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Caring for patients with burn injuries

By Alicia L. Culleiton, DNP, RN, CNE, and Lynn M. Simko, PhD, RN, CCRN

BURN INCIDENCE has decreased slightly over the years, but burn injuries still occur all too often, with an estimated 3,400 fire and burn deaths each year (this figure includes deaths from smoke inhalation and toxicity).¹ This article reviews types of burns and discusses how to provide initial resuscitative care for a patient who can't be immediately transferred for treatment in a designated burn center or burn ICU.

About 45,000 patients who sustain burn injuries require medical treatment or hospitalization yearly. According to the American Burn Association (ABA), hospital admission based on the type of burn breaks down as follows:

- fire or burn injury, 44%
- scald injury, 33%
- injury from contact with hot objects, 9%
- electrical burns, 4%
- chemical burns, 3%
- miscellaneous causes, 7%.¹

Burn injuries are among the most expensive catastrophic injuries to treat. For instance, a burn injury of 30% of total body surface area (TBSA) can cost as much as \$200,000 in initial hospitalization costs; in addition, significant costs related to reconstructive surgery and rehabilitation are associated with more extensive burns.² Mortality is higher for children younger than age 4 (especially from birth to age 1), and for adults over age 65.³

Breaching a protective barrier

One of the largest organs of the body, the skin has many functions. Besides providing a protective barrier against physical injury and microorganisms, it's crucial for thermoregulatory control, prevention of fluid loss, synthesis of vitamin D, and sensory contact with the environment.

The skin has two layers: an outer epidermis and an inner dermis, separated by a basement membrane. (See *Skin layers and structures*.) Burn injuries involving the partial or complete destruction of the skin and its appendages (hair follicles, nails, and sweat glands) cause local and systemic disturbances, such as compromised immunity, hypothermia, severe fluid loss, infection, and changes in appearance, function, and body image.

A burn injury is described based on its cause: thermal, chemical, electrical, radiation, smoke or inhalation, or frostbite.

- **Thermal burns** result from contact with hot substances, including flame, hot liquids, hot solid objects, and steam, that cause cell injury by coagulative necrosis.⁴ The longer the skin is in contact with these hot substances, the deeper the wound. Because oil-based liquids such as grease and cooking oil have higher boiling points, they cause deeper burns than scalds with water or other liquids.⁵ Burns from hot solid objects such as solid metal, hot plastic, glass, or stone are all considered thermal burns.

- **Chemical burns** destroy tissue and continue to do damage for up to 72 hours unless neutralized. Causes of

chemical burns are strong acids, alkalis, and organic compounds. *Acids*, common in household cleaners such as rust removers and bathroom cleaners, cause protein coagulation, which results in less extensive injuries. *Alkalis* such as oven cleaners and fertilizers cause deeper burns due to liquefactive necrosis, which lets the chemical penetrate deeper into tissues. *Organic compounds* that cause chemical burns include gasoline and chemical disinfectants, which can cause severe coagulative necrosis and produce a layer of thick, nonviable tissue called eschar, which is normally present in full-thickness burns.⁶

- **Electrical burns** are classified as low voltage (under 1,000 V) or high voltage (1,000 V or higher).⁶ Electrical injuries can cause death by triggering ventricular fibrillation

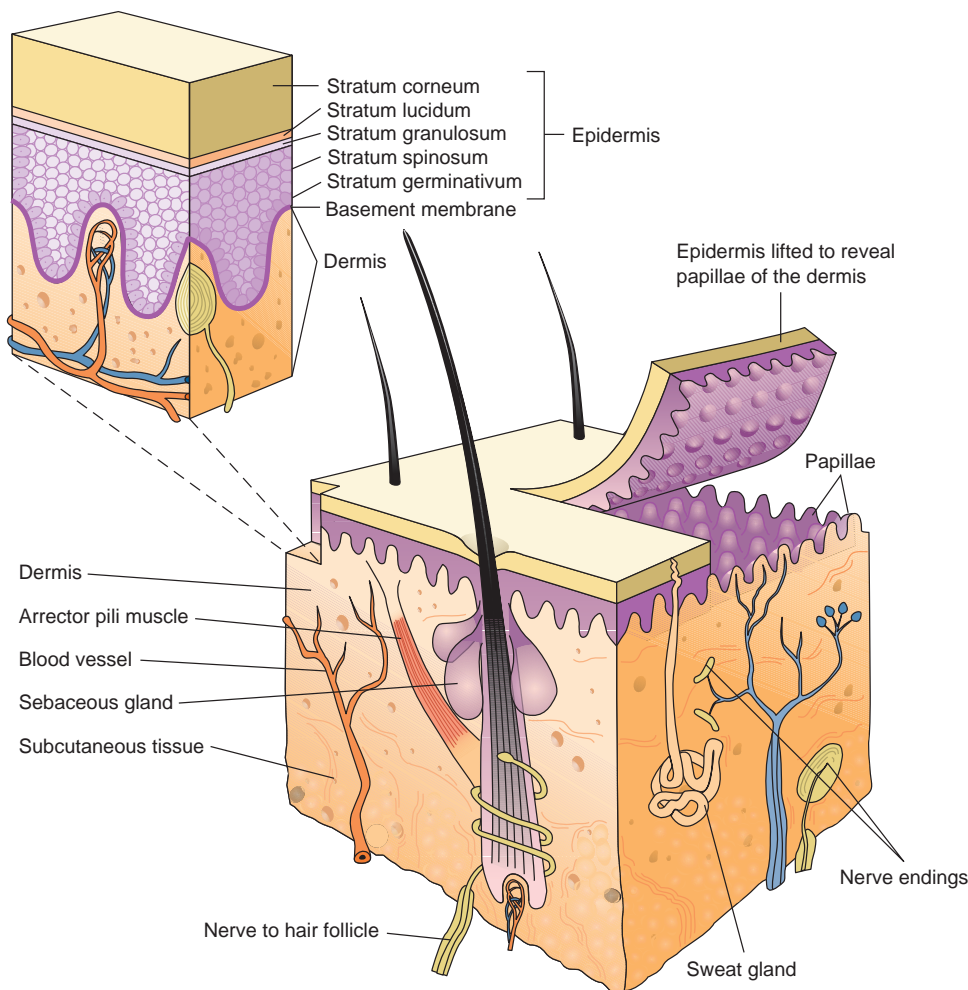
Skin layers and structures²⁰

The skin's two layers, the outer epidermis and the inner dermis, are separated by the basement membrane.

- The avascular epidermis is composed of four to five layers of stratified squamous keratinized epithelial cells, which migrate to the skin surface to replace cells lost during normal skin shedding.

- The basement membrane, which cements the epidermis to the dermis, is involved in blister formation.

- The dermis, which contains blood vessels and nerves, separates the epidermis from the subcutaneous fat layer.



or paralyzing respiratory muscles. Although dysrhythmias can be triggered by low-voltage injuries, they're more common in high-voltage injuries.

The extent of damage from an electrical burn may initially appear minor—the patient may have only small entry and exit wounds. Extensive damage can appear within several days to weeks—a phenomenon known as the *iceberg effect* because the skin shows little injury on the surface and hides massive injury beneath.⁶

Instead of conducting the electricity, bones, muscle, tendon, and fat respond to electrical injury by producing heat. Most injuries occur to muscles surrounding the long bones.⁶

- **Radiation burns** can result from exposure to radiofrequency energy or ionizing radiation such as sunlight, tanning booths, X-rays, or nuclear emissions or explosions. Ionizing radiation can produce tissue damage directly by striking a vital molecule such as DNA.⁵ Sunburn usually causes a first-degree or superficial burn, but radiation therapy can cause full-thickness burns.

- **Smoke and inhalation burns** can occur concurrently with thermal or chemical burns. If the patient has thermal burns, look for signs of inhalation burns: facial burns, hoarseness, soot in the nose or mouth, carbon in the sputum, lip edema, and singed eyebrows or nasal hair. Manufacturing illegal methamphetamine can cause thermal and chemical burns and associated inhalation burns.⁶ Regardless of the cause of the inhalation injury, the patient needs immediate interventions such as endotracheal intubation, bronchoscopy, and measurement of carboxyhemoglobin (COHb) levels.

- **Frostbite** is temporary or permanent tissue damage resulting from exposure to very cold temperatures. Any area of the body left uncovered in very cold temperatures can become frostbitten, but the most commonly affected areas are the fingers, toes, chin, earlobes, cheeks, and nose.⁷ Without treatment, frostbite can progress to cellular necrosis, gangrene, hypothermia, and

Classifying burn injuries

- **Superficial burns** caused by the sun or low-intensity heat flashes damage only the epidermis. These first-degree burns cause erythema, skin blanching on pressure, mild pain and edema, and no blisters or vesicles, although after 24 hours the skin may blister and peel. Symptoms include hyperesthesia, mild pain, and tingling. Healing typically takes 3 to 6 days.

- **Partial-thickness burns** caused by chemicals, flame, or hot liquids damage the epidermis and part of the dermis. These second-degree burns appear as fluid-filled vesicles that are red and shiny (and wet if the vesicles have ruptured). Symptoms include edema, hyperesthesia, pain caused by nerve injury, and sensitivity to cold air. Healing typically takes 10 to 21 days for superficial partial-thickness burns, which involve part of the dermis, and 2 to 6 weeks for deep partial-thickness burns, which involve more of the dermis.

- **Full-thickness burns** may extend into the subcutaneous tissue, meaning the skin can't heal on its own. These burns, classified as third- and fourth-degree burns, are caused by prolonged exposure to chemicals, electrical current, flame, hot liquids, or tar. The skin appears dry, waxy, white, leathery, or hard. Thrombosed vessels will be visible, and muscles, tendons, and bones may be involved. Signs and symptoms include lack of pain, possible hematuria, possible entrance and exit wounds from an electrical burn, and shock. Skin grafting is often required for healing, and patients may lose function of extremities or digits, or need amputation.



Superficial (first degree) burn of the back.



Deep partial-thickness (second degree) burns of the hands.



A full-thickness (third degree) burn of the feet.

cardiac arrest. Because frostbite damages the skin, some patients are treated in the ICU as burn patients, although initial treatment for frostbite is different than that for other burns.

Depth of injury

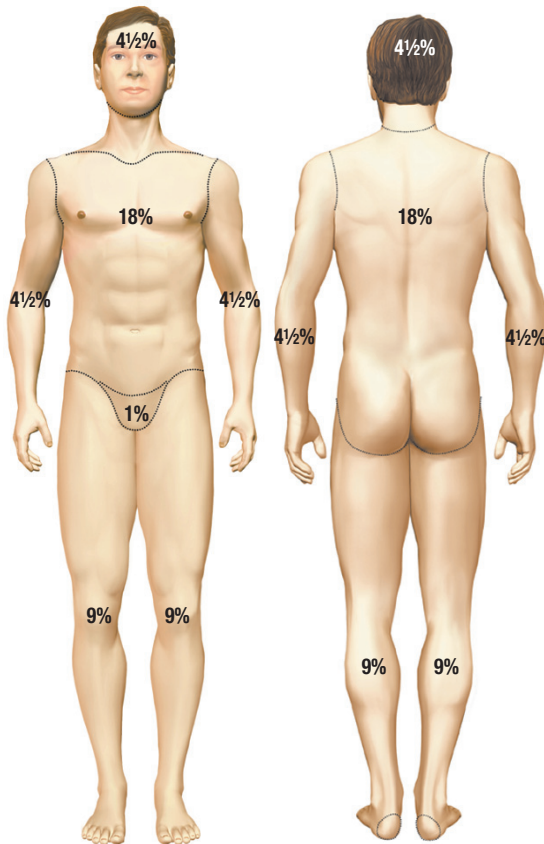
Burns are also categorized according to the depth of injury. In the past, burn injuries were classified as first, second, third, and occasionally fourth degree. In recent years, the

ABA has recommended a more precise classification of burns, categorizing them according to depth of tissue injury:

- epidermal or superficial (first degree)
- partial-thickness (second degree), which may also be classified as superficial or deep partial-thickness
- full-thickness (third degree), which may also be classified as deep full-thickness (fourth degree).⁸

For details, see *Classifying burn injuries*.

Rule of nines: Estimating burn size in adults



Source: Anatomical Chart Company. *Pathology/Laboratory Medicine*; 2008.

Should the patient go to a burn center?²¹

Patients with burn injuries who should be referred to a burn center include:

- All patients under age 1.
- All patients ages 1 to 2 with burns over 5% or more of TBSA.
- Patients of any age with full-thickness burns of any size.
- Patients over age 2 with partial-thickness burns greater than 10% of TBSA.
- Patients with burns of special areas such as the face, hands, feet, genitalia, perineum, or major joints.
- Patients with electrical burns, including lightning injuries.
- Patients with chemical burns.
- Patients with inhalation injury resulting from a fire or hot liquid burn.
- Patients with circumferential burns of the limbs or chest.
- Patients with preexisting medical conditions that could complicate burn management, prolong recovery, or affect survival.
- Patients with burns and concomitant trauma.
- Children with burns who are suspected to be victims of child abuse.
- Patients with septic burn wounds.
- Patients whose burns require treatment that exceeds the capabilities of the referring facility.

Size matters

The size of the burn is expressed as the percentage of TBSA. A partial-thickness burn of more than 10% TBSA is serious and requires referral to a burn center. (See *Should the patient go to a burn center?*)

Estimate the TBSA burned on an adult by using 9 or multiples of 9, known as the rule of nines. The rule of nines varies between infants and adults because infants' heads are proportionally larger compared to adults. (See *Rule of nines: Estimating burn size in adults*.) Although the rule of nines provides a rapid method for calculating the size of the burn injury, it can lead to an overestimation of the TBSA burned, so follow facility protocol for estimating the extent of a burn injury. Most burn centers repeat the estimation of TBSA burned in 72 hours, when burns and their depth are more clearly demarcated and the burned area can be more easily quantified.⁹

Other common methods for measuring burn size include the Lund-Browder chart and the palm method.

- The Lund-Browder method is highly recommended because it corrects for the large head-to-body ratio of infants and children.¹⁰
- The palm method is used for small scattered burns such as grease and scald burns. Often, the rule of palms will be completed first as a quick assessment until the Lund and Browder assessment can be completed. The patient's palm (not including the fingers or wrist) equals 0.5% of TBSA. The entire palm including the fingers equals 1% in children and adults.⁴

Location matters too

Depending on a burn injury's location, the patient may be predisposed to initial complications or complications during wound healing.¹¹ Circumferential burns of the extremities, for example, can lead to vascular compromise resulting in compartment syndrome (see *Ring of fire*). Circumferential burns to the thorax can

impair chest wall expansion, causing pulmonary insufficiency. Burns of the chest, head, and neck are also associated with pulmonary complications.

Facial burns are associated with corneal abrasions and burns of the ears with auricular chondritis. Burns of the perineal area are prone to autocontamination by urine and feces.^{11,12}

Burns over joints immediately affect the patient's range of motion, which may be exacerbated later by hypertrophic scarring (see *Troublesome scars*). Intensive therapy to prevent permanent disability is crucial.

Taking an inside look

Understanding the pathophysiology of a major burn injury (sometimes called burn shock) is key to effective management. Different causes lead to different burn injury patterns, which require different management.

The body's compensatory mechanisms start with the inflammatory response, which is initiated by cellular injury. The most important activator of the inflammatory response is the mast cell, which releases biochemical mediators, such as histamine and chemotactic factors, and synthesizes other mediators, such as prostaglandins and leukotrienes.¹³ Histamine, the major vasoactive amine released by the mast cells, increases capillary permeability and exudation, resulting in edema at the burn injury site, decreased intravascular volume, hypotension, tachypnea, tachycardia, oliguria, and shock.¹³

The sympathetic nervous system (SNS) is stimulated and the fight-or-flight response activated, causing thirst, gastrointestinal hypomotility (ileus), adrenal gland stimulation (causing increased circulating catecholamines, increased metabolic rate, and increased aldosterone secretion), hepatic stimulation (causing release of glycogen stores and elevated blood glucose levels), and vasoconstriction.¹³

Ring of fire

Circumferential burns of the extremities can lead to compartment syndrome.



A major burn injury affects every body system.

- *Respiratory system effects* include direct airway injury; inhalation injury; carbon monoxide poisoning; smoke inhalation (damage to epithelial cells in the lower respiratory tract secondary to inhaling oxides, the products of combustion); alveolar damage; pulmonary edema; and decreased oxygen diffusion.⁵

- *Cardiovascular system effects* include fluid volume deficit, decreased mean arterial pressure, decreased cardiac output, hypovolemic shock (secondary to extensive fluid shifts), and decreased myocardial contractility (impaired cardiac function improves 24 to 30 hours postinjury). Electrical burns can cause ECG changes, myocardial infarction, and cardiac dysrhythmias including ventricular fibrillation.⁶

- *Renal system effects* are indirect. Decreased cardiac output leads to decreased renal perfusion and oliguria that can culminate in acute kidney injury (AKI). In addition, after a burn injury, damaged red blood cells release hemoglobin and potassium, and skeletal muscle cells release myoglobin. Both hemoglobin and myoglobin are filtered by the glomerulus and degraded,

releasing heme pigment. Heme pigment, especially in the setting of fluid volume deficit, can cause AKI.¹⁴ Marked release of hemoglobin or myoglobin usually causes red or brown urine.

- *Gastrointestinal system effects* include ileus secondary to SNS activation. Stress ulcer formation is triggered by the stress response and the histamine released in the acute inflammatory response. Intra-abdominal hypertension and abdominal compartment syndrome can damage the gut, kidneys, and liver.^{6,9}

- *Neuroendocrine system effects* include increased metabolic rate to compensate for the initial low core body temperature due to loss of skin. The increased metabolic rate increases caloric needs and leads to catabolism and a negative nitrogen balance that slows tissue building and healing.⁶ Increased cortisol levels may cause insulin resistance and hyperglycemia.¹³

- *Immune system effects* include immunosuppression secondary to the immediate, prolonged, and severe immunologic and inflammatory response to a major burn injury.¹³

- *Musculoskeletal system effects* include contractures and complications secondary to immobility and scar

tissue formation during the healing process.

Initial assessment and management

Emergency management of a patient with a burn injury begins with the initial assessment and treatment of life-threatening injuries. Stabilize the patient's cervical spine if this hasn't already been done. The true mechanism of injury may not be clear (for example, the patient may have been burned and propelled in an explosion).

Follow these specific aspects of the ABCDE (Airway, Breathing, Circulation, Disability, and Exposure/Environmental control) assessment:^{6,9,15}

- **Airway.** Maintaining the airway is the primary concern, especially if a patient has an inhalation injury. Assess for stridor (an ominous sign that suggests the patient's upper airway is at least 85% narrowed), facial burns, soot in the nares or mouth, singed facial hair or nasal hair, edema of the lips and oral cavity, coughing, hoarse voice, and circumferential neck burns.^{6,9}

- **Breathing.** Determine adequacy of ventilation by assessing the patient's respiratory rate and depth and observing for dyspnea. Auscultate the

lungs, noting any adventitious breath sounds. Obtain a pulse oximetry reading (remembering that it may be inaccurate in the presence of carbon monoxide), and a co-oximetry reading if indicated and available.^{6,9,15}

- **Circulation.** Observe for obvious arterial bleeding. Assess for the presence, symmetry, amplitude, rate, and rhythm of pulses; evaluate capillary refill time, skin color, and temperature.⁹

- **Disability.** Use the AVPU (Alert, Verbal, Pain stimuli, Unresponsive) scale to determine the patient's level of consciousness and carefully evaluate any abnormalities. (See *Reading the AVPU scale*.) Assess for hypoxia, decreased cerebral perfusion related to hypovolemia, and cerebral injury resulting from head trauma. Assess the patient's pupillary response to light and sensory and motor function.^{3,6}

- **Exposure/environmental control.** Gently remove the patient's nonadherent clothing and jewelry to prevent continued tissue damage. If the patient's face is burned, remove glasses or contact lenses. Cover the patient with a dry sterile sheet to prevent further contamination of the burn wounds and to provide warmth.^{3,9,10,15}

Obtain vital signs and establish I.V. access with two large-bore catheters if

the patient has burns over 15% of TBSA. Under ABA practice guidelines, fluid resuscitation is indicated for any patient with nonsuperficial burns covering more than 15% of TBSA.^{1,16} Elevate burned extremities above heart level to decrease edema. Administer I.V. analgesia as prescribed and assess its effectiveness often, using a valid and reliable pain intensity rating scale.

Obtaining a history

After the initial focused assessment is completed and the patient is stabilized, obtain a history of the events while performing a comprehensive physical assessment. The main priorities are to determine the potential for an inhalation injury, presence of concomitant injuries or trauma, and any preexisting conditions that may influence the physical assessment or patient outcomes. A simple way to initially accomplish this is to use the SAMPLE mnemonic: **S**igns and symptoms, **A**llergies, current **M**edications (including illegal substances or alcohol), **P**ertinent history, **L**ast oral intake, and **E**vents leading up to the injury.¹⁷

After determining the extent and depth of the burn, ask the following questions:

- What's the patient's chief complaint (for example, dyspnea or pain)?
- Did the burn occur in an enclosed space?
- Were explosives or chemicals involved?
- What was the source of the burning agent (for example, liquid, metal, or chemicals)?
- What's the status of the patient's tetanus immunization?¹⁰

Stages of burn management

Care for a patient with burn injuries is organized into three stages: emergent (resuscitative), acute (wound healing), and rehabilitative (restorative).⁹ The assessment and management of specific problems overlap and may span two or three stages. For example, rehabilitation begins on the first day after the burn injury,

Troublesome scars

Hypertrophic scarring of a deep partial-thickness burn can cause pruritus, warmth, and other patient discomfort, and the raised scar can limit function if joints are affected.



although the formal rehabilitative phase begins when the burn wound is almost healed.¹⁵

About fluid resuscitation

Fluid resuscitation efforts are started as soon as possible for patients with burns covering more than 15% of TBSA; otherwise, the patient may experience hypovolemic shock.⁶ Insert an indwelling urinary catheter to closely monitor urinary output. Fluid resuscitation is usually accomplished with an isotonic crystalloid such as lactated Ringer's solution; the lactate helps to buffer the metabolic acidosis commonly seen with hypoperfusion and burn shock.⁶ Several fluid resuscitation formulas are available (for example, the Parkland formula) and usually is prescribed by the burn trauma surgeon. All formulas are based on the percentage of TBSA burned, the patient's weight in kilograms (kg), and the patient's age.

Half of the prescribed fluid volume is administered in the first 8 hours postburn, and the remainder is given over the next 16 hours. The ABA recommends titrating the fluids to maintain a urine output of 30 to 50 mL/hour in adults and 1 mL/kg/hour in children weighing less than 30 kg (66.1 lb).⁶ (The adult guideline is used for children weighing 30 kg or more.) In the case of a patient who's sustained a high-voltage electrical burn, the target range for urine output is 75 to 100 mL/hour to prevent renal tubular obstruction from heme pigment.⁶ Monitor the patient's mental status, vital signs, hourly urine output, and urine specific gravity; these are valuable indicators of the patient's response to fluid resuscitation.

Because of the massive volumes of I.V. fluids administered to patients with burns (rates of 1,000 mL/hour are common), closely monitor the patient's hemodynamic status to prevent fluid overload. Signs and symptoms of "fluid creep," or fluid resuscitation in excess of that predicted by the Parkland formula, include abdominal

Reading the AVPU scale

The AVPU scale can be used to determine a patient's level of consciousness.

Alert: Patient is alert, awake, responds to voice, and is oriented to time, place, and person.

Verbal: The patient opens his or her eyes to verbal stimuli, but isn't fully oriented to time, place, or person.

Painful: The patient responds to painful or noxious stimuli, such as nail bed pressure or a sternal rub, but doesn't respond to verbal stimuli.

Unresponsive: The patient is nonverbal and doesn't respond to painful stimuli.

Source: <http://www.ahrq.gov/research/esi/esi2.htm>.

compartment syndrome, extremity compartment syndrome, and acute respiratory distress syndrome.^{18,19}

Fluid resuscitation after the first 24 hours is accomplished with isotonic crystalloids as well as colloids. Dextrose solutions and electrolyte replacement (especially potassium replacement) is initiated. Lactated Ringer's solution is isotonic and doesn't increase intravascular oncotic pressure. Because of increased capillary permeability in patients with burns, only 25% of the lactated Ringer's solution infused in the initial fluid resuscitation will actually stay in the intravascular space. This is one reason for the large fluid volumes needed in fluid replacement.⁶

Once capillary permeability has decreased (8 to 12 hours after the burn injury), colloids such as albumin may be given to help restore intravascular volume. By increasing oncotic pressure in the vascular space, colloids pull interstitial fluid into blood vessels. This also helps decrease the edema associated with burn injuries.

Interventions for specific burn types

For all patients, monitor level of consciousness, respiratory status, cardiac rate and rhythm, vital signs, and oxygen saturation. Identify and treat associated injuries, such as head injury, pneumothorax, or fractures. In addition, initiate specific interventions for these common burn types.

- **Thermal.** Assess the patient for inhalation injuries. For adults with

burns of more than 15% of TBSA, begin fluid replacement as prescribed and insert an indwelling urinary catheter.

- **Chemical.** Assess the patient's ABCs before starting decontamination procedures. Patients with significant inhalation injuries or circumferential full-thickness burns to the neck or chest may need endotracheal intubation and mechanical ventilation.

Remove dry chemicals from the patient's skin, then use saline or tap water to flush chemicals from the burn. Protect yourself and others from exposure and contact the poison control center for more information about the chemical involved.^{9,15}

- **Electrical.** Closely monitor pulses distal to the burn. Because many electrical injuries affect the extremities, depending on where the current entered and exited, patients must be watched for development of compartment syndrome.⁶

Also monitor for myoglobinemia (myoglobin released from injured muscle tissue and hemoglobin from damaged red blood cells). To prevent renal failure from renal tubular obstruction, large amounts of fluid are needed to maintain urine output at 100 mL/hour. Be prepared to administer I.V. mannitol, an osmotic diuretic, to maintain urine output, and I.V. sodium bicarbonate to alkalinize the urine.^{6,9,15}

Because the patient is at high risk for dysrhythmias, initiate continuous cardiac monitoring. Cervical collars and backboards should be used and kept in place until X-rays rule out

spinal injury—many electrical injuries occur from contact with high voltage wires, causing a fall.⁶

• **Inhalation.** Obtain an arterial blood gas analysis, COHb level, and chest X-ray. Prepare the patient for fiberoptic bronchoscopy or endotracheal intubation if indicated.

Effective interventions

By understanding the types of burns and how to assess and manage them, nurses can immediately implement effective interventions while arrangements are made for patient transfer to a burn specialty center. ■

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At Duquesne University's School of Nursing in Pittsburgh, Pa., Alicia L. Culleton is an assistant clinical professor and Lynn M. Simko is an associate clinical professor.

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