are used on burn wound, but no systemic antibiotics are indicated unless signs of specific infection are present. Check tetanus immunization status; give booster if needed.
Prevents water loss	Patient loses tremendous amount of fluid into burned skin. Burn also causes release of factors that make all body tissues, not just skin, "leaky" to protein as well as water. Intravascular volume can be greatly depleted by large burn (> 20% body surface area) Common cause of death from large burn is renal failure due to inadequate fluid resuscitation during first 24–48 hrs after acute burn (see "Basic rules for fluid resuscitation" below for prevention strategies)

Mechanism of Injury

A burn can be caused by thermal (heat) injury, electricity, or caustic chemicals. Aside from the resultant skin damage, each mechanism has associated complicating factors of which you should be aware.

Thermal Injury

Thermal injury is the most common cause of burns. In addition to damage to the skin, you must be alert for the possibility of **inhalation injury**—a burn to the patient's airway (pharynx, trachea, even lungs). Failure to diagnose inhalation injury can result in airway swelling and obstruction, which, if untreated, can lead to death.

Signs that may indicate inhalation injury include singed nasal hairs, carbon particles in the sputum, hoarseness, and elevated carbon monoxide (CO) levels in the blood. If you can test for CO, do so. Another way to tell whether the blood contains a significant amount of CO is to look at its color. Blood is bright red when CO is present.

Optimally, bronchoscopy is used to assess edema of the airways and signs of burns in the oropharynx, pharynx, or lower airways.

If signs of airway swelling or burns are present, an endotracheal tube should be placed to protect the airway. Because the swelling worsens over the first 24–48 hours after acute injury, it is best to intubate early. It may be impossible to get the endotracheal tube in place once significant airway swelling has occurred.

Electrical Injury

Electrical burns cause injury by a combination of thermal injury and direct effects of the electrical current (cell membrane instability and denaturation of cell proteins).

It is often difficult to assess the magnitude of injury because the only visible indication may be damaged skin at the entrance and exit sites. *Significant deep tissue injury often is present along the course of the electrical current through the body.*

Muscle is often the most seriously injured tissue. You must be on the alert for compartment syndrome (swelling of muscle groups that can lead to muscle necrosis). In patients with significant muscle damage, myoglobin is present in the urine, which appears purplish or red. Myoglobinuria requires aggressive treatment to prevent renal failure. The patient should be given sodium bicarbonate in intravenous fluids to make the urine more alkaline, and urine output should be maintained at over 50 ml/hr by giving intravenous fluids as well as intravenous furosemide or mannitol.

Because the heart is a muscle, be alert for cardiac dysfunction. Arrhythmias are common. Patients should be monitored closely and arrhythmias treated appropriately.

Chemical Injury

Chemicals cause damage by reacting with the tissue proteins in a manner that leads to tissue death. Chemical injury is different from thermal injury in that *chemicals can continue to cause damage until they are removed or neutralized*.

In general, the chemical agents are either acids or bases. Basic solutions tend to penetrate deeper into the tissues and thus cause more damage than acidic solutions.

The key to initial treatment is to remove all clothing that may have contacted the chemical and to irrigate the injured area continuously with water for at least 2 hours or longer.

Try to find out the exact chemical that caused the injury. Poison control centers located in almost every state are useful sources of information about the best way to treat various chemical injuries. A useful web address is:

www.medwebplus.com/subject/Poison_Control_Centers.html

It is difficult to estimate the depth of injury from a chemical at initial presentation. Close observation and daily examination of the burn wound are vital for proper treatment.

No matter what the inciting incident, patients with a burn are evaluated and treated in the same manner as outlined below.

Initial Treatment

1. Remove all clothing from the affected area.
2. Immediately cover the burned areas with saline-moistened gauze. Use saline that is lukewarm—*not* too cool.

Special Considerations

If the patient has been injured by hot tar: Tar is not absorbed; do *not* try to remove it by scraping and pulling. Such actions serve only to worsen the burn and injure additional skin. Simply apply petrolatum-based antibiotic ointments to the area (Neosporin or Bacitracin), and the tar will separate as the burns heal.

If grease is present on the burned tissues: Grease often can be removed by gently rubbing with the same petrolatum-based antibiotic ointments.

For **chemical burns**, the area should be rinsed continuously with water for several hours instead of merely applying saline-moistened gauze.

Intravenous access should be obtained for delivering fluids.

Check the tetanus immunization status, and give a booster if needed.

The patient should *not* be given intravenous antibiotics initially. They are used only in the presence of signs that the burn wound has become infected or for treatment of other diagnosed infections (e.g., pneumonia).

Once you have evaluated the extent of the injury, apply a topical agent to the burned areas and cover with sterile gauze. For large burns (> 20% BSA), consider transfer to a burn unit if available (see below).

Table 2. Commonly Used Agents for Burn Wounds

Agent	Applications Per Day	Indications/Precautions
Bacitracin, Neosporin, or triple antibiotic ointment	1–2	Useful for face burns* or burns over relatively small areas. Do not come in large enough containers for use on large burns.
Silver sulfadiazene (Silvadene)	1–2	Most commonly used agent for burn wounds. Comes in large containers for use on large burns and can be used on all parts of body except face. Does not cause pain upon application. Major side effect is decrease in white blood cell count, which necessitates stopping its use. Do not use in patients allergic to sulfa drugs.
Mafenide acetate (Sulfamylon)	1–2	Comes in large containers. Better burn wound penetration than Silvadene, but painful when applied to burn. Also may cause electrolyte disturbances. Best used for small areas only. Especially indicated for burns on ears to protect cartilage from getting infected. Do not use in patients allergic to sulfa drugs.
Silver nitrate (0.5%)	Several (at least 4 times/day)	Can be used on large burns and is not painful to apply. Should be applied in wet, bulky dressings. Does not penetrate burn wound as well as Silvadene and may cause severe drop in serum sodium concentration; you must monitor electrolytes closely. Annoying problem is that silver nitrate turns everything it contacts black (e.g., skin, clothing, bedding).

* Keep out of the eyes. Use only ophthalmic preparations for the eyes or areas immediately around the eyes.

Determining Percent of Total Body Surface Area (BSA) Burned

Adults

The rule of nines

- Each entire arm: 9%
- Each entire lower extremity: 18%
- Anterior trunk: 18%
- Posterior trunk: 18%
- Head / neck: 9%
- Genital area: 1%

Children

Modification of the rule of nines

The adult proportions are slightly different in children because of the relatively large size of a child's head in relation to the rest of the body:

- Infant head: ~20%
- Each lower extremity decreased to ~10%
- Other areas remain essentially the same

BURN FORM

Name _____ Age _____ Number _____

Burn record. Ages 7 to adult. Date of observation _____

BURN FORM

Name _____ Age _____ Number _____

Burn record. Ages Birth 7½ Date of observation _____

Relative percentages of area affected by growth

Area	Age 10	15	Adult
A ½ of head	5½	4½	3½
B ½ of one thigh	4¼	4½	4¼
C ½ of one leg	3	3¼	3½

% Burn by areas

Probable 3rd* burn { Head ___ Neck ___ Body ___ Up arm ___ Forearm ___ Hands ___
Genitals ___ Buttocks ___ Thighs ___ Legs ___ Feet ___

Total burn { Head ___ Neck ___ Body ___ Up arm ___ Forearm ___ Hands ___
Genitals ___ Buttocks ___ Thighs ___ Legs ___ Feet ___

Relative percentages of area affected by growth

Area	Age 0	1	5
A ½ of head	9½	8½	6½
B ½ of one thigh	2¼	3¼	4
C ½ of one leg	2½	2½	2¾

% Burn by areas

Probable 3rd* burn { Head ___ Neck ___ Body ___ Up arm ___ Forearm ___ Hands ___
Genitals ___ Buttocks ___ Thighs ___ Legs ___ Feet ___

Total burn { Head ___ Neck ___ Body ___ Up arm ___ Forearm ___ Hands ___
Genitals ___ Buttocks ___ Thighs ___ Legs ___ Feet ___

Sum of all areas _____ Probably 3rd* _____ Total burn _____

Rule of nines in adults and children. Modification of Lund and Browder chart for determining body surface area. (From Jurkiewicz MJ et al (eds): Plastic Surgery: Principles and Practice. St. Louis, Mosby, 1990, with permission.)

Determining Depth of Burn

It is often difficult to determine the exact severity of the burn at the initial examination. Therefore, reevaluation of the patient once the burns have been cleansed and again 24 hours later is vital.

Burns are classified as first-, second-, or third-degree, depending on the depth of injury. A first-degree burn implies injury to the superficial surface of the skin; it is similar to a sunburn. A second-degree burn involves varying levels of the dermis, and a third-degree burn completely destroys the dermis and may injure even the underlying subcutaneous tissue.

The burn injury is often not uniform. There may be areas of first-, second-, and third-degree burn on different parts of the body. This variation should be noted in your examination. The distinction among burn types is important. In general, the deeper the burn, the greater the amount of intravascular fluid that is lost into the burned tissues and the greater the overall physiologic injury.

Table 3. Burn Wound Classification

Burn Depth	Appearance	Pain	Sensation
Superficial (first-degree)	Erythema	+	Yes
Partial-thickness (second-degree)*	Blisters, hairs (if present) stay attached	+++	Yes
Full-thickness (third-degree)	Thick, leathery feel Pale color Hairs, if present, do not stay attached May see thrombosed veins	0	No (nerve endings are destroyed)

* Partial-thickness burns can be superficial or deep. A superficial partial-thickness burn may have a thin blister, and the skin is soft and pink. A deep partial-thickness burn appears white but some hair follicles are still attached. It feels softer than a full-thickness burn. A deep partial-thickness burn often behaves like a full-thickness burn.

Basic Rules for Fluid Resuscitation

A burn injury results in dramatic loss of fluids from the intravascular space. To prevent kidney damage or failure, the patient requires a large amount of fluids compared with the baseline state. In patients with second- and third-degree burns affecting > 15–20% BSA, proper fluid resuscitation is vital for survival.

Estimating Fluid Needs for the First 24 Hours after Injury

The Parkland Formula is a good way to estimate fluid needs. The patient must be monitored closely for blood pressure, heart rate, and urine output. Adjustments in fluid rate should be based on these parameters. If necessary and if available, central venous pressure or Swan-Ganz catheter monitoring should be used because they provide more precise measurements of circulatory status. Urine output should be at least 20–30 ml/hr for adults and 1–2 ml/kg/hr for infants or children. Increase output by giving additional intravenous fluids, *not* diuretics.

Parkland Formula

$$4 \text{ ml} \times \text{patient wt (kg)} \times \% \text{BSA} = \text{fluids for first 24 hr}$$

One-half of this amount is given over the first 8 hours after injury; the rest is given over the next 16 hours.

The intravenous fluid of choice in adults is **Ringer's lactate**. Normal saline is the next best option. Do not use dextrose solutions for the initial fluids. In children, use Ringer's lactate, but also administer 5% dextrose in one-fourth normal saline solution ($D_5^{1/4}NS$) for maintenance glucose needs.

Example: A 70-kg man has sustained a 55% BSA burn, of which 10% is first-degree, 20% is second-degree, and 10% is third-degree. Fluids required for the first 24 hours:

$$4 \text{ ml} \times 70 \text{ kg} \times (20 + 10)\% \text{BSA} = 8400 \text{ ml}$$

(I told you that we were talking a lot of fluid!) The total BSA that you calculate includes second- and third-degree burns; first-degree burns are not included.

Give 4200 ml over the first 8 hours, then 4200 ml over the next 16 hours. The amount of fluid given per hour is also an important point:

- If the patient presents immediately after the burn, give $4200/8 = 525$ ml/hr for the first 8 hours, then $4200/16 = 262$ ml/hr for the next 16 hours.
- If the patient presents 2 hours after the injury, give $4200/6$ (fluid must be given over 8 hours after injury, *not* after presentation) = 700 ml/hr over the next 6 hours, then $4200/16 = 262$ ml/hr for the next 16 hours.

Pain Control

Few injuries are more painful than a burn. Thus, an important part of the management is adequate pain control. Everything related to a burn injury and its treatment is painful. Keep this in mind, and do *not* skimp on pain medications. Morphine is often the medication of choice. For patients with large burns, intravenous injection is the best way to administer the medication. Absorption of subcutaneous or intramuscular injections is not reliable. Oral pain medications may be indicated with a small burn wound, but they are not useful in patients with significant burn injury.

Morphine

Intravenous morphine is the pain medication of choice. An adult can be given 2–3 mg at a time, titrated to pain control. Do *not* give too

much, because excessive morphine can cause the patient to stop breathing.

Guideline for dosing: do not administer more than 0.1 mg of morphine per kg of patient weight (0.1 mg/kg) over a 1–2-hour period. This rule applies to both children and adults.

Sedation

Intravenous sedation can be given along with pain medication. It is especially useful during the initial evaluation and before dressing changes. Sedation may decrease the need for pain medication and alleviates the anxiety often associated with painful procedures. Be cautious, and monitor the patient closely because sedatives also can depress the respiratory drive.

A short-acting agent such as midazolam (Versed) is quite useful. If none is available, diazepam (Valium) is another option. See chapter 3, “Local Anesthesia,” for detailed dosing information.

Subsequent Care of Burn Wounds

Patients with a large burn have difficulty in maintaining body temperature. During dressing changes, the patient may become quite hypothermic if precautions are not taken. If possible, warm the room, use warming lights, uncover parts of the wound individually instead of removing all of the dressings at the same time, and use lukewarm, not cold saline.

Examine the burns daily to look for signs of infection (e.g., induration, blanching erythema, increased redness/warmth).

First-degree Burns

Clean daily with gentle soap and water.

Apply a gentle moisturizer (aloe, cocoa butter, something without perfumes) or antibiotic ointment once or twice daily.

First-degree burns require several days to heal.

Second-degree Burns

If the blisters are intact, it is usually best to leave them alone. The area under the blister essentially represents a sterile environment and promotes healing. An exception is the blister that is so tight that it interferes with the circulation of surrounding tissues. Such blisters should be opened and the loose skin removed.

If the blisters have opened, the skin should be removed gently. This procedure usually requires a pair of forceps and a pair of scissors. Removing the skin should not hurt.

Apply antibiotic ointment—usually Silvadene on the body, Bacitracin on the face—twice daily, and cover with dry gauze.

Clean the burn wound with saline, and remove the old ointment before applying new ointment.

Dressing and cleansing the wound are often quite painful. Be sure to give pain medication before changing the dressings.

Superficial second-degree burns usually heal within 10–14 days, whereas deep second-degree burns often take 3–4 weeks. Deeper burns are also prone to thick, hypertrophic scarring. Therefore, unless the area is very small (< 4–5 cm in diameter), tangential excision (see below) is often recommended for deep second-degree burns.

Third-degree Burns

Apply antibiotic ointment—usually Silvadene on the body, Bacitracin on the face—twice daily, and cover with dry gauze.

Clean the burn wound with saline and remove the old ointment before applying new ointment.

Full-thickness burns take at least 4 weeks to heal and often heal with a hypertrophic scar. Except for small (< 4–5 cm in diameter) third-degree burns, tangential excision and split-thickness skin grafting usually are recommended

Fluids after the First 24 Hours

Because the capillaries are no longer as “leaky” after the first 24 hours, the fluids are changed from crystalloid (Ringer’s lactate) to protein-containing solutions (colloids). Colloids provide improved intravascular volume expansion.

In general, give 0.3–0.5 ml/kg/%BSA over 24 hours.

In addition, 5% dextrose in water or 5% dextrose in 0.45 saline is given to maintain urine output of at least 20 ml/hr.

After this regimen, fluids should be administered according to the patient’s overall condition.

Nutritional Concerns

A severe burn injury causes severe metabolic disturbances and a concomitant increase in caloric requirements. Chapter 8, "Nutrition," explains how to estimate caloric needs; for a severe burn injury (> 40% BSA), the basal metabolic rate is multiplied by a factor of 2–2.5, a larger factor than for any other injury. Depletion of nutritional stores is a distinct risk. Caloric requirements reach their peak at approximately 7–10 days after injury and do not return to normal until all burns have healed.

Nutritional support is vital for the treatment of a severely burned patient. If the patient cannot ingest enough calories orally, a nasogastric or other type of enteral feeding tube must be placed to supply calories. If the patient cannot tolerate feedings through the gastrointestinal tract, central intravenous nutritional support should be started.

Tangential Excision

For deep second- and third-degree burns larger than a few centimeters, tangential excision followed by split-thickness skin grafting is recommended. It leads to faster healing, with more stable skin coverage. In tangential excision, only the burned tissue is removed; uninjured tissue is left alone.

Careful tangential excision of the burn and split thickness skin grafting should be done relatively early (within days of the injury) if possible. Usually the procedure is done in the operating room under general anesthesia. A special knife or dermatome (see chapter 12, "Skin Grafts") is used. Be sure to excise only the tissue that is burned. You will know when you have reached healthy tissue because it will bleed. In general, dead tissue does not bleed.

This procedure can cause significant blood loss. Usually only small areas (< 10% BSA) are done at any one time, and blood should be available for transfusion. Patients always lose more blood than you expect. Hemostasis usually can be obtained by holding a gauze pad over the area and applying pressure for a few minutes. Sometimes topical thrombin or epinephrine solutions can be applied as well.

The wound is then ready for split-thickness skin grafting (see chapter 12, "Skin Grafts," for details).

Caution: Tangential excision should be done only by a practitioner with special surgical skills who is comfortable performing skin grafting. Unless only a small area (e.g., part of the arm) is involved, this procedure can be quite difficult to perform safely.

Specific Injuries

Hand Burns

See chapter 34, “Hand Burns,” for detailed information. Simple techniques can prevent permanent loss of hand function.

Electrical Burns of the Mouth in Children

Electrical burns of the mouth usually occur when the child bites down on an electrical cord. Such injuries usually involve a burn of the lip commissure (where the upper lip meets the lower lip).

The eschar (scab) that forms at the commissure separates after 10–14 days. Separation may be accompanied by significant bleeding from the labial artery. You should warn parents about this potential event. They can control the bleeding by holding gauze over the area and pinching the lip at the commissure. The bleeding should stop after 5–10 minutes of pressure, but medical treatment may be needed.

Burns on the Dorsum of the Foot

Second-degree burns on the top of the foot initially may seem insignificant and, in fact, often heal with local care alone. However, improper management may result in a more extensive tissue loss than you expect. Exposure or injury to the underlying tendons may result and can be quite problematic to treat.

Proper Treatment

1. Apply the usual antibiotic ointment and dressings, as described above.
2. The patient should wear no shoes or boots on the injured foot until the burn is healing well.
3. The foot should be **kept elevated at all times**.
4. The patient should not put weight on the affected foot until you are sure that the burn is healing properly.

Referral to Burn Center

A burn center is a tertiary care center that specializes in the multidisciplinary care of patients with acute burn injuries. Burn centers serve an important purpose and are responsible for improved outcomes in severely injured burn patients. Only second- or third-degree burns should be referred. If you are lucky enough to have one available, the following criteria may be applied for referral:

1. Burns of the genitalia, face, hands, and feet
2. Burns involving over 10% BSA in patients younger than 10 years or older than 50 years
3. Burns involving over 20% BSA in patients of any age
4. Inhalation injury
5. Other significant trauma
6. Third-degree burns involving over 5–10% BSA
7. Multiple medical problems as well as significant burn injury

Do not be reluctant to transfer. Burn patients are seriously ill and have the potential for developing many complications. They are best treated at centers that specialize in burn care.

Even if you decide to transfer the patient to a burn center, you should not hesitate to start the appropriate treatment. The first few hours after an injury are critical, and measures such as fluid resuscitation, burn dressings, and pain control must be initiated and implemented appropriately while awaiting transfer.

Frostbite

Frostbite is an injury caused by prolonged exposure to cold temperature that results in freezing of soft tissues and formation of ice crystals. Ice crystals form not only inside cells but also inside the smallest of blood vessels, causing occlusion. Occlusion ultimately leads to tissue loss.

Initial Treatment

This information applies to patients who present at the time of injury. Some patients do not seek treatment for several days or weeks after injury. The treatment that follows is *not* for delayed presentation (see next section for treatment after the acute thermal process has resolved).

Rapid Rewarming

1. The first line of treatment for patients with acute frostbite injury is rapid rewarming of the tissue. Rewarming should be done only when you are certain that the tissue will not again be exposed to cold.
2. Immerse the affected part in warm water (104–108°F or 40–42°C). Use of hotter water may cause a burn injury, whereas use of cooler water may not provide the benefits of rewarming. It usually takes about 20–30 minutes to rewarm the tissues.

3. Rewarming *hurts*. Give the patient pain medication, preferably intravenous morphine.
4. Do not massage the affected tissue.

*After Tissues are Rewarmed or
if Patient Presents Days after Injury*

1. Unroof only those blisters with clear fluid.
2. Blisters filled with blood should be left alone. They are signs of deeper tissue injury.
3. Gently elevate the affected area to decrease swelling.
4. Apply aloe vera to the affected areas, and cover with a gauze dressing.
5. Antiplatelet medications may be useful (e.g., aspirin, 80–325 mg/day).
6. Use gentle range-of-motion exercises to prevent joint stiffness.
7. For hand injuries, remember to splint the hand in neutral position.
8. Change the dressing daily, or prescribe whirlpool treatments, if available.
9. Check the patient's tetanus toxoid status, and treat appropriately.
10. Antibiotics are used only if signs of infection are present in the surrounding soft tissue.

Note: The cornerstone of treatment of a frostbite injury is to allow the injured tissues to demarcate. The dead tissue turns black, gradually shrivels, and eventually falls off. After demarcation, you will debride only the tissue that does not survive the injury.

During the first few days or even weeks after the initial injury, tissue that at first appeared unlikely to survive may actually heal. By waiting for the tissues to demarcate, you can tell definitively which tissue is dead, and you will not remove more tissue than necessary. Another indication for surgical debridement of injured tissue is development of an infection that does not resolve with antibiotic therapy.

Long-term Effects

1. Joint stiffness and arthritis are common.
2. The affected area may be permanently sensitive to cold temperatures.
3. In children, frostbite injures the growth plate of the bones and may result in diminution of bone growth.

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