



American Burn Association



Advanced Burn Life Support Course

Provider Manual

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Introduction

I. PROGRAM OBJECTIVES

The quality of care during the first hours after a burn injury has a major impact on long-term outcome. Yet most initial burn care is provided outside of the burn center environment. The Advanced Burn Life Support (ABLS) Provider Course is an eight-hour course designed to provide physicians, nurses, nurse practitioners, physician assistants, and paramedics with the ability to assess and stabilize patients with serious burns during the first critical hours following injury and to identify those patients requiring transfer to a burn center. The course is not designed to teach comprehensive burn care, but rather to focus on the first 24 post-injury hours.

Upon completion of the course, participants will be able to provide primary treatment of the burn area, associated injuries, and common complications within the first 24 hours post burn. Specifically, participants will be able to demonstrate an ability to do the following:

- Evaluate a patient with a serious burn
- Define the magnitude and severity of the injury
- Identify and establish priorities of treatment.
- Manage the airway and support ventilation
- Initiate and monitor fluid resuscitation
- Apply correct methods of physiological monitoring
- Determine which patients should be transferred to a burn center
- Organize and conduct the inter-hospital transfer of a seriously injured burn patient

The American Burn Association is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians. The ABA designates this continuing medical education activity for up to 8

credit hours in Category 1 of the Physician's Recognition Award of the American Medical Association. Each physician should claim only those hours of credit he/she actually spent in the educational activity.

This program also has been approved by an AACN Certification Corporation–approved provider 0009100 under established AACN Certification Corporation guidelines for 10 contact hours, CERP Category A.

II. COURSE CONTENT

Burn care is multidisciplinary. Therefore, the ABLS Course is designed in a multidisciplinary format and is based on the guidelines for initial burn care developed by the American Burn Association. The ABLS Provider Course presents a series of didactic presentations on initial assessment and management, airway management, smoke inhalation injury, shock and fluid resuscitation, wound management, electrical injury, chemical injury, the pediatric patient, and transfer and transport principles. Participants then apply these concepts during case study discussions. Participants are also given the opportunity to work with a simulated burn patient, both to reinforce the assessment and stabilization principles and as a means of applying the American Burn Association criteria for transfer of patients to burn centers. Final testing consists of a written exam and a practical assessment.

III. CONCLUSION

The management of a seriously burned patient in the first few hours can significantly affect the long-term outcome. Therefore, it is important that the patient be managed properly in the early hours after injury. The complexity, intensity, multidisciplinary character and expense of the care required by an extensively burned patient have led to the development of burn centers. The regionalization of burn care at such centers has optimized the long-term outcomes of extensively burned patients. Because of regionalization, it is extremely common for the initial care of the seriously burned patient to occur outside the burn center, while transport needs are determined and transportation is effected. The goal of the ABLS Course is to transmit the information that will enable those who only rarely treat burn patients to provide the care needed by a burn patient in the first 24 hours after injury.

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1 Initial Assessment & Management

OBJECTIVES

Upon completion of this topic the participants will be able to:

- Identify components of a primary and secondary survey
- Apply the “Rule of Nines” to make an initial estimate of burn extent
- Distinguish between partial-thickness and full-thickness burns
- State the ABA Referral Criteria

I. PRIMARY SURVEY

The initial assessment of the burn patient is like that of any trauma patient. Immediate priorities are those outlined by the American College of Surgeons Committee on Trauma and promulgated in the Advanced Trauma Life Support Course.

- **Airway** maintenance with cervical spine protection
- **Breathing** and ventilation
- **Circulation** with hemorrhage control
- **Disability** (assess neurologic deficit)
- **Exposure** (completely undress the patient, but maintain temperature)

B. Airway

The airway must be assessed immediately. The compromised airway may be controlled by simple measures, including:

- Chin lift
- Jaw thrust
- Insertion of an oral pharyngeal airway in the unconscious patient
- Assessment of the need for endotracheal intubation

It is important to protect the cervical spine before doing anything that will flex or extend the neck. In-line cervical immobilization is performed during initial assessment, in general, and during endotracheal intubation, in particular, for those patients in whom cervical spine injury is suspected by the mechanism of injury or for those with altered mental status.

B. Breathing and Ventilation

Ventilation requires adequate functioning of the lungs, chest wall, and diaphragm. Each of these must be evaluated as part of the primary survey:

- Listen to the chest and verify breath sounds in each lung.
- Assess adequacy of rate and depth of respiration.
- High flow oxygen is started on each patient at 15 L (100%), using a non-rebreathing mask.
- Circumferential full-thickness burns of the trunk may impair ventilation and must be closely monitored.

D. Circulation

Assessment of the adequacy of circulation includes evaluation of blood pressure, pulse rate, and skin color (of unburned skin). Intravenous cannulation is performed by inserting two large bore catheters (in unburned skin, if possible) to begin fluid administration. Doppler examination can be used to determine whether there is a

circulation deficit in a circumferentially burned extremity. Physical indicators of a circulation deficit include: decreased sensation, diminished distal pulses, and slowed capillary refilling. The circulation in a limb with full-thickness burns may be impaired as a result of subeschar edema formation.

D. Disability, Neurologic Deficit

Typically, the burn patient is initially alert and oriented. If not, consider associated injury, carbon monoxide poisoning, substance abuse, hypoxia, or pre-existing medical conditions. Begin the assessment by determining the patient's level of consciousness using the AVPU method:

- A – Alert
- V – Responds to verbal stimuli
- P – Responds only to painful stimuli
- U – Unresponsive

F. Exposure/Environmental Control

Remove all clothing and jewelry to complete the primary and secondary assessment. Maintaining the patient's temperature is a priority. The room should be warmed and, after the assessment is completed, the patient should be covered with dry sheets and blankets to prevent hypothermia. Warmed intravenous fluid (37-40° C) may also be used for resuscitation.

II. SECONDARY SURVEY

The Secondary Survey does not begin until the primary survey is completed and after resuscitative efforts are well established. A secondary survey entails a complete head-to-toe evaluation of the patient. The burn is often the most obvious injury, but other serious and even life-threatening injuries may be present. A thorough history and physical examination are necessary to ensure that all injuries and preexisting diseases are identified and appropriately managed. A complete neurologic examination is performed, and indicated radiologic and laboratory studies are obtained.

A. History

Every attempt should be made to obtain as much information as possible regarding the incident. Initial management as well as definitive care is dictated by the mechanism, duration, and severity of the injury. The following information must be obtained:

1. Circumstances of Injury

a. Flame

- How did the burn occur?

- Did the burn occur inside or outside?
- Did the clothes catch on fire?
- How long did it take to extinguish the flames?
- How were the flames extinguished?
- Was gasoline or another fuel involved?
- Was there an explosion?
- Did the patient get thrown?
- Was there a house fire?
- Was the patient found inside a smoke-filled room?
- How did the patient escape?
- If the patient jumped out of a window, from what floor?
- Were others killed at the scene?
- Was the patient unconscious at the scene?
- Was there a motor vehicle accident?
- How badly was the car damaged?
- Was there a car fire?
- Are there other injuries?
- Are the purported circumstances of the injury consistent with the burn characteristics (i.e., is abuse a possibility)?

c. Scald

- How did the burn occur?
- What was the temperature of the liquid?
- What was the liquid?
- How much liquid was involved?
- What was the water heater set at?
- Was the patient wearing clothes?
- How quickly were the patient's clothes removed?
- Was the burned area cooled?
- Who was with the patient when the burn took place?
- How quickly was care sought?
- Where did the burn occur (e.g., bathtub, sink) ?
- Are the purported circumstances of the injury consistent with the burn characteristics (i.e., is abuse a possibility)?

c. Chemical

- What was the agent?
- How did the exposure occur?
- What was the duration of contact?
- What decontamination occurred?
- Is there an MSDS?
- Was there an explosion?

d. Electrical

- What kind of electricity was involved?
- What was the duration of contact?
- Was the patient thrown or did he or she fall?
- What was the estimated voltage?
- Was there loss of consciousness?
- Was CPR administered at the scene?

2. Medical History**a. Factors to Consider**

- Pre-existing disease or associated illnesses (e.g., diabetes, hypertension, cardiac or renal disease, seizure disorder)
- Medications/alcohol/drugs
- Allergies
- Tetanus immunization history

b. Mnemonic

An easy aid in obtaining the above-needed information is by using the mnemonic, "AMPLE":

A - allergies

M - medications

P - previous illness, past medical history, pregnancy

L - last meal or drink

E - events/environment related to the injury

B. Complete Physical Examination**1. "Head to Toe" Examination**

- Head

- Maxillofacial
- Cervical spine and neck
- Chest
- Abdomen
- Perineum, genitalia
- Back and buttocks
- Musculoskeletal
- Vascular
- Neurologic

2. Determining the Severity of a Burn

The severity of a burn injury is determined primarily by the extent of the body surface area involved and, to a lesser extent, by the depth of the burn. However, other factors (such as age, the presence of concurrent medical or surgical problems, and complications that accompany burns of certain areas such as the face, hands, and genitalia) must be considered.

a. Extent of Burn

The most commonly used guide for making an initial estimate of burn extent in second and third degree burns is the “Rule of Nines,” which is based on the fact that in the adult various anatomic regions represent approximately 9%—or a multiple thereof—of the total body surface area (TBSA). In the infant or child, the “Rule” deviates because of the large surface area of the child’s head and the smaller surface area of the lower extremities. (Burn diagrams take these factors into account.)

b. Estimating Scattered Burns of Limited Extent

The size of the patient’s hand—including the fingers—represents approximately one percent of his/her total body surface area. Therefore, using the patient’s hand-size as a guideline, the extent of irregularly scattered burns can be estimated.

c. Depth of a Burn

The depth of tissue damage due to a burn is largely dependent on four factors:

- Temperature
- Duration of contact
- Thickness of the dermis
- Blood supply

Special consideration must be given to very young and elderly patients due to their thin skin. Burns in these age groups may be deeper and more severe than they initially appear.

C. Management Principles/Adjuncts to the Secondary Survey

Depending upon the type and extent of the burn and the length of transport, the following stabilization procedures may be implemented in the pre-hospital setting or in the receiving hospital's emergency department.

1. Stop the Burning Process

Remove clothing from the involved areas; flush all areas in contact with a chemi-cal; remove from the electric contact in the case of electrical injury.

2. Universal Precautions

Burn care personnel are at risk for pathogenic organism (e.g., HIV, Hepatitis B, Hepatitis C) transmission while caring for the burn patient. Therefore, universal precautions appropriate for each burn patient must be implemented by each member of the health care team.

3. Fluid Resuscitation

The consensus fluid formula for the first 24 hours post burn for adult burn patients is: **2-4 ml Ringer's Lactate x Body weight in kg x % BSA burn**. In the first eight hours post injury, half of the calculated amount is given. In the second eight hours, 25% is given. And in the third eight hours, the remaining 25% of the fluid is given. (This is discussed in more detail in Chapter 3, Shock and Fluid Resuscitation.) The IV rate should be adjusted as needed to maintain adequate urine output.

4. Vital Signs

Vital signs should be monitored at frequent intervals.

5. Insertion of Nasogastric Tube

Patients with burns of more than 20 % TBSA are prone to gastric dilatation due to ileus.

6. Insertion of Urinary Catheter

Insertion of a urinary catheter is important because urine output is the best guide for ensuring the appropriateness of fluid resuscitation.

7. Assessment of Extremity Perfusion

In constricting circumferential extremity burns, edema developing in the tissue under the eschar may gradually impair venous return. If this progresses to the point where capillary and arterial flow is markedly reduced, ischemia and ne-crosis may result. Early signs and symptoms include numbness and pain in the

extremity. When compartment pressure in an extremity is elevated, an escharotomy is indicated to restore adequate circulation. (Escharotomy procedures are discussed in Chapter 4, Burn Wound Management.)

8. Continued Ventilatory Assessment

Circumferential chest and/or abdominal burns may restrict ventilatory excursion and chest/abdominal escharotomy may be necessary in adults and children. A child has a more pliable rib cage (making it more difficult to work against constriction resulting from a circumferential chest burn) and may need an escharotomy earlier than an adult burn victim.

9. Pain Management

Morphine is indicated for control of the pain associated with burns. Changes in fluid volume and tissue blood flow make absorption of any drug given intramuscularly or subcutaneously unpredictable. The intramuscular or subcutaneous routes should not be used, and narcotics should only be given intravenously and in doses no larger than those needed to control pain.

10. Psychosocial Assessment

Health care providers must be sensitive to the variable emotions experienced by burn patients and their families. Feelings of guilt, fear, anger, and depression must be recognized and addressed. In cases where intentional burning is suspected, either from self-immolation or abuse, efforts should be instituted to protect the patient from further harm. Psychiatric consultation should be obtained.

III. INITIAL CARE OF THE BURN WOUND

A. Thermal Burns

Cover the burn area with a clean, dry sheet. Covering all burn wounds prevents air currents from causing pain in partial thickness burns. Ice or wet dressings should never be applied directly to the burn, due to the possibility of frostbite. Cold applications should not be used, except in the most minor of burns.

B. Electrical Injuries

As electric current passes through an individual, it may cause cutaneous burns as well as extensive internal damage. A major concern is the effect the electrical current has on normal cardiac electrical activity. Serious dysrhythmias may occur even after a stable cardiac rhythm has been obtained. Therefore, continuous cardiac monitoring may be necessary during the first 24 hours post injury. Note that even if the visible surface injury does not appear serious, there may be occult severe, deep tissue injury. (A discussion of the management of these patients appears in Chapter 5, Electrical Injuries).

C. Chemical Burns

Any chemical agent should immediately be flushed from the body surface with copious amounts of water. Powdered chemicals should be brushed from the skin prior to flushing the body surface area. All contaminated clothing should be re-moved. Chemical eye injuries require continuous irrigation until instructed other-wise by a burn physician or ophthalmologist. (A discussion of the management of these patients is discussed further in Chapter 6, Chemical Injuries.) Emergency team members must also be appropriately protected from chemical exposure.

IV. INITIAL LABORATORY STUDIES

Burn injuries can cause dysfunction of any organ system. For this reason, baseline laboratory tests, such as the following, are often performed. Such tests can be helpful in evaluating the patient's subsequent progress:

- Hematocrit
- Electrolytes (e.g., Na^+ , K^+ , Cl^-)
- Blood urea nitrogen
- Urinalysis
- Chest roentgenogram

Where special circumstances exist, additional specialized tests, such as the follow-ing, may be appropriate:

- Arterial blood gases (if inhalation injury is suspected)
- Carboxyhemoglobin
- ECG —With all electrical burns or pre-existing cardiac problems
- Glucose (in children) and diabetics

W. BURN CENTER REFERRAL

A. Burn Center Characteristics

A burn center is a service capability based in a hospital that has made the institu-tional commitment to care for burn patients. The burn center is staffed by a team of professionals with expertise in the care of burn patients, which includes both acute care and rehabilitation. The burn team provides educational programs regarding burn care to all health care providers and involves itself in research related to burn injury. A burn unit is a specified area within a hospital, which has a specialized nursing unit dedicated to burn patient care.

B. Referral Criteria

The American Burn Association has identified the following injuries as those usually requiring a referral to a burn center. Patients with these burns should be treated in a specialized burn facility after initial assessment and treatment at an emergency department.

Burn injuries that should be referred to a burn unit include the following:

1. Partial thickness burns greater than 10% total body surface area (TBSA).
2. Burns that involve the face, hands, feet, genitalia, perineum, or major joints.
3. Third degree burns in any age group.
4. Electrical burns, including lightning injury.
5. Chemical burns.
6. Inhalation injury.
7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality.
8. Any patients with burns and concomitant trauma (such as 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.
9. Burned children in hospitals without qualified personnel or equipment for the care of children.
10. Burn injury in patients who will require special social, emotional or long-term rehabilitative intervention.

Questions about specific patients can be resolved by consultation with the burn center.

VI. SUMMARY

A burn of any magnitude can be a serious injury. Health care providers must be able to assess the injuries rapidly and develop a priority-based plan of care. The plan of care is determined by the type, extent, and degree of burn, as well as by available resources. Every health care provider must know how and when to contact the closest specialized burn care facility/burn center. Consultation with the physician at the burn center will determine the best method of therapy. If the attending physician determines that the patient should be treated at the burn center, the extent of

treatment provided at the referring hospital—and the method of transport to the burn center—should be decided in consultation with the burn center physician.

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2

Airway Management and Smoke Inhalation Injury

OBJECTIVES

Upon completion of this topic, the participant will be able to:

- Discuss the pathophysiology of inhalation injury
- List three types of inhalation injury
- Describe indications for early airway intervention
- Discuss principles of management
- List special considerations for children with inhalation injuries

I. INTRODUCTION

Inhalation injury is manifested by the pathology and dysfunction that become evident in the airways, lungs and respiratory system within the first five days after inhaling smoke and the irritating products of incomplete combustion. Inhalation injury is an important determinant of mortality in fire victims. Inhalation injuries are present in 20-50 percent of the patients admitted to burn centers and 60-70 percent of the patients who die in burn centers. Patients receiving massive fluid resuscitation can develop upper airway edema, with subsequent asphyxiation. Prophylactic intubation to protect the airway is required.

There are three distinguishable types of airway inhalation injury:

- carbon monoxide poisoning
- inhalation injury above the glottis
- inhalation injury below the glottis

JJ. PATHOPHYSIOLOGY

A. Carbon Monoxide Poisoning

Most fatalities occurring at a fire scene are due to asphyxiation and/or carbon monoxide poisoning. Carboxyhemoglobin levels of 50-70 percent or more are often found in such patients. Among survivors with severe inhalation injury, carbon monoxide poisoning can be the most immediate threat to life. Carbon monoxide binds to hemoglobin with an affinity 200 times greater than oxygen, and if sufficient hemoglobin is bound to carbon monoxide, tissue hypoxia will occur.

The most immediate threat is to hypoxia-sensitive organs, such as the brain. Levels of 40-60 percent carboxyhemoglobin cause obtundation and loss of consciousness. Levels of 15-40 percent cause central nervous system (CNS) dysfunction of varying degrees. Carboxyhemoglobin levels of 5 to 10 percent are often found in smokers and in people exposed to heavy traffic. In this situation, carboxyhemoglobin levels are rarely symptomatic.

A finding typically associated with high carboxyhemoglobin levels is a cherry red coloration of the skin. However, this finding may be present in only 50% of patients with severe carbon monoxide hypoxemia. In fact, patients with severe carbon monoxide poisoning may have no other significant findings on initial physical and laboratory exam. Cyanosis and tachypnea are not likely to be present because CO₂ removal is not affected. Although the O₂ content of blood is reduced, the amount of oxygen dissolved in the plasma (PaO₂) is unaffected by carbon monoxide poisoning, making the blood gas analysis normal except for carboxyhemoglobin. Oxygen saturation is also usually normal because an oximeter detects hemoglobin saturated by oxygen and *does not measure* carbon monoxide. Due to the variability of symptoms,

it is essential to determine the carboxyhemoglobin level in patients exposed to carbon monoxide.

B. Inhalation Injury Above the Glottis

Except for rare events (such as steam inhalation, aspiration of scalding liquid, or explosions occurring while a patient is breathing very high concentrations of oxygen or flammable gases under pressure), thermal burns to the respiratory tract are limited to the upper airway above the glottis (nasopharynx, oropharynx, and larynx). The respiratory tract's heat exchange capability is so efficient that most absorption and damage occurs above the true vocal cords. Heat damage of the pharynx is often severe enough to produce upper airway obstruction, and may cause obstruction at any time during resuscitation. In unresuscitated patients, supraglottic edema may be delayed in onset until fluid resuscitation is well underway. In these situations, early airway intervention with intubation may be preferable to waiting because of the loss of landmarks with edema. Generalized edema related to the size of burns can occur without thermal injury.

C. Inhalation Injury Below the Glottis

In general, inhalation injury above the glottis can be thermal or chemical, while that below the glottis is almost always chemical. Smoke contains noxious chemicals such as aldehydes, sulfur oxides, and phosgenes, which cause direct damage to the epithelium of the large airways. With prolonged exposure to such smoke, particularly in patients who are unconscious, the smaller airways and terminal bronchi are usually affected.

Pathophysiologic changes associated with injury below the glottis include:

- impaired ciliary activity
- erythema
- hypersecretion
- edema
- ulceration of the airway mucosa
- increased blood flow
- spasm of bronchi and bronchioles
- impaired immune defenses

Tracheobronchitis with severe spasm and wheezing may occur in the first minutes to hours post injury. Although there are exceptions, the higher the dose of smoke absorbed the more likely it is that the patient will have an elevated carboxyhemoglobin level and respiratory distress in the early post-burn hours. However, it must be noted that the severity of inhalation injury and the extent of damage are clinically unpredictable based on the history and initial examination. Also, chest x-rays are often normal upon admission of patients with inhalation injuries. While inhalation injury below the glottis without significant associated cutaneous burns has a relatively good prognosis, the presence of such burns in addition to inhalation injury

markedly worsens prognosis, especially if the burn is large and the onset of respiratory distress occurs in the first few hours post injury. The onset of symptoms is so unpredictable that the patient with possible inhalation injury must be observed closely for at least 24 hours. Mucosal sloughing may occur as late as 4-5 days following an inhalation injury.

Experimental evidence exists that inadequate volumes of fluid resuscitation may be as damaging—and perhaps even more damaging—to pulmonary function than excessive fluid resuscitation post burn. Therefore, careful monitoring and appropriate resuscitation are desirable in this condition. Neither the presence nor the absence of colloid in resuscitation fluids has been correlated with better outcome after inhalation injury.

III. INITIAL MANAGEMENT

A. Oxygen Therapy and Initial Management of the Airway

Any patient with suspected carbon monoxide poisoning and/or inhalation injury should immediately receive humidified 100% oxygen by mask until carboxyhemoglobin approaches normal levels.

Stridor or noisy breath sounds are indicators of impending upper airway obstruction and mandate emergency endotracheal intubation. Intubation should be accomplished by whatever route is most appropriate under the circumstances: transnasally if possible; transorally if necessary. In the face of potential cervical spine injury, the stability of the spine should be determined by appropriate radio-logical imaging prior to airway intubation.

After ascertaining that the endotracheal tube is in the proper position by auscultation and roentgenogram, safety requires that the tube be secured in place. An endotracheal tube that becomes dislodged may be impossible to replace due to obstruction of the upper airway by edema. Adhesive tape adheres poorly to the burned face; therefore, secure the tube with an umbilical tape passed around the head.

Intubation is indicated if airway obstruction is imminent, as signaled by progressive hoarseness and/or stridor, or if the level of consciousness is such that airway protective reflexes are impaired. Intubation should be performed by an experienced individual, because in this setting intubation can be rendered difficult by swelling of the face and hypopharynx. Rarely, emergency cricothyroidotomy is required.

B. Factors to Consider When Deciding Whether to Intubate a Burn Patient

In deciding whether to intubate a burn patient, the following factors should be considered:

- Size of the burn (>40-50%)

- Extensive face burns
- Burns inside mouth
- Significant edema or risk for edema
- Signs of airway obstruction
- Difficulty swallowing
- Hoarseness
- Stridor
- Significant changes in the voice
- Use of accessory respiratory muscles
- Panicked appearance
- Significant inhalation injury
- Need for pulmonary toilet
- Inability to protect airway
- Inability to handle secretions
- Signs of respiratory fatigue
- Poor oxygenation or ventilation
- Need for large doses of narcotics

IV. ASSESSMENT AND MANAGEMENT

A. General Assessment Findings

After adequate airway, ventilation, and oxygenation are assured, assessment may proceed with less urgency.

1. History of Event

Historical facts most important in evaluation are:

- Is there a history of unconsciousness?
- Were noxious chemicals involved?
- Did injury occur in a closed space? (A high percentage of people with documented inhalation injury were injured in a closed area, and people in such conditions have a more prolonged exposure to smoke.)

3. Physical Findings

Physical findings suggesting respiratory tract injury include the following:

- Carbonaceous sputum

- Facial burns, singed nasal hairs
- Agitation, anxiety, stupor, cyanosis, or other general signs of hypoxemia
- Rapid respiratory rate, flaring nostrils, or intercostal retractions, especially of the lower rib cage
- Hoarse voice, brassy cough, grunting, or guttural respiratory sounds
- Rales, rhonchi or distant breath sounds
- Erythema or swelling of the oropharynx or nasopharynx
- Inability to swallow

C. Treatment for Each Type of Inhalation Injury

1. Carbon Monoxide Poisoning

The half-life of carbon monoxide in the blood is about 4 hours for patients breathing room air and is decreased to about one hour on 100% oxygen. For this reason, patients with high carboxyhemoglobin levels should receive 100% oxygen until levels of less than 15 percent are achieved. Hyperbaric oxygen for these patients is of unproven value. Transfer to a burn center should not be delayed by efforts to institute hyperbaric oxygen therapy.

2. Inhalation Injury Above the Glottis

Upper airway obstruction can progress very rapidly when it occurs. Patients with pharyngeal edema or burns, hoarseness, or stridor have a high likelihood of developing upper airway obstruction and should be intubated prior to transfer to the burn center. Blood gas monitoring is not useful in this context. Reliance should be placed on physical findings of potential airway injury and extent of the cutaneous burn.

3. Inhalation Injury Below the Glottis

Patients with inhalation injury present chiefly with symptoms of bronchial and bronchiolar injury—bronchorrhea and/or expiratory wheezing. Prior to transfer, intubation is indicated to clear secretions, relieve dyspnea, and/or ensure adequate oxygenation and ventilation.

On other occasions, inhalation injury occurs chiefly at the level of respiratory gas exchange. This form of injury is often delayed in onset, with its earliest manifestation being impaired arterial oxygenation rather than an abnormal chest roentgenogram. Careful monitoring is essential to identify the need for mechanical ventilation if the patient's condition deteriorates.

Circumferential burns of the chest or abdomen may necessitate escharotomies to improve ventilation. (This procedure is described in Chapter 4, Burn Wound Management.) Steroids should not be used as a prophylaxis in patients with inhalation injury.

4. Inhalation Injury in Pediatric Patients

Because children's airways are relatively small, upper airway obstruction may occur more rapidly. If intubation is required, great care should be taken to utilize a tube of proper size, which is properly positioned. Small uncuffed tubes are particularly easy to displace and must be well secured.

A child's rib cage is not ossified and is more pliable than an adult's. Therefore, retraction of the sternum with respiratory effort can be used as an indication for intubation. In addition, children become rapidly exhausted due to the decrease in compliance associated with constrictive circumferential chest/abdominal burns. An escharotomy should be performed promptly with the first evidence of ventilatory impairment.

V. SUMMARY

There are three distinguishable types of inhalation injury:

- Carbon monoxide poisoning
- Inhalation injury above the glottis
- Inhalation injury below the glottis

The onset of symptoms associated with all types of inhalation injury is so unpredictable that the patient must be observed closely for complications. Any patient with the possibility of inhalation injury should immediately receive 100 percent humidified oxygen by mask. Burn patients with inhalation injuries will require burn center care. The burn center should be contacted early to assist in coordinating a plan of care prior to transfer.

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3 Shock & Fluid Resuscitation

OBJECTIVES

Upon completion of this topic, the participant will be able to:

- Discuss post-burn hemodynamic changes
- Identify post-burn fluid requirements
- Describe physiologic monitoring of resuscitation
- List common complications of burn injury and resuscitation therapy
- Identify patients requiring special fluid management

I. INTRODUCTION

Proper fluid management is critical to the survival of patients with extensive burns. Fluid resuscitation for any burn patient must be aimed at maintaining tissue perfusion and organ function while avoiding the complications of inadequate or excessive fluid therapy. An understanding of the local and systemic effects of burn injury facilitates patient management in the early post-burn period. Burn shock is readily preventable by physiologically-based early management of patients with major burn injury.

II. SYSTEMIC EFFECTS OF BURN INJURY

A marked increase in peripheral vascular resistance accompanied by a decrease in cardiac output is one of the earliest manifestations of the systemic effects of thermal injury. These initial changes appear to be unrelated to hypovolemia and have been attributed to neurogenic and humoral effects. Blood pressure changes reflect the effects of edema formation in the area of burn injury, decreased blood volume, and falling cardiac output, resulting in compensatory vascular responses. The magnitude and duration of the systemic response are proportional to the extent of body surface injured.

The aggregate effect of these pathophysiologic changes is a diminution and redistribution of tissue blood flow. Infusion of adequate amounts of resuscitation fluid restores cardiac output and blood flow to unburned tissues.

III. RESUSCITATION

A. Goal of Resuscitation

The goal of resuscitation is to maintain tissue perfusion and organ function while avoiding the complications of inadequate or excessive fluid therapy.

B. Results of Excessive Resuscitation

The edema that forms in dead and injured tissue reaches its maximum in the second 24 hours post burn. Administration of excessive volumes of resuscitation fluid or inappropriate post-resuscitation fluid management exaggerates edema formation, compromising the local blood supply and delivery of nutrients. Patients sensitive to fluids include:

- Children
- The elderly
- Patients with preexisting cardiac disease

As evaporative water losses from the wound surface and renal excretion reduce the resuscitation-related water and salt loading, the edema resolves.

C. Results of Inadequate Resuscitation

Shock and organ failure, most commonly acute renal failure, may occur as a consequence of hypovolemia in a patient with an extensive burn who is untreated or receives inadequate fluid. The increase in capillary permeability caused by the burn is greatest in the immediate post-burn period and diminution in effective blood volume is most rapid at that time. Prompt administration of adequate amounts of resuscitation fluid is essential to prevent the occurrence of burn shock and organ failure.

IV. FLUID NEEDS IN THE IMMEDIATE POST-BURN PERIOD

Resuscitation fluid needs are related to the extent of burn and body size. Patient age further influences the relationship of fluid needs to body size since children have a greater surface area per unit body mass. To calculate fluid needs, weigh the patient or obtain from the patient or family an estimate of pre-injury weight. The percentage of the body surface area that has been burned is then estimated using the Rule of Nines or any of several commonly available burn diagrams.

Reliable peripheral veins should be used to establish an intravenous cannulae. Use vessels underlying burned skin if necessary. If it is not possible to establish peripheral intravenous access, a central line is necessary, using unburned areas if possible. Pediatric patients less than 8 years old may be resuscitated using the intraosseous route.

A. Resuscitation Fluid

In the presence of increased capillary permeability, colloid content of the resuscitation fluid exerts little influence on intravascular retention during the initial hours post burn. Consequently, crystalloid fluid is the cornerstone of initial resuscitation of burn patients.

Calculation of Fluids

- **Adults:** $\text{Ringer's Lactate } 2\text{--}4 \text{ ml} \times \text{Kg body weight} \times \text{percent burn}$
 - **Children:** $\text{Ringer's Lactate } 3\text{--}4 \text{ ml} \times \text{Kg body weight} \times \text{percent burn}$
 - **Infants and Young Children:** Infants and young children should receive fluid with 5% dextrose at a maintenance rate in addition to the resuscitation fluid noted above for children. Liberal consultation with the burn center is advised when resuscitating infants and young children.
-

The infusion rate is regulated so that one-half of the estimated volume is administered in the first 8 hours post burn. That is the time during which capillary permeability and intravascular volume loss are greatest. The remaining half of the estimated resuscitation volume is administered over the subsequent 16 hours of the first post burn day. The volume of fluid actually infused is adjusted according to the individual patient's response to the burn and the treatment regimen.

The IV rate should be adjusted to maintain adequate urine output:

Adults: 0.5 ml/kg/hr (30-50ml/hr)

Children: 1 ml/kg/hr

Promptly initiated, adequate resuscitation permits a modest decrease in blood and plasma volume during the first 24 hours post burn and restores plasma volume to predicted normal levels by the end of the second post-burn day. *In the event that the patient transfer must be delayed beyond the first 24 hours, consult with the burn center regarding ongoing resuscitation fluid requirements.*

V. FLUID RESUSCITATION OF PEDIATRIC PATIENTS

The greater surface area per unit body mass of children necessitates the administration of relatively greater amounts of resuscitation fluid. The surface area/body mass relationship of the child also defines a lesser intravascular volume per unit surface area burned. This makes the burned child more susceptible to fluid overload and hemodilution.

Hypoglycemia may occur if the limited glycogen stores of the child are rapidly exhausted by the early post-burn elevation of circulating levels of steroids and catecholamines. Therefore, it is important to monitor blood glucose levels and, if hypoglycemia develops, to continue resuscitation using glucose containing electrolyte solutions.

VI. REQUIREMENT FOR MORE THAN FORMULA-PREDICTED NEEDS

Estimates of resuscitation fluid needs are precisely that—estimates. Individual patient response to resuscitation should be used as the guide to add or withhold fluid. The fluid infusion rate should be increased or decreased by one-third if the urinary output falls below or exceeds those limits by more than one-third for two to three hours. Fluid requirements in excess of the formula estimates are common in the following groups:

- Patients with associated injuries
- Patients with electrical injury

- Patients with inhalation injury
- Patients in whom resuscitation is delayed
- Patients with prior dehydration
- Patients with alcohol and/or drug dependencies
- Patients with very deep burns

VII. MONITORING OF RESUSCITATION

Each patient reacts differently to burn injury and resuscitation. The actual volume of fluid infused should be varied from the calculated volume as indicated by physiologic monitoring of the patient's response. It is easier during resuscitation to infuse additional fluid as needed than to remove excess fluid. A resuscitation regimen that minimizes both volume and salt loading, prevents acute renal failure, and is associated with a low incidence of pulmonary and cerebral edema is optimal.

Cardiac output, which is initially depressed, returns to predicted normal levels between the 12th and 18th hours post burn, during a time of modest progressive decrease in blood volume. In those patients in whom cardiac output does not re-spond in this fashion, one should entertain the diagnosis of a myocardial infarction or some degree of myocardial insufficiency. Invasive monitoring may be required and treatment may have to be modified.

The patient's general condition also reflects the adequacy of fluid resuscitation and should be assessed on a regularly scheduled basis. Assessment of mental status should be done frequently. Anxiety and restlessness are early signs of hypovolemia and hypoxemia. Fluid and ventilatory support should be adjusted as needed.

A. Hourly Urinary Output

The hourly urinary output obtained by use of an indwelling bladder catheter is the most readily available and generally reliable guide to resuscitation adequacy.

- **Adults: Adults: 0.5 ml per Kg per hour (or 30-50 cc/hour)**
- **Children weighing less than 30 kg: 1 ml per Kg per hour**

The fluid infusion rate should be increased or decreased based on urine output.

B. Management of Oliguria

Oliguria, in association with an elevation of systemic vascular resistance and reduction in cardiac output, is most frequently the result of inadequate fluid administration. In such a setting, diuretics are contraindicated, and the rate of resuscitation fluid infusion should be increased. Such oliguria requires a more rapid fluid infusion.

C. Management of Hemochromogenuria (Red Pigmented Urine)

Patients with high voltage electrical injury and patients with associated soft tissue injury due to mechanical trauma may have significant amounts of myoglobin and hemoglobin in their urine. The administration of fluids at a rate sufficient to maintain a urinary output of 1.0-1.5 ml per Kg per hour in the adult (approximately 75-100 cc/hour) will often produce clearing of the heme pigments with sufficient rapidity to eliminate the need for a diuretic.

If urine output and pigment clearing do not respond to vigorous fluid administration, 12.5 gm of the osmotic diuretic Mannitol should be added to each liter of resuscitation fluid. When an adequate urinary output has been established and the pigment density decreases, therapy is continued without addition of the diuretic agent to the resuscitation fluid. Since the heme pigments are more soluble in an alkaline medium, sodium bicarbonate can be added to the resuscitation fluids as needed to maintain a slightly alkaline urine. Uncleared pigment may indicate compartment syndrome.

Administration of a diuretic precludes subsequent use of hourly urinary output as a guide to fluid therapy; other indices of volume replacement adequacy must be relied upon.

D. Blood Pressure

Sphygmomanometric measurement of blood pressure can be misleading in the burned limb in which progressive edema formation occurs. As the swelling increases, the auditory signal becomes progressively diminished. If, on the basis of such findings, fluid infusion is increased, edema formation is exaggerated, which further impairs the auditory assessment of blood pressure. If unrecognized, this misinterpretation of change in detected blood pressure can lead to massive fluid overload.

Even intra-arterial monitoring of blood pressure may be unreliable in patients with massive burns because of peripheral vasoconstriction, secondary to the marked elevation of vasoactive humoral factors such as catecholamines.

E. Heart Rate

Heart rate is also of limited usefulness in monitoring fluid therapy. A tachycardia of 100 to 120 per minute is common in adult patients who, on the basis of other physiologic indices of blood volume, appear to be adequately resuscitated. The levels of tachycardia in pediatric patients depend upon their normal heart rate.

F. Hematocrit and Hemoglobin

During the first 24 hours post burn, neither the hemoglobin level nor the hematocrit is a reliable guide to resuscitation. Whole blood or packed red cells should not be used for resuscitation unless the patient is anemic due to pre-existing disease or

blood loss from associated trauma at the time of injury. In that case, red cells should be administered to maintain the hematocrit between 30 and 35 percent.

G. Serum Chemistries

Baseline serum chemistries should be obtained in patients with serious burns and in patients with significant inhalation injury. Subsequent measurements are keyed to the patient's response to treatment. To ensure continuity of care and patient safety during transfer, the treatment of hyperkalemia and other electrolyte abnormalities should be coordinated with the referral burn center physicians.

VIII. SUMMARY

The goal of resuscitation is to maintain tissue perfusion and organ function while avoiding the complications of inadequate or excessive therapy. Excessive volumes of resuscitation fluid can exaggerate edema formation, thereby compromising the local blood supply. Inadequate fluid resuscitation may lead to shock and organ failure.

The formulae used for calculating fluids for the first 24 hours are:

- **Adults: 2-4 ml Ringer's Lactate x Kg body weight x % BSA burn**
- **Children: 3-4 ml Ringer's Lactate x Kg body weight x % BSA burn**
- **Infants < 12 months and young children: Fluid with 5% dextrose at a maintenance rate in addition to the resuscitation fluid noted above for children.**

The infusion rate is regulated so that one-half of the estimated volume will be administered in the first eight hours post burn—the time when capillary permeability and intravascular volume loss are greatest. The remaining half of the estimated resuscitation volume should be administered over the subsequent 16 hours of the first post-burn day. The fluid infusion rate should be increased or decreased by one-third, if the urinary output falls below or exceeds the desired level by more than one-third for two to three hours. The actual volume of fluid infused should be varied from the calculated volume, as indicated by physiologic monitoring of the patient's response.

Monitoring and observation should include the following:

- Measurement of urine output hourly
- Frequent assessment of the patient's general condition, including mental status
- Baseline determination of hematocrit, hemoglobin, serum chemistries and arterial blood gases. Repeat studies as indicated.

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4 Burn Wound Management

OBJECTIVES

Upon completion of this topic, the participant will be able to:

- Differentiate between partial-thickness and full-thickness burns
- Describe the procedure for chest and extremity escharotomy
- Discuss management of patients with burns of special areas

I. INTRODUCTION

The treatment of other life- and limb-threatening injuries always takes precedence over the treatment of the burn wound per se. Attention is directed to the burn wound only after life-saving support of other organ systems has begun. Even so, the burn patient's outcome depends on the effective treatment and ultimate healing of the burn wound. Furthermore, the severity of the patient's multiple-system response to injury, the likelihood of complications, and the ultimate outcome are all intimately linked to the extent of the burn wound and to its successful management.

II. ANATOMY AND PHYSIOLOGY OF THE SKIN

A. Structure

The skin is composed of two layers, the epidermis and dermis. The epidermis is the outer, thinner layer; the dermis is the deeper, thicker layer. The dermis contains hair follicles, sweat glands, sebaceous glands, and sensory fibers for pain, touch, pressure and temperature. The subcutaneous tissue lies beneath the dermis and is a layer of connective tissue and fat.

B. Functions

The skin provides at least four functions crucial to survival:

- Protection from infection and injury
- Prevention of loss of body fluid
- Regulation of body temperature
- Sensory contact with environment

D. Burn Depth

The physiologic impact of a burn is proportional to the extent of body surface area involved. Burn depth determines the wound care needed, the need for grafting, and the functional and cosmetic outcomes. Burns are commonly described as first, second or third degree in nature:

First Degree Burns

First degree burns are superficial burns involving only the epidermis. The skin will be red and hypersensitive.

Second Degree Burns

Second degree burns involve the epidermis and part of the dermis. The skin will be red, blistered, and edematous. Because sensory nerves are partially damaged, the patient may report extreme pain.

Third Degree Burns

Third degree burns are full-thickness burns that destroy both layers of the skin and have a whitish, charred, or translucent appearance. Sensory nerves are destroyed in full-thickness burns. Therefore, all sensation to pinprick is lost in the burned area. The coagulated dead skin in third degree burns forms an eschar that is tough and leathery.

Although more commonly used in Europe than in the US, the phrase ***fourth degree burn*** is used by some to describe burns involving underlying fat, fascia, muscle and/or bone.

III. PATHOPHYSIOLOGY OF THE LOCAL THERMAL INJURY

A. Cellular Damage

The degree of tissue destruction, and thus the depth of burn, correlate with both the temperature and the duration of exposure to the heat source. The physiologic impact of a burn varies with the extent of the burn (total body surface area injured with 2nd and 3rd degree burns) and its depth.

The central area of the burn wound, that having the most intimate contact with the heat source, is characterized by coagulation necrosis of the cells. Therefore, it is termed the zone of coagulation.

Extending peripherally from this central zone of coagulation lies a labile area of injured cells with decreased blood flow, which under ideal circumstances may survive, but which more often than not undergo necrosis in the ensuing 24 to 48 hours following injury. This zone has been designated the zone of stasis. Lying farther peripherally is the zone of hyperemia, which has sustained minimal injury and which will recover over a period of seven to ten days.

The implications of these zones is that improper wound care and resuscitation may lead to extensive injury. *The likelihood of survival depends on optimizing resuscitation.* Improper fluid management may extend the zone of stasis and cause conversion into the zone of coagulation.

B. Depth of Burn

Clinically, the depth of burning is important in terms of necessary wound care, need for grafting, and the ultimate functional and cosmetic result. The skin consists of an outer layer—the epidermis—and an inner layer—the dermis. Within and deep into the dermis are the epidermal appendages, consisting of hair follicles, sweat glands, and sebaceous glands.

1. Partial-Thickness Burns

A first degree burn is a superficial injury limited to the epidermis, and is characterized by redness, hypersensitivity and—sometimes—pain. Within a few days,

the outer layer of injured cells peels away from the totally healed subjacent skin, with no residual scarring. First-degree burns are seldom medically significant.

Second-degree burns involve the entire epidermis and a variable portion of the dermis. The skin may be red and blistered or whiter, yet edematous. Survival of uninjured dermis and of the associated epidermal appendages is in jeopardy, unless optimal conditions for preservation of these elements can be maintained. Such wounds may heal spontaneously, though healing may require two to three weeks or even longer. Scarring is minimal if healing occurs within 2-3 weeks. If the wound is open for a longer period of time, grafting is indicated. Skin grafting may improve the time to healing and the long-term functional and cosmetic outcome.

2. Full-Thickness Burns

Full-thickness (or third degree) burns involve the destruction of the entire thickness of the epidermis and dermis, including the epidermal appendages. These injuries produce a whitish or charred appearance to the skin and coagulated vessels are often seen. Although the area of a full-thickness burn does not appear edematous, subeschar fluid may develop.

C. Fluid Accumulation (Edema Formation)

In addition to cellular damage, the classic inflammatory reaction is generated by thermal injury, with early and rapid accumulation of fluid (edema formation) in the burn wound. Following the burn, capillaries in the burn wound become highly permeable. This results in leakage of fluid, electrolytes and proteins into the area of the wound. In patients with large burns, edema formation occurs in unburned tissues as well. This plasma loss into both burned and unburned tissues causes hypovolemia, and is the primary cause of shock in burn patients. At the same time, edema formation can also cause decreased blood flow to the extremities and/or impaired chest movement during breathing.

Circumferential burns and very deep injuries may lead to inadequate chest wall excursion and tissue perfusion. Although fasciotomies are rarely needed in thermal injuries, escharotomies are occasionally needed in the immediate post-burn period and consultation with the burn center is indicated.

IV. INITIAL MANAGEMENT

Evaluation and treatment of life-threatening problems in the patient always takes precedence over the management of the burn wound. Priorities of treatment established for the patient with multiple injuries apply equally to the burn patient.

A. Topical Wound Management

When anticipating early transfer to a burn center (within the first 24 hours following injury), it is unnecessary to debride the burn or to apply topical antimicrobial

agents. The burn wound should be covered with clean dry sheets prior to transfer. To minimize heat loss, a thermal insulation blanket should be applied in the emergency department and during transfer. Because wet dressings cause evaporative heat loss and hypothermia, wet dressings or wet sheets should never be applied to a burn patient.

If for any reason transfer to the burn center must be delayed, the burn center physicians who will provide definitive treatment should be contacted regarding further wound care. As a general rule, patients whose transfer is delayed beyond 24 hours should undergo bedside debridement of large (greater than 2 cm) blisters and cleansing with chlorhexidine gluconate, followed by twice daily application of silver sulfadiazine cream or mafenide acetate cream. If neither of these creams are available, consult the receiving burn center to identify a suitable alternative. Any escharotomy incisions should be treated the same way the rest of the burn wound is treated, with liberal application of burn creams.

B. Escharotomies and Fasciotomies

Escharotomies and fasciotomies are rarely indicated prior to transfer of a burn patient. Certain patients, however, may require these procedures to allow normal ventilation and peripheral perfusion:

- Circumferential burns
- Very deep burns
- Delayed resuscitations
- Cyanosis
- Deep tissue pain
- Progressive paresthesias
- Progressive decrease or absence of pulse

2. Circumferential Trunk Burns

The adequacy of respiration must be monitored continuously throughout the resuscitation period. If early respiratory distress is present, it may be due to a deep circumferential burn wound of the chest, which makes it impossible for the chest to expand adequately with each breath attempt.

When this problem is present, relief by escharotomy is indicated and may be life-saving. Other causes of respiratory distress such as airway obstruction and/or inhalation injury must also be considered.

Escharotomies for circumferential chest wall burns are performed in the anterior axillary line bilaterally.

If there is significant extension of the burn onto the adjacent abdominal wall, the escharotomy incisions should be extended to this area and should be connected by a transverse incision along the costal margin.

2. Circumferential Extremity Burns

Edema formation in the tissues under the tight unyielding eschar of a circumferential burn of an extremity may produce significant vascular compromise in that limb. This sequelae may occur in patients with deep (third degree or deep second degree) burns, which are circumferential (or nearly so). Serious neurologic and vascular deficits may occur if this problem goes unrecognized and untreated.

During the initial evaluation of all burn patients, all rings, watches, and other jewelry must be removed from injured limbs to avoid distal vascular ischemia. Elevation and active motion of the injured extremity may alleviate minimal degrees of circulatory distress. Skin color, sensation, capillary refill and peripheral pulses must be assessed and documented hourly in any extremity with a circumferential burn.

Use of an ultrasonic flowmeter is the most reliable means to assess arterial blood flow and the need for an escharotomy in burn patients with circumferential extremity burns. In the upper extremity, the radial, ulnar, and palmar arch pulses should be checked hourly. In the lower extremity, the posterior tibial and dorsalis pedis pulses should be checked hourly. Loss—or a progressive diminution (decrease)—in Doppler pulses is an indication for escharotomy. Before proceeding with escharotomy, it should be verified that pulselessness is not due to profound hypotension or arterial injuries if compatible with the injury.

This situation is analogous to the patient with a tight-fitting orthopedic cast. Just as relief is obtained by splitting the cast, an escharotomy is performed to divide the eschar. The escharotomy is carried out as a bedside procedure, utilizing a sterile field and scalpel and/or electrocautery device. Taking the patient to the operating room is not necessary and will cause unacceptable delay. Local anesthesia is needed very rarely, because the third degree eschar is insensate. However, small doses of intravenous narcotics or ketamine may be utilized for analgesia. The incision—which must avoid major nerves and vessels, and all tendons—should be placed along either the mid-medial or mid-lateral aspect of the extremity and should extend through the eschar down to the subcutaneous fat to permit adequate separation of the cut edges for decompression. The incision should extend through the length of the constricting third degree burn and, particularly, should be carried across involved joints.

Following the escharotomy, assess whether it was effective. For example, recheck peripheral pulses with the ultrasonic flowmeter. A single escharotomy incision in an extremity may not result in adequate distal perfusion, in which case a second escharotomy incision on the contralateral aspect of the extremity should be performed. If there is still no improvement, a fasciotomy may be necessary.

3. Hand and Finger Escharotomies

Loss of the palmar arch pulse of the hand, in the presence of full-thickness burns across the dorsum of the hand and intact radial and ulnar pulses, is an indication for escharotomies of the dorsum of the hand. In contrast, a finger

escharotomy is seldom required. Hand and finger escharotomies should be performed only after consultation with the receiving burn center physician.

4. Extremity Compartment Syndrome

In contrast to the decreased flow seen in circumferential burns requiring escharotomies, the compartment syndrome features edema within (beneath) the deep investing fascia of the muscles. Compartment syndrome can occur in burned or unburned limbs, and may result from massive fluid resuscitation, high-voltage electrical injury, delay in escharotomy (ischemia-reperfusion injury), crush injury, etc. This syndrome is frequently diagnosed by the measurement of compartment pressures in the appropriate clinical setting, and is treated by fasciotomy performed in the operating room by a surgeon.

The great majority of burn patients with circumferential burns of the extremities and decreased Doppler arterial flow respond well to escharotomy and do not require fasciotomy.

V. SPECIFIC ANATOMICAL BURNS

Burns of different anatomical areas require unique management. Consultation with a burn center is strongly recommended for patients with burns of the face, feet, eyes, axilla, perineum, hands, or major joints.

A. Facial Burns

Facial burns are considered a serious injury and usually require hospital care. The possibility of respiratory tract damage must always be considered.

Due to the rich blood supply and loose areolar tissue of the face, facial burns are associated with extensive edema formation. To minimize this edema formation, the patient's upper trunk and head should be elevated at a 30-degree angle if the patient is not hypotensive.

To avoid chemical conjunctivitis, water or saline should be used to clean facial burns. The eyes should be protected while cleaning the face.

B. Burns of the Eyes

Careful examination of the eye should be completed as soon as possible because the rapid onset of eyelid swelling will make ocular examination extremely difficult thereafter. Fluorescein should be used to identify corneal injury. Chemical burns to the eye should be rinsed with copious amounts of saline as indicated (see Chapter 6, Chemical Injuries).

Instillation of a mild ophthalmic solution during the period of maximal eyelid edema is indicated. Ophthalmic antibiotic ointments or drops may be used if corneal injury has been diagnosed, but should be employed only after consultation

with the burn center. Ophthalmic solutions containing steroids can be dangerous and should be avoided.

Tarsorrhaphy (a surgical procedure in which the eyelids are sutured closed) is never indicated in the acute phase.

C. Burns of the Ears

Burns of the ears require examination of the external canal and drum early, before swelling occurs. It is important to determine whether external otitis or otitis media are present, especially in children. Patients injured in an explosion (blast injury) are likely to have sustained tympanic membrane perforation.

Avoid additional trauma or pressure to the ear. This is best achieved by avoiding occlusive dressings on the ears and by not permitting pillows under the head.

D. Burns of the Hands

Minor burns of the hands may result in only temporary disability and inconvenience; however, more extensive thermal injury can cause permanent loss of function.

The most important aspect of the physical assessment is to determine the vascular status and the possible need for an escharotomy. Monitoring the digital and palmar pulses with an ultrasonic flowmeter is the most accurate means of assessing perfusion of the tissues in the hand. It is also important to monitor the motor and, if possible, the sensory function of the radial, median, and ulnar nerves at the level of the hand.

The burned extremity should be elevated above the level of the heart—for example, on pillows—to minimize edema formation. Active motion of the involved limb for five minutes each hour will further minimize swelling. Dressings will only impair the ability to monitor circulation and should be avoided. Digital escharotomies are not indicated prior to transfer to the burn center.

E. Burns of the Feet

As with burns of the upper extremity, it is important to assess the circulation and neurologic function of the feet on an hourly basis. Edema should be minimized by elevating the extremity, and dressings should be avoided—just as with hand burns.

F. Burns of the Genitalia and Perineum

Burns of the penis require immediate insertion of a Foley catheter to maintain the patency of the urethra. Consultation with the burn center is recommended.

Scrotal swelling, though often significant, does not require specific treatment.

Burns of the perineum may be difficult to manage. However, a diverting colostomy is **not** indicated.

VI. SUMMARY

The successful treatment of the patient with thermal burns requires attention to wound management, in order to promote healing and closure of the wound. Burn wound management never takes precedence over life-threatening injuries or the management of fluid resuscitation, but it is an important aspect of care during the acute burn phase. Specific anatomical burns present special challenges. Functional outcome of the patient is often related to the initial management measures for these special areas. Severe burns to these areas may result in significant functional or aesthetic deformities and frequently mandate early transfer to a burn center.

5 Electrical Injury

OBJECTIVES

- Describe the pathophysiology that occurs with electrical injuries
- Discuss specialized assessment techniques utilized when caring for a patient with an electrical injury
- Outline the principles of management for the patient with electrical injury

I. INTRODUCTION

Electrical injury has been called the “grand masquerader” of burn injuries because small surface injuries may be associated with devastating internal injuries. Electrical injuries account for approximately 3% of all burn center admissions and cause around 1,000 deaths per year. Frequently these are work-related injuries and, as such, have a significant public health and economic impact.

Electrical injuries are arbitrarily divided into high and low voltage, the former being 1,000 volts or greater. Electricity can cause injury by current, arc, flash, and ignition of clothing. Understanding these different mechanisms may help to predict the severity of the injury and the potential sequelae.

II. PATHOPHYSIOLOGY

A. Tissue Injury

When the body becomes part of an electrical circuit, the extent of injury is determined by the strength of the current and the duration of the exposure. This concept is defined by Ohm's Law, where current (I) is directly proportional to the voltage (V) and inversely proportional to the resistance (R): $I = V/R$. Tissue injury from electrical trauma results from electrical energy being converted to heat energy. This concept is known as the Joule Effect. Heat production (in joules) is the current times the resistance, multiplied by the time of contact ($J = I^2 \times R \times T$). The extent of injury depends on the type of current, the pathway of flow, the local tissue resistance, and the duration of contact. Current flow at a given voltage is also related to the cross-sectional area of the involved body part.

Tissue resistance is an integral part of the pathophysiology of electrical injury. The skin is the most resistant organ; the greatest resistance is in the epidermis of the skin. (At high voltages, however, the differences in tissue resistance appear to be clinically unimportant.) Once resistance is overcome, current flows through the underlying tissue. Although various underlying tissues have different resistance to current flow, once skin resistance is overcome the body acts as a volume conductor and current flows throughout the involved body part. Bone has a very high resistance because of its density. Current will flow along the surface of the bone, and the heat generated will cause damage to adjacent muscle. Consequently, deep muscle injury may be present even when superficial muscles appear normal or uninjured.

Findings that suggest electrical conduction injury include the following:

- Loss of consciousness
- Paralysis or mummified extremity
- Loss of peripheral pulse
- Flexor surface burns (antecubital, axillary, inguinal or popliteal)

- Myoglobinuria
- Serum CK above 1,000 IU

C. Current

Current is measured in amperes (A) and is either alternating (AC) or direct (DC). Alternating current is produced by the reversal of electron flow every half cycle.

Alternating current has generally replaced direct current for most commercial applications because it is cheaper to transmit. Common direct current injuries are encountered with lightning and car batteries. AC is far more dangerous to the human body, producing tetany and death from cardiac fibrillation and respiratory muscle paralysis.

C. Types of Injury, Based on Mechanism

1. Current

With alternating current (AC), the electricity flows back and forth from the power source to the anatomic contact point on the patient. There are no entrance and exit sites. Direct current (DC) travels in one direction and, therefore, an entrance and exit site may be evident.

2. Arcing

This term refers to the ionization of air particles between two conductors. The heat generated in the arc can be as high as 4,000° C and can vaporize metal. This process frequently causes a patient's clothing to ignite, thereby causing flame burns. A form of explosion dissipates excess energy from the arc. This may result in associated blunt trauma.

3. Flash

A flash can result from the power source or from the ignition of clothing or surroundings. A flame burn can occur without underlying tissue injury.

D. Lightning Strike

The risk of being struck by lightning is about 1:280,000. Lightning kills 80 to 100 people in the US annually. Lightning injuries are associated with a 30% mortality, and up to 70% of survivors suffer serious complications. Lightning is direct current with voltage that may exceed 200,000 volts; the common range, however, is between 10,000 and 50,000 V, with peak current measured up to 200,000 A, but median current at about 30,000 A.

Lightning injuries are usually not associated with deep burns, but most often with superficial injury to the skin and underlying soft tissue. On the other hand, significant cardiac and neurological damage may result. The presentation of the lightning strike varies widely, even among groups of people struck at the same time. Injury results from either a direct strike or a side flash, in which current discharges from a nearby object through the air to an adjacent object (victim). The electrical discharges (side flashes) from the struck victim or object may travel through the ground or air

and kill or injure people standing nearby—this is the most common type of injury. The lightning flashes result in immediate deep polarization of the entire myocardium and can lead to asystole and respiratory paralysis.

III. MANAGEMENT

A. Primary Survey

1. Airway—Cervical spine precautions are dictated by the mechanism of injury
2. Breathing
3. Circulation
4. Disability—Determine GCS and check pupils
5. Exposure/Environment—Protect patient from hypothermia

B. Secondary Survey

1. Head-to-toe physical examination
2. Remove all clothing and jewelry
3. Identify all contact points—Carefully check hands, feet, and scalp (hair may obscure wounds)
4. Estimate extent of surface burn
5. Detailed neurological examination and document changes with time
6. Check for fractures/dislocations, occult internal injury, and evidence of compartment syndrome

C. Resuscitation

1. Place two large bore intravenous catheters
2. Initiate Ringer's Lactate fluid therapy
 - a. If surface burns are present, minimal fluid requirements are based on the formula of 2-4 cc/KG/percent burn of thermal injury.
 - b. This volume of fluid may be inadequate if associated injuries are present (commonly muscle).
 - c. Ringer's Lactate is infused at a rate sufficient to maintain a urine output of 0.5-1.0 cc/Kg/hr if there are hemochromogens in the urine.

- d. If there is evidence of hemochromogens (myoglobin) the urine output should be maintained between 75-100cc per hour until the urine grossly clears.
- e. A Foley catheter is inserted.

D. Cardiac Monitoring

1. A 12-lead ECG is obtained.
2. Continuous cardiac monitoring is initiated for dysrhythmias or ectopy.
3. Monitoring is not recommended if there is a normal EKG, and no history of unconsciousness, cardiac arrest, or abnormal rate or rhythm.

E. Maintenance of Peripheral Circulation

1. Skin color, sensation, capillary refill and peripheral pulses must be assessed hourly in any extremity with either a circumferential cutaneous burn or an electric contact site.
2. All rings, watches and other jewelry must be removed from injured limbs, other-wise a “tourniquet-like” effect may cause distal vascular ischemia.
3. Surgical correction of vascular compromise. If clinical signs and/or symptoms of vascular compromise are present, immediate decompression of either constrict-ing eschar or fascia, or both, is necessary.
 - a. Escharotomy, as described in Chapter 4, may be sufficient if vascular compro-mise is secondary to a constricting circumferential eschar as a result of the cutaneous burn.
 - b. Fasciotomy
 - i.) Extremities without circumferential burns but with a contact site can develop subfascial edema, which may cause tissue ischemia if muscle compartmental pressure increases sufficiently. The involved muscle compartment will be stony hard to palpation.
 - ii.) Upper limb - The musculature of the forearm is very susceptible to is-chemic injury. If a fasciotomy is needed to decompress the involved muscle compartments, the ulnar nerve must be protected. Local anesthe-sia can be used to infiltrate the tissue. Using either a scalpel or electro-cautery, the skin and subcutaneous tissue are incised and the underlying fascia opened. Particular attention is paid to circumferential contact points corresponding to a wristwatch band or rings. A carpal tunnel release may be necessary, but is performed only after unsucces-sful fasciotomy and consultation with the burn center physician.
 - iii.) Lower limb - All four compartments of the leg are susceptible to ischemia from subfascial edema because the muscle is enclosed between the rigid tibia, fibula, and tight intermuscular septum. Decompressive fasciotomy is accomplished with two incisions. The lateral incision is made beginning at the lateral fibular tuberosity and extends parallel to and directly over

the fibula for approximately 20-25 cm. The incision is carried through the subcutaneous tissue to the underlying fascia, taking care to avoid the peroneal nerve. The intramuscular septum separating the anterior and lateral compartments is identified and separate incisions are made over each muscle compartment for the length of the previously made incision. Next the medial incision is made, beginning at the same proximal level and extending slightly posterior and medially down to the level of the medial malleolus. The incision is carried down to the level of the investing fascia, care being taken not to injure the saphenous nerve and vein. Through this incision, the deep and posterior muscle compartments can be decompressed for the full length of the incision.

- iv.) Blood loss from a fasciotomy incision can be considerable. Use of the electric cautery is an effective means of minimizing this blood loss. If a fasciotomy is performed early post burn (during the first eight hours after injury) when the patient is hypovolemic and vasoconstricted peripherally, blood loss may not be great initially. Once hypovolemia is corrected, the previously cut blood vessels may begin to bleed and a pressure dressing, suture ligation, or electrocautery may be necessary to control bleeding.

F. Special Situations

1. Cardiac Arrest

- a. Ventricular fibrillation, asystole, and other life-threatening arrhythmias are treated as outlined by the Advanced Cardiac Life Support course.
- b. Endotracheal intubation may be necessary because of burns involving the head, face, or neck.

2. Muscle Compartment Syndrome

- a. Elevated pressure within a fascial compartment secondary to edema may cause decreased blood flow to the muscle. When the pressure exceeds the capillary pressure, muscle damage will occur.
- b. If compartment pressure is not relieved, muscle necrosis will occur. Decompression may be necessary within several hours of the injury. Symptoms include: severe pain with flexion or extension of the muscles within the compartment, numbness or tingling in a hand or foot, and decreased or absent pulses.

3. Hemochromogens in Urine

- a. Presence of pigment in the urine (pink to dark red) indicates underlying muscle damage. The urine output must be maintained between 75 - 100 cc/ hr until it is grossly clear.
- b. 44mEq of sodium bicarbonate is added per liter of Ringer's Lactate until the urine pH is > 6.0

- c. Mannitol (0.5g/kg) IV is given immediately if hemochromogens are noted in the urine. This will aid initiating a urine output. Contact the burn center before administering Mannitol.

G. Wound Care

1. General principles of burn wound care are described in Chapter 4, Burn Wound Management.
2. If underlying muscle damage is present or suspected, use acetate cream.

IV. ELECTRIC BURNS IN THE PEDIATRIC PATIENT

Low voltage accidents are most common in children and generally occur in the household. Common etiologies include faulty insulation, electric appliances, frayed electric cords, and the insertion of metal objects into wall sockets. This type of injury creates minimal cutaneous injury and usually no deep muscle damage.

Injuries involving the oral commissure or other facial areas commonly look much worse than they really are and no initial surgical debridement should be performed. Follow-up care should be coordinated with the burn center physician.

V. SUMMARY

Electrical injuries are frequently encountered in the emergency setting. Prompt initiation of fluid resuscitation and high urine volume when hemochromogens are evident are important. Assessment of peripheral circulation to determine if compartment syndrome is present must be determined early. A 12-lead ECG is important to determine if abnormalities of rate or rhythm are present and, if so, monitoring will be necessary.

6 Chemical Burns

OBJECTIVES

Upon completion of this topic, the participant will be able to:

- List three major classes of potentially injurious chemicals and their mechanism of action
- Outline the initial management of chemical burns
- List the factors that contribute to the severity of a chemical burn
- Identify and describe the treatment for special chemical burns, including hydrofluoric acid, phenol, and petroleum exposure
- Describe the initial management of chemical eye injuries
- Identify the most commonly used chemical warfare agents

I. INTRODUCTION

There are currently over 500,000 different chemicals in use in the United States, including more than 30,000 chemicals that have been designated as hazardous by one or more regulatory agencies. Approximately 60,000 people seek professional medical care annually as the result of chemical burns. Chemical burn injury accounts for 2-6% of all burn unit admissions.

The extent of a chemical burn is directly related to the interval between injury and institution of appropriate medical therapy. Prompt recognition and timely treatment of chemical burns is essential. The initial appearance of a chemical burn can be deceptive; thus, any patient with a serious chemical burn injury should be referred to a burn center.

II. CLASSIFICATION

The most common chemicals that cause cutaneous burns fall into three categories: alkalis, acids, and organic compounds. Alkalis and acids are used both in the home and at work for cleaning and for hobbies. Organic compounds, found in petroleum products, can be topically irritating and systemically toxic.

A. Alkalis

Alkalis include the hydroxides, carbonates or caustic sodas of sodium, potassium ammonium, lithium, barium and calcium. They are commonly found in oven cleaners, drain cleaners, fertilizers and heavy industrial cleansers. They form the structural bond in cement and concrete. Wet cement, with a pH of approximately 12, can cause a severe alkali chemical burn. Alkalis damage tissue by liquefaction necrosis and protein denaturation. This allows deeper spread of the chemical and more severe burns.

B. Acids

Acids are likewise prevalent in the home and in industry. They may be found in many household products. Hydrochloric acid is the active ingredient in many bathroom cleansers. Oxalic acid and hydrofluoric acid are common products utilized in rust removers. Concentrated hydrochloric and muriatic acid are the major acidifiers for home swimming pools. Concentrated sulfuric acid is utilized in industrial drain cleaners. Acids damage tissue by coagulation necrosis and protein precipitation, which tends to limit the depth of tissue damage. The exception to this is hydrofluoric acid, which will be discussed later.

C. Organic compounds

Organic compounds, including phenols, creosote, and petroleum products, produce contact chemical burns and systemic derangements. Phenols are prevalent in a variety of chemical disinfectants. Petroleum, which includes creosote and gasoline,

is commonly used in the home, in industry, and in recreation. Organic compounds cause cutaneous damage due to their fat solvent action (cell membrane solvent action). Once absorbed, they can produce toxic effects on the kidneys and liver.

III. FACTORS THAT DETERMINE SEVERITY

The severity of a chemical injury is related to:

- agent
- concentration
- volume
- duration of contact
- mechanism of action of the agent

The concentration of the chemical influences the depth of injury, and the volume of the chemical affects the extent of body surface involved. Immediate irrigation decreases the concentration and duration of contact, thereby reducing the severity of the injury.

Delay in institution of treatment permits continued tissue damage. Prompt removal and dilution of the chemical is vital to minimize tissue injury. Delay in implementation of resuscitation contributes significantly to major disability.

IV. TREATMENT

Universal precautions should be observed in the treatment of all patients with a suspected chemical injury. All personnel should wear gloves, gown, and eye protection prior to contact with the patient. It is important to remember that patient clothing often contains remnants of the injurious agent. Failure to take simple precautions can lead to significant provider injury. Don't become a victim!

Initial treatment of all chemical burns consists of removing the saturated clothing (including underwear, gloves and shoes); brushing the skin if the agent is a powder; and continuously irrigating the involved areas with copious amounts of water. No substance has been proven to be superior to water for initial therapy. Irrigation should be continued from the pre-hospital scene through emergency evaluation in the hospital. Efforts to neutralize the chemical are contraindicated due to the potential generation of heat, which could contribute to further tissue destruction. In general, irrigation should be continued until the patient experiences a decrease in pain or burning in the wound or until the patient has been evaluated in a burn center.

Support the “ABCs” (airway, breathing, circulation): Chemical agents can often impact both the respiratory and circulatory status of the patient. It is important to evaluate continually the patient’s airway status and to address promptly any evidence of airway compromise. Intravenous access should be obtained for all significant chemical injuries.

Identification of the agent after institution of therapy may provide insight into additional medical considerations, including potential drug toxicity. However, initial therapy should *NOT* be delayed while attempts are made to identify the agent involved. A Poison Control Center may be helpful in identifying the active agent in many commercial products.

V. SPECIFIC CHEMICAL BURNS

A. Chemical Injuries to the Eye

Alkalis are a frequent cause of chemical eye injuries. They are twice as frequent as acid eye injuries and occur primarily in young adults at home, in industrial accidents, and in assaults. Alkalis bond to tissue proteins and require prolonged irrigation to dilute the chemical and stop progression of injury. Water or saline irrigation is the emergency treatment of choice. Irrigation from the scene to the emergency room is mandatory to minimize tissue damage. In the case of a chemical burn to the eye, call an ophthalmologist and continuously irrigate the eye.

The majority of patients presenting with an alkali eye burn will have swelling and/ or spasm of the eyelids. To irrigate adequately for extended periods of time, the eyelids must be forced apart to allow flushing of the eye. In the emergency department, irrigation should be performed by placing catheters in the medial sulcus for irrigation with normal saline or a balanced salt solution. This allows for prolonged irrigation without runoff of the solution into the opposite eye. Alternatively, an irrigating (Morgan) catheter may be fitted over the globe. Extreme caution should be used when employing this irrigating modality to prevent additional injury to the eye.

Continue irrigation until the patient has been fully evaluated by a qualified professional. All alkali ocular injuries should be seen by an ophthalmologist, in consultation with the burn center.

B. Hydrofluoric Acid

Hydrofluoric acid is used in industry to etch glass, make Teflon, clean semiconductors and for a variety of other uses. It is used in home cleaners as a rust remover. Although it is a weak acid, the fluoride ion is very toxic. Exposure to low concentration (less than 10 percent) causes severe pain, which does not appear for 6-18 hours. Higher concentrations cause immediate pain and tissue necrosis. Death can occur from hypocalcemia as the fluoride rapidly binds free calcium in the blood.

After hydrofluoric acid exposure, the wound is flooded with water, followed by topical calcium gel to neutralize the fluoride (one amp calcium gluconate and 100 gm of lubricating jelly). This is applied with the gloved hand to avoid spread of the fluoride to other body parts. Patients who have persistent pain may require intra-arterial infusion of calcium at a regional burn center.

Severe pain indicates exposure to a high concentration, which may be life threatening. In addition to topical calcium, begin cardiac monitoring and place an intravenous catheter in anticipation of calcium gluconate infusion to treat hypocalcemia. Burn center consultation is required, since early excision of the wound may be lifesaving.

C. Phenol Burns

Phenol, an acidic alcohol with poor solubility in water, is frequently used in disinfectants and chemical solvents. It damages tissue by causing coagulation necrosis of dermal proteins. Initial treatment consists of copious water irrigation followed by cleansing with 50% polyethylene glycol (PEG) or ethyl alcohol, which increases the solubility of the phenol and allows more rapid removal of the compound. Of note, diluted solutions of phenol penetrate the skin more rapidly than concentrated solutions, which form a thick eschar via coagulation necrosis.

D. Petroleum Injuries (Not Flame Burns)

Gasoline and diesel fuel are petroleum products that may cause tissue damage. Prolonged contact with gasoline or diesel fuel may produce (by the process of delipidation) a chemical injury to the skin that is actually full thickness but initially appears to be only partial thickness or second degree. Sufficient absorption of the hydrocarbon can cause organ failure and even death. These injuries often occur in conjunction with motor vehicle accidents and tend to be identified somewhat later, due to the presence of other injuries. It is important to look for petroleum exposure in the lower extremities, the back, and the buttocks after a motor vehicle accident involving petroleum products.

Systemic toxicity may be evident within 6 to 24 hours with evidence of pulmonary insufficiency, hepatic and renal failure. Within 24 hours, hepatic enzymes are elevated and urinary output is diminished. Lead toxicity may occur if the gasoline contains tetraethyl lead. Patients with these injuries require immediate transfer to a burn center.

E. Tar Burns

Hot tar burns are often considered under the category of chemical burns, although they are, in essence, contact burns. The bitumen compound itself is not absorbed and is not toxic. Emergency treatment consists of cooling the molten material with cold water. Physical removal of the tar is not an emergency. The urgent need is to cool the burn. Cold applications are indicated to stop the burning process. Adherent

tar should then be covered with a petrolatum-based ointment (such as white petrolatum jelly) and dressed to promote emulsification of the tar. Two solvents are available for removal of tar.

F. Anhydrous Ammonia

Anhydrous ammonia is commonly used as a fertilizer or industrial refrigerant. It is also used in the manufacture of illicit methamphetamine. It is a strong base with a penetrating odor. Exposure causes blistering of the skin and injury to the lungs if the fumes are inhaled. The wounds are flooded with water to remove the smell of ammonia, which may prevent the need for subsequent skin grafts. Eye injuries are also common and require prolonged irrigation of the eye, in consultation with an ophthalmologist. Inhalation injuries with hypoxemia and copious secretions may require ventilator support.

VI. AGENTS OF CHEMICAL WARFARE

The use of chemicals in battle has been practiced for hundreds of years. Chemical agents played a major role in the morbidity and mortality associated with World War I and have also been used in terrorist attacks. Agents used in chemical warfare can be divided into several categories: vesicants, such as mustard agents and Lewisite, and nerve agents, such as Sarin. These chemicals can produce both cutaneous and systemic toxicity, including pulmonary, hepatic, and neurologic damage. Treatment of victims of chemical attacks should follow the same basic principles used for other chemical agent exposures: removal of all involved clothing, brushing away dry chemicals, and copious irrigation with water. Patients with respiratory compromise should be intubated if necessary. In cases involving large numbers of victims, particular care should be taken to establish a single area for isolation of clothing and other items containing the injurious chemical, in order to avoid provider injury from environmental contamination. Agents used in chemical attacks frequently have both short and long-term morbidity and toxicity. All such patients should be referred to a burn center for definitive management.

VII. SUMMARY

Chemical burns constitute a special group of injuries and should be referred to a burn center for evaluation and definitive management. Individuals caring for patients exposed to chemical agents must always wear protective clothing to avoid personal contact with the chemical. To ensure an optimal result and to limit tissue damage, immediate removal of the agent followed by copious irrigation with water is essential. Irrigation should be continued until patient pain is relieved or the patient is transferred to a burn center. Phenol, petroleum, and hydrofluoric acid burns, as well as any chemical injury to the eye, require special consideration. Adherence to

basic therapeutic treatment principles can significantly decrease patient morbidity after a chemical injury.

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7 Pediatric Burn Injuries

OBJECTIVES

Upon completion of this topic, the participant will:

1. Know how the child is different from the adult in:
 - Size
 - Body surface, including temperature regulation
 - Skin thickness
 - Metabolic rate
 - Psychological and developmental characteristics
2. Be able to discuss principles of management for the pediatric patient with burns caused by heat, electrical, or chemical agents
3. Know how to recognize and report burns due to child abuse

I. INTRODUCTION

Each year, more than 2,500 children die from thermal injury and nearly 10,000 children suffer severe permanent disability from thermal injury. Scald burns are the most common thermal injuries in children under the age of three, while flame burns are more commonly seen in older children. Scald burns are also prevalent in cases of child abuse.

II. PATHOPHYSIOLOGY

A. Body Surface Area

When compared with adults, the infant and young child have a relatively greater surface area per unit of body weight. A seven kilogram child, for example, is only one-tenth the weight of his/her 70 kilogram adult counterpart, but has one-third the body surface of the adult. As a consequence of this relatively large body surface area, the child is more in contact with the environment and has relatively greater fluid needs and evaporative water loss per unit of weight than the adult. Adult relationships between surface and weight are established by age 15.

Children under age 2 also have disproportionally thin skin, which commonly results in full-thickness, third-degree burns that may initially appear to be partial-thickness in depth.

B. Temperature Regulation

Temperature regulation in the infant and child is also influenced by the child's relatively greater body surface area, thus compromising conservation of body heat. Intrinsic heat generation by shivering is hampered by a relatively small muscle mass. Temperature regulation in infants under six months depends less on shivering and more on intrinsic metabolic processes and the environmental temperature. Children older than this can generate heat by shivering.

C. Skin Thickness

Exposure of tissue to temperatures at or below 111° F (44° C) can be tolerated for extended periods of time by infants and adults. In the adult, exposure for 30 seconds at 130° F (54° C) is required to produce burn injury. Because of the thinner dermal layer in children, exposure at 130° F (54° C) for 10 seconds produces more severe tissue destruction. At 140° F (60° C), a common setting for home water heaters, tissue destruction occurs in five seconds or less in children. At 160° F (71° C), a full-thickness burn is almost instantaneous. This is why water heaters should be set no higher than 120° F.

III. INITIAL EVALUATION

A. History

The events leading to the thermal injury and the past medical history are extremely important in the initial evaluation of an infant and child. The potential for child abuse must always be considered, particularly in children under 4 years of age. A careful and detailed history is essential and should include a record of past illnesses, immunizations, and allergies.

B. Physical (Extent of Injury)

The severity of injury depends on age, body surface involvement, and depth of burn. Measurement of body surface can be related to the Rules of Nines when one considers that the head and neck represent 18 percent of body surface rather than nine percent, and each lower extremity represents 14 percent body surface area as compared to the adult's 18 percent. A Lund & Browder Chart is helpful in detailing the extent of burn and in calculating the percentage of body at different stages.

IV. IMMEDIATE RESUSCITATIVE MEASURES

A. Airway

Fundamental considerations of airway thermal injuries have been discussed in Chapter 2. Children may have few physical or radiographic signs of pulmonary injury in the first 24 hours post burn. All pediatric patients with suspected inhalation injury should be prepared for immediate transfer to a burn center. Endotracheal intubation is indicated in infants and children with significant respiratory distress or compromise of the airway by edema involving the glottis and upper airway. Younger children and those with larger burns are more likely to require intubation. For those children being transported to a burn center, the airway should be assessed and secured prior to transport. Endotracheal intubation may also be indicated for those children requiring large volume I.V. fluid resuscitation during transport.

Intubation should be undertaken by one experienced in managing the child's airway. The infant's larynx is located more cephalad than the adult's. Angulation of the infant glottis is more acute in an infant and the glottis is found more anteriorly than in the adult. These anatomical differences make intubation by the inexperienced more difficult. The diameter of the child's external nares or small finger should be used to gauge the size of the endotracheal tube (or the equation $[16 + \text{age in years}] / 4$). An uncuffed endotracheal tube should be used in infants and small children. Remember that the narrowest point of the pediatric airway is at the cricoid and not at the glottis.

Repeated unsuccessful efforts at intubation may create sufficient edema to obstruct the airway.

Open (or surgical) cricothyroidotomy is rarely indicated in the infant or small child. A large bore needle placed through the cricothyroid membrane may be used as an expedient airway. Injured infants and children often cry and gasp. Swallowed air from crying distends the stomach. Nasogastric tube decompression is necessary in most cases.

B. Circulatory Status

Infants and children with burn injuries in excess of ten percent of the body surface should be hospitalized in a burn center. After the airway has been secured, the immediate measures prior to transfer of the child include establishment of intravenous access and administration of resuscitative fluid. Delay in initiation of fluid resuscitation may result in both acute renal failure and higher mortality.

Intravenous cannulae may be inserted percutaneously or by cutdown. In patients with extensive burn injury, intravenous cannulae can be inserted through burned skin. Large bore peripheral access is preferred. Femoral venous catheterization has been demonstrated to be safe for children with massive burns. Intraosseous infusion may be lifesaving in the severely burned infant, but is indicated only when intravenous line placement has been unsuccessful prior to interhospital transfer or in the likelihood of cardiac arrest.

Ringer's Lactate solution should be started in patients of all age groups. In infants, hypoglycemia may develop due to limited glycogen reserves; therefore, blood glucose levels should be monitored and maintenance rate infusions of Ringer's Lactate with 5% dextrose should be included in resuscitation fluids. Young children and infants should have both maintenance fluids with 5% dextrose and glucose-free resuscitation fluids.

Calculation of fluid infusions in burned children must include both estimated fluid resuscitation needs and maintenance fluids. Fluid requirements in children are often underestimated for large burns and overestimated for small burns. Resuscitation fluids (Ringer's lactate) in the infant and child can be estimated by the following formula:

Initial volume(ml) (to be given over first 24 hours): 3 - 4 ml x weight in kg x percent body surface burned.

Partial- and full-thickness burns should be considered in the % body surface area calculation. The maintenance fluid requirements for a child may be calculated from the child's weight as follows:

For the first 10 kg of body weight: 100 ml per kg over 24 hours

For second 10 kg of body weight: 50 ml per kg over 24 hours

For each Kg body weight above 20 kg: 20 ml per kg over 24 hours

For example, initial fluid requirements in a 23 kg child with a 20 percent burn would be calculated as follows.

| | |
|-----------------------------|---|
| Resuscitative fluid: | 3ml X 23 kg X 20 (%BSA) = 1380 ml (as RL) |
| Maintenance fluid: | 100 ml X 10 kg = 1000 ml |
| | 50 ml X 10 kg = 500 |
| | 20 ml X 3 kg = 60 |
| | 1560 ml (as D5RL) |

Total fluid requirements for first 24 hours are therefore 2940 ml

Response to this fluid therapy will determine the rate and volume of fluid administration. A urinary catheter is needed to monitor the effectiveness of fluid resuscitation. Urinary output is generally a reliable indication of renal blood flow. In children weighing less than 30 kg, adequate fluid resuscitation is assumed with an average urinary output of 1 ml/kg/hr. In children over 30 kg, adequate fluid resuscitation is assumed with a urinary output of ½ ml/kg/hr.

Adequacy of resuscitation is also assessed by monitoring the sensorium, the blood pH, and the peripheral circulation. Delay or underestimation of fluid resuscitation may result in increased mortality. After starting fluids, consult with the burn center regarding ongoing fluid requirements.

C. Wound Care

Management of the burn wound should include stopping the burning process, removing all clothing, examining the entire body surface to determine the extent of the burn injury, and covering the burned areas with clean linen. Topical antimicrobial dressings are not indicated prior to transfer. During transfer, measures to conserve body heat, including thermal blankets, are essential for the infant and young child.

D. Escharotomy

Escharotomy in pediatric burn patients may be necessary to relieve vascular compromise or to overcome ventilatory impairment, although rarely prior to burn center transfer. (The technique of escharotomy is described in Chapter 4, Burn Wound Management). Vascular impairment may be produced by circumferential burns of the limbs. Pain, paresthesia, pallor, and pulselessness are classic manifestations, but are frequently absent in appearance. Ultrasonic doppler flowmeter assessment of distal pulses (radial, ulnar, posterior tibial, dorsalis pedis, etc.) are the most reliable means of monitoring the circulatory status of a child's burned extremity. Repeated studies will frequently document a change in the circulatory status of the burned extremity. It is wise to consult the burn center when escharotomy is being considered. In addition to escharotomy, fasciotomy is frequently necessary due to the relatively small size of the pediatric patient's compartments in each extremity.

The chest wall is more compliant in children than in adults. Consequently, the child may become rapidly exhausted by the edema and restrictive effects of a circumferential chest-wall burn. If such occurs, chest wall escharotomy is required. Incisions along the anterior axillary lines must extend well into the abdominal wall and be accompanied by a transverse costal margin bridging incision.

E. Child Abuse

Burned children, particularly those under the age of four, should be evaluated for child abuse. Documentation, including photographs, is essential. In order to detect such an event, the examining physician must have a high level of suspicion, which should be triggered when:

- The pattern of injury is not compatible with the history given.
- The lines of demarcation between normal and burned skin are straight or smooth or when there is “glove” or “stocking” distribution of the burn.
- There is a long delay between burn injury and the seeking of treatment.

W. TRANSFER CRITERIA

Infants and children with third degree burns; burns of the face, hands, feet, genitalia, or perineum; as well as those with inhalation, electrical or chemical injuries should be transferred to a burn center. All pediatric patients with burns of ten percent or more total body surface area—regardless of specific areas of burns—should be transferred to a burn center. Also, burned children in hospitals without qualified personnel or equipment for the care of children should be transferred. (For a complete listing of the criteria for referral to a burn center, see Chapter 8, Stabilization, Transfer and Transport.)

VI. SUMMARY

Emergency management of each pediatric burn patient requires an individual care plan. Consideration must be given to the age-specific relationship between body surface area and body weight when calculating fluid replacement. A knowledge of normal physiology and how it changes with age is important in planning therapy for the burned child. It is extremely important to be aware of those factors that influence the care needed by the burned child, such as:

- thin skin, which makes initial determination of the severity of the burn difficult
- impaired capacity for thermal regulation, which leads to hypothermia
- lesser metabolic reserve, which may be associated with hypoglycemia
- possibility of child abuse/neglect

VII. SELECTED REFERENCES

Sheridan RL. The seriously burned child: resuscitation through reintegration—part 1 (1998;28:105-27) and part 2 (1998;28:139-67). *Current Problems in Pediatrics*. (A comprehensive review of burn injury management in children.)

8

Stabilization, Transfer & Transport

OBJECTIVES

Upon completion of this session, the participant should be able to:

- Identify the criteria established by the American Burn Association for burn injuries requiring referral to a burn center
- Describe pre-transfer stabilization
- Describe transfer procedures

I. INTRODUCTION

The patient with electrical, chemical or thermal injury requires immediate assessment and stabilization at the closest appropriate hospital. Hospital personnel must complete a primary and secondary assessment and evaluate the patient for potential transfer. Burn injuries may be a manifestation of multiple trauma, and the patient must be evaluated for associated injuries. All procedures employed must be documented to provide the receiving burn center with a transfer record that includes a flow sheet. Transfer agreements should exist to ensure orderly transfers.

II. BURN CENTER REFERRAL CRITERIA

The American Burn Association has identified the following injuries as those requiring referral to a burn center. A burn unit may treat adults or children or both.

Burn injuries that should be referred to a burn unit include the following:

1. Partial thickness burns greater than 10% total body surface area (TBSA).
2. Burns that involve the face, hands, feet, genitalia, perineum, or major joints.
3. Third-degree burns in any age group.
4. Electrical burns, including lightning injury.
5. Chemical burns.
6. Inhalation injury.
7. Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality.
8. Any patient with burns and concomitant trauma (such as 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.
9. Burned children in hospitals without qualified personnel or equipment for the care of children.
10. Burn injury in patients who will require special social, emotional and/or long-term rehabilitative intervention.

Pre-existing medical conditions frequently complicate burn management and prolong recovery.

Patients at the age extremes are subject to variable physiologic response to thermal injury. Infants and elderly patients are less tolerant of thermal, electrical or chemical injuries. The burn team approach, utilizing physicians, nurses, psychologists, dietitians, social workers, physical and occupational therapists, has a significant influence on outcome for major burn and electrical injuries.

III. STABILIZATION IN PREPARATION FOR TRANSFER

Once the decision has been made to transfer a burn patient, it is essential that the patient be properly stabilized prior to the transfer process. The principles of stabilization are implemented during the primary and secondary assessment in the following manner.

A. Respiratory Support

The upper airway should be evaluated for potential obstruction. Signs of lower airway respiratory compromise should be identified. One-hundred percent oxygen should be administered or a nasotracheal intubation should be performed, when indicated.

B. Circulatory Support

Major thermal injury results in a predictable shift of fluid from the intravascular space. Two 16 gauge intravenous catheters should be placed in non-burned areas if possible. If necessary, a venous cutdown should be utilized in preference to central venous access to avoid the risks of hemothorax or pneumothorax.

Ringer's Lactate solution is the fluid of choice, initially infused at 3-4 ml/kg/per-cent TBSA. A bladder catheter should be inserted to provide a means of monitoring the adequacy of fluid resuscitation. Intravenous fluids in the thermally injured adult patient are administered to establish a urinary output of 30-50 ml/hr. In the infant of less than 30 kg, the goal should be 1 ml/kg body weight/hr. In children over 30 kg, adequate fluid resuscitation is assumed with a urinary output of ½ ml/ kg/hr. Fluid resuscitation in patients with electrical injuries is less predictable. Ringer's Lactate solution should be infused at a rate to provide an hourly urinary output in the adult of 75-100 ml/hr.

C. Gastrointestinal

All patients should be NPO until transfer has been accomplished. A nasogastric tube should be inserted in all patients with burns that exceed 20 percent BSA and in all intubated patients.

D. Burn Wound Care

All burn wounds should be covered with a clean, dry sheet. A blanket may be needed to maintain body temperature. It is imperative that the patient remain warm during stabilization and transfer. Do not delay transfer for debridement of the

wound or application of an antimicrobial ointment. Cold application is to be avoided.

E. Pain Medication

Small doses of intravenous narcotics are often needed. Dosages are influenced by co-existing injury or pre-existing medical conditions. It is essential to monitor patients for respiratory depression induced by pain medications.

F. Tetanus Immunization

The tetanus prophylaxis administered should be consistent with the recommendations of the American College of Surgeons. Tetanus prophylaxis can be delayed for 72 hours to ascertain patient tetanus immunization status, but such a deferral must be specifically recorded so prophylaxis will not be overlooked.

G. Documentation

Transfer records need to include information about the circumstances of injury as well as physical findings and the extent of the burn. A flow sheet to document all resuscitation measures must be completed prior to transfer. All records must include a history and document all treatments and medications given prior to transfer. (See Sample Form)

SAMPLE TRANSFER INFORMATION FORM

Today's date: _____ Time: _____

Information Obtained From: _____ Referring Agency: _____

Referring Physician: _____ Phone #: _____

Patient's Name: _____ Age: ____ Sex: ____ Wt: ____ lb
= ____ kgTime of Burn: _____ Source of Burn: _____ Est
%BSA: _____

Body Areas Burned: _____

Associated Injuries: _____

Other procedures performed (e.g., x-ray): _____

Allergies: _____ Current Meds: _____

Past Medical History: _____

Tetanus: _____ Analgesics Given: _____ Route/Dosage: _____
Time: _____Inhalation: Yes No Intubated: Yes No O₂ _____ per _____

Circumferential: Yes No Where: _____ Distal Pulses: Yes No

Escharotomies: Yes No Where: _____ Pulses After: Yes No

IVs: 1. _____ Rate _____ /hr.

2. _____ Rate _____ /hr

Total IV since burn _____ ml

Output (Foley) _____ past hr. Total Output post burn _____ ml

Rx of Burn _____

Present status of pt: BP _____ P _____ R _____ Combative: Yes No

IV. TRANSFER PROCESS

Physician-to-physician contact is essential to ensure that the patient's needs are met throughout every aspect of the transfer. The referring physician should provide both demographic and historical data, as well as the results of his/her primary and secondary assessment.

The decision as to the means of transportation and the required stabilization measures should be made by the burn center and the referring physician, working in collaboration. The actual transport should be conducted by personnel trained in burn resuscitation. In most cases and subject to state law, the referring physician maintains responsibility for the patient until the transfer is completed.

A transfer agreement between the referring hospital and the burn center is desirable and should include a commitment by the burn center to provide the transferring hospital with appropriate follow-up. Quality indicators will provide continuing education on initial stabilization and treatment of burn patients.

V. SUMMARY

Patients with electrical, chemical or thermal injuries who meet the ABA Criteria for Burn Center Referral should be assessed, stabilized, and promptly transferred to a burn center. Burn center personnel must be available for consultation and may assist in stabilization and preparation for transfer.

VI. SELECTED REFERENCES

Sheridan R, Weber J, Prelack K, Petras L, Lydon M, Tompkins R. Early burn center transfer shortens the length of hospitalization and reduces complications in children with serious burn injuries. *J Burn Care Rehabil* 1999 Sep-Oct. 2000;20:347-50. *(Demonstrates that delay in transfer of seriously burned patients compromises outcome, increases length of hospitalization and increases costs.)*

Vestrup JA. Interinstitutional transfers to a trauma center. *American Journal of Surgery*. 1990;159:462-5. *(Reviews protocols for transfer of seriously injured patients.)*

Young JS, Bassam D, Cephas GA, Brady WJ, Butler K, Pomphrey M. Interhospital versus direct scene transfer of major trauma patients in a rural trauma system. *American Surgeon*. 1998;64:88-91. *(Reviews indications for transfer of seriously injured patients directly to specialty centers.)*

9

Disaster Management and the ABA Plan

OBJECTIVES

Upon completion of this session, the participant will understand:

- Why burn injuries are best cared for at hospital burn centers
- The tiered system of local, state and federal response to mass casualty disasters
- The key role of the incident commander in the primary triage of burn patients to burn centers
- The guidelines for secondary triage when a burn center has reached surge capacity

I. KEY BACKGROUND FACTS

Burn injuries are common in mass disasters and terrorist acts.

In general, in most traumatic events, approximately 25% – 30% of the injured will require burn care treatment. About one-third of those hospitalized in New York City on 9/11 had severe burn injuries; the Pentagon attack resulted in 11 burn patients, again a high percentage of those injured.

Burn center care is the most efficient and cost-effective care for burn injuries.

Burn injuries are not like other trauma injuries; burn injuries often require a lengthy course of treatment as compared to simple or even complex trauma patients. For example, for burn patients with 50% body surface area burn (BSA), the average length of stay in the ICU = 50 days. In a mass casualty, the average burn is typically greater than 50% BSA.

Burn centers are not the same as trauma centers.

While there are literally thousands of trauma centers in the United States, there are only 132 burn care centers throughout the country, representing 1,897 burn beds nationwide. And of the 132 burn centers, only 43 are currently verified through a rigorous joint review program of the American Burn Association (ABA) and the American College of Surgeons (ACS) to assure the center has the resources for the provision of optimal care to burn patients.

Burn centers are a unique national resource.

Given the unique nature of burn care and the nationwide availability of highly-specialized burn care systems established to address the complex nature of burn injuries, burn centers have been specifically recognized in federal bioterrorism legislation, with subsequent action of the U.S. Department of Health & Human Services (HHS) to incorporate burn centers in state and local disaster plans. Furthermore, while most burn surgeons have the expertise and training to treat burn—as well as trauma—victims in the event of a mass casualty, the reverse is not necessarily so—which supports the need for unique benchmarks to ensure that the needs of the burn-injured are met in the event of a terrorist incident.

The American Burn Association has the capacity to be a key component in national disaster readiness for mass burn casualties.

The ABA responded within hours to national and state agencies with burn resource information following the 9/11 tragedies, and on an ongoing basis during preparations for the war in Iraq.

II. DEFINITIONS, SUPPORTING DOCUMENTATION, AND KEY POLICY STATEMENTS

Mass Burn Casualty Disaster

Any catastrophic event in which the number of burn victims exceeds the capacity of the local burn center to provide optimal burn care. Capacity includes availability of: burn beds, burn surgeons, burn nurses, other support staff, operating rooms, equipment, supplies, and related resources.

Surge Capacity

Surge capacity is the capacity to handle up to 50% more than the normal number of burn patients when there is a disaster. Normal capacity will be different for each burn center, may be seasonal, and will vary from week to week or possibly even day to day.

Primary Triage

Primary triage is triage which occurs at the disaster scene or at the emergency room of the first receiving hospital. Primary triage should be handled according to local and state mass casualty disaster plans. Under the federal bioterrorism legislation and the implementation actions of the Health Resources and Services Agency (HRSA) of HHS, state disaster plans must incorporate burn centers into such plans.

ABA Primary Triage Policy

Burn patients should be triaged to a burn center within 24 hours of an incident. The disaster site incident commander should call the nearest verified burn center regarding available capacity and alternate site burn center information if needed. Appropriate field triage may depend upon the first-responders' and hospital emergency room personnel knowledge of burn triage recommendations. ABA's recommended triage decision table – specific for mass burn casualty disasters and not other situations - is attached hereto as Appendix I.

Secondary Triage

Secondary triage is the transfer of burn patients from one burn center to another burn center upon reaching surge capacity. Secondary triage policy should be put in place at every burn center, with formal written transfer agreements in place.

ABA Secondary Triage Policy

Secondary triage should be implemented by the Burn Center Director when the burn center's surge capacity is reached. Transfer of burn patients should be to verified burn centers when feasible, then to other burn centers, within the first 48 hours following the incident when possible.

III. TIERED RESPONSE PLANS

The magnitude of a disaster will determine whether the response needed is local, regional, or national, and the involvement of local, state or federal government agencies. It is imperative that all elements of the ABA, from local burn units to the national office work together efficiently and interact in a similar manner with various federal, state, and local agencies to create the maximum state of preparedness and the most effective response when a burn mass casualty event occurs. Disaster response in the U.S. is multi-tiered, reflecting limits placed on federal – in particular the military – involvement in local affairs.

Levels of medical response for a burn mass casualty disaster can be ranked as follows, from most to least likely to be employed:

1. State and local response systems

2. National Disaster Medical System (NDMS)

- a) Disaster Medical Assistance Teams (DMAT)
- b) Burn Specialty Teams (BST)

3. Military support to civil authorities

- a) U.S. Army Special Medical Augmentation Response Teams (SMARTs)

Under Homeland Security Presidential Directive 5 (HSPD5), the Secretary of the Department of Homeland Security (DHS) is the principal federal official responsible for domestic incident management. Initial responsibility lies with local and state officials; the federal government assists when state capabilities are overwhelmed, or when federal interests are involved. Implementation of HSPD5 involves two core documents:

- 1) National Incident Management System
- 2) National Response Plan, which includes the National Disaster Medical System

National Disaster Medical System (NDMS)

NDMS manages and coordinates the federal medical response to major emergencies and federally-declared disasters, including natural disasters, technological disasters, major transportation accidents, and acts of terrorism, including those that might involve weapons of mass destruction. NDMS is a section within the Federal Emergency Management Agency (FEMA) in the Department of Homeland Security and works closely with the Department of Health & Human Services (HHS); the Department of Defense (DOD), and the Department of Veterans' Affairs (DVA).

NDMS has three functions:

- 1. medical response to the disaster site
- 2. patient movement from the disaster area to unaffected areas of the nation
- 3. definitive medical care in unaffected areas

Under NDMS, the patient regulation and movement mission is the responsibility of the DOD, and specifically of the Global Patient Movement Requirements Center (GPMRC) of the U.S. Transportation Command, Scott Air Force Base, Illinois.

NDMS may be activated in three ways:

1. the Governor of an affected state may request a Presidential declaration of disaster or emergency
2. a state health officer may request NDMS activation by the Department of Homeland Security
3. the Assistant Secretary of Defense for Health Affairs may request NDMS activation when military patient levels exceed DOD and DVA capabilities

Once NDMS is activated, Federal Coordinating Center (FCC) coordinators collect available bed data and the number of patients who can be processed through a patient receiving area and transported to local NDMS hospitals within a 24-hour period. The DOD operates 24 FCCs and the DVA operates 37 FCCs.

It should be noted that in the preparations for the Iraqi war, there was considerable inaccurate information on burn bed availability through this system. The American Burn Association Central Office worked directly with the U.S. Army Institute of Surgical Research to provide much more accurate and timely burn bed availability information.

Disaster Medical Assistance Teams (DMATs)

NDMS helps to develop local DMATs – each DMAT is sponsored by a major medical center and is comprised of approximately 35 physicians, nurses, technicians and administrative support staff designed to provide medical care during a disaster.

Burn Specialty Teams (BSTs)

BSTs are specialized DMATs affiliated with a local DMAT to allow sharing of assets. They are designed to be deployed along with a DMAT to provide burn expertise. DMATs and BSTs provide a community resource for local and state requirements but can also be federalized to support national needs (see above for the three ways in which NDMS can be activated). Since the inception of BSTs, Dr. Susan Briggs has been the coordinating BST Program Manager. Dr. Briggs is a long-time ABA member and provides an excellent liaison between the American Burn Association and NDMS.

BSTs are primarily designed to augment existing local capabilities. As such, deployment may not involve the entire team. A major goal is to have NDMS teams on scene within 12 hours. The team may direct secondary triage and transfer efforts or assist with evaluation and resuscitation. Each BST is currently led by an ABA member and is comprised of approximately 15 burn-experienced personnel, including: 1 surgeon (team leader); 6 registered nurses; 1 anesthesia provider; 1 respiratory therapist; 1 administrative officer; and 5 support personnel selected based on mission requirements

BST Team 1 –Boston, Medical Director – Robert Sheridan, MD
(rsheridan@partners.org)

BST Team 2 – Tampa, Medical Director – David Barillo, MD (dbarillo@earthlink.net)

BST Team 3 — Galveston, Medical Director – David Herndon, MD
(dherndon@shrinenet.org)

BST Team 4 — Minneapolis/St. Paul: Medical Director – William Mohr, MD
(William.j.mohr@healthpartners.com)

Two more BSTs are currently planned. All BSTs are looking for additional volunteers. When a BST is activated, team members become federal employees during activation, which provides liability coverage and obviates state licensure needs.

IV. ABA ^{needs.} NDMS POLICY

Clearly, there are limitations of the current NDMS system regarding BSTs: not all burn centers are members of NDMS; burn centers that are not located in one of the NDMS metropolitan areas would not receive burn casualties under the NDMS system; some hospitals which report burn bed availability to the NDMS do not ordinarily care for burn patients.

For purposes of NDMS involvement in regional burn disasters, the ABA recommends that the primary function of the NDMS disaster teams should be to assist the local burn center director with secondary triage of burn patients to other burn centers, according to the following prioritization:

- (1) burn centers currently verified jointly by the ABA/ACS;
- (2) other burn centers.

V. ABA BURN BED AVAILABILITY POLICY

The ABA's Central Office is working with the U.S. Department of Health and Human Services Office of Public Health Emergency Preparedness to establish and maintain a real-time burn bed availability program for the nation. In the recent past, the ABA worked with the U.S. Army Institute of Surgical Research on a burn bed resource capacity project. The ABA Central Office will continue to work with HHS and others to develop and maintain a real-time burn bed resource capacity reporting system.

VI. MILITARY SUPPORT TO CIVIL AUTHORITIES (MSCA)

MSCA is the final tier in the nation's disaster response system. Federal resources that may be implemented in the event of a major biochemical or radiation disaster are the U.S. Army Special Medical Augmentation Response Teams (SMARTs). The mission of the SMART teams is to provide short-duration medical liaison to local, state, federal, and DOD agencies responding to disasters, civil-military cooperative actions, humanitarian assistance missions, weapons of mass destruction incidents, or chemical, biological, radiological, nuclear, or explosive incidents. There are thirty-seven SMART Teams, including two Burn SMART Teams operated by the U.S. Army Institute of Surgical Research, Brooke Army Medical Center, Fort Sam Houston, TX.

Since direct involvement of the DOD in a domestic incident is considered beyond NDMS, and is intended to be limited in extent and duration, the Burn SMART Teams have not yet been utilized under MSCA, and have been utilized primarily for long-range air-medical evacuation of combat burn casualties or for assistance to foreign governments following mass casualty events.

VII. ABA BURN SMART TEAM POLICY

The ABA recommends that if needed, the involvement of Burn SMART Teams in regional burn disaster management should be in facilitating secondary triage and transport of burn patients to burn centers outside the disaster area.

VIII.ABA ACTION ITEMS ON DISASTER PREPAREDNESS

In addition to greater interaction between the American Burn Association and HHS, DHS, NDMS and USAISR, following are a number of specific action items that will be taken to enhance overall mass burn casualty disaster preparedness at the national, regional, and local level.

- 1) Distribution of the publication "Burn Care Resources in North America" to the disaster planning agency in every state.
- 2) Communication to the nation's 33,000 fire departments of the availability of burn center resource information and triage recommendations on the ABA web site, as well as the availability of burn center transfer stickers with specific burn center contact information for their area that are designed for placement on first-responder incident boards.
- 3) Communication to fire departments and other first-responders, hospital emergency room physicians in the nation's 7,000 hospitals and others regarding the availability of advanced burn life support (ABLS) training through both the traditional ABLS courses and the new web-based ABLS Now[®] course (federal grants will be sought to underwrite production costs and expansion of this ABLS training).
- 4) Provision of a laminated burn transfer criteria guide to all hospital emergency rooms in the nation, to also contain reference to the ABA web-site information on verified and other burn centers in their area.
- 5) Work with the U.S. Departments of Health & Human Services and Homeland Security to assist in development of mass burn casualty disaster planning at the federal level to include :
 - (a) Provision of the ABA Mass Burn Casualty Disaster Plan and other resource information, such as the ABA's "Burn Care Resources in North America" to relevant federal disaster planning agencies, including information on ABA web-site access for ongoing updates and ABA Central Office contact information.
 - (b) ABA development, in conjunction with HHS, DHS, and private sector entities, of a real-time communication system for burn bed, as well as supplies and personnel, availability.
 - (c) Surge capacity issue discussion, addressing
 - Educational efforts regarding assessment of current nation-wide surge capacity of burn centers and of the desirability of transporting burn victims when secondary triage is necessary rather than transporting burn surgeons and nurses to the

disaster area (noting the potential desirability of temporary use of Burn Specialty Teams under the National Disaster Medical System to both augment burn services at the disaster area and to assist with secondary triage transfer of burn patients to burn centers outside the disaster area);

—Potential for deployable burn care facilities;

—Increasing the number of the National Disaster Medical System (NDMS) Burn Specialty Teams (BSTs).

(d) Related issues for discussion/possible federal legislation proposals include:

—Compensation for the receiving burn center and burn surgeons when the persons transferred are uninsured;

—Preferential reimbursement for verified burn centers, so that these facilities will survive economically and be there as a national resource for mass disaster preparedness;

—The different levels of burn supplies that should be in reserve in the National Strategic Stockpile overseen by the Centers for Disease Control (CDC) in HHS for different numbers of mass disaster burn casualties and interacting with efforts such as the “Customs Trade Partnership Against Terrorism” and the industrial hotline to obtain supplies in a disaster, and drawing upon the expertise of the American Association of Tissue Banks (AATB) relative to availability/transport of skin for burn victims;

—Possible grant funding and/or legislative initiatives to increase the supply of burn surgeons and nurses through educational loan forgiveness and fellowship support;

—Federal grants to increase widespread knowledge of initial burn evaluation and treatment through ABLS and expansion of ABA’s National Burn Repository program to better ascertain resource needs in disaster situations and the most effective triage and care components.

6) Encourage all burn centers to execute a Burn Center Transfer Agreement with other burn centers, as secondary triage transfer from one burn center to another will require a transfer agreement. (The ABA will give consideration to requiring burn center transfer agreements to be in place for verification.)

7) Encourage incorporation into the hospital-specific disaster plan of ABA recommended-triage plan for burn casualty mass disaster situations and provide outpatient care for non-intubated patients with burns < 20% TBSA; also, address issues of communication with families, psychological support needs, and media control.

8) Communication systems to ensure the ability of ongoing communication between emergency personnel, hospitals and disaster response coordinators is a critically important issue that needs to be addressed from the federal, state and local levels.

CHAPTER 9: Appendix 1

Age/TBSA Survival Grid

Provided by Jeffrey R. Saffle, MD
Director, Intermountain Burn Center
Salt Lake City, UT

CAVEAT: This grid is intended only for mass burn casualty disasters where responders are overwhelmed and transfer possibilities are insufficient to meet needs.

This table is based on national data on survival and length of stay.

Triage Decision Table of Benefit-to-Resource Ratio based on Patient Age and Total Burn Size

| Age/ years | Burn Size (%TBSA) | | | | | | | | | |
|---------------|-------------------|--------|--------|--------|--------|-----------|-----------|-----------|-----------|-----------|
| | 0 – 10% | 11-20% | 21-30% | 31-40% | 41-50% | 51-60% | 61-70% | 71-80% | 81-90% | 91+% |
| 0-1.99 | High | High | Medium | Medium | Medium | Medium | Low | Low | Low | Expectant |
| 2-4.99 | Outpatient | High | High | Medium | Medium | Medium | Medium | Low | Low | Low |
| 5-19.9 | Outpatient | High | High | High | Medium | Medium | Medium | Medium | Medium | Low |
| 20-29.9 | Outpatient | High | High | High | Medium | Medium | Medium | Medium | Low | Low |
| 30-39.9 | Outpatient | High | High | Medium | Medium | Medium | Medium | Medium | Low | Low |
| 40-49.9 | Outpatient | High | High | Medium | Medium | Medium | Medium | Low | Low | Low |
| 50-59.9 | Outpatient | High | High | Medium | Medium | Medium | Low | Low | Expectant | Expectant |
| 60-69.9 | High | High | Medium | Medium | Medium | Low | Low | Low | Expectant | Expectant |
| 70+ | High | Medium | Medium | Low | Low | Expectant | Expectant | Expectant | Expectant | Expectant |

Definitions:

OUTPATIENT: Survival and good outcome expected without requiring initial admission

HIGH BENEFIT/RESOURCE: Survival and good outcome expected (survival greater than/equal to 90%) with limited/short term initial admission and resource allocation (LOS less than or equal to 14 days, 1-2 surgical procedures).

MEDIUM BENEFIT-RESOURCE: Survival and good outcome likely (survival greater than 50%) with aggressive care and comprehensive resource allocation, including initial admission (greater than/equal to 14 days), resuscitation, multiple surgeries.

LOW BENEFIT-RESOURCE: Survival and good outcome less than 50% even with long-term, aggressive treatment and resource allocation.

Appendix

I. SPECIAL CONSIDERATIONS

II. RADIATION BURNS

III. TOXIC EPIDERMAL NECROLYSIS ("TEN")

IV. COLD INJURIES

V. CHILD ABUSE

VI. PREGNANT BURN PATIENT

VII. TETANUS



APPENDIX 1. SPECIAL CONSIDERATIONS

A. INITIAL ASSESSMENT AND MANAGEMENT

1. Admission Data

The circumstances surrounding the injury can be very important to the initial and ongoing care of the burn patient. When obtaining a report from pre-hospital personnel, try to obtain as much information as possible in regards to the scene and the circumstances surrounding the injury. Check with family members or co-workers regarding events surrounding the injury. You may obtain additional important information. Document as many details as possible.

For example:

"Prehospital personnel report that the patient stated he was burned while priming the carburetor. However, at the scene the patient was found in a garage with the door closed, no car was in the garage, and there was methamphetamine paraphernalia in the garage."

or

"Prehospital personnel report that the patient's mother stated the burn injury to the toddler was caused by hot soup pulled off the stove. However, pre-hospital personnel report that no soup was found anywhere in the kitchen."

2. Initial Care Considerations

- Initially burn patients are awake, alert, and oriented. This is an important time to gain as much information as possible from the patient, such as: history of events, AMPLE (allergies, medications, previous illness, last meal or drink, and events related to the injury), family information, phone numbers, and advance directives.
- Remember although a major burn patient may "look good" initially, he or she has the potential for becoming critically ill over the next several hours. The need for reassessment cannot be over emphasized.
- Don't let the sight and smell of the burn distract you from performing a very thorough, step-by step assessment.
- Check blood work and notify physician of results.
- Healthcare personnel should wear appropriate isolation attire to protect themselves and the patient.

3. Heat Loss and Hypothermia

- The burn patient is in constant danger of becoming hypothermic due to skin loss. Therefore, the mechanisms by which hypothermia is precipitated should be kept in mind: conduction-heat loss occurs when warm surfaces are in direct contact with cold surfaces, convection-heat loss occurs when air is circulated over body surfaces ('chill factor'), evaporation-heat loss occurs from perspiration, open wounds, and respiration; and radiation-heat loss occurs when infrared or electromagnetic waves radiate from the warm body to cold surfaces.

- In addition to the burn injury, the following can predispose the patient to hypothermia: alcohol intoxication, malnutrition, and vasodilators.
- Nurses can play a key role in the prevention of hypothermia. The following are a few suggestions to maintain body temperature:
 - Ensure that no wet dressings or linens are in contact with the patient
 - Use a fluid warmer to infuse fluids
 - Maintain a warm ambient room temperature (e.g., close doors to avoid drafts)
 - Cover the patient, including burned areas, with a clean blanket and cover the patient's head with a towel or sheet (as much as 50% of heat loss is from the head)
 - Tuck sheets in under the patient to prevent heat loss

4. Patient/Family Teaching

Shock and disbelief are early emotional responses to traumatic events. For most individuals, cognition is greatly diminished and the ability to problem-solve is impaired. Anger can also be a component of the early emotional response. Some individuals move quickly to a stage of attribution of blame or fault.

The nurse should provide general information to the family before their initial encounter with the burn patient. The nurse should answer the patient's questions honestly and provide emotional support, recognizing the psychological reactions to trauma. Essential points during this interaction include:

- Introduction of personnel who will be caring for the patient
- Reassurance that measures are being taken to provide for the patient's comfort
- Identification of a family spokesperson
- Clarification of information provided by the medical team.

B. AIRWAY MANAGEMENT AND SMOKE INHALATION INJURY

1. Admission Data

- Assess and reassess the patient for inhalation injury. REMEMBER—inhalation injury may not be apparent initially.
- Observe the patient for subtle voice changes.
- If inhalation injury is suspected, have the patient take a deep breath and cough into a white tissue. Observe sputum for soot or carbon particles.
- If intubation is required, make every effort to obtain history of events, AMPLE (allergies, medications, previous illness, last meal or drink, and events related to the injury), family information, phone numbers, advance directive, etc., prior to intubation.

2. Patient Care and Comfort

- Elevate the head of the bed 30 degrees to minimize facial and airway edema, and to prevent possible aspiration.
- Secure the endotracheal tube once the patient is intubated. REMEMBER—adhesive tape does not stick to burned skin. Document the size of the endotracheal tube and marking on tube at the teeth (or gumline).
- Medical immobilization utilizing soft restraints may be necessary to prevent self-extubation.
- Use appropriate medication for pain and sedation in order to facilitate maintenance of the airway.
- Perform pulmonary toilet using sterile technique as often as is necessary to maintain a clear airway and minimize contamination.

3. Patient/Family Teaching

- Provide explanations regarding smoke inhalation and/or compromise to the airway. Intubation and mechanical ventilation usually will cause a tremendous amount of anxiety in the patient and family members. Answer all questions as needed.
- Reinforce any information provided by the physician and instruct the patient to report any change in feelings of discomfort or difficulty in breathing.

C. SHOCK AND FLUID RESUSCITATION

1. Admission Data

- Fluids must be changed to Lactated Ringer's as soon as possible. Often patients come from the field with Normal Saline running instead of the recommended Lactated Ringer's.
- Documentation of the type and amount of fluid received in the field and in the emergency department is important to prevent over- or under-resuscitation.
- Obtain a "dry weight" on the patient as early as possible in order to accurately calculate resuscitation fluid requirements.
- Urine output, central venous pressure, and pulmonary artery pressures must be monitored and documented hourly and trended to identify changes in response to resuscitation.
- Monitor for common electrolyte abnormalities which include: acidosis, hyperkalemia, and hyponatremia. Appropriate resuscitation will often correct these abnormalities in the first 24-48 hours.

2. Patient Care and Comfort

- Fluid may require administration via a blood/fluid warmer to prevent and/or correct hypothermia.
- Use of a fluid administration pump is often necessary to maintain accurate fluid administration.

- Monitor glucose at the bedside in pediatric patients, in order to prevent hypoglycemia.
- Diuretics are rarely indicated in the emergent phase of burn injury.
- The consensus formula is only a guideline for resuscitation. Patients with electrical injury, inhalation injury, delayed resuscitation, and prior dehydration may require additional fluid.
- “Volume-Sensitive Patients” include those at the extremes of age as well as patients with pre-existing cardiopulmonary disease.
- Ensure that the intravenous line is well secured. REMEMBER—adhesive tape will not stick to burned skin.
- Ensure that intravenous fluids are infusing at the appropriate rate.
- Ensure that the intravenous site has not infiltrated.

3. Patient / Family Teaching

- Provide explanations about fluid resuscitation, as needed.

D. BURN WOUND MANAGEMENT

1. Admission Data

- Continuously assess the patient for signs and symptoms of circulatory compromise of burned extremities. Due to edema, you may be unable to palpate a pulse. In this case, a Doppler flowmeter can be useful in detecting the pulse.
- REMEMBER: Changes from baseline status are important.

2. Patient Care and Comfort

- Initial wound care includes removal of burning agent and keeping the patient warm.
- Elevation of all burned extremities—preferably above the level of the heart—is important to minimize edema. Slings or multiple pillows may be used to facilitate extremity elevation.
- If escharotomies are performed at the bedside it is important to minimize bleeding and promote hemostasis. This can be facilitated by use of a surgical bovie, packing of escharotomy sites, application of a pressure dressing, and elevation of the extremity.
- Prevention of hypothermia will also help with hemostasis, as hypothermia can result in coagulopathy.
- The head of the bed should be elevated to 30 degrees when facial burns are present.
- Pillows should be avoided for patients with neck or ear burns.
- Prior to dressing application, remember to keep sheets tucked in around the patient. This will decrease air currents over the wound, which can cause pain and hypothermia.

3. Patient/Family Teaching

- Provide explanations of the appearance of the burn patient, especially if there are significant facial burns. The patient and his or her family should be prepared for facial edema and the subsequent swelling shut of the eyes. They should be informed that this is only temporary.
- Provide information to the family regarding the extent and depth of the burn.

E. ELECTRICAL BURNS

1. Admission Data

- Compartment syndrome commonly occurs with high voltage electrical injury when an extremity is involved. Monitor the patient for signs and symptoms of compartment syndrome: pain, pallor, pulselessness, paresthesia, or paralysis.
- Continuous ECG monitoring may be required for patients who have sustained a high voltage electrical injury.
- Electrically injured patients have a higher risk for associated trauma, fractures, and spinal cord injuries.

2. Patient Care and Comfort

- Preparation for surgical fasciotomy may be necessary.
- Control of bleeding after the fasciotomy can be facilitated by use of a surgical drape, packing of fasciotomy sites, application of a pressure dressing, and elevation of the affected extremity.

3. Patient/Family Teaching

Provide the patient with emotional support and answer questions honestly.

F. CHEMICAL BURNS

1. Admission Data

- While the immediate treatment of water irrigation will stop the burning process, the systemic absorption of the chemical agents may be a concern. Many toxic materials and liquids have complex chemical compositions. Therefore, additional data should be gathered, which may be useful if systemic treatment is needed. If there is suspicion of systemic absorption in sufficient quantities to cause systemic pathology, the nurse should identify any individual with immediate knowledge of the injury event and gather information regarding the time of exposure and administered first aid—in order to augment data from EMS personnel. Also, if possible, the medical team should determine the specific chemical agent involved, by directing an individual with injury-event knowledge (other than the patient) to obtain the container of the product and bring it to the hospital.
- Take necessary caretaker precautions. Wear protective clothing, including eyewear.

2. Patient Care and Comfort

- Removal of the chemical must occur with the primary survey and removal of all clothing.

- Irrigation is often uncomfortable and injury pain can be severe. Nursing interventions include efforts to minimize patient cooling, by warming irrigant and by using warming lights, fluid warmers, and bed warmers.

3. Patient/Family Teaching

- Provide explanations of the irrigation process, the extent and depth of the chemical burn, and any information you have on the chemical.

G. PEDIATRIC BURN INJURIES

1. Admission Data

- Obtain basic health status information including immunization history and last tetanus inoculation, allergies, and other health problems. Admission weight is important.
- Identify the parent, guardian, or significant-other most likely to be able to provide support to the child.
- Direct other family members and significant-others to an identified waiting area.

2. Patient Care and Comfort

- Stabilization of the pediatric artificial airway requires special caution.
- Prevention of hypothermia is a priority of care with pediatric burn patients. Measures to increase environmental temperature and the use of warming devices are necessary to prevent hypothermia.
- Hypoglycemia is common in children, so it is important to monitor resuscitation glucose at the bedside routinely.
- Maintenance fluids must also be added into the fluid requirements for a pediatric burn patient.
- Nursing interventions to relieve pain and fear responses are both pharmacologic and non-pharmacologic. The latter include efforts to establish a calm environment, eliminate loud noises, limit intrusions, minimize activity at the bedside, and reduce lighting if possible.
- Minimize the time needed for procedures by preparing all necessary equipment and supplies in advance.
- Perform procedures with the patient in the most comfortable position, such as being held by a family member.

3. Patient/Family Teaching

- The family of the injured child plays an integral role in the treatment of the child. In the case of a severely burned child, immediate family presence may be an obstruction to the accomplishment of life-sustaining measures. However, in most cases, the direct involvement of a trusted adult can help alleviate the fright that many children feel when they are seriously injured. Conversely, if this adult is visibly, emotionally distraught, the child's feelings of fear may escalate. Enlistment of a family member to support the child during care is a priority.
- Some individuals move quickly to a stage of attribution of blame or fault, especially in the case of pediatric injuries. Expressions of strong emotion in the presence of the injured child are not helpful and need to be avoided.

- Age-appropriate explanations of all procedures should be provided to the patient before performing them.

4. Considerations in Suspected Non-Accidental Injury

- Nursing interventions to ensure patient safety include listening to the report of mechanism of injury carefully and documenting statements precisely, including the name and relationship of the individual making the comments.
- Consider the reported mechanism of injury in relationship to the distribution and depth of the burn injury and the child's developmental ability to have been injured in the manner described.
- If non-accidental injury is suspected, intervene to provide patient safety by ensuring continual staff presence with the patient and by arranging for medical care transport of the patient if the severity of the injury dictates further care at another facility.
- If possible, ask the child what happened without potential abusers in the room. Document the child's comments precisely.

H. STABILIZATION, TRANSFER AND TRANSPORT

1. Admission Data

- Be sure that all forms, labwork, and patient belongings accompany the patient.
- Make sure that all fluids, narcotics (including route administered), and output has been accounted for on the documentation.
- Remember to pass along to the burn center important scene information that was obtained by pre-hospital personnel or witnesses.

2. Patient Care and Comfort

- Whenever possible, try to provide an opportunity for a visit between the burn patient and his or her family members prior to transfer. It may be several hours before the family is able to see the patient, and during this time their condition can worsen drastically.
- Prior to transfer, make sure that actions have been taken to reduce the risk of hypothermia.
- Prior to transfer, ensure that intravenous lines and other access devices are very well secured.

3. Patient / Family Teaching

- The nurse (in collaboration with the physician) should inform the patient and family of plans to transfer the patient. This should include: the method of transfer; the time it will take to reach the destination; the name, address and telephone number of the hospital; and the physician who will be assuming the care of the patient.
- Provide the family with directions to the burn center.

APPENDIX II. RADIATION BURNS

I. Introduction

Radiation burns are usually localized and are indicative of high radiation doses to the affected area. Radiation burns are identical in appearance to thermal burns with the major difference being in the time between exposure and the clinical manifestation of the injury. This time delay may be from days to weeks depending on the level of the dose.

II. History

A careful history of potential radiation exposure is critical. For example, a radiation worker who developed a skin burn without any recollection of heat exposure would be suspect for having received a radiation burn.

III. Safety Priorities

Priorities when encountering a radiation-injured patient are saving of life, prevention of further injury, decontamination, prevention of exposure to attending personnel, reduction of the spread of contamination, and prevention of damage to the facility.

IV. Wound Management

Any wound to the skin should be presumed to be contaminated until there is evidence to the contrary. Decontamination should, therefore, commence on the wounded areas before proceeding to the intact skin. Copious irrigation with water or saline will remove most of the contaminants from the area. Continue irrigation until a survey of the area indicates a steady state or minimum radiation count.

V. Radiation Effects

Radiation doses in excess of 300 RAD cause erythema similar to a first-degree thermal burn. Blistering occurs with doses between 1000 and 2000 RAD and doses greater than 2000 RAD may produce radionecrosis or full thickness injury. In most cases, radiation burns are usually contamination free and represent no hazard to anyone other than the patient as these are often caused by x-ray or gamma radiation sources.

What other issues are important in the later medical management in such a patient? Mature cells suffer little damage from radiation in most instances while those with a high degree of mitotic activity are vulnerable. Blood cells and intestinal cells have short lives and therefore depression of blood cell counts in peripheral blood and intestinal ulceration develop rapidly in the presence of high doses of radiation. In doses exceeding 200 RAD, a severe reduction in circulating leucocytes, nausea and vomiting, hair loss and immunosuppression may occur. As the dose may never be known with certainty in patients sustaining a radiation injury, definitive care will involve monitoring the patients for signs of bone marrow failure, gastrointestinal symptoms and immunosuppression.

Patients with severe radiation injury are rarely encountered. Early notification of the hospital's radiation safety officer as well as early communication with the nearest burn center should occur.

APPENDIX III. TOXIC EPIDERMAL NECROLYSIS ("TEN")

I. Introduction

Toxic Epidermal Necrolysis (TEN) is an exfoliative dermatitis frequently associated with mucosal involvement of the conjunctiva and gastrointestinal tract. The syndrome has multiple etiologies including a reaction to drugs or staphylococcal toxin. It has also been described in association with viral infections. Of interest, in about 26 percent of the cases, no etiology can be found.

Staphylococcal scalded skin syndrome (SSS) occurs primarily in children and shares some characteristics with TEN. It is caused by a strain of *S. aureus*, which releases an exotoxin that causes subgranular intra-epidermal cleavage. A distinguishing feature is the absence of mucous membrane involvement.

The most common etiological agents have been drugs, including penicillin, sulfas, anticonvulsants, and anti-inflammatory agents. Infectious causes such as herpes simplex, mycoplasma, meningococcus, septicemia, and measles have also been implicated. In contrast to SSS, in Stevens-Johnson Syndrome, the epidermal split is at the dermal/epidermal junction, thus one can quickly differentiate SSS from TEN by microscopic examination of the denuded skin.

Recommended treatment for TEN in the past has included steroids and prophylactic antibiotics. However, the similarity in the wounds of thermally injured and TEN patients has resulted in the management of TEN patients in burn centers, with a marked increase in survival. In addition to the superficial loss of epithelium, TEN patients also have increased evaporative water losses, a need for nutritional support, and the application of biological dressings.

II. Initial Assessment

A. History

With skin lesions that do not have a history of thermal injury, one must obtain a careful history for recent infectious diseases and drug usage. A history of the prodrome of fever, malaise, and systemic toxicity is frequently obtained.

B. Physical Examination

Initially, the target lesions have a central blister with circumscribed erythematous zones. The areas of erythema are secondary to extravasation of erythrocytes from the dermal plexus. The lesions often combine to form a generalized erythematous papules and bullae. Edema of the face and perioral ulceration are common. In severe cases, the disease process is not limited to cutaneous regions and frequently involves oral, genital, and ocular mucosa. Mucosal ulcerations and cutaneous lesions classically become denuded, appear "lobster-red," and are tender. Clinically, the areas are identical to partial thickness thermal burns.

III. Initial Stabilization

A. General Clinical Management

- Patients should not be treated with steroids.

- Systemic antibiotics should be limited to use for specific infections.
- Adequate electrolyte and fluid replacement should include evaporative water loss prior to the application of biological dressings.
- Supportive care should be directed toward limiting or preventing pulmonary complications, maintaining normal nutrition, and preventing infection.

B. Wound Management

Sophisticated wound management is necessary in the care of the patient with TENS. Therefore, to decrease desiccation of the dermal layer, provide appropriate wound management, and increase patient survival, immediate transfer to a burn center is mandatory.

IV. Summary

Toxic epidermal necrolysis is a superficial exfoliative dermatitis with clinical manifestations very similar to superficial partial-thickness burn injury. Early coverage of the denuded areas with biological dressings has provided the best wound management. Early consultation and transfer to a regional burn center is essential.

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APPENDIX IV. COLD INJURIES

I. Introduction

Cold injury most commonly occurs secondary to environmental exposure without appropriate protection. Injury can be localized (frostbite) or systemic (hypothermia). The physiological changes associated with cold injuries are distinct from heat injury and a distinct therapeutic approach is required. Military personnel, winter sports enthusiasts, older adults, and the homeless are the populations most at risk for these injuries.

II. Frostbite

A. Pathophysiology

Injurious cold exposure causes a chilling of the body tissue fluids, followed by the formation of ice crystals within the extracellular and intracellular fluid. This causes the cells to dehydrate and shrink, and alters blood flow to the area, produces abnormal intracellular salt concentrations, and leads to tissue destruction. With thawing, further damage occurs as barrages of emboli race through the microvasculature. Not all tissue components freeze/thaw at the same rate; blood vessel linings are particularly sensitive. It often takes several weeks to determine the full extent of injury.

B. Signs and Symptoms

The patient presents with coldness of the extremity, and most report that the affected area is insensate, clumsy, or feels as though it is missing. The limb appears mottled blue or yellow-white. Rapid rewarming produces immediate redness of the affected extremity, and this is often accompanied by pain. Edema (swelling) and blisters soon follow over the next 24 hours, and these can last five days or longer depending on the severity of the injury. By 2 weeks, severely frostbitten skin forms a thick black dry eschar. This progresses to mummification with a clear line of demarcation by 3 to 6 weeks. It is difficult to discern the depth of injury on early examination, despite the suggested depth noted in the following table. Time and patience often result in remarkable preservation of tissue.

| MILD INJURY | DEEP INJURY |
|---------------------------------|--|
| Bright red or normal coloration | Deep purple and cool |
| Warm | Blisters containing red or purple fluid |
| Pinprick sensation present | Does not blanch with pressure |
| Painful | Minimal pain |
| Paresthesias | Small hemorrhagic vesicles that occur late and do not extend to the tips of digits |
| Large vesicles with clear fluid | Slow onset of edema |
| Rapid onset of edema | Deep structures demarcate and mummify |
| Superficial eschar | |

C. Treatment

The initial therapy for frostbite is the same regardless of the perceived depth of injury. All constrictive and damp clothing should be removed and replaced with dry, loose garments. No attempt should be made to rewarm the extremity prior to transfer to a specialized treatment unit (if possible within 2 hours). The injured limb should not be rubbed or massaged, as this might exacerbate the injury. The extremity should be padded, splinted and elevated. Exposure to car heaters or campfires that might produce a partial rewarming should be avoided. If transport is prolonged and the extremity thaws, great care should be taken to prevent re-freezing of the extremity, and the patient should be protected from cold exposure. Care must be taken to diagnose and treat concomitant injuries, including systemic hypothermia. Fluid resuscitation is rarely required for isolated frostbite.

Once admitted to the specialized center, the affected areas should be rewarmed by immersion into gently circulating water at 40–42° C for 15 to 30 minutes. Pain medication should be provided as needed. Clear or white blisters are debrided, while purple/bluish blisters are left intact. Tetanus prophylaxis should be administered. Ibuprofen may be of some benefit in limiting injury. Early amputation prior to definitive demarcation (which can take weeks or months to occur) is generally discouraged, as patience can often result in increased functional limb length.

III. Hypothermia

A. Pathophysiology.

Primary accidental hypothermia due to overwhelming environmental exposure or cold water immersion is relatively rare, accounting for approximately 500 deaths per year in the United States. Mortality is 23% if core temperature drops to 32°C, and deaths are attributable to associated diseases. Alternatively, **secondary** accidental hypothermia occurs when a mild cold stress is combined with illness, injury (such as a major burn wound) or drug-induced alterations in heat production and thermoregulation. For example, older adults have impaired ability to increase heat production and decrease heat loss by vasoconstriction, placing them at risk for hypothermia even in moderately cold environments. This is often a much more lethal situation; a core temperature reduction to 32°C in secondary accidental hypothermia is almost always fatal.

| Hypothermia Class | Core Temperature (°C) | Core Temperature (°F) | Characteristics |
|-------------------|-----------------------|-----------------------|--|
| Mild | 32°C-35°C | 90°F-95°F | Alterations in oxygen supply and demand; coagulopathy |
| Moderate | 28°C-32°C | 82.4°F-89.6°F | Altered level of consciousness, cardiac dysrhythmia, altered pH regulation, cold-induced diuresis, respiratory depression, rewarming shock, core afterdrop |
| Severe | 20°C-28°C | 68°F-82.3°F | No shivering, decreased metabolism, passive heat loss accepted |
| Profound | 14°C-20°C | 57.2°F-67.9°F | Asystolic arrest |

Severity of hypothermia is outlined in the above table. There are four primary mechanisms of heat transfer: conduction, convection, radiation and evaporation. These are important in planning heat loss prevention and in selecting methods for active rewarming.

B. Signs and Symptoms of Hypothermia

Signs and symptoms of hypothermia are vague and non-specific. Altered levels of consciousness are present in 90% of patients with core temperatures less than 32°C and range from mood changes, poor judgement, and confusion to severe agitation and coma. Because of this, hypothermia can mimic other disease states, such as cerebral vascular ischemia, hypothyroidism, alcoholism, and diabetic coma.

A standard clinical thermometer will not register below 93°F; therefore, a laboratory thermometer or a special thermocouple must be used to determine temperatures this low. Core temperature is clinically approximated by rectal temperature.

C. Treatment

The prompt initiation of rewarming is important. All wet clothes are removed. If the patient has mild hypothermia and is alert, wrapping the patient with warm blankets and giving him or her hot liquids to drink is the preferred method of rewarming. Shivering will generate body heat, albeit at a metabolic cost. Even with moderate hypothermia, passive warming is effective if shivering is present. Since many of these patients are unconscious, warm intravenous fluids are also highly effective. Other active rewarming techniques are necessary if these measures fail to elevate the body temperature faster than 1 to 2°C per hour, if the initial core temperature is below 28°C, or if cardiac activity has ceased before or during rewarming.

Active rewarming can be accomplished by placing the patient in a circulating water bath at 40°C. Warm water immersion is the most effective conductive rewarming technique. However, it is complicated by sudden ventricular fibrillation, especially in hypovolemic patients. If this occurs, the patient must be dried prior to defibrillation or the charge can short to the ground, making it ineffective or even causing burn injury. It is impractical to use in many surgical patients.

External heating using convective heating blankets is more effective than electric or cotton hospital blankets and is based on the principle that nearly all heat loss occurs through the skin surface. At 37°C, all conductive, convective and radiant heat loss will cease. Overhead radiant heat shields are inefficient at heat transfer, and can place a patient at risk for burns and interfere with the shivering mechanism. Aluminized space blankets can minimize radiant heat loss but allowing air to circulate between the patient and the blanket interferes with their effectiveness. Proper use requires that the patient be carefully wrapped and that additional standard blankets be placed on top of the aluminum blanket to minimize air flow around the patient.

Core heating can be accomplished with pleural and peritoneal lavage. Difficulties with fluid return make pleural lavage easier to perform than peritoneal lavage. In general, a two tube approach is used with a continuous infusion and a continuous outflow. Cardiopulmonary bypass is the most effective rewarming technique, and has the additional advantage of supporting the circulation at the same time. The potential complications of such invasive procedures, however, may outweigh any advantages. Newer methods of extracorporeal circulation or continuous arteriovenous hemodialysis could prove to be just as effective.

Systemic acidosis needs to be continuously monitored with arterial blood gases during resuscitation and rewarming. Periodic sodium bicarbonate therapy may be utilized to control the systemic acidosis. Electrocardiographic monitoring should be carried out continuously during rewarming. Ventricular dysrhythmias should be treated with intravenous Lidocaine if necessary. Ventricular fibrillation should be anticipated and measures for immediate resuscitation should be provided during the rewarming phase.

If asystole/ventricular defibrillation occurs, CPR should be initiated and should continue during rewarming efforts. CPR should not be discontinued until the patient's temperature reaches 36° C or until unassisted perfusion returns to normal. Patients in cardiac arrest should not be declared dead until they are rewarmed and continue to fail to respond to CPR.

Following rewarming, secondary assessment should be carried out to identify predisposing or contributing diseases, which may include septicemia, diabetes mellitus, cerebral ischemia, hypothyroidism, or alcoholism.

IV. Summary

Cold injuries can range from very mild frostbite to systemic hypothermia. Many times the severity of the exposure to cold and the associated injuries are underestimated. Hypothermia may mimic other disease states and tissue damage because exposure to the cold is often more extensive than it initially appears. Consultation with a burn center is encouraged to help plan the appropriate course of management for these individuals.

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APPENDIX V. CHILD ABUSE

I. Introduction

Child abuse is a social stigma that surfaces in all cultures of society. The frequency of thermal injury in child abuse cannot be understated. It is essential for health care providers to be aware of the possibility of child abuse and need for protection of the child if indicated.

II. Characteristics of Abusing Parents

Socioeconomic barriers do not exist in child abuse. It has been suggested that reporting child abuse frequently falters in the middle and upper income families. Parents lacking adequate social support have been identified as more abusive to their children. Parents who abuse each other may be more violent with their children. Certainly parents who were abused in their childhood tend to be abusing parents themselves. Although guardians, friends, and babysitters have abused children, most abuse occurs by the parents. Children born with birth defects, a last born child, or a child living in the midst of marital turmoil are also identified as those highly susceptible to child abuse.

III. Physical Manifestations

The physical manifestations of child abuse have been described as the battered child syndrome. The battered child was initially associated only with physical injury such as bruises, burns, and fractures. However, multiple family studies support the concept of child abuse as a spectrum of maltreatment. Abuse may range from psychological abuse or simple neglect to calculated, repeated physical or sexual abuse. Physical child abuse victims frequently present with thermal injuries of varying degrees.

IV. Thermal Injuries

Thermal injuries most frequently associated with child abuse are contact burns or scald injuries. Each member of the health care team must be alert to the thermal component of child abuse. Alerting factors include the history of injury, the compatibility of the history with the manifest injury, and the physical aspect of the injury.

A. History

The history of injury should correlate with the physical findings. For example, a child presenting with burns on the palmar surface of the hand and fingers was reported to have crawled across the grate of a floor furnace. The examination revealed burns on the entire palm of the hand as well as the flexor surfaces of all fingers, suggesting that the outreached hand was held in contact with the hot surface. Of equal significance was the symmetrical finding of thermal injury to both hands, strongly suggesting that the child was forcibly held in contact with the grate. The history also becomes important in identifying repetitious hospital visits for accidental injury. Not infrequently, the hospital visits will be made at different hospitals to avoid disclosure and identification.

B. Manifested Injury

The symmetry of burns should strongly suggest child abuse in the patient under four years of age. Careful correlation with the provided history will raise the index of suspicion, as in the child whose parents indicated that the child

climbed into a bathtub of hot water. Examinations revealed symmetrical scald injuries of the lower extremities. Infants and children have some awareness of heat and will seldom enter a bathtub without testing the water with one foot. Other instances of scald injury are more blatant with symmetrical scald of the perineum and lower extremities confirming immersion as the mode of injury.

The index of suspicion may be heightened by physical examination of the child. Evidence of multiple injuries of variable duration should strongly suggest abuse. A child presented with scald burns of the perineum with a compatible history that he had spilled a pot of coffee at the breakfast table. Further examination of the child revealed bruises behind the ear and on the chest wall leading to an investigation that established abuse by a boyfriend of the mother.

V. Summary

Failure to recognize the thermal manifestations of child abuse not only negates protection of the child but predicates potential lethal injury.

The responsibility to recognize and report suspected child abuse rests with every member of the health care team. Good Samaritan immunity has been established as a part of the reporting law in each of the 50 states. Most jurisdictions impose a penalty for failure to report.

The ultimate goal in the management of child abuse is the protection of the child from further injury and the initiation of therapeutic measures to restore the family to a stable, healthy environment. Awareness of the patterns of abuse, the behavior patterns of the parents, and the physical manifestations will protect the child by early recognition and reporting.

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APPENDIX VI. THE PREGNANT BURN PATIENT

I. Introduction

The presence of pregnancy in a burn patient must be considered, due to the complications that may occur for the mother and/or child. The possibility of pregnancy must be assumed in any female of the reproductive age group.

Flame and explosions are the most frequent mechanisms of burns. The outcome of the pregnancy is determined by the extent of the mother's burn injury and by the ultimate fate of the mother. Spontaneous termination of pregnancy may be anticipated in those patients with 60 percent or greater body surface burns.

II. Assessment

Initial assessment of the pregnant burn patient should follow the ABCs outlined in Chapter One, Initial Assessment and Management.

Early assessment of the extent and severity of the burn should be estimated utilizing the principles previously outlined. Additionally, assessment of the viability of the pregnancy should be confirmed by fetal monitoring. Uterine contractions or vaginal bleeding may indicate fetal distress or impending delivery. Early consultation with an obstetrician is mandatory.

Fetal life is totally dependent upon stable maternal vital functions. Fetal and maternal monitoring is imperative from the moment of hospital admission until care is complete. In no other instance is continuous communication with and immediate transfer to the burn center more necessary.

III. Management

Initial management of the pregnant burn patient must include immediate stabilization of the airway and provision for oxygen either by nasal prongs or by endotracheal intubation and ventilatory support dependent upon the patient's airway status. Hypoxia is poorly tolerated by both the patient and fetus and predisposes to premature labor or miscarriage.

Respiratory distress and hypoxia increase uterine vascular resistance and thus reduce the uterine blood flow and oxygen delivery to the fetus. Therefore, adequate maternal oxygenation must be maintained in the early hours following the burn injury and particularly during transport to a burn center.

Obstetrical management should be individualized for each patient. Fetal monitoring is useful in detecting fetal distress, and consultation with the obstetrician is helpful. Pregnancy does not seem to alter maternal outcome, and maternal survival is often accompanied by fetal survival. The delivery of a term infant is likely when the mother recovers from a thermal injury.

IV. Complications

Burn complications contribute significantly to the termination of the pregnancy. These complications include hypotension, hypoxia, and fluid and electrolyte disturbances due either to the injury per se or associated conditions such as inhalation injury and mechanical trauma.

Delayed or inadequate early fluid resuscitation may predispose the pregnant burn patient to premature labor and fetal loss. Maternal hypotension may decrease uterine blood flow by as much as 45 percent with a concomitant drop in fetal tissue PO_2 . Since pregnancy is associated with expansion of blood volume, primarily in the plasma fraction, fluid needs may exceed those estimated by the formula; careful and frequent monitoring is essential.

Disseminated intravascular coagulopathy is an OB emergency and patients in the third trimester may appear with resultant alteration in clotting factors, depletion of fibrinogen, and platelets.

V. Summary

Any pregnant patient with thermal injuries requires consultation with a burn center and should be transferred as quickly as possible. The incidence of spontaneous abortion or premature labor is reduced by fluid resuscitation, adequate oxygenation, and the prevention of electrolyte imbalances. These patients need continuous oxygen support in the early hours post burn and fluid resuscitation must be initiated immediately. Constant fetal monitoring is imperative in the second and third trimester.

VI. Selected References

Any BW, McManus WF, Goodwin CW, Mason A, Jr., Pruitt BA, Jr. Thermal injury in the pregnant patient. *Surg Gynecol Obstet.* 1985;161:209-12. (*Review of outcome of burn injury in pregnant patients.*)

Guo SS, Greenspoon JS, Kahn AM. Management of burn injuries during pregnancy. *Burns.* 2001;27(4):394-7. (*A review of the pathophysiology and management of burns in pregnant women.*)

APPENDIX VII. TETANUS IMMUNIZATION

I. Introduction

Attention must be directed to adequate tetanus prophylaxis in the patient with multiple injuries, particularly if open extremity trauma is present. Tetanus immunization depends on the patient's previous immunization status and the tetanus-prone nature of the wound. The following guidelines have been adapted from the ACS Committee on Trauma's "A Guide to Prophylaxis Against Tetanus in Wound Management."

II. General Principles

A. Individual Assessment

The attending physician must determine the requirements for adequate prophylaxis against tetanus for each injured patient individually.

B. Surgical Wound Care

Regardless of the active immunization status of the patient, meticulous surgical care (including the removal of all devitalized tissue and foreign bodies) should be provided immediately for all wounds. Such care is essential as part of the prophylaxis against tetanus; it is the basis of definitive surgical management. Such treatment must be instituted as soon as possible. Therefore, minimal delay in definitive care is indicated.

C. Human Tetanus Immune Globulin (TIG)

Passive immunization with Human Tetanus Immune Globulin (TIG, 250 units) must be considered individually for each patient. The characteristics of the wound, conditions under which it occurred, its age, TIG treatment, and the previous active immunization status of the patient must be considered. TIG is not indicated, however, if the patient has ever received two or more injections of toxoid, unless the wound is judged to be tetanus-prone and is more than 24 hours old. (Equine tetanus antitoxin should not be administered, except when the human antitoxin is not available, and only if the possibility of tetanus outweighs the potential reactions of horse serum.)

D. Documentation

A wallet-sized card documenting the immunization received and the date of the immunization should be given to every injured patient. The patient should be instructed to carry the written record at all times and, if indicated, to complete active immunization. For precise tetanus prophylaxis, an accurate and immediately available history regarding previous active immunization against tetanus is required, or rapid laboratory titration is necessary to determine the patient's serum antitoxin level.

E. Antibiotics

The effectiveness of antibiotics for prophylaxis of tetanus is uncertain. Proper immunization plays the most important role in tetanus prophylaxis.

F. Contraindications

The only contraindication to tetanus and diphtheria toxoids in the wounded patient is a history of neurologic or severe hypersensitivity reaction following a previous dose. Local side effects alone do not preclude continued use. If a systemic reaction is suspected to represent allergic hypersensitivity, immunization should be postponed until appropriate skin testing is undertaken at a later time. If a contraindication to a tetanus toxoid containing preparation exists, passive immunization against tetanus should be considered for a tetanus-prone wound.

For infants and children less than seven years old, the presence of an evolving neurologic disorder contraindicates the use of pertussis vaccine. A static neurologic condition like cerebral palsy or a family history of neurologic disease is not a contraindication to giving vaccines containing pertussis antigen. If such a contraindication to using pertussis vaccine exists, diphtheria and tetanus toxoids absorbed (DT - For Pediatric Use) are recommended.

G. Adult Immunization

Immunization in adults requires at least three injections of toxoid. A routine booster of absorbed toxoid is indicated every ten years thereafter.

H. Pediatric Immunization

For children under seven, immunization requires four injections of diphtheria and tetanus toxoids combined with pertussis vaccine. A fifth dose may be administered at four to six years of age. Thereafter, a routine booster of tetanus and diphtheria is indicated at ten-year intervals.

SPECIFIC MEASURES FOR PATIENTS WITH WOUNDS

Recommendations for tetanus prophylaxis are based on:

1. The condition of the wound
2. The patient's immunization history.

This table outlines some of the clinical features of wounds that are prone to develop tetanus. A wound with any one of these features is a tetanus-prone wound.

| CLINICAL FEATURES | TETANUS-PRONE WOUNDS | CLEAN, MINOR WOUNDS |
|--|----------------------------|----------------------------------|
| Age of wound | > 6 hours | < 6 hours |
| Configuration | Stellate, avulsion | Linear abrasion |
| Mechanism of injury | Missile, crush, heat, cold | Sharp surface (eg. knife, glass) |
| Signs of infection | Present | Absent |
| Devitalized tissue | Present | Absent |
| Contaminants (dirt, feces, soil, saliva) | Present | Absent |

III. Previously Immunized Individuals

A. Fully immunized

When the attending physician has determined that the patient has been previously and fully immunized, and the last dose of toxoid was given within ten years:

1. For tetanus-prone wounds, if more than five years has elapsed since the last dose, 0.5 ml absorbed toxoid should be given.
2. If excessive prior toxoid injections have been given, this booster may be omitted.

B. Partially immunized

When the patient has had two or more prior injections of toxoid and received that last dose more than ten years previously, 0.5 ml absorbed toxoid should be given for both tetanus-prone and non-tetanus-prone wounds. Passive immunization is not considered necessary.

IV. Individuals Not Adequately Immunized

When the patient has received only one or no prior injections of toxoid, or the immunization history is unknown:

A. Non-tetanus-prone wounds

Give 0.5 ml of absorbed toxoid

B. Tetanus-prone wounds

1. Give 0.5 ml absorbed toxoid
2. Give 250 units TIG (Tetanus Immune Globulin, human)
3. Consider providing antibiotics, although effectiveness of antibiotics for prophylaxis of tetanus remains unproven
4. Administer, using different syringes and sites of injections

V. Immunization Schedule

A. Adult

1. Three injections of toxoid
2. Booster every ten years

B. Children

1. Four injections DPT
2. Fifth dose DPT at four to six years of age
3. Booster every ten years

TETANUS PROPHYLAXIS OF THE WOUNDED PATIENT

HISTORY OF**TETANUS IMMUNIZATION (doses)****CLEAN, MINOR WOUNDS****TETANUS-PRONE WOUNDS**

| | TD¹ | TIG | TD¹ | TIG¹ |
|-----------|-----------------------|------------|-----------------------|------------------------|
| Uncertain | Yes | No | Yes | Yes |
| 0-1 | Yes | No | Yes | Yes |
| 2 | Yes | No | Yes | No ³ |
| 3 or more | No ⁴ | No | No ⁴ | No |

KEY:

1. For children less than seven years old, DPT (DT, if pertussis vaccine is contraindicated) is preferred to tetanus toxoid alone. For people seven years old and older, TD is preferred to tetanus toxoid alone.
 2. When TIG and TD are given concurrently, separate syringes and separate sites should be used.
 3. Yes, if wound is more than 24 hours old.
 4. Yes, if more than ten years since last dose.
 5. Yes, if more than five years since the last dose. (More frequent boosters are not needed and can accentuate side effects.)
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