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Burns and Smoke Inhalation

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Upon completion of this self-study module, you should be able to:

- List the basic function of skin
- Describe the initial evaluation and assessment of the burned patient
- List the different types of burns and their distinguishing characteristics
- Name the potential for comorbid injuries in inhalational injury
- List the basic principles of burn management regarding:
    - Minor burn treatment
    - Fluid resuscitation
    - Infection control
    - Management of inhalational injuries

Each year approximately 500,000 burn patients seek medical care in the US. Burn injury can result from heat (thermal burn), chemicals, cold (frost bite), or electricity (flash or internal). However, the clinical significance of a burn depends more on the depth of the burn, the total body surface area (TBSA) involved, the specific area involved, associated injuries, and the promptness of therapy than on the mechanism. Inhalational injuries may result from heat, carbonaceous particles, or the inhalation of abnormal gases such as smoke, carbon monoxide, or cyanide.

Quickly and accurately evaluating the burned or inhalational injured patient in the emergency room is difficult because the extent of injury is not always obvious, often evolves over time, and may mask other, more immediately life-threatening injuries. Therefore, it is very important for the emergency physician to understand the complex pathophysiology and clinical management of these patients.

For a more detailed discussion of frost bite, hypothermia, and other cold-related injuries, please refer to the hypothermia section.

Basic Pathophysiology

Skin is the body's largest organ system and is composed of three layers: the epidermis, dermis, and hypodermis. The epidermis is the outermost layer, does not contain any neurovascular structures, and constantly regenerates mitosis and keratinization. The dermis is the middle layer and contains hair follicles, sweat and sebaceous glands, and lymph and blood vessels. The hypodermis is the deepest layer, is comprised of adipose and larger neurovascular structures, and acts to anchor the skin to underling muscle, bone, and fascia.

(Insert skin layers diagram picture)

Intact skin has many functions including:

- Protection
- Fluid retention
- Electrolyte homeostasis
- Thermoregulation
- Sensory
- Metabolic (vit D synthesis)

All of these functions are potentially disrupted with burns, regardless of the severity of injury, source of damage, or the mechanism of burn. In general, the extent of the burn injury worsens as temperatures that the skin is exposed to increases. For example, with temperatures between 40-44ºC, enzymes begin to malfunction, proteins denature, & cellular pumps fail. With temperatures above 44ºC, this damage occurs faster than the skin cells can heal and injury develops. This injury typically exhibits three zones:

- Zone of Coagulation. In this area, cell death is complete. This is usually nearest to the energy source and forms the eschar of the burn wound
- Zone of Stasis. In this area, cells are viable but circulation is impaired. If the injury continues, then increased damage and tissue ischemia may result
- Zone of Hyperemia. In this area, there is minimal cellular injury but there is increased blood flow due to vasodilatation. This tissue usually recovers without intervention

Initial Actions

Burns often occur as a result of explosions, building collapse, or motor vehicle accidents. In addition, patients involved in fires will often go to extremes, including jumping out of tall buildings, to get out of harm's way. Therefore, it is important to remember that ALL burn patients should be thought of as trauma patients and the initial assessment and stabilization should be conducted according the principles of Advanced Trauma Life Support (ATLS).

- Primary assessment: airway, breathing, circulation, disability, exposure
- Secondary assessment: detailed head to toe examination, AMPLE history

The burn-specific assessment occurs during the secondary assessment and is focused on the following areas:

Primary Survey

- Airway: Is there carbonaceous sputum? Soot Hair singed? If noted, patient may require prophylactic intubation or laryngoscopy/bronchoscopy.
- Breathing: Are there burns to lung or chest wall? Gas/toxin inhalation? If noted, patient may require a variety of interventions, including an ABG to check pH, a carbon monoxide level, or an escharotomy, a procedure to release tension due to scar formation.
- Circulation: Are there signs of decreased perfusion? Monitor vital signs, I/O?s. All significant burns require IV access. The patient may require central line access for volume resuscitation, HD monitoring, etc.Significant burns may require extensive fluid resuscitation based ont eh Parkland formula (described below)
- Disability/Exposure: Carefully examine all skin areas to determine wound location & depth, remove all jewelry. This may require detailed drawings to document the injuries and to calculate the extent of burned tissue (discussed below in more detail). Decontaminate if burn is from chemical source

History

If possible a burn history should be elicited regarding:

- The circumstances & mechanism of injury
- Type(s) of material burning and length of exposure to them
- Exact time of injury
- Actions taken prior to arrival
- Associated signs and symptoms

Rule of Nines

Second-, Third-, and Fourth-degree burns are classified according to the percentage of the total body surface area (%TBSA) that they involve. This area can be estimated by either the ?palm estimate? or the ?rule of 9?s?. In the first case, the burned patient?s palm (ventral surface of the hand excluding the fingers) is estimated to be equal to 1% of the TBSA and then used to measure the size of the burn. In the latter case, the entire head and each arm are estimated at 9% of the TBSA while each entire leg, the anterior thorax plus abdomen & back is each estimated at 18% of the TBSA. The perineum is estimated at 1% of the TBSA. In children, due to their relatively larger head size, the head is estimated at 18% with the other areas adjusted as seen in the accompanying diagram.

(Insert rule of 9?s picture)

Classic Presentation of Burns

The classic presentation of a burn patient is not related to the source of injury (i.e. heat, chemical, electrical, etc.) but instead depends on the extent and depth of injury. The diagnosis is made based on a careful clinical evaluation, rather than based on any specific laboratory or radiologic studies.

Classification of Burns		
First-degree (1º)	superficial, limited to the epidermis, wound is red, painful, and well demarcated	
Second-degree(2º)	partial thickness, involves the epidermis and part of the dermis. May involve hair & glands. Wounds are painful, blister, & blanch with pressure. Tends to be wet & slippery to touch.	

Third-degree(3°)	Full thickness. Involves all epithelial and dermal elements. Specific wound is painless (but will often be surrounded by painful tissue so patients may report pain). It is depressed, non-edematous, and leathery. May be white, brown, or black	
Fourth-degree(4°)	Deep tissue. Extends through all layers of skin and involves underlying tissue. Wound is painless but injury is extensive and often requires amputation	
Electrical burns	Electrical energy is converted to heat which causes thermal injury and burns. However, unlike conventional thermal burns, the electricity may flow in unpredictable pattern and significant injury may not be evident at site of entry. Therefore, a detailed skin exam, including evaluation of the palms and soles is essential. Cardiac arrhythmias are common in electrical burns if the flow of electricity crosses through the thorax and across the heart. Extent of injury is determined by voltage type, voltage strength, the resistance of tissue, and the duration of contact.	

Classic Presentation of Inhalational Injury

The evaluation of inhalational injury is difficult since patients will often have few external signs of injury. Therefore, in addition to the detailed history and physical exam described above, a chest x-ray, detailed oropharyngeal exam, nasopharyngeal laryngoscopy, or bronchoscopy should also be considered in order to fully assess the extent of inhalational injury. Complete vital signs including continuous pulse oximetry are essential. Laboratory tests such as an ABG, carboxyhemoglobin level, or methemoglobin level may also be useful at detecting poisonings or metabolic disturbances. More specifically, inhalational injuries may be grouped as temperature-related, smoke-related, or gas-related.

Temperature-related injuries

Heat tends to affect the upper airway more than the lower airways. There are two likely explanations for this: Vocal cord spasm protects the lower airway from the heat or the air is cooled and moisturized as it enters through the nose and mouth.

Patients will develop edema, erythema, and ulcerations of lips, tongue, posterior oropharynx, and upper airway. Onset may be delayed for up to 24hrs & resolve in 4-5 days. May require early intubation before edema develops and tracheostomy if edema continues.

(Insert orofacial and airway edema picture)

Smoke-related injuries

Smoke tends to affect the lower airways more than the upper airways. There are several explanations for this including: Injury occurs when particles & soot settle in the medium and distal airways, direct thermal injury occurs when hot particles contact alveolar membranes ands maller airways are at increased risk of occlusion due to debris accumulation.

Smoke-related damage leads to reduced mucociliary function. Patients may develop pneumonia in part due to impaired clearance.

Gas-related injuries

Oxygen is consumed during combustion. Fires create hypoxic environments and patients may be hypoxic on scene as well as on arrival in the ED. Carbon dioxide (CO2) & carbon monoxide (CO) are produced by combustion. Symptoms of CO are related to the amount of carboxyhemoglobin present in the blood as well as age and health of patient and can range from a slight headache or confusion to chest pain, stroke, or seizure, coma, & death.

Burning of home furnishings and other synthetic materials release various toxins into the environment such as plastics releasing cyanide.

Water soluble chemicals (ammonia, chlorine, etc.) can lead to bronchospams, edema. Lipid soluble chemicals (phosgene, nitrous oxide, etc) ? direct cell damage, impaired ciliary clearance.

Treatment

Minor Burns

The management of the patient with minor burns (either by extent of TBSA involved or by depth of burn) can be treated with basic local wound care and is focused on the following principles.

First, stop the burning process by removing clothes or other materials and running warm water over the area until the skin temperature has normalized. Next, initiate pain control with NSAIDS (anti-inflammatory properties) narcotics (better pain control), etc. Follow this with washing the burned area thoroughly with soap & water before careful drying of area.

Finally, apply topical ointment and sterile dressing. There are numerous options for this. Generally, Bacitracin is used for burns on the face. A combination of Bacitracin and Xeroform dressings are used for many areas of the body. Silvadene (SSD) or newer silver based products may also be used is used for burns that can be easily and thoroughly washed off before reapplication.

(Insert ssd picture)

A newer compliment to burn management is the use of commercially available ?new skin? like burn dressings that are applied to the cleaned burn and remain in place as the burn heals. Each specific brand has its own indications and contraindications. As the burn heals, dressings should be changed at a minimum of once daily by the patient with the same procedure as above with careful monitoring for cellulitis and wound healing.

Arranging for follow up by returning to the ED for a wound check, with primary care doctors, or at a regional burn center.

There is debate in the literature about whether to debride intact bullae. In general, intact bullae (blisters) are considered to be sterile dressings and may be left intact unless they are quite large, painful, or in areas that interfere with functioning. However, the physician may debride the bullae and then dress the wound under sterile technique as this also provides a sterile barrier and some evidence suggests that the material within the bullae is cytotoxic.

Tetanus prophylaxis may also need to be administered.

Do not treat with oral antibiotics on initial presentation.

Treatment of Significant Burns

The management of the patient with significant burns is focused on accounting for the impaired functioning of the damaged skin; especially regarding the role of the skin in fluid retention and as a barrier to infection.

Large, deep burns can lead to the loss of massive amounts of fluids and electrolyte imbalances for several reasons including: increased microvascular permeability that leads to extracellular edema and cell membrane defects that contribute to intracellular swelling. Additionally, burn patients have increased metabolic and respiratory rates that lead to increased evaporation and other insensible losses and often become hypoproteinemic leading to decreased intravascular oncotic pressures. Therefore, adequate fluid resuscitation is of paramount importance. The resuscitative fluid of choice is Lactated Ringer?s (LR) solution, given according to the Parkland formula.

Parkland formula: %TBSA burn x wt in kg x 4cc/kg = volume of LR that should be administered over the first 24 hours

Half should be given in the 8 hours following the burn and the remaining half should be given over next 16 hrs (24hrs total). Remember, this is extra fluid in addition to the patient's baseline fluid requirements.

Case One

You see a patient who sustained second degree burns two hours prior to coming to your ER. He weighs 70 kg and has 20% TBSA burns.

(70 kg) x (20%) x (4 cc/kg) = 5,600 L

Remembering that he gets half of this in the first 8 hours and half in the next 16 hours, you calculate he'll need two boluses, each being 5,600 L / 2 = 2,800 L.

Since two hours of the first 8 hours has already passed from the initially injury, he will need to get that first bolus over the next six hours.

2,800 L / 6 hrs = 467 cc/hr (additional fluid given over the next 6 hours)

The remaining 2,800 L would have to be administered over the next 16 hours.

2,800 L / 16 hrs = 175 cc/hr (additional fluid given over the next 16 hrs)

This is in addition to his maintenance fluids, which for a 70 kg man would be 104 cc/kg. So his final fluid orders would be:

467 cc/hr (bolus) + 104 cc/hr (maintenance) = 571 cc/hr (for the first 6 hrs)

175 cc/hr (bolus) + 104 cc/hr (maintenance) = 279 cc/hr (for the following 16 hrs)

Remember, these calculations are just a general guide. You must also monitor urine output to ensure adequate fluid resuscitation and adjust fluids as necessary to achieve a target urine output.

- Adult urine output: 0.5cc/kg/hour
- Pediatric urine output: 1-2cc/kg/hour

Infection Control: Sepsis is the leading cause of death in patients with large burns, accounting for up to 75% of deaths. Although the specific pathogens vary from patient-to-patient and between burn centers, patients with large burns have increased susceptibility to infection for several reasons: the normal skin barrier is lost and they are in a hypermetabolic & catabolic state. Patients develop depleted energy stores and various metabolic deficiencies. The local release of cytokines, breakdown of normal tissues, and circulating cellular components contribute to a global immune system impairment. Burned tissue creates a favorable bacterial environment. Eschar has increased moisture, acidic pH, and little blood flow.

More specifically, the prevention and control of infection in the burned patient takes three main forms:

- Debridement of devitalized tissue: cut away dead, necrotic tissue and exposure underlying viable tissue,
- Wound management: Limit bacterial invasion by covering affected areas with antibiotic dressings and through early wound closure with skin grafting and/or commercial products.
- Preventing the delayed development of pneumonia and sepsis: universal precautions and general infection control practices are of paramount importance. Contact isolation with gown, gloves, and mask. Frequent changing of central lines, etc.Aggressively evaluate fevers by pan-culturing and initiating broad-spectrum antibiotics.

Disposition

Patients with superficial or localized burns are generally discharged with close outpatient follow-up. Patients with cosmetically or functionally significant burns, such as to the face, hands, feet, or perineum, may be admitted or transferred to a regional burn center for evaluation

Adult patients with >20% TBSA burns are generally transferred to a regional burn center for evaluation. Pediatric patients with >10% TBSA burns are generally transferred to a regional pediatric burn center for evaluation.

Pearls and Pitfalls

- Don’t be distracted by the sight and smell of the burns. Burn patients are trauma patients and often have concomitant injuries that must be addressed.
- Inhalation injuries are common but difficult to assess initially. Don’t forget to carefully assess burn patients for potential delayed airway compromise
- Don’t worry about going through burned skin for IV access, chest tubes, and other essential procedures
- Do not place moist towels or gauze of burned areas as this will contribute to hypothermia. Just cover burns with Xeroform or SSD dressings and gauze

References

- American Burn Association. Multiple educational resources and a listing of US burn centers is available on line at http://www.ameriburn.org (http://www.ameriburn.org/).
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