BURNS/THERMAL TRAUMA

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OBJECTIVES:

Upon completion of the class, each participant will independently do the following with a degree of accuracy that meets or exceeds the standards established for their scope of practice:

1. Discuss the epidemiology of burn injuries.
2. List the functions of the skin.
3. Name the five layers of the skin.
4. Describe mechanisms of heat transfer and correlate the mechanism with the depth and severity of burn injury.
5. Determine causative factors involved and correlate the factors with the depth and severity of anticipated burn injuries.
6. Describe the appearance of the various burn wounds depending on depth.
7. Discuss the pathophysiology of burn injuries.
8. Calculate the total body surface area burned using the Rule of Nine's or the Rule of Palms.
9. Anticipate conditions that are associated with burn trauma including inhalation burns, hypovolemic shock, burn wound sepsis, decreased cardiac output, gastrointestinal complications, vascular insufficiency, ARDS, compartment syndrome and acute tubular necrosis.
10. Describe the physiologic response to burn injury which contributes to the development of burn shock and how it impacts the emergency plan and rationale for initial crystalloid versus colloid resuscitation including burn fluid replacement formulas.
11. Explain the Parkland and Consensus formulas and calculate the amount and infusion rate of crystalloid fluid replacement.
12. Discuss the psychosocial aspects of burn injury.

CJM 4/07; 1-10

Burns/Thermal Trauma

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I. **Epidemiology of burns**

A. **Incidence**

1. About 1.25 million people are burned annually. The incidence of burn injury in the U.S. has declined by about 50% since 1971 from 10/10,000 to 4.2/ 10,000. The decrease is attributable to improved building codes, safer construction techniques, and the use of smoke detectors. Effective prevention techniques include reducing hot-water heater temperatures to below 130° F (54.4° C) to prevent severe scalds.

2. Forty five thousand patients require in-hospital care annually. About half are admitted to 125 specialized burn treatment centers and half to other hospitals. Of these, up to 6% are considered life threatening.

3. **Persons at greatest risk for serious burns**

a. **Young children**

(1) 2nd leading cause of accidental death in children. 35% of all burns occur in children; 85% of these in toddlers (Supple, 2005). Scald injury incidence is high in ages 18 mos – 3 yrs.

(a) 2,500 die annually
(b) 10,000 experience severe permanent disability

(2) May be difficult to get an accurate history
(3) Greater BSA/kg – Larger evaporative surface creates a decreased ability to conserve heat. Increased risk for hypothermia.
(4) Higher fluid needs, less metabolic reserves – higher incidence of hypoglycemia.
(5) Increased risk of inhalation injury.
(6) Airways more difficult to intubate and secure.

b. **Elderly**

(1) Burns in elderly often result from cooking while wearing loose clothing, house fires, unattended cigarettes and scalds.

(2) 1000 die/yr from home fires

(3) Decreased reaction time, poor dexterity, decreased mobility, & impaired senses contribute to injury or evaluation of elderly.

(4) Normal changes of aging affect cardiovascular, pulmonary, sensory, renal, musculoskeletal, immune and integument systems (Supple, 2005).

(5) Increased M&M is due to preexisting diseases, skin changes, altered nutrition, & decreased ability to fight infection.

c. The infirm

d. Workers: Firefighters, metal smelters, chemical workers who are exposed to occupational sources of combustion and chemicals (Bledsoe, 2006).

B. **Mortality**

1. About 4,500 people die annually as a result of thermal injuries and their complications.

a. 3,750 from fires
b. 750 from MVC and aircraft crashes, contact with electricity, chemicals and substances, and other sources of burn injury (ABA, 2000)

2. People who die in fires usually expire from asphyxiation and/or CO poisoning.

3. Fourth leading cause of trauma deaths after MVC, penetrating trauma and falls (Bledsoe, 2006).

C. **Economic impact**

1. One million work days are lost each year.
2. Direct cost of burn care exceeds one billion dollars annually.
3. Indirect cost for vocational and physical rehab is 3 billion dollars annually.

II. **Anatomy and physiology of the integument system**

A. Body tissues are predominantly water and do not support combustion. When heated, body tissues change chemically, evaporating water and denaturing the proteins that make up cell membranes. The result is widespread damage to the skin (integument system). To understand, assess and treat burn injury, one needs a good understanding of the structures and functions of the skin and the pathological processes that affect it (Bledsoe, 2006).

B. **Skin is the largest organ of the body.** It is durable, flexible, and usually able to repair itself. It varies in thickness from almost 1 cm on the heel to 1 mm on the eye surface.

C. **Layers of the skin**

1. To carry out its functions, skin needs a specialized structure.

2. **Epidermis**

a. Outermost and thinnest layer of the skin. It is subdivided into five layers composed of dying and dead cells that are pushed outward by new cells growing from beneath.

b. As the cells reach the surface, they are sloughed away during normal activities. This normal outward migration helps to prevent invasion of bacteria and other pathogens.

3. **Dermis**

a. The dermis lies under the epidermis and is a thicker layer that consists of collagen and connective tissue.

b. It contains organelles such as blood vessels, hair follicles, sudoriferous glands that secrete sweat, and sensory fibers for pain, touch, pressure and temperature. Sebaceous glands secrete **sebum**, an oil that coats the epidermis and hair follicles making them pliable and providing a barrier to the flow of water through the skin (Bledsoe, 2006).

4. **Subcutaneous tissue**

a. Layer beneath the dermis
b. Composed of connective tissue and fat
c. Provides insulation against trauma and heat loss

5. **Underlying structures** - Not part of integument, but important to burn care.

a. **Muscle**

(1) All types of muscles can be affected by burn injury.
(2) Muscles have thick, fibrous capsules of fascia and are prone to hypoxia and anaerobic metabolism in a burn state.

b. Tendons; nerves

c. **Bone**: A living changing tissue that can be severely injured in a major burn and may need grafting.

d. Vital organs are sensitive to the effects of thermal, chemical, electrical and radiation injury.

D. **Functions of the skin**

1. Protect body from injury due to extremes of temperature, ultraviolet radiation, mechanical forces, toxic chemicals, and invading microorganisms.
2. Thermoregulation: Natural radiator to retain or dissipate body heat through the secretion of sweat and shunting of blood.
3. Massive surface area for sensory stimuli
4. Protects against injury by providing insulation
5. Prevents bacterial invasion
6. Prevents excessive fluid loss
7. Excretes waste products
8. Produces vitamin D
9. Determines identity (cosmetic)
10. Flexible to accommodate free body movement

III. Pathogenesis of burn injuries

A. Types of burns

1. Thermal
2. Chemical
3. Electrical
4. Environmental (lightning)
5. Radiation exposure (not covered in the TNS course)
6. Inhalation

B. Thermal burns

1. **Mechanisms of burn injury**

   a. Scalding; steam; superheated gases
   b. Flame
   c. Flash
   d. Retained heat
   e. Hot substances/surfaces

2. Human skin can tolerate temperatures of 44° C (111° F) without injury. A thermal burn increases the rate at which tissue molecules move and collide with each other. As temperatures increase, molecular speed increases, and the cell components begin to break down, especially membranes and proteins. Proteins will break down or **denature**. The result is progressive injury and cell death (Bledsoe, 2006).

3. Injury correlates directly with temperature, the concentration or amount of heat energy possessed by the object or substance, and the duration of exposure. Example: solids generally have higher heat content than gasses.

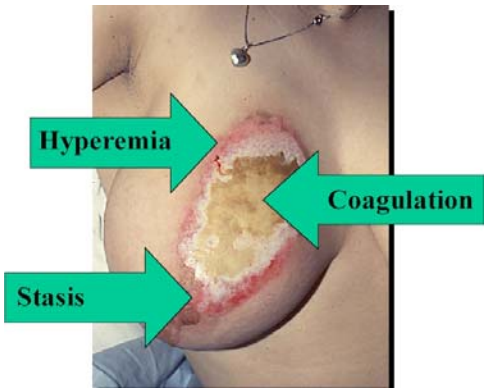
4. Burns are a progressive process. The greater the heat energy, the deeper the wound. Thus, the burn may involve any of the skin or underlying structures.

5. **Jackson's thermal wound theory**

   a. Skin nearest the heat source suffers the most profound changes. Cell membranes rupture and are destroyed, blood coagulates, and proteins denature. The central area with the most intense heat contact and the most damage is called the **ZONE OF COAGULATION**. If this zone penetrates the dermis, the resulting injury is classified as full thickness.

b. The area of the burn extending peripherally from the zone of coagulation is an inflamed area where blood flow decreases. These cells may or may not survive. This area can undergo necrosis 24 to 48 hours following the injury and is called the **ZONE OF STASIS**.

c. The burn perimeter is called the **ZONE OF HYPEREMIA**, and has sustained minimal injury. Inflammation and changes in blood flow are limited and cells will recover in 7-10 days. This area produces the erythema associated with some burns.



6. **Burn shock**

a. Large burns (> 15% to 20%) produce profound pathological effects on the whole body

b. **Emergent (Ebb) phase:** Body's initial reaction to the burn

(1) Pain response

(2) Outpouring of catecholamines in response to pain and stress cause vasoconstriction.

(3) Patient demonstrates tachycardia, tachypnea, mild hypertension, and mild anxiety.

c. **Fluid shift phase:** Begins shortly after the burn and peaks in 6 to 8 hours. It can last up to 18 to 24 hours.

(1) Damaged cells release mediators that initiate an inflammatory response.

(2) The mediators increase blood flow to the capillaries surrounding the burn and increase capillary permeability to fluid. They produce large fluid shifts out of the vascular space into the interstitial space, creating massive edema (3rd space loss).

(3) The capillaries leak water, electrolytes and some dissolved proteins, but no red blood cells. Whole blood loss is usually minimal unless complicated by other trauma. This decreases the vascular volume while increasing viscosity.

(4) Leaky capillaries are the reason fluid therapy is increased during first 8 hours following the burn and tapered after that.

d. **Hypermetabolic phase**

(1) May last days to weeks depending on burn severity.
(2) There is a large increase in metabolic demand for nutrients as the body begins the repair phase.
(3) Nutritional needs become enormous during this phase.

e. **Resolution phase**

(1) Scar tissue is created and remodeled.
(2) Burn patient begins to rehabilitate and return to function.

7. **Treatment specific for thermal injuries**: See end of outline

IV. **Assessing burn severity**

A. **Depth classifications**: Consider the presence/absence of pain, color, capillary refill, moisture, blisters, and appearance.

1. The depth of the burn is important in terms of

a. wound care,
b. need for grafting, and
c. ultimate functional and cosmetic result.

2. **Superficial** (old first degree): Epidermis only
   a. Redness; will blanche and refill
   b. Warm; may be moist
   c. Locally painful; nerve endings are exposed to the air.
   d. Will heal spontaneously as basement membrane of dermis is still intact.

3. **Partial thickness** (old second degree): Epidermis + varying degrees of dermal involvement - with basement membrane still intact.

   a. Redness; will blanche and refill
   b. Edematous tissue
   c. Moist; often blisters
   d. Extreme local pain
   e. Will heal spontaneously, but may scar or have changed appearance.

4. **Full thickness** (old third degree): Both layers of skin are destroyed including the basement membrane of dermis which produces new skin cells.

   a. White, pale, brown and leathery, or charred in appearance
   b. Dry; sweat glands are destroyed.
   c. No capillary refill (capillaries are destroyed).
   d. Sensory nerves are destroyed so there is **NO** pain.
   e. Coagulated dead skin forms a tough, leathery eschar.
   f. Will require skin grafting as dermis is destroyed.

5. **Fourth degree (not a universally accepted category)**: Destroys down to muscle and bone which usually requires excision of tissue and grafting, even though the burn may appear small. Seen with electrical and deep chemical burns.

6. In serious burns, depth may need to be confirmed with wound biopsy examining tissue for evidence of blocked and patent vasculature. Laser Doppler imaging (LDI) is also used (Teague et al, 2005).

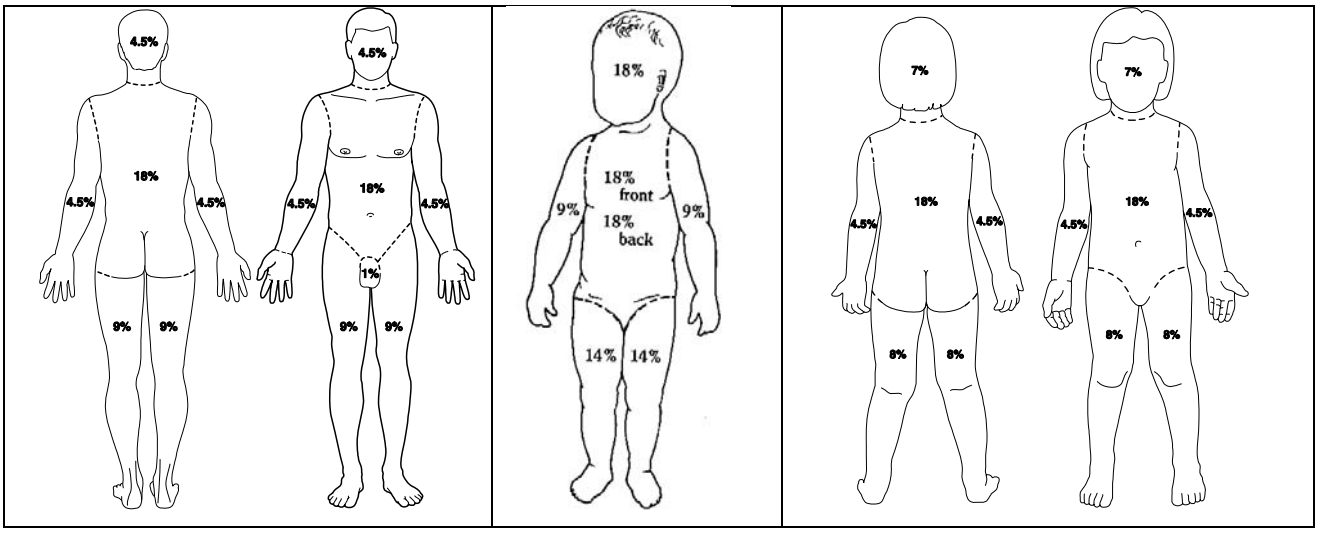
B. **Total body surface area (TBSA) burned**: May be determined by at least three methods. Accurate percentage assessment may not be possible for hours to a day. (See appendix for Rule of 9s and Lund and Browder chart.)

1. **"Rule of Nines"** is based on fractionalizing the body into 9% segments
   a. Entire head (front of head is 4.5%, back of head is 4.5%)
   b. Chest
   c. Abdomen
   d. Each entire arm
   e. Anterior of each leg
   f. Posterior of each leg
   g. Upper back
   h. Lower back and buttocks
   i. Perineum is 1%

2. Different for adults vs. infants and small children. Head is a proportionately larger % in infants. See below.

a.	Entire head	18%
b.	Chest	9%
c.	Abdomen	9%
d.	Entire leg	14%

e.	Entire arm	9%
f.	Upper back	9%
g.	Lower back and buttocks	9%



3. **"Rule of Palms"**: The size of the patient's palm roughly represents about 1% of the body surface area. While the least accurate of the methods, use the patient's palm as a guide to map the extent of smaller or patchy burns less than 10% BSA.

4. **Lund and Browder chart** and its modifications takes into account the proportional differences in adults and children; recognizes that the proportion of body surface covering specific body parts changes with age, e.g. head and neck of an infant constitute 20% BSA compared with 9% in an adult.

   a. Provides most reliable estimate of extent of injury.

   b. Used in acute phase of injury at the hospital to determine treatment and prognosis and as a guide to appropriate patient referrals and planning for wound closure.

5. **Caveat on the morbidly obese patient**: Underestimation of burn area on the trunk and legs becomes more common with increasing obesity. The trunk may constitute up to 50% of the TBSA, while each leg may account for 20%. The head and arms may account for a smaller surface area than that assigned in the rule of nines (Teague et al, 2005).

C. The **burning agent** plus the **time of exposure**

D. The **duration of contact**

E. The **temperature of the burn exposure**

F. Patient **age:** The very young (<2 years) and older adults (> 60) do poorly

G. **Past medical history** and current state of health: Chronic illnesses can impair the body's ability to withstand the stress of the burn or delay healing.

H. **Parts of the body burned:** Special consideration should be given to burns that involve the face, hands, feet, perineum, and major joints.

I. **Concomitant injuries;** i.e., smoke inhalation, fractures

J. **Burn severity classifications** (American Burn Association)

1. **Minor**

   a. Superficial: BSA less than 50% (sunburns, etc)
   b. Partial thickness: BSA less than 15%
   c. Full thickness: BSA less than 2%

2. **Moderate**

   a. Superficial: BSA greater than 50%
   b. Partial thickness: BSA less than 30%
   c. Full thickness: BSA less than 10%

3. **Critical**

   a. Partial thickness: BSA greater than 30%
   b. Full thickness: BSA greater than 10%
   c. Inhalation injury
   d. Partial or full thickness burn involving hands, feet, joints, face or genitalia

K. **Conditions associated with burn injuries**

1. Trauma; soft tissue and musculoskeletal injuries
2. Blast injuries
3. Airway and/or respiratory compromise
4. Child abuse

V. **Organ responses to burn injury**

A. **Local response**

1. **Erythema** may be seen, but refer back to the types of burns and how they present - superficial, partial and full thickness.

2. **Pain**: Often present, but will vary according to the type and depth of burn and the individual patient response.

3. **Swelling** will occur early with rapid 3rd space losses.

B. **Systemic responses and complications of burns**

1. **Hypothermia:** Tissue destruction impairs the body's ability to retain fluids and regulate body temperature. Plasma and other fluids evaporate from the burns rapidly removing heat. The patient may shiver with rapid and severe hypothermia.

2. **Cardiovascular system:** Responds with a marked increase in peripheral vascular resistance accompanied by a decrease in cardiac output, and is one of the earliest manifestations of a systemic response (ABLS, 2000).

   a. The initial drop in cardiac output is unrelated to hypovolemia. There is a marked increase in PVR. The clinical presentation resembles hypovolemic shock but results from humoral & neurogenic influences.

   b. Increased capillary permeability causes a shift of proteins, fluid and electrolytes into the burned tissue producing edema. Protein losses reduce the blood's osmotic gradient and may contribute to profound **hypovolemia**. Massive 3rd space losses of fluids impair the body's ability to regulate sodium, potassium and other electrolytes.

   c. Decreased blood volume reduces cardiac output (CO). This can lead to heart failure (decreased preload, decreased myocardial contractility).

   d. Changes in BP reflect the above plus compensatory vascular responses.

   e. Large thermal and electrical burns cause significant tissue destruction that releases cellular components (potassium, myoglobin) into the bloodstream.

   f. Life-threatening dysrhythmias that can be due to regional hypoxia or electrolyte imbalances.

3. **Respiratory system**: Responds to the actual inhalant, but poisonous gasses affect many systems. Hypoxia is common and may progress to anoxia. Observe for stridor and other breath sounds that may indicate impending upper airway obstruction due to swelling or bronchorrhea and/or expiratory wheezing due to lower airway obstruction and/or swelling.

4. **Infection**

   a. Most persistent killer of burn patients (Bledsoe, 2006). Pathogens enter the wound shortly after injury and continue to do so until the wound heals.

   b. To avoid: Use careful BSI, apply sterile dressings; use clean equipment, and avoid gross contamination of the wound.

5. **Endocrine system** (metabolic demands)

   a. Hypermetabolism characterizes the endocrine response to thermal injuries, and is seen as a catecholamine release in response to the burn injury. The catecholamines cause vasoconstriction.

   b. Evaporative water loss and external cooling are not the primary stimulants for increased metabolism, as is exhibited by a burn patient's inner core remaining warm (unless hypothermia is already in existence). Evaporation contributes to only 20% of the increased metabolic rate (ABLS, 2000).

   c. The increase in metabolic rate leads to negative nitrogen balance, loss of intracellular components, and a rapid decrease in body weight.

   d. Increased nitrogen loss occurs when amino acids are released from the muscle bed, transported to the liver and converted to glucose during periods of starvation. Since glycogen stores are limited and fatty acids can't be converted to glucose, the amino acid transport system provides a steady flow of glucose at the expense of body protein. Massive weight loss will occur, if a burn patient's metabolic needs aren't met.

   e. Hypermetabolism directly correlates to the extent of a patient's burn; therefore caloric requirements must be calculated and met.

   f. Assess for electrolyte balance. Patient will be hyperglycemic until the healing process and the nutritional needs have been met.

6. **Gastrointestinal system:** Generally responds to burns over 20% with an ileus, so an NG tube is appropriate. Tube feedings into the duodenum are usually started as soon as possible and if they aren't tolerated, hyperalimentation is used. The patient is at risk for liver failure due to suppressed portal blood flow.

7. **Renal system** is extremely important to keep intact

   a. Myoglobin is released into the blood from damaged muscle or hemoglobin from damaged RBCs and is excreted by the kidneys (rhabdomyolysis). This increases the risk of kidney damage due to the myoglobin molecule's large size and resultant blockage of the renal tubules. The urine turns a very pale pink to a ‘port wine’ color.

   b. Renal failure may also be due to direct kidney injury from electrical current or poor renal perfusion due to hypovolemia.

   c. Urine output is a determinant of fluid resuscitation needs. The hourly output should be at least:

      (1) Adults: 1 mL/kg/hr (> 50 mL/hr)
      (2) Children less than 30 kg: 1-2 mL/kg/hr

      The fluid infusion rate should be increased or decreased by 1/3 if the urinary output falls below or exceeds the above limits by more than 1/3 for 2-3 hours (ABLS, 2000).

8. **Neurologic system**

   a. No specific neurological injuries are associated with burn trauma.

   b. Major burn patients, do however, frequently exhibit signs of disorientation, may withdraw, may become combative and do experience hallucinations and nightmares due to hypoxia or toxic gas inhalation.

c. Delirium is usually manifested at night and is seen more frequently in the elderly.

d. Symptoms are transient lasting from a day or two to several weeks.

e. A major burn may precipitate a psychiatric crisis that requires psychiatric intervention and medication.

9. **Hematologic system**

a. Burn injury is characterized by fluid and electrolyte losses.

b. Hematocrit should be maintained between 30 and 35.

c. Check for a decrease in platelets, they may need to be replaced.

d. Acidosis is usually relieved by increased fluid administration.

e. Hyperkalemia will be present as cells release potassium into the blood. Urinary excretion generally keeps the serum K from reaching toxic levels. If hyperkalemia reaches toxic levels it must be treated.

f. Hyponatremia will be present at the end of the first 24 hours of resuscitation, but again, this usually takes care of itself with appropriate fluid management, urinary excretion and evaporation.

VI. **ABA Criteria for referral to a burn center** - a burn center may treat adults and/or children

A. Partial thickness burns greater than 10% total body surface area (TBSA)
B. Full thickness burn in any age group
C. Burns that involve the face, hands, feet, genitalia, perineum, or major joints
D. Chemical burns
E. Electrical burns including lightning injury
F. Inhalation injuries
G. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality, e.g., diabetes, COPD, CAD, etc.
H. Burns involving concomitant trauma (fractures) in which the burn injury poses the greatest risk of morbidity or mortality. In such cases, if the trauma poses the greater immediate risk, the patient may be initially stabilized in a trauma center before being transferred to a burn unit. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
I. Burned children in hospitals without qualified personnel or equipment for the care of children
J. Burn injury in patients who will require special social, emotional and/or long-term rehabilitative intervention (ACS, 1999)

VII. **Acute resuscitation** of thermal burn injury/using a priority approach

A. **Stop the burning process**

1. Cool partial thickness burns less than 10% BSA or full thickness burns less than 2% BSA with irrigating solution in the first 10-15 minutes after the burn. Bringing the surface temperatures to normal may help reduce pain and may limit the depth of the burning process (Bledsoe, 2006).

   Do not overcool and **do not apply ice to the wound**! Cooling larger surface areas will contribute to hypothermia and ice may cause a cold thermal injury. Apply cold for at least 10 minutes and a maximum of 20 minutes (Teague et al, 2005).

2. Remove wet/burned clothing and apply a clean, **dry** sheet and blanket. If clothing has adhered to the skin leave in place until it can be removed safely.

3. Remove anything that would hold heat or restrict circulation, i.e. clothing, rings, watches, jewelry, belts, suspenders, steel toed shoes, etc.

4. **Substances with retained heat** (tar, grease, metal, etc.) should be cooled and removed as soon as possible. Tip – petroleum-based products like tar can be

removed with mayonnaise or mineral oil. Grease can be removed with mild soap and water if available.

B. **Airway:** Signs of pulmonary injury may occur anywhere from the first to the 15th day after inhalation with peak incidence of symptoms on day two

1. **Inspect face for evidence of burns**: 66% have facial burns; but 86% of patients with facial burns have NO inhalation injury

   a. Eyebrows, eyelashes, nasal hairs (vibrissae) for singeing
   b. Swelling, edema
   c. Tissue destruction

   If present; suspect inhalation injury and anticipate edema, obstruction, spasm, tracheobronchial injury, and/or respiratory arrest

2. Look for evidence of **carbonaceous sputum**

3. **Listen for airway sounds**: stridor, hoarseness or coughing that indicates irritation or inflammation of the mucous membranes.

4. Assess for

   a. dry mouth, sore throat;
   b. dyspnea; adventitious lung sounds;
   c. dysphagia (difficulty swallowing); and/or
   d. dysphasia (difficulty speaking).

5. Open airway using spine precautions if appropriate. An oral airway may be used in an unconscious patient without a gag reflex.

6. **Consider the need for intubation**. Burn centers have modified their approach and do not intubate unless absolutely necessary due to the increased risk of infection.

   Intubation should be considered if there is severe respiratory distress, acute airway edema; severe inhalation injury; associated neck trauma; and/or associated significant chest wall injury where assisted ventilations are ineffective. If it is delayed until the patient is extremely dyspneic or goes into respiratory arrest, the airway may be so narrowed and edematous that it will be difficult, if not impossible to intubate (Bledsoe, 2006). Attempt to insert the largest tube that will pass through the cords, but prepare smaller tubes than usual if needed due to airway edema.

C. **Breathing**

1. **Assessment**

   a. General respiratory rate, depth. Ask about C/O chest tightness.

   b. Observe for dyspnea due to bronchospasm and upper airway obstruction

   c. Listen for decreased breath sounds with diffuse expiratory wheezes. Respiratory distress, sternal retractions and stridor are found less commonly. Crackles heard in the first few hours post-inhalation imply a poor prognosis.

   d. **Skin:** Cyanosis may be present or skin may have a cutaneous flush if CO levels are extremely high or cyanide poisoning is present.

   e. **Impaired gas exchange** may be caused by smoke inhalation, CO inhalation, interstitial edema, atelectasis, pneumonia, ARDS, or severe metabolic acidosis due to electrical injury.

2. **Resuscitative interventions**

   a. Ensure adequate tidal volumes, ventilatory rates, and gas exchange.
   b. O_2 12-15 L/NRM or BVM for any moderate or major burns
      15 L O_2 will decrease CO half-life by up to 2/3rds.
   c. Apply SpO_2 , capnography monitors. If CO poisoning, SpO_2 is unreliable.

D. **Circulation**

1. **Assessment**

a. General pulse rate, quality, location; monitor ECG
b. Mental status
c. Skin color, temperature, moisture
d. Estimate the volume of blood lost if multiple trauma

2. **Treatment**

a. Initiate/continue CPR if no carotid pulse or heart action is detectable.

b. Treat dysrhythmias per protocol.

c. Initial management of a burn > 15% includes infusion of NS or LR through a large bore peripheral intravenous or IO catheter.

d. While not optimal, IVs may have to be started through partial thickness burns proximal to a more serious injury. Do not start through full thickness burns. Use extreme caution. The upper skin may be leathery, but the underlying tissues are very delicate (Bledsoe, 2006).

e. Formulas, such as **Parkland,** Baxter, or **Consensus**, calculate **adequate fluid resuscitation** in adults for the first day. Formulas range from **2-4 mL X patient's weight in kg X % TBSA burn**. Half of the fluid is delivered in the first eight hours and the remaining half is infused over the next 16 hours. Be cautious with fluid volumes in any patient with airway or lung injury. Frequently listen to breath sounds.

f. **Children less than 3 years old**: 4 mL LR X kg X % TBSA burned + normal maintenance fluid. Authorities suggest adding the patient's normal daily fluid requirements to the fluid replacement calculation in children.

3. **Maintain circulation in those with circumferential full-thickness burns: Interventions for eschar**

Full thickness burns destroy dermal cells. They become hard and leathery, producing **eschar**. The skin constricts over the wound, restricting blood flow like a tourniquet and increasing the pressure of any edema beneath.

a. If the burn encircles a limb, the constriction may be sufficient to occlude all blood flow into the distal extremity (compartment syndrome).

b. If the burn encircles the neck, thorax, or abdomen respiratory compromise secondary to reduced chest excursion and tidal volumes may occur.

c. **Clinical signs of impaired circulation**

(1) Cyanosis
(2) Impaired capillary refill
(3) Progressive neurologic deficits; paresthesias and deep tissue pain
(4) Doppler determination of peripheral pulses

(5) If circumferential full thickness burn with impaired perfusion or chest excursion, prepare for escharotomy.

d. **Escharotomy** is an incision through the burned skin down to subcutaneous fat that relieves the constricting effects of the burn; allows tissue expansion, restores adequate blood supply, and decreases neurovascular compression. No anesthesia is necessary as nerve endings are destroyed in the full-thickness burn. It may be needed for trunk or extremity burns during the first six to 24 hours post burn.

e. **Fasciotomy** is an incision through a full-thickness burn into underlying subcutaneous fat and fascia to relieve edema and compartment syndrome. It is used in electrical and deep thermal burns involving muscle. Recommended as an OR procedure.

E. **Evaluate level of consciousness:** May range from fully awake and aware to altered mental status (AMS) to unconsciousness. Restless, confused? If AMS, consider the presence of possible head trauma or a toxic inhalation.

F. **Expose to examine**

1. Remove all clothing to adequately assess the following:
   a. Total BSA burned (calculate partial and deep thickness only)
   b. Depth of the burns
   c. Circumferential burns

2. **Alteration in thermal regulation:** The patient loses the ability to regulate body heat peripherally due to damaged skin microcirculation and large evaporative losses. Anticipate shivering and hypothermia in all burns exceeding 20% TBSA.

   Keep patient warm. Maintain a warm environment; prepare radiant warmers. Cover partial thickness burns of more than 15% or full thickness burns of more than 5% BSA with dry sterile dressings and clean, dry sheets (Bledsoe, 2006; Mleak, 1998). Warm all IV crystalloids to maintain neutral thermal environment.

G. **Secondary survey**

1. Full set of **vital signs** including temp and SpO_2 if not already done.

2. **SAMPLE history**
   a. Age, body weight in kg
   b. Signs & symptoms
   c. Allergies
   d. Current meds, especially those with implications for wound healing, i.e., steroids, aspirin, epinephrine, antibiotics
   e. Past medical history; especially conditions that affect healing, i.e., diabetes, prior splenectomy, alcohol or drug use
   f. Last oral intake; tetanus immunization history
   g. Events surrounding the incident
      (1) Mechanism of injury: heat, chemical, electrical, gaseous, radiation, possible contaminants, and time of injury
      (2) Location where found; i.e., closed or open space
      (3) Any loss of consciousness
      (4) Consider and examine for other mechanisms associated with the burn; did they jump from a high window to escape flames?

3. **Rapid review of systems – integument**

a. **Inspection**

(1) Erythema; swelling
(2) Sloughing of the affected skin; blisters
(3) Circulatory status to skin: color, temperature
(4) Moist or dry
(5) Changes in skin condition relative to the affected burn site
(6) Burnt/singed hair; hair loss
(7) Appearance of wound edges; presence of foreign bodies, debris, contaminants, bleeding and circulatory adequacy. If bleeding, assess for concomitant soft tissue injury.
(8) Musculoskeletal injuries: With electrical burns, they may have musculoskeletal trauma from tetanic spasms.

b. **Palpate**: Presence of distal pulses, capillary refill, tissue sensitivity (paresthesias, hyperesthesia, or anesthesia)

H. **Definitive interventions**: Depends on the mechanism of burn

1. **Pain is** related to tissue destruction, edema, and interventions for wound care.

a. **Expected outcomes**

(1) Patient states that wound discomfort is tolerable.
(2) Patient is able to rest and/or concentrate on diversions and participate in care appropriately.
(3) Patient exhibits relaxed facial muscles and body position.
(4) Patient verbalizes need for pain relief and responds to appropriate measures for increased comfort.

b. **Interventions**

(1) Administer IV analgesics such as Morphine or Fentanyl as needed to make pain tolerable: until pain is controlled or side effects occur.
(2) Monitor respirations and BP carefully.
(3) Evaluate response
(4) Position patient to promote comfort.

2. **Wound care of thermal burns**

a. Outpatient management of burns can be divided into the six Cs: clothing, cooling, cleaning, chemoprophylaxis, covering, and comforting (Teague et al, 2005).

b. Clothing (should already have been removed)

c. Cooling: Burning process should already have been stopped.

d. **Potential for infection** related to open wound, wound contamination, or poor wound healing. Infection remains the most common persistent killer of burn patients after the first 24 hours.

(1) **Systemic changes**

(a) Loss of skin barrier to infection
(b) Decreased serum immunoglobulins
(c) Abnormal neutrophil function
(d) Altered cellular immunity and lymphocytopenia
(e) Rapid colonization of wound surfaces may lead to sepsis
(f) Susceptible to potentially fatal septicemia

(2) **Expected outcomes**

(a) Absence of local or systemic signs of infection such as local warmth, redness, and pain surrounding burn or fever, decreased bowel sounds or hyperpnea
(b) Wound exudate cultures are negative
(c) Wound heals normally

e. **Interventions**

(1) Institute infection control measures employing personal barrier precautions and asepsis until all burns are cleansed and covered with dry sterile dressings and/or clean, dry sheets. Wash hands thoroughly before and after burn care.

(2) **Covering:** Dry dressings reduce air movement past the sensitive partial thickness burn and help to reduce pain. They also absorb wound moisture and help to prevent the development of hypothermia and provide padding against additional trauma. Bacteria do not move through dry dressings as easily as moist.

When applying dressings to digits or other surfaces that may contact each other, place gauze between the burned skin areas. Ensure that no wound surfaces touch so they don't stick together and cause further damage when pulled apart (Mleak, 1998).

VIII. **Psychosocial aspects of burn injury**

A. **Emotional support** is paramount as feelings of guilt, fear, anger, and depression must be recognized and addressed. The burn generally does not affect a person’s mentation, so they may be awake and alert.

B. Alterations in coping will be noted related to overwhelming pathophysiology, fear of death or horrible disfigurement and length of recovery.

C. Alterations in self concept will be noted related to scars, powerlessness and finances.

D. Self-esteem will be lowered and must be rebuilt in terms of independence and integration back into the community.

E. Counseling should be available, as their transition back into the home, work place, school and community will most likely be a painful psychological experience

IX. **Prevention is the key to these devastating injuries**

A. Teach children to "stop, drop, and roll"; stress the dangers of fire; encourage them to plan an escape route from their homes, and have them demonstrate how to call 911.

B. Teach parents not to put children in tubs without checking the water temperature first; reduce the temperature of water heaters, and keep matches or lighters out of the reach of children etc.

C. Encourage the use of smoke detectors.

D. Never leave burning candles unattended.

E. Promote programs that help get drunk drivers off the road.

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