25 BURNS

CORE CONCEPTS

- Define various depths of burns.
- Estimate burn size using the Rule of Nines or Rule of Palm.
- Discuss the Rule of Ten for burn resuscitation.
- Discuss the four causes of burn injury and treatment of each.

INTRODUCTION

Burns can cause devastating injuries involving the skin and other organ systems. Patients suffering from significant burns require special critical care. Burn casualty evaluation is often complicated by the dramatic presentation of other types of traumatic injuries. Casualties whose only wounds are major burns rarely die in the short-term period after acquiring the injury itself. Casualties who die shortly after being badly burned die as a consequence of related trauma or associated conditions, such as airway compromise or smoke inhalation. During emergency medical technician training, each combat medic establishes a foundation for treating burn casualties; however, the ability to perform more advanced interventions will save more soldiers' lives.

ANATOMY AND PHYSIOLOGY OF THE SKIN

The skin is the largest organ of the body and is made up of three layers: the epidermis, the dermis, and subcutaneous tissue (Figure 25-1). The epidermis is the outermost layer of skin and is made up of epithelial cells without blood vessels. The epidermis is nourished by capillaries located in the dermis. The dermis is a thick layer of collagen connective tissue that is positioned below the thin layer of the epidermis. The dermis contains important support structures and sensory nerves, such as hair follicles, sweat glands, and oil glands. The subcutaneous layer of skin is composed of adipose tissue that helps insulate the body from the outside environment. The skin acts as a barrier between the body and the environment and covers underlying tissues, protecting them from dehydration and injury. The skin helps regulate body temperature by controlling the amount of heat lost (through vasodilation and constriction of capillaries, as well as perspiration) and is the site of many nerve endings. Skin tissue temporarily stores fat, glucose, water, and salts. The skin has properties that allow for absorption of certain drugs and other chemical substances (see Chapter 12, Skin Disease Primary Care).

BURN ASSESSMENT

Assessment of burns to determine type and severity is important for effective and successful treatment. You must evaluate the severity or depth and size of the burn as a percentage of body surface area. Working knowledge of these assessment criteria and tools are critical skills for combat medics.

Burn Causes

Assessing the cause of a burn injury will assist you in making appropriate treatment and evacuation decisions. In some cases, understanding the cause of the burn enables you to protect yourself from injury as well. The following forms of transmitted energy and physical agents can cause burns:

- thermal (heat or fire),
- electrical,
- radiation, or
- chemical.

Each of these types of burns requires specific treatments.

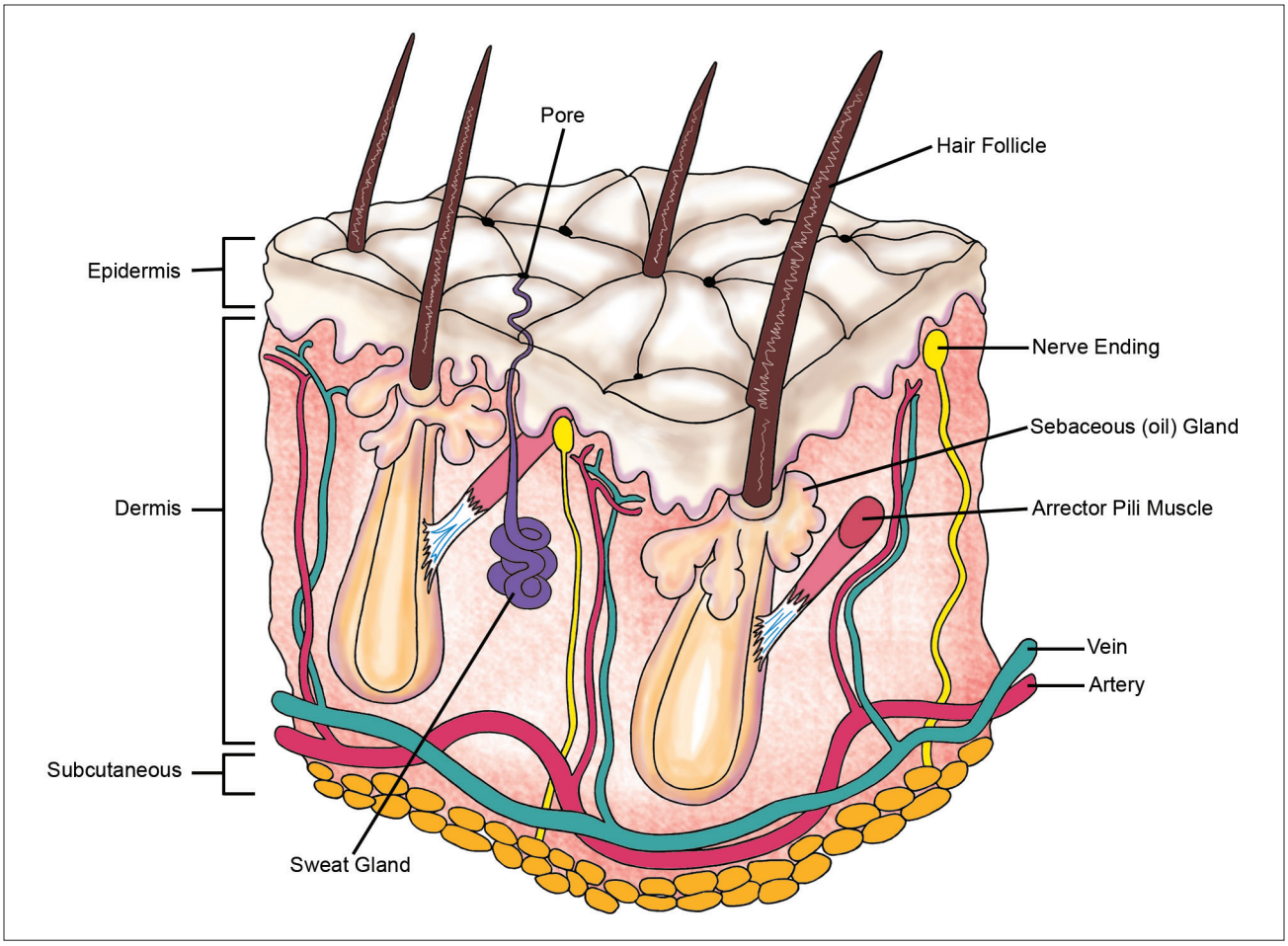

Figure 25-1. The three layers of the skin and other important structures.

Burn Depth

First-degree Burns

Minor tissue damage that reddens only the epidermis and heals in 3 to 6 days is known as a superficial, or first-degree, burn (Figure 25-2). First-degree burns can be painful, but pain management with ibuprofen or acetaminophen, as well as aloe vera gel that contains lidocaine (local anesthetic), usually is the only treatment necessary.

Second-degree Burns

A partial-thickness, or second-degree, burn causes damage through the epidermis and into the dermis (Figure 25-3). In second-degree burns, the skin appears mottled (blotchy) and red, with weeping (oozing) blisters. These burns are painful and typically heal in 2 to 4 weeks, depending on their depth. Surgical repair or skin grafting may be necessary to facilitate healing of large second-degree burns. A skin graft involves surgically removing a partial thickness of skin from an unburned area and placing it over the burned area to "reseed" it with new skin tissue.

Third-degree Burns

Full-thickness, or third-degree, burns extend through the epidermis and dermis and appear charred, translucent, or pearly white, with a surface that is dry and has **thrombosis** (Figure 25-4). Third-degree burns are not normally painful because the nerve endings in the dermis have been destroyed. However, third-degree burns are also associated with second- and first-degree partial-thickness burns on the outer borders of a full-thickness burn, which results in pain. Surgical repair with skin grafting and rehabilitation is necessary for casualties with deep partial-thickness and full-thickness burns. The term fourth-degree burn

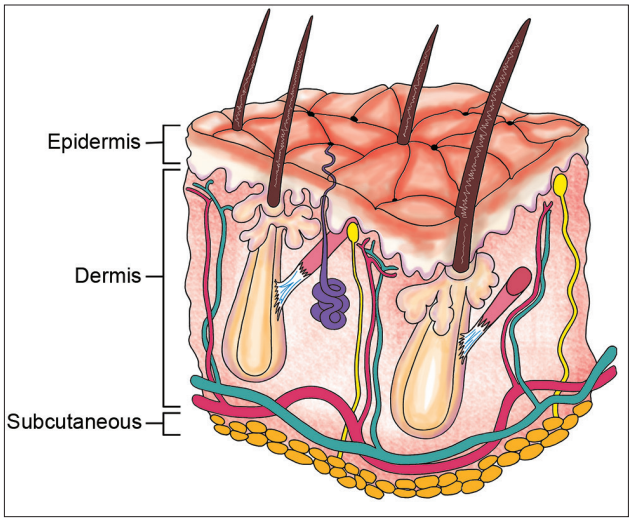

Figure 25-2. First-degree burns involve only the epidermis.

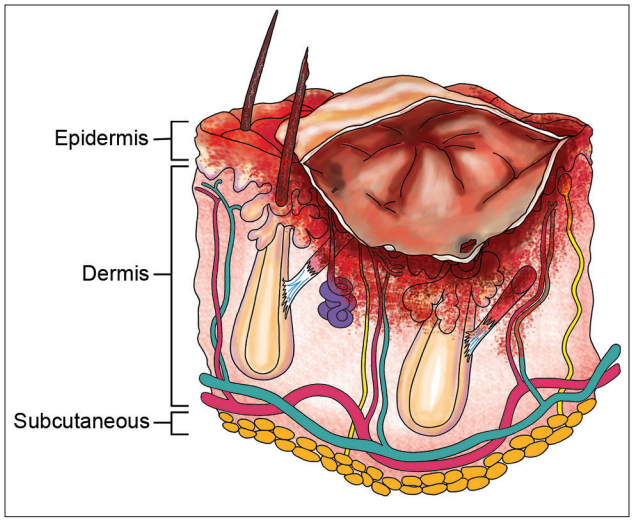

Figure 25-3. Second-degree burns involve the epidermis and dermis.

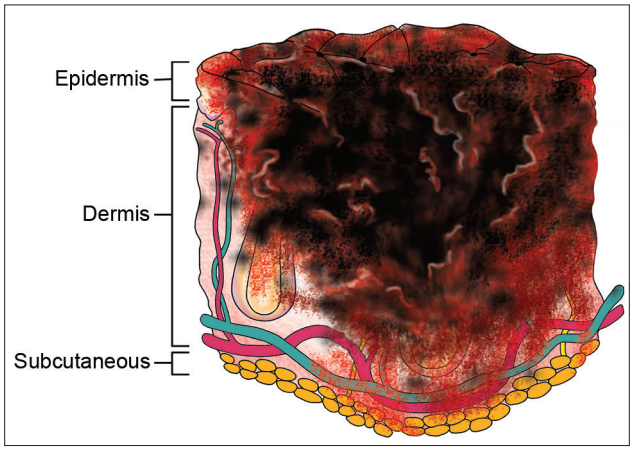

Figure 25-4. Third-degree burns involve all three layers of skin.

is sometimes used to describe burns that involve underlying layers of fat, muscle, or bone.

Burn Size

The **Rule of Nines** describes a quick way to estimate burn size. When using the Rule of Nines, major body parts are assigned percentages as shown in Figure 25-5, and the percentages for each burned body part are added. By applying this rule, you can determine the percentage of total body surface area (**TBSA**) burned. Pediatric assessments are different than adult assessments; children have larger heads (18%) and smaller extremities (14% each leg). If the burn areas are scattered or irregularly dispersed, use the **Rule of Palm:** estimate the TBSA using the palm surface of the casualty's hand to represent approximately 1% of the skin surface.

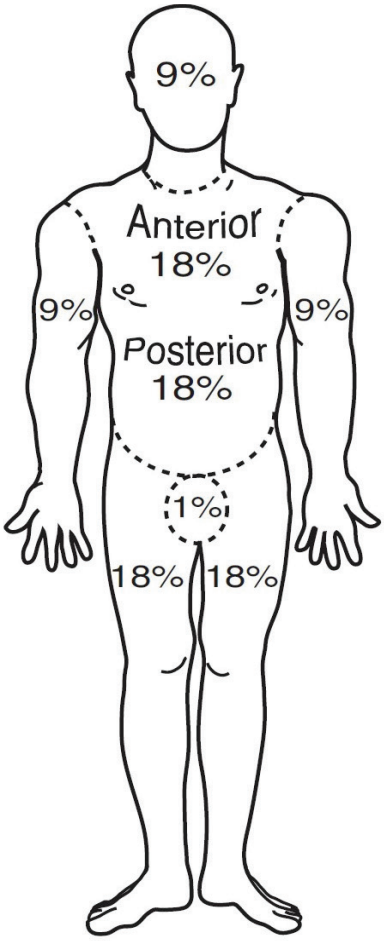

Figure 25-5. The Rule of Nines breakdown of body area percentages. Reproduced from: Cubano MA, Lenhart MK, eds. *Emergency War Surgery*. 4th ed. Washington DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2013: 381.

COMBAT CASUALTY ASSESSMENT

During care under fire, the first priority is to gain fire superiority, and then control life-threatening extremity hemorrhage with hasty tourniquets (see Chapter 16, Combat Casualty Assessment). During tactical field care, the priority for badly burned casualties is to remove the patient from the burn source and stop the burning process. Burn casualties are often trauma casualties as well, and they may have sustained injuries other than thermal trauma, such as blunt or penetrating trauma. Follow the steps below to evaluate a burn casualty and perform initial treatments.

1. Evaluate the casualty's level of consciousness (see Chapter 16, Combat Casualty Assessment).
2. Check for hemorrhage by performing a blood sweep (see Chapter 16, Combat Casualty Assessment).
3. Ensure airway patency. Hot gases and flames can cause edema of the airway above the vocal cords and may occlude the airway, so early airway control is essential (Figure 25-6). For more information see Chapter 18, Airway Management. Always assume an inhalation injury when the casualty was injured in an enclosed-space fire, such as in a vehicle or building. Confusion or agitation, facial or chest burns, singed eyebrows, carbonaceous sputum, and hoarseness or stridor are all signs of an inhalation burn.

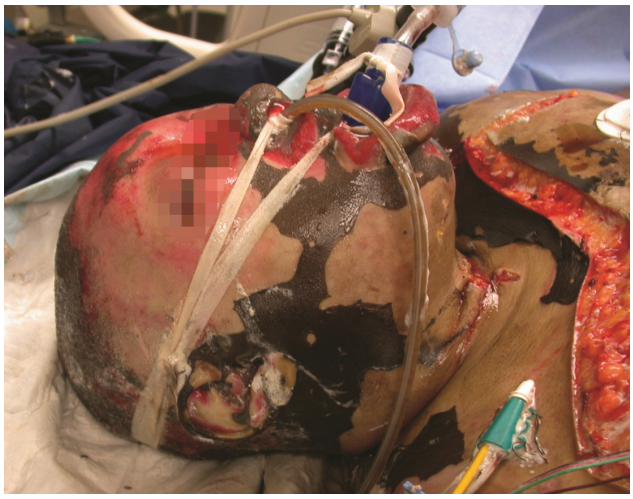

Figure 25-6. A combat casualty with inhalation burns. Reproduced from: Renz EM, Cancio LC. Acute burn care. In: Savitsky E, Eastridge B, eds. *Combat Casualty Care, Lessons Learned from OEF and OIF*. Washington DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2012: 600.

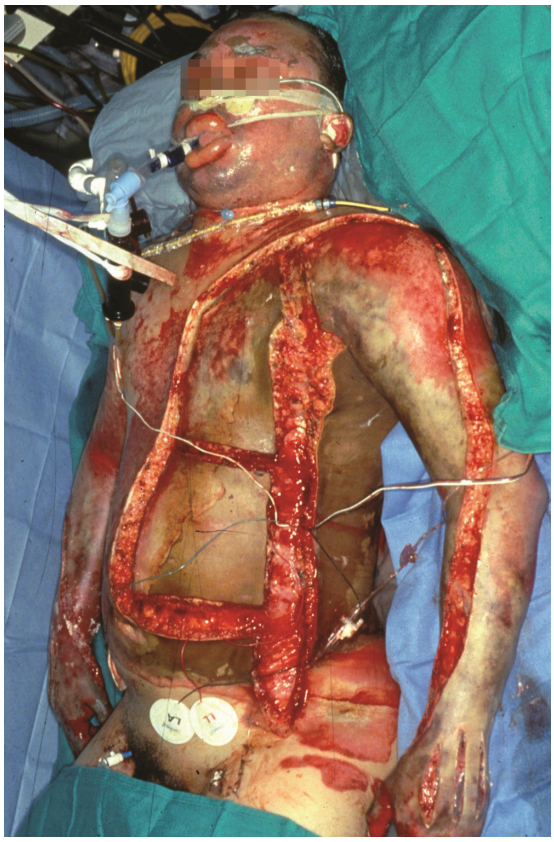

Figure 25-7. A combat casualty with circumferential burns around chest. Note that escharotomies have been performed to allow the movement of the chest during inspiration. Reproduced from: Renz EM, Cancio LC. Acute burn care. In: Savitsky E, Eastridge B, eds. *Combat Casualty Care, Lessons Learned from OEF and OIF*. Washington DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2012: 599.

4. Check breathing. A circumferential chest burn (Figure 25-7) can constrict the chest wall to such a degree that the casualty suffocates from the inability to inhale deeply. Categorize all casualties with circumferential chest burns as "urgent surgical" and evacuate to a military treatment facility with oxygen supplementation (if available) adjusted to maintain an oxygen saturation of at least 92%.
5. Evaluate the casualty's circulation needs by assessing radial pulses and establishing vascular access. For casualties who have sustained burns covering more than 20% of the TBSA, first establish intravenous (IV) access and provide fluid resuscitation. Avoid gaining vascular access through burned tissue, unless no other sites are available.

If IV access cannot be established after two attempts, place an intraosseous (IO) catheter and immediately begin fluid resuscitation following the **Rule of Ten** if radial pulses are present (see Fluid Resuscitation for a Burn Casualty in this chapter). If the casualty is in shock and radial pulses are not present, the shock fluid resuscitation protocol should be followed (see Chapter 20, Shock).

6. Expose the casualty completely and inspect the entire body for any other possible life-threatening injuries (see Chapter 16, Combat Casualty Assessment).

Check on Learning

1. A TBSA greater than or equal to _____% requires intravenous fluid resuscitation.
2. What are the signs or symptoms of an inhalation burn?

BURN WOUND CARE

The goals of burn wound care are to prevent shock and infection and to minimize disfiguration. Cover the casualty's burn in dry, sterile dressings. Dry, sterile sheets or towels are sufficient to use before transporting the casualty. Place several layers of blankets over the casualty to prevent hypothermia. Then, place the casualty in a hypothermia prevention kit or place air-activated heating cells inside blankets with the casualty.

Note: Elevating burned extremities during evacuation will assist in decreasing tissue edema in the first 48 hours of burn management.

Provide fluid resuscitation (see Fluid Resuscitation for a Burn Casualty in this chapter). Use tactical combat casualty care pain management guidelines for pain control (see Chapter 3, Pharmacology). Adverse effects of fentanyl and morphine include respiratory depression, nausea, and vomiting; monitor the casualty closely.

In cases of inhalation burns, stay alert for behavioral changes. Altered mental status is a sign that the brain is not receiving enough oxygen. If breathing becomes more difficult, be prepared to perform a surgical cricothyroidotomy (see Chapter 18, Airway Management).

Do not apply ointments or solutions until the casualty has been evaluated by a medical officer. Do not open blisters, and do not open eyelids if they are thermally burned. An escharotomy may be required to release pressure from swelling in the case of a circumferential burn (see Figure 25-7 and Figure 25-8). This procedure would be performed by a medical officer at a battalion aid station or higher level of care, NOT by a combat medic.

Remove nonadherent clothing, jewelry, and watches. Frequently monitor extremity pulses in circumferential burns to legs and arms. Edema formation beneath the elastic eschar may gradually constrict the venous outflow and, ultimately, arterial inflow. Frequently monitor an extremity's pulse in circumferential burns to the legs and arms.

Figure 25-8. Right hand escharotomies. The burned skin is incised to the subcutaneous level, providing decompression while avoiding deeper structures. Reproduced from: Renz EM, Cancio LC. Acute burn care. In: Savitsky E, Eastridge B, eds. *Combat Casualty Care, Lessons Learned from OEF and OIF*. Washington DC: Department of the Army, Office of The Surgeon General, Borden Institute; 2012: 614.

For casualties who have sustained burns alone, with no other injury, antibiotics are not indicated because a thermal injury that destroys the skin also destroys cutaneous bacterial flora. For those suffering from a combination of burns and penetrating trauma, antibiotics are indicated (as with any other combat trauma casualty).

Burn casualties are not able to control their own body temperature effectively and are susceptible to hypothermia, even in warm or hot environments. Preserve body temperature with blankets, clothing, or whatever is available

Electrical Burns

If a casualty has sustained an electrical burn from a wire source, **do not** attempt to remove wires unless you

are trained to do so. Objects commonly thought to be safe for moving a wire or casualty (eg, wooden sticks, rope, and firefighting gloves) may actually conduct electricity, resulting in the rescuer being electrocuted. If possible, turn off the source of electricity before any rescue attempt is made.

Figure 25-9. Electrical burn to left upper extremity. Reproduced from: Cioffi WG, Loring WR, Buescher TM, Pruitt BA. The management of burn injury. In: Bellamy RF, Zajtchuk R, eds. *Conventional Warfare: Ballistic, Blast, and Burn Injuries*. In: Zajtchuk R, Jenkins DP, Bellamy RF, eds. Washington, DC: Department of the Army, Office of The Surgeon General, Borden Institute; 1991: 374.

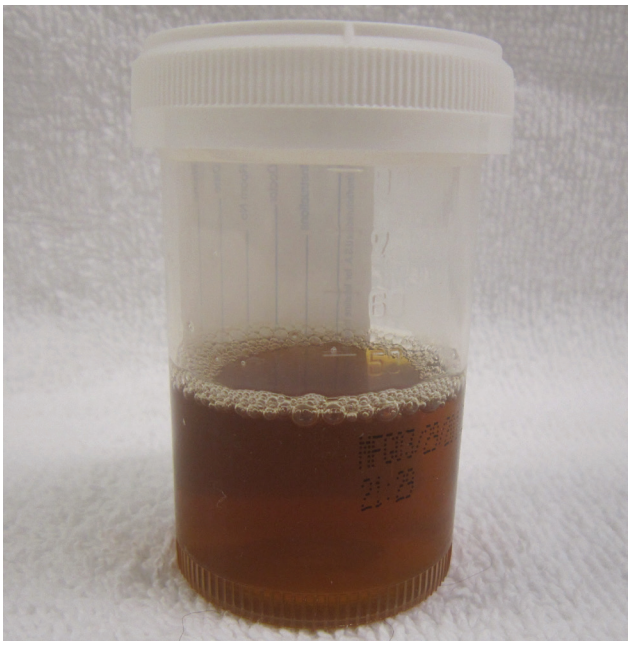

Figure 25-10. Urine from a person with myoglobinuria resulting from muscle tissue destruction. Photograph by James Heilman, MD. Reproduced from: Wikimedia Commons. https://commons.wikimedia.org/wiki/File%3ARhabdoUrine.JPG

Electrical burns (Figure 25-9) are usually more serious than they appear on the skin surface because the current burns deep tissue along an unpredictable path or can cause heartbeat problems (dysrhythmias). The most common dysrhythmia encountered after electrocution is an abnormal heartbeat such as premature ventricular contractions and ventricular fibrillation (pulseless). If the casualty has no pulse, and the tactical situation permits, start cardiopulmonary resuscitation and treat the casualty with an automated external defibrillator. These casualties usually have normal healthy hearts and the chances for resuscitation are excellent. Electrical injuries and crush injuries have many similarities and may both result in **myoglobinuria** (Figure 25-10) and associated complications (see Chapter 26, Musculoskeletal Trauma). Other injuries associated with electricity include ruptured tympanic membranes and fractures to multiple areas of the spine and long bones (resulting from intense and sustained muscle contractions).

Radiation Burns

Many of the treatment interventions for radiation casualties are the same as for other types of burns. Remove the casualty from the burning source and treat immediately life-threatening injuries. Remove contaminated clothing and irrigate the injury with water. Provide fluid resuscitation; if IV fluids are not available, consider providing oral fluids. Irradiated casualties may experience nausea and vomiting, thus increasing the need for fluids. The most devastating effects of radiation poisoning in casualties who survive the initial exposure will not appear until a few hours after the exposure.

Chemical Burns

Chemicals are not always easy to detect, either on a casualty or in the environment. Some chemicals may also be absorbed into the body and cause internal organ failure. In the past, rescuers have sustained severe chemical burns when they attempted to treat burn casualties who were contaminated with an unknown chemical agent. Remove the casualty's clothing to remove a possible source of continuing contamination and to better determine the type and TBSA of the burn.

If a dry chemical is seen on the skin, brush it away and then irrigate with copious amounts of water. Take care to prevent skin contact with any dry chemical while brushing. Remove liquid chemicals from a burn casualty (including burns to the eyes) by flushing

the area with as much water as possible to dilute the concentration and wash away remaining chemicals.

Caution: Ensure that enough water is used to wash the chemical (wet or dry) completely off the skin. If too little water is used, it is possible to spread the chemical over a wider area of the body, increasing the TBSA burned.

Injuries from white phosphorus are occasionally seen in military settings. White phosphorus is a chemical substance that will ignite and burn when exposed to oxygen (Figure 25-11). Grenades, shells, or bombs that contain white phosphorus can cause severe thermal and chemical burns. Cover white phosphorus burns with anything that seals the white phosphorus from the air (eg, water, saline, a wet cloth, or mud). The seal must be maintained until the phosphorus is removed to prevent retained particles from reigniting and burning further.

Figure 25-11. A US Air Force Douglas A-1E Skyraider drops a white phosphorus bomb on a Viet Cong position in South Vietnam in 1966. Author: US Air Force. Reproduced from: Wikimedia Commons. https://commons.wikimedia.org/wiki/File:A-1E_drops_white_phosphorus_bomb_1966.jpg

Fluid Resuscitation for a Burn Casualty

IV or IO fluids prevent a burn casualty from going into hypovolemic shock (see Chapter 20, Shock). The objective is to determine an appropriate rate or amount of fluid to prevent hypovolemia after the burn injury. Initiate fluid resuscitation as soon as IV or IO access is established. Ringer solution is the fluid of choice, if available. If the casualty is in shock secondary to other injuries, resuscitation may be started with Hextend (Hospira, Inc, Lake Forest, IL). Do not give more than 1,000 mL of Hextend to a casualty. Estimate the initial IV/IO rate using the Rule of Ten. Historically, overhydration with IV fluids has been a problem for burn casualties. Massive amounts of IV fluids are no longer the standard of care. Estimate the initial IV or IO rate using the US Army Institute of Surgical Research Rule of Ten for burn resuscitation of adults:

% TBSA burned × 10 = initial hourly IV fluid infusion rate.

Steps for calculating IV fluid rate:

1. Estimate the TBSA burned to the nearest 10% using the Rule of Nines or Rule of Palm.
2. For the initial rate, multiply the TBSA (to the nearest 10%) by 10 mL/h for adults weighing 88 to 175 lb (40–80 kg).
   For example, for a 170 lb (77 kg) male who has burned approximately 30% of his body:
   30 × 10 mL/h = 300 mL/h
3. For patients weighing 176 to 200 lb (80–91 kg), increase the initial rate by 100 mL/h. (For every 25 lb [11 kg] above 175 lb [40 kg], increase the initial rate by 100 mL/h.)
   For example: a 195 lb (88 kg) male has burned approximately 50% of his body.
   50 × 10 mL/h = 500 mL/h + 100 mL/h = 600 mL/h
4. If the casualty weighs 201 to 225 lbs (91–102 kg), increase the initial rate by 200 mL/h.
   For example: a 210 lb (95 kg) male has burned approximately 50% of his body.
   50 × 10 mL/h = 500 mL/h + 200 mL/h = 700 mL/h
5. If the casualty weighs 226 to 250 lbs (103–113 kg), increase the initial rate by 300 mL/h.
   For example: a 230 lb (104 kg) male has burned approximately 50% of his body.
   50 × 10 mL/h = 500 mL/h + 300 mL/h = 800 mL/h

Table 25-1 summarizes how to calculate the fluid volume infusion rate when applying the Rule of Ten.

Table 25-1. Fluid Requirements for Burn Victims

Burn victim's weight (lb)	Initial infusion rate per hour	Added volume per hour
88–175 lb (40–80 kg)	TBSA % x 10 = mL/hour	None
176–200 lb (80–91 kg)	Same	100 mL
201–225 lb (91–102 kg)	Same	200 mL
226–250 lb (103–113 kg)	Same	300 mL

Once IV access is established, secure the IV catheter by suturing or stapling it to the skin. Adhesive tapes or dressings will not secure the catheter when the skin is burned.

If in a battalion aid station or military treatment facility, placing a urinary catheter and monitoring urine output are essential for ensuring the effectiveness of burn fluid resuscitation. Titrate fluids until the urine output is 30 to 50 mL/h for catheterized patients. Burns to the genitalia or perineal region are not contraindications for urinary catheterization. However, patients with trauma to the pelvis should not be catheterized without direct medical provider oversight.

Special Considerations

The very young and very old respond poorly to burn injuries. The death rate in burn casualties over the age of 65 is three times that of the overall burn population. The leading cause of death in fires is not thermal injury but the inhalation of toxic smoke. The three elements of smoke inhalation are thermal injury, asphyxiation, and toxin-induced lung injury (delayed effects). Always assume there is an inhalation injury in an enclosed-space fire.

Check on Learning

3. How do circumferential burns complicate casualty care?
4. What type of dressing is used on a burn?
5. What should you do if a casualty develops increased difficulty breathing?
6. How are white phosphorus burns treated?
7. In combat, you are called to a small vehicle fire. Your patient has partial-thickness thermal burns to his anterior trunk, anterior arms, anterior legs, and groin. His estimated weight is 180 lb (82 kg).
   a. Using the Rule of Nines, calculate the percentage of TBSA burned.
   b. Calculate the casualty's fluid resuscitation needs using the Rule of Ten.
8. Sergeant First Class Romero went to the beach and fell asleep on the sand. When he awoke, he noticed his posterior trunk, posterior arms, and posterior legs were painful, red, and blistered. He went to the battalion aid station for care. SFC Romero's body weight is 189 lb.
   a. What classification of burn does this soldier have?
   b. Using the Rule of Nines, calculate the percentage of TBSA burned.
   c. Calculate the casualty's fluid resuscitation needs using the Rule of Ten.

TRANSPORTATION CONSIDERATIONS

Once the casualty has been assessed, formulate an evacuation plan. The following conditions are classified as urgent surgical:

- inhalation injury;
- partial-thickness burns greater than 20% TBSA;
- full-thickness burns;
- burns on the face, hands, feet, genitalia, perineum, or major joints (hips, knees, ankles, shoulders, elbows, or wrists);
- electrical burns (including from lightning);
- radiation burns —
  - considered hazardous materials burns,
  - priorities are to remove patient from contamination source and decontaminate them;
- chemical burns —
  - chemicals may be absorbed into the body and cause internal organ failure,
  - casualties require prompt evacuation; and
  - medical personnel can be harmed if casualties are not properly decontaminated;
- significant thermal injuries in patients with preexisting medical conditions (eg, diabetes, cancer, immune deficiency, obesity, or poor circulation due to vascular disease).
- combined burns and trauma (lightning, explosions, and other impact forces may throw a casualty some distance from the original injury location); and

- pediatric burns (where there are no qualified pediatric personnel and equipment).

Check on Learning

9. Which type of burn injuries should be considered a priority for transport?
   a. electrical burns
   b. partial thickness burns to 10% of TBSA
   c. noncircumferential partial-thickness burns to both anterior forearms
   d. first-degree burns to the entire back

SUMMARY

Burns are often serious injuries requiring urgent care. Critical problems that require immediate interventions are airway compromise, the presence of major injuries, or hemorrhage in addition to the burn. Clues that may indicate life-threatening problems include a history of being confined in a closed-space fire, inhalation burn, electrical burn, chemical burn, and radiation burn. Understanding each type of burn and its complexities in treatment will give the casualty a better chance of survival, a faster recovery, and better quality of life after the burn injury.

KEY TERMS AND ACRONYMS

Myoglobinuria. Myoglobin (a protein found in muscle cells) in the urine.
Rule of Nines. A formula for estimating percentage of body surface areas, particularly helpful in judging the portion that has been burned.
Rule of Palm. A method of calculating the body surface area of burns that uses the size of the patient's palm as an approximate representation of 1% of the body surface area.
Rule of Ten. An adult burn fluid resuscitation protocol created by the US Army Institute of Surgical Research that rounds up the casualty's total body surface area to the nearest 10 and then uses the casualty's body weight in calculating the amount of fluid to be administered.
TBSA. Total body surface area.
Thrombosis. A blood clot in the vascular system.

CHECK ON LEARNING ANSWERS

1. A TBSA greater than or equal to_____% requires intravenous fluid resuscitation.

   20%.

2. What are the signs or symptoms of an inhalation burn?

   The burn occurred in a confined space; confusion or agitation; burns to face or chest, singeing of eyebrows or nasal hair, or soot in the sputum; hoarseness or loss of voice; stridor.

3. How do circumferential burns complicate casualty care?

   They lead to an increased chance of compromise to distal circulation due to edema.

4. What type of dressing is used on a burn?

   A dry, sterile dressing.

5. What should you do if a casualty develops increased difficulty breathing?

   Secure the airway with a surgical cricothyroidotomy.

6. How are white phosphorus burns treated?

   Cover the area with water, saline, a wet cloth, or wet mud. Keep the area covered to exclude air and prevent any retained particles from reigniting.

7. In combat, you are called to a small vehicle fire. Your patient has partial-thickness thermal burns to his anterior trunk, anterior arms, anterior legs, and groin. His estimated weight is 180 lb (82 kg).

   a. Using the Rule of Nines, calculate the percentage of TBSA burned.

   47% BSA.

   b. Calculate the casualty's fluid resuscitation needs using the Rule of Ten.

   600 mL/h.

8. Sergeant First Class Romero went to the beach and fell asleep on the sand. When he awoke, he noticed his posterior trunk, posterior arms, and posterior legs were painful, red, and blistered. He went to the battalion aid station for care. SFC Romero's weight is 189 lb.

   a. What type of burn does this soldier have?

   Second-degree (partial thickness).

   b. Using the Rule of Nines, calculate the percentage of TBSA burned.

   45%.

   c. Calculate the casualty's fluid resuscitation needs using the Rule of Ten.

   600 mL/h.

9. Which type of burn injuries should be considered a priority for transport?

   Electrical burns.

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