Northwest Community Healthcare
Paramedic Program

BURNS/THERMAL TRAUMA

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Assigned readings:
Bledsoe Vol 4: pp. 116-136; this handout
SOP: Burns (pp. 43-44)

National EMS Education Standards:
Complex depth, comprehensive breadth; pathophysiology, assessment, and management of burns: electrical, chemical, thermal

OBJECTIVES:

Upon completion of the assigned readings, class, and homework questions, each participant will independently do the following with at least an 80% degree of accuracy and no critical errors:

1. Discuss the epidemiology of burn injuries and identify populations at risk.
2. List the structures and functions of the integumentary system.
3. Describe mechanisms of heat transfer and explain how the skin is injured in a burn including a description of Jackson's thermal wound theory.
4. 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 resuscitation.
5. Sequence the assessment and resuscitation of a patient experiencing a thermal burn (including the rationales for each step).
6. Differentiate the various burn IV fluid resuscitation formulas and calculate the amount and infusion rate of crystalloid fluid replacement using the ABA criteria and the Parkland Formula.
7. Describe the appearance of the various burn wounds depending on depth.
8. Calculate the total body surface area burned using the Rule of Nine's or the Rule of Palms.
9. Determine burn severity and identify those patients that may benefit from direct transport to a burn center vs. those that should be taken to the nearest trauma center.
10. Anticipate conditions that are associated with burn trauma including inhalation burns, hypovolemic shock, burn wound sepsis, decreased cardiac output, gastrointestinal complications, vascular insufficiency, ARDS, need for escharotomy, compartment syndrome and acute tubular necrosis.
11. Discuss the psychosocial aspects of burn injury.
12. Explain new burn treatments being advanced by the government under the Department of HHS.

Psychomotor objective

1. Competently assess and manage a patient with thermal burn wounds per SOPs.

Affective objective

1. Value and defend the need for adequate pain management and psychological support of patients suffering from severe burn trauma.

NCH Paramedic Program

Burns/Thermal Trauma

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I. Epidemiology of burns

A. Mechanisms causing burns

1. Thermal
2. Electrical
3. Chemical
4. Radiation
5. Friction

B. 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. 486,000 receive medical treatment annually
3. Factors associated with fire-related burn injuries include substance abuse, alcohol and smoking, violence, medical co-morbidities, and other social, economic, and cultural factors.
4. Forty thousand patients require hospitalization including 30,000 at 128 specialized burn treatment centers. Of these, up to 6% are considered life threatening.
5. Selected statistics: 2005-2014 Burn Admissions to Burn Centers (ABA, 2016)
   a. Survival Rate: 96.8%
   b. Gender: 68% Male, 32% Female
   c. Ethnicity: 59% Caucasian, 20% African-American, 14% Hispanic, 7% Other
   d. Admission cause: 43% Fire/flame, 34% Scald, 9% Contact, 4% Electrical, 3% Chemical, 7% Other
   e. Place of occurrence: 73% Home, 8% Occupational, 5% Street/Highway, 5% Recreational/Sport, 9% Other

C. Mortality

1. 4th leading cause of trauma deaths after MVC, penetrating trauma, and falls
2. About 3,275 people die annually as a result of fire/smoke inhalation
   a. 2,756 from residential fires; 310 vehicle crash fires
   b. 220 other sources
3. People who die in fires often expire from asphyxiation and/or CO poisoning.

D. Persons at greatest risk for serious burns

1. **Young children**
   a. 2nd leading cause of accidental death in children; 35% of all burns occur in children; 85% of these in toddlers (Supple, 2005, reviewed 2013). Scald injury incidence is high in ages 18 months to 3 years
      (1) < 8 yrs: 20.5%
      (2) 8-18 yrs: 13.4%
   b. May be difficult to get an accurate history
   c. Greater BSA/kg – Larger evaporative surface creates a decreased ability to conserve heat. Increased risk for hypothermia.
   d. Higher fluid needs, less metabolic reserves – higher incidence of hypoglycemia.

e. Increased risk of inhalation injury.

f. Airways more difficult to intubate and secure.

2. **Elderly**

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

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

c. Normal changes of aging affect cardiovascular, pulmonary, sensory, renal, musculoskeletal, immune and integument systems.

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

3. The infirm

4. Workers: Firefighters, metal smelters, chemical workers who are exposed to occupational sources of combustion and chemicals.

E. **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. **Skin is the largest organ of the body.** It is durable, flexible, and usually able to repair itself.

B. **Skin functions**

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

C. Varies in thickness from 1.5 cm on the soles or palm to 0.5 mm on eyelid or behind the ear

D. **Layers of the skin:** To carry out its functions, skin needs a specialized structure.

1. **Epidermis**

a. Outermost (surface) 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. Complex mixture of many different cell types — each with a very specific job. The production, or differentiation, of such a sophisticated tissue requires an immense amount of coordination at the cellular level, and glitches in the process can have disastrous consequences.

c. 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.

2. **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.

3. **Subcutaneous tissue**

a. Layer beneath the dermis – not part of integument
b. Composed of connective tissue and fat
c. Provides insulation against trauma and heat loss

4. **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.

III. Pathogenesis of burn injuries

A. Human skin tolerates 44° C (111° F) w/o injury

B. Thermal injury increases rate at which molecules move and collide with each other

C. 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. As temperatures increase, molecular speed increases, and the cell components begin to break down, especially membranes and proteins.

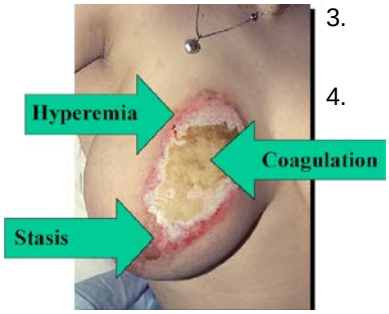
D. The result is widespread damage to the skin (integument system). To understand, assess and treat burn injury, one needs a good understanding of the structures and functions of the skin and the pathological processes that affect it.

E. **Thermal burns**

1. **Mechanisms of burn injury**

a. Fire/fame
b. Hot liquids, scalds
c. Hot substances/surfaces
d. Steam; superheated gasses

2. 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.



3. 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.

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

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

b. **ZONE OF STASIS:** The area extending peripherally from the zone of coagulation has decreased blood flow. These cells may or may not survive. This area can undergo necrosis 24 to 48 hours following the injury.

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.

IV. **Burn assessment & early resuscitation: ITC Primary Assessment**

A. Situational awareness; dynamic risk assessment

1. P:
2. E:
3. N:
4. M:
5. A:
6. N:

B. Scene safety

C. ***Rescue*** (Scene response and safety) starts with a 9-1-1 call and involves the initial response of locating the burn-injured patient and taking steps to get them to a safe area. No rescue should be attempted that places the responder at risk unless they are equipped and trained and the effort is consistent with the mission and direction of their agency (Kearns, 2013).

1. **High index of suspicion for toxic gasses produced by combustion**

a. Carbon monoxide
b. Carbon dioxide
c. Hydrocyanide
d. Hydrogen sulfide
e. Acid anhydrides: Chlorine, nitrogen dioxide, sulfur dioxide
f. Aldehydes: Phosgene, acrolein, ammonia
g. Hydrochloric acid

2. **Caveats on CO screening**

a. (Oct. 2010) Performance of RAD-57 pulse CO-oximeter compared with lab carboxyhemoglobin measurement. Ann Emerg Med., 56(4), 382-8. RAD correctly identified only 11 of 23 pts w/ SpCO >15%.

b. Caution if using the RAD-57, due to device sensitivity of only 48%. Will miss CO poisoning > 50% of the time. Monitor the patient, not the monitor!

3. Contain hazards

4. **Look for MOI associated with burn**

a. Did patient jump from a height to escape flames?

b. Electrical burns may have titanic spasms, respiratory arrest, skeletal trauma or cardiac dysrhythmias

5. Evaluate need for resources: law enforcement; Aeromedical transport

D. **Resuscitation: Stop the burning process**

1. Stop the burning process (remove from source; extinguish, remove burning or contaminated clothing)

2. Remove anything that would hold heat or restrict circulation, i.e. clothing, rings, watches, jewelry, belts, suspenders, steel toed shoes, etc. Cool synthetic materials that retain heat.

3. **COOL per thermal wound care SOP:** Partial thickness burns <10% BSA or full thickness burns <2% BSA with water or NS for 10 minutes. The first objective in

burn wound care is to dissipate the heat. The subcutaneous temperature continues to rise for a while even after the heat source has been removed. Thereafter, it takes about 3 minutes for the tissues to return to body temperature. Immediate active cooling of burn wounds with water or saline (lavage, soaks, compress or immersion) is effective. Continuous cooling for the first 10 minutes dissipates heat, reduces pain, delays onset and minimizes the extent of burn edema by decreasing the histamine release from the skin mast cells.

4. 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.

5. **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.

6. Keep burn as clean as possible; wear gloves/mask until burns covered

E. **Airway**

1. Airway impairment is significant risk if exposed to smoke, fire gases, or have facial burns
2. Is airway obstructed or clear? Any difficulty moving air?
3. **Inspect face for evidence of burns and/or inhalation injury**: 66% have facial burns; but 86% of patients with facial burns have NO inhalation injury
   a. Eyebrows, eyelashes, nasal hairs (vibrissae) for singeing
   b. Look for evidence of **carbonaceous sputum**
   c. Observe for dyspnea, edema, obstruction, inflammatory changes in pharynx or upper airways

   If present; suspect inhalation injury and anticipate edema, airway obstruction, spasm, tracheobronchial injury, and/or respiratory arrest
4. **Listen for airway sounds**: stridor, hoarseness or coughing that indicates irritation or inflammation of the mucous membranes.
5. Assess for
   a. dry mouth, sore throat;
   b. dyspnea; adventitious lung sounds;
   c. dysphagia (difficulty swallowing); and/or
   d. dysphasia (difficulty speaking).
6. Observe for tissue destruction from the burns
7. **Airway management**
   a. Airway: compromise, hoarseness, wheezing? Access may be difficult w/ burns of face or anterior neck.
   b. HOB elevated to decrease airway edema.
   c. Open airway with manual maneuvers; protect c-spine prn
   d. If unconscious & breathing: NPA/OPA depending on the nature of tissue trauma/swelling and presence or absence of a gag reflex
   e. **Consider the need for intubation**
      (1) Burn centers have modified their approach and do not intubate unless absolutely necessary due to the increased risk of infection.
      (2) **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.

(3) Person with the best intubation skills should do the procedure

(4) Attempt to insert the largest tube that will pass through the cords, but prepare smaller tubes than usual if needed due to airway edema. If airway diameter is narrowed by ½, resistance will increase by 16 fold!

(5) Secure w/ commercial device; don't apply tape to facial burns.

f. If you cannot intubate or ventilate – consider the need for an extraglottic airway or cricothyrotomy based on patient need.

F. **Breathing**

1. **Breathing problems likely if**
   a. AMS
   b. Deep and/or circumferential chest burn preventing expansion; ask about chest tightness
   c. Trauma to chest wall
2. Assess general respiratory rate, depth, effort. Observe for dyspnea due to bronchospasm and upper airway obstruction
   a. Assess chest wall movement; WOB
   b. Breath sounds: 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.
3. **Causes of impaired gas exchange in acute setting**
   a. Smoke inhalation
   b. CO poisoning
   c. Interstitial edema
   d. Atelectasis, Acute lung injury (ALI)
   e. Severe metabolic acidosis due to electrical injury.
4. Signs of pulmonary injury may occur anywhere from the first to the 15th day after inhalation with peak incidence of symptoms on day two
5. **Assess pulse oximetry (SpO_2) & capnography monitors;** use central sensory for SpO_2 if poor perfusion to limbs or cold. Anticipate false high (unreliable) reading if CO poisoning.
6. **Skin:** Cyanosis may be present or skin may have a red flush if CO levels are extremely high or cyanide poisoning is present.
7. **Resuscitative interventions**
   a. Ensure adequate tidal volumes, ventilatory rates, and gas exchange.
   b. O_2 12-15 L/NRM or BVM for any emergent to critical burns; 15 L O_2 will decrease CO half-life by up to 2/3, but if CO levels are >25-30 may consider need for a hyperbaric chamber if one available.

G. **Circulation**

1. **Assessment**
   a. General pulse rate, quality, location; monitor ECG
   b. Mental status
   c. Skin color, temperature, moisture (evidence of shock)
   d. Estimate the volume of blood lost if multiple trauma
2. **Emergent phase**
   a. Large burns (> 20%) produce profound effects on whole body

b. Immediately following a big burn, there is an outpouring of catecholamines that produce vasoconstriction and reduced blood flow to tissues

c. Patient presents w/ tachycardia, mild hypertension (HTN), and anxiety

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

a. Damaged cells release chemical mediators that initiate an inflammatory response.

b. 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 the potential for massive edema (3^{rd} space loss).

c. 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 blood viscosity.

d. **Burn shock does not happen immediately**, thus there is often no acute need for immediate IVF resuscitation at the scene. However, these leaky capillaries are the reason fluid therapy is increased during first 8 hours following the burn and tapered after that.

e. BEWARE – Life-threatening facial/airway edema can occur quickly

f. Monitor ECG if exposure to smoke or electric shock; dysrhythmia present

4. **Treatment**

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

b. **Vascular access Indications**

(1) Adults > 20% TBSA
(2) Children >15% TBSA
(3) Presence of hypovolemic shock
(4) Need for IV meds

c. 14-16 g catheter in adequate vein. While not optimal, IVs may need to be started through burns proximal to a more serious injury. Do not start through full thickness burns unless absolutely necessary using extreme caution. The upper skin may be leathery, but the underlying tissues are very delicate.

d. If no peripheral vascular sites available: IO (proximal humerus preferred)

e. **Fluid resuscitation**

(1) **Hemostatic resuscitation goals**

(a) Carefully manage IV fluids
(b) Avoid fluid creep - Maintain circulating volume while avoiding complications of aggressive crystalloids (lung water, edema)
(c) Also linked to abdominal compartment syndrome
(d) Prevent the lethal triad

(2) Warm NS; be cautious with fluid volumes. Do not overhydrate! Reassess lung sounds frequently.

(3) Do not delay transport to start IV

(4) **If NOT in shock: EMS IVF volume recommendations (ABA)**

(a) 0-5 yrs: 125 mL/hr
(b) 6-13 yrs: 250 mL/hr
(c) ≥ 14 yrs: 500 mL/hr

(5) If in shock, IVF per ITC.

(6) **Document the total amount of IV fluid infused by EMS; report that volume upon arrival to receiving facility**

(7) Hospitals should calculate **fluid resuscitation formulas**, such as **Parkland,** Baxter, or Consensus, to determine **adequate fluid resuscitation** for the first day.

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.

Example: An adult weighing 70 kg has deep partial thickness burns totaling 50% TBSA. Using the **Parkland formula**, how much IV fluid in liters is needed during the first 8 hours?

Formula: 4 mL x TBSA x weight in kg; ½ in first 8 hours

4mL X 50 (TBSA) X 70 (kg) = 14,000 mL total first day
½ in first 8 hours = 7 L (that's less than 1 L per hour)

(8) **Children <3 yrs at hospital**: 4 mL LR X kg X % TBSA burned + normal maintenance fluid. Authorities suggest adding pt's normal daily fluid requirements to the fluid replacement calculation in children.

H. **D: Disability/Drugs**

1. May range from fully awake and aware to altered mental status (AMS) to unconsciousness. Restless, confused?
2. If AMS consider presence of
   a. Hypoxia, shock
   b. Head trauma
   c. Toxic inhalation
   d. Alcohol/drug impairment
   e. Hypoglycemia: Obtain/document glucose level – treat hypoglycemia/SOP
3. Consider presence of cyanide poisoning with rapid cardiovascular collapse if patient presents with hypotension, CNS depression, metabolic acidosis, soot in the nares or respiratory secretions central apnea, and seizures. Consider need for antidotes such as amyl nitrite inhalents or **HYDROXOCOBALAMIN** 5 gm IV as possible if available
4. **Pain management**: Pain is inevitable…suffering is optional!
   a. Pain is related to tissue destruction, edema, and wound care
   b. Document severity
   c. If hemodynamically stable, FENTANYL -Give until pain is tolerable, max dose given, or SE evident
   d. Nausea: ONDANSETRON prn
   e. Monitor VS carefully; evaluate response
5. Expected outcomes
   a. Patient states that wound discomfort is tolerable.
   b. Patient is able to concentrate on diversions and participate in care appropriately.
   c. Patient exhibits relaxed facial muscles and body position.

I. **Expose to examine (and then recover to maintain body heat)**

1. Remove burned clothing and anything else that can retain heat or impair circulation (if not done already). If clothing has adhered to the skin, leave in place (cut around) until it can be removed safely.

2. **Prevent lethal triad: Prone to 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. Anticipate shivering and temp loss in burns > 20% TBSA. Cover to keep warm! Approximately 40% of severely burned patients are hypothermic when arriving at a burn center (Weaver et al, 2014). These patients are nearly twice as likely to die in the hospital. Even mild hypothermia (T ≤ 36.5 degrees C) is associated with nearly twice the likelihood of death after adjustment for confounding factors. Burn patients with mild hypothermia have an adjusted odds of mortality of 1.91 (Hosler et al, 2013).
3. Open burn sheet on stretcher before placing pt. Cover pt. with clean dry sheet (sterile not necessary) and blanket; place in warm environment ASAP.

V. **Secondary assessment**

A. **Full set of vital signs:**

1. Assess P & BP on unburned extremity if possible. Place dressing over burned skin under BP cuff if necessary to take BP in area of burn
2. Edema may make palpation of radial artery difficult; use carotid or femoral

B. **SAMPLE history**

1. Age, weight in kg: Children < 2 yrs have a very thin dermis; prone to deeper injuries. Around 50, dermis loses elasticity & thickness – predisposes to deeper injuries
2. Signs & symptoms
3. **Allergies**: Sulfa? Some burn creams contain sulfa.
4. **Current meds,** especially those with implications for wound healing, i.e., steroids, aspirin, epinephrine, antibiotics
5. **PMH**: Chronic illnesses; social habits; conditions that affect healing, i.e., diabetes, prior splenectomy, alcohol or drug use. Smoking may worsen inhalation burn, impair healing and/or ability to withstand stress of the burn
6. Last oral intake; tetanus immunization history
7. Events surrounding the incident
   a. Mechanism of injury: heat, chemical, electrical, gaseous, radiation, possible contaminants, and time of injury
   b. Location where found; i.e., closed or open space
   c. Time of injury; any delay?
   d. Any loss of consciousness
   e. Alcohol/drug use
   f. Signs of abuse or neglect
   g. Consider and examine for other mechanisms associated with the burn

C. **Rapid Review of Systems**

1. HEENT
2. Chest
3. Abdomen/pelvis
4. Extremities
5. Back
6. 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)

D. **Assessing depth of burn**

1. Assess the presence/absence of pain, swelling, skin color, capillary refill, moisture, presence of blisters, hair loss, appearance of wound edges, foreign bodies, debris, contaminants, bleeding/soft tissue trauma

2. The depth of the burn has implications for
   a. wound care,
   b. need for grafting, and
   c. ultimate functional and cosmetic result.

3. **Superficial** (old first degree): Involves epidermis and outer dermis only
   a. Skin is red; will blanche and refill
   b. Warm to touch; may be moist
   c. Locally painful; nerve endings are exposed to the air
   d. Usually no blisters
   e. Heals in 3-7 days; basement membrane of dermis still intact
   f. Sloughs without scarring
   g. Example: **sunburn**
      (1) Heavy alcohol use is associated with sunburn
      (2) History and symptoms for sunburn may include the following:
         (a) Recent sun exposure or outdoor activity; outdoor occupations or hobbies; use of indoor tanning equipment
         (b) Ultraviolet radiation may be transmitted through clothing, especially when wet, so sunburn may occur under clothed skin.
         (c) Erythema (develops after 3-4 hours and peaks at 12-24 hours; resolves over 4-7 days, usually with skin scaling and peeling)
         (d) Possible fever, chills, malaise, nausea, or vomiting in severe cases

4. **Partial thickness**
   a. Heat travels into dermis involving more tissue & resulting in greater destruction, but basement membrane still intact
   b. **S&S:** Edema, hairs anchored, red, cap refill intact; moist, often blisters, extreme local pain
   c. High risk of infection; can convert to full thickness
   d. Heals w/o grafting – may take months if deep; may scar or have changed appearance.

5. **Full thickness** (old 3rd degree): All skin layers are destroyed including the basement membrane of dermis that produces new skin cells.
   a. S&S: White, pale, brown and leathery, or charred in appearance; dry (sweat glands are destroyed); no capillary refill (capillaries are destroyed); sensory nerves are destroyed so there is **NO** pain in the area of the FT burn; however, may still have pain due to PT burn surrounding areas of FT
   b. Thrombosed vessels may be seen through the translucent skin surface.
   c. Coagulated dead skin forms a tough, leathery eschar.
   d. Will require skin grafting as dermis is destroyed.

e. Natural wound healing may produce contracture deformity and severe scarring

6. **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.

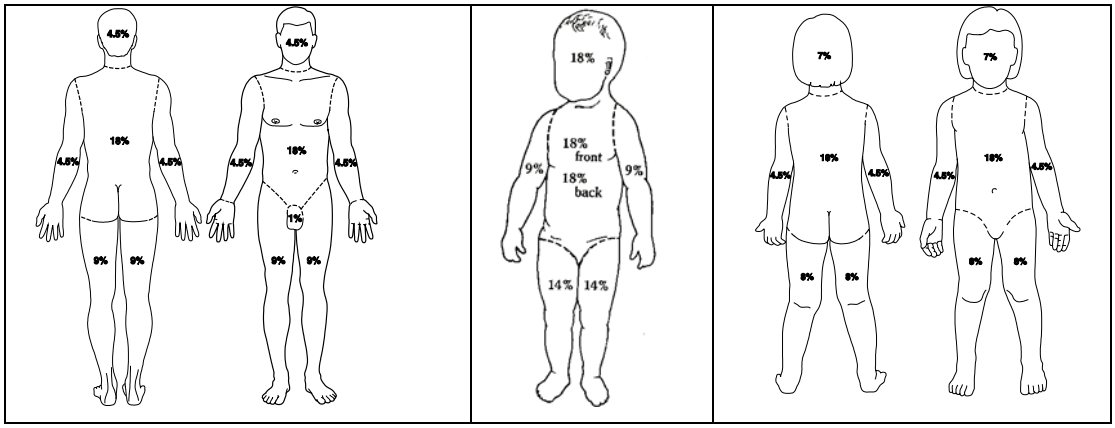
7. In serious burns, depth may need to be confirmed with wound biopsy examining tissue for evidence of blocked and patent vasculature or Laser Doppler imaging.

E. **Total body surface area (TBSA) burned**: Accurate percentage assessment may not be possible for hours to a day. Calculate only areas of partial & full thickness burns. Superficial burns do not contribute to fluid shifting & do not usually require IVF unless very large.

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 infants and small children. Head is a proportionately larger % in infants. For infants, 4% is taken from each leg (along w/ 1% from perineum) and given to the head

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** 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.

VI. **Management of burns and burn-related problems**

A. **Wound care: minimize contamination**

1. **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.

a. **Systemic changes**

(1) Loss of skin barrier to infection
(2) Decreased serum immunoglobulins
(3) Abnormal neutrophil function
(4) Altered cellular immunity and lymphocytopenia
(5) Rapid colonization of wound surfaces may lead to sepsis
(6) Susceptible to potentially fatal septicemia

b. Institute infection control measures employing personal barrier precautions and asepsis until all burns are cleansed and covered. Wash hands thoroughly before and after burn care.

2. Air currents over acute burn are very painful**. Cover burns with plastic wrap to diminish pain, reduce fluid loss, prevent hypothermia, and prevent bacterial contamination** (ACEP News, 2008).

3. Leave blisters intact. Do not break, deroof, or aspirate blisters, debride skin, or apply topical ointments, creams, or anti-microbials in the field

4. Wrap digits individually or place gauze between burned skin areas

5. If PT> 15% and/or FT> 5% cover with dry dressings. Smaller burns and those of the eyelids can be treated with moist dressings.

B. **Psychosocial support**

1. **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.

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

3. Counseling will ultimately be needed as their transition back into the home, work place, school and community will most likely be a painful psychological experience

VII. **Determining burn severity**

A. **Depth** of burn

B. **Extent** of burn (TBSA)

C. **Burning agent** plus the **time of exposure**

D. **Duration of contact**

E. **Temperature of the burn exposure**

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

G. **PMH** 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 >50%
b. Partial thickness: BSA 15-30%
c. Full thickness: BSA 2-10%
d. No complications
e. Not involving hands, face, feet, major joints, or perineum
f. No electrical or inhalation injury
g. No other trauma or PMH

3. **Critical**

a. Partial thickness: BSA >30%
b. Full thickness: BSA >10%
c. Inhalation or electrical injury
d. Burns to critical areas: hands, face, feet, joints, or perineum
e. Concomitant injury
f. Severe preexisting medical problems

VIII. **Transport decision** – time-sensitive patients

Burns: (Severe) without trauma MOI: consider transport directly to burn center (must call OLMC to approve and make arrangements) if they meet criteria below; all moderate-severe burns with trauma MOI go to the nearest TC.

IX. **Criteria for referral to a burn center**

A. Partial-thickness burns >10% TBSA
B. Full thickness burns in any age group
C. Burns involving face, hands, feet, genitalia, perineum, or major joints
D. Electrical burns (lightning injury); Chemical burns; Inhalation injury
E. Burn injury in pts with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality
F. Burns and 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 pt's condition may be stabilized initially in a trauma center before transfer to a burn center. Physician judgment will be necessary in such situations and should be in concert with the regional OLMC plan and triage protocols.
G. Burned children in hospitals w/o qualified personnel or equipment to care for them.
H. Burn injury in pts who will require special social, emotional, or rehabilitative intervention. (ACS Comm on Trauma. (2014). Resources for Optimal Care of the Injured Patient, p. 101).

X. **Conditions associated with burn injuries: Definitive care at hospitals**

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

5. **Maintain circulation in those with circumferential full-thickness burns:**

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) May need a Doppler to assess peripheral pulses
(5) If circumferential full thickness burn with impaired perfusion or chest excursion, hospitals will perform an escharotomy.

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.*

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.*

XI. **Organ responses to burn injury**

A. **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.

1. The initial drop in CO is unrelated to hypovolemia. The clinical presentation resembles hypovolemic shock but results from humoral & neurogenic influences.
2. 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.
3. Decreased blood volume reduces cardiac output (CO). This can lead to heart failure (decreased preload, decreased myocardial contractility).
4. Changes in BP reflect the compensatory vascular responses.
5. Large thermal and electrical burns cause significant tissue destruction that releases cellular components (potassium, myoglobin) into the bloodstream.
6. Life-threatening dysrhythmias can be due to regional hypoxia or electrolyte imbalances.

B. **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.

C. **Infection**

1. Leading cause of burn deaths after first 24 hours. Pathogens enter the wound shortly after injury and continue to do so until the wound heals.
2. To avoid: Use careful BSI, use clean equipment, avoid gross contamination of the wound and cover quickly.

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

1. Hypermetabolism characterizes the endocrine response to thermal injuries evidenced by catecholamine release. Catecholamine release causes vasoconstriction.
2. The increase in metabolic rate leads to negative nitrogen balance, loss of intracellular components, and a rapid decrease in body weight.

3. 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.

4. Assess glucose: Patient will be hyperglycemic until the healing process and the nutritional needs have been met.

E. **Gastrointestinal system:** Generally, burns >20% result in an ileus, so an NG tube is inserted at the hospital. 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.

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

1. 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.

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

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

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

G. **Neurologic system**

1. No specific neurological injuries are associated with burn trauma.
2. Major burn patients, do however, frequently exhibit signs of disorientation, may withdraw, may become combative or experience hallucinations and nightmares due to hypoxia or toxic gas inhalation.
3. Delirium is usually manifested at night and is seen more frequently in the elderly.
4. Symptoms are transient lasting from a day or two to several weeks.
5. A major burn may precipitate a psychiatric crisis that requires psychiatric intervention and medication.

H. **Hematologic system**

1. Burn injury is characterized by fluid and electrolyte losses.
2. Acidosis is usually relieved by increased fluid administration.
3. 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.
4. 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.

XII. **New burn wound therapies**

A. **Silverlon dressings**

1. Silverlon, manufactured by Argentum of Geneva, Illinois, is a long-acting silver-impregnated nylon bandage available commercially and used widely to cover acute wounds and superficial and partial thickness thermal burns.

2. The silver helps control bacterial growth within the dressing. Silverlon, could improve care for burn patients before they reach the hospital and receive a surgical treatment for their burn injuries.

B. **NexoBrid**

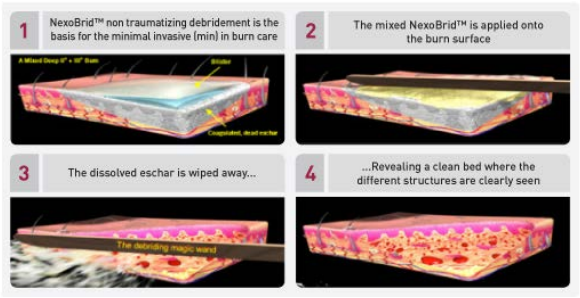
1. Under a five-year contract, MediWound of Israel will develop NexoBrid, a topical gel made of pineapple-based enzymes and designed to dissolve the damaged or dead skin tissue to create a clean wound-bed for skin grafting.

2. If successful, NexoBrid could eliminate the need to surgically remove damaged or dead tissue, a technically-demanding and time-intensive step in burn care, and may decrease the required amount of skin grafting which could speed recovery. This contract has a total value up to $112.8 million (Burns May 2014. 40(3), 466–474).

3. Excisional debridement followed by autografting is the standard of care (SOC) for deep burns, but is associated with serious potential complications. Conservative, non-surgical and current enzymatic debridement methods are inefficiently slow. They studied whether a non-surgical option of rapid enzymatic debridement with the debriding enzyme NexoBrid™ (NXB) would reduce need for surgery while achieving similar esthetic and functional outcomes as SOC.

4. **Results:** NXB significantly reduced the time from injury to complete débridement (2.2 vs. 8.7 days, need for surgery (24.5% vs. 70.0%, the area of burns excised (13.1% vs. 56.7%) and the need for autografting (17.9% vs. 34.1%). Scar quality and quality of life scores were similar in both study groups as were the rates of adverse events.

5. **Conclusions:** Enzymatic débridement with NXB resulted in reduced need for and extent of surgery compared with SOC while achieving comparable long-term results in patients with deep burns.

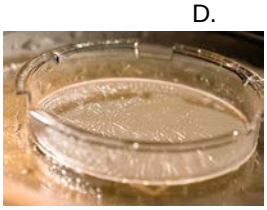


C. **ReCell**

AVITA Medical announced that the FDA has approved the RECELL Autologous Cell Harvesting Device to treat thermal burns in patients aged ≥18 years in Sept. 2018. The RECELL System is intended for use at the point of care by trained healthcare professionals. It can be used alone for treating partial-thickness burns, or in combination with autografting to treat full-thickness burns. A small sample of the patient's own skin is immersed in the Enzyme solution in the RECELL System, which separates the skin cells to produce Spray-On Skin Cells in as little as 30 minutes. The resulting Regenerative Epidermal Suspension (RES) includes keratinocytes, fibroblasts, and melanocytes, which are involved in wound healing. The RES is then sprayed directly on the burn wound, covering the entire wound bed. The RECELL System can prepare enough RES to treat a wound up to 80 times the size of the donor's skin sample.

The FDA approval was supported by 2 randomized controlled trials that showed acute burn wounds treated with the RECELL System required substantially less donor skin than that required with standard-of-care split-thickness autografts, to close burn wounds. In one trial, the patient donor skin required to treat second-degree burn sites with the RECELL System was 97.5% less than the amount harvested using standard-of-care. This led to a statistically significant reduction in patient-reported pain, increased satisfaction, and improved donor scar outcomes. In addition, the burn sites treated with RECELL System achieved definitive closure comparable to burn sites treated with standard-care (Han, 2018).

D. **StrataGraft**



1. Proprietary human skin cell line: When properly cultured, forms a fully stratified multilayered human tissue with physical strength and biological characteristics of intact human skin

2. Stratatech Corporation of Madison, Wisconsin will advance its development of a novel cell-based skin substitute made from living human cells called StrataGraft. If

successful StrataGraft could reduce the need to remove healthy donor-skin from the person's own body to graft over the burned skin, instead offering an off-the-shelf alternative to using animal or cadaver skin for skin grafts. This contract has a total value up to $246.7 million.

XIII. **Prevention is key**

A. Keep matches or lighters out of the reach of children etc.; cigarette lighter childproofing
B. Sleepwear flammability standards
C. Improved building codes; safer construction; use of smoke detectors
D. 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.
E. Scald awareness educations - teach parents not to put children in tubs without checking the water temperature first; reduce the temperature of water heaters,
F. Never leave burning candles unattended.
G. Promote programs that help get drunk drivers off the road.

Celsius (C) Temperature	Fahrenheit (F) Temperature	2nd Degree Burn	3rd Degree Burn
45°	113°	2 hours	
47°	116.6°	20 minutes	
48°	118.4°	15 minutes	
49°*	120°*	8 minutes	20 minutes
51°	124°	2 minutes	5 minutes
55°	131	17 seconds	25 seconds
60°	140°	3 seconds	5 seconds
63°	150°	1 second	2 seconds
68°	156°		1 second

*120°F (49°C) is considered to be the safe maximum water temperature for domestic use.

(IAFF, ABA, 2007)

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Think Plastic Wrap as Wound Dressing for Thermal Burns

ACEP News August 2008; By Patrice Wendling; Elsevier Global Medical News

Ordinary household plastic wrap makes an excellent, biologically safe wound dressing for patients with thermal burns en route to the emergency department or burn unit. The Burn Treatment Center at the University of Iowa Hospitals and Clinics, Iowa City, has advocated prehospital and first-aid use of ordinary plastic wrap or cling film on burn wounds for almost two decades with very positive results, Edwin Clopton, a paramedic and ED technician, explained during a poster session at the annual meeting of the American Burn Association.

"Virtually every ambulance in Iowa has a roll of plastic wrap in the back," Mr. Clopton said in an interview. "We just wanted to get the word out about the success we've had using plastic wrap for burn wounds."

Dr. G. Patrick Kealey, newly appointed ABA president and director of emergency general surgery at the University of Iowa Hospital and Clinics, said in an interview that plastic wrap reduces pain, wound contamination, and fluid losses. Furthermore, it's inexpensive, widely available, nontoxic, and transparent, which allows for wound monitoring without dressing removal.

"I can't recall a single incident of its causing trouble for the patients," Dr. Kealey said. "We started using it as an answer to the problem of how to create a field dressing that met those criteria. I suppose that the use of plastic wrap has spread from here out to the rest of our referral base."

Although protocols vary between different localities, plastic wrap is typically used for partial- and full-thickness thermal burns, but not superficial or chemical burns. It is applied in a single layer directly to the wound surface without ointment or dressing under the plastic and then secured loosely with roller gauze, as needed.

Because plastic wrap is extruded at temperatures in excess of 150° C, it is sterile as manufactured and handled in such a way that there is minimal opportunity for contamination before it is unrolled for use, said Mr. Clopton of the emergency care unit at Mercy Hospital, Iowa City. However, it's best to unwind and discard the outermost layer of plastic from the roll to expose a clean surface.

To assess concerns about sterility, Mr. Clopton and his associates at the U of Iowa obtained samples of plastic wrap from 5 newly opened rolls and 13 rolls that were already in use. Two samples - one taken from the already exposed outer layer and one from a freshly unrolled surface - were taken from each roll, pressed against the surface of a blood agar culture plate, and incubated at a temperature of 35° C.

After 48 hours of incubation, 14 (39%) of the 36 samples showed no bacterial growth and 29 (81%) of the 36 samples grew 3 or fewer colonies. No growth was observed on freshly unrolled surfaces in 4 of the 5 new rolls and in 7 of the 13 rolls already in use, Mr. Clopton reported in the poster.

Contaminating organisms that were identified in the culture plates were typical of the flora normally found on human skin. The organisms included *Bacillus* (which were identified on seven samples), *Enterobacter* (two samples), *Micrococcus* (seven samples), and *Staphylococcus* (four samples).

"Plastic wrap is sufficiently clean for first-aid and prehospital use to dress burn wounds that will promptly receive medical attention, especially if freshly exposed film is used," he wrote.

Concerns have been expressed about the toxicity of certain plasticizers, especially diethylhexyl phthalate (DEHP), used in toys and medical equipment, and formerly in food packaging. DEHP is no longer used in food packaging in the United States.

Moreover, because a patient's exposure to plasticizers from a wound dressing usually is only for a brief period of time, lasting a few hours at most, Mr. Clopton suggested that plasticizer toxicity is of minimal concern.