

# American Burn Association

## Advanced Burn Life Support Course



# PROVIDER MANUAL

## 2011

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## Ch. 1. Introduction

### Objectives:

At the conclusion of this lecture the participant will be able to:

- Define “burn”.
- List leading causes of burn injuries and deaths in the United States.

### I. Burn Basics

A burn is defined as damage to the skin and underlying tissues caused by heat, chemicals, or electricity. Each year in the United States 450,000 people receive medical attention for burn injuries. An estimated 4,000 people die annually due to fires and burns, primarily from residential fires (3,500). Other causes include motor vehicle and aircraft crashes, contact with electricity, chemicals or hot liquids and substances, and other sources of burn injury. About 75% of these deaths occur at the scene of the incident or during initial transport. The leading cause of fire death in the United States is fires due to smoking materials, especially cigarettes. The ABA has been a lead organization in the attempt to require all cigarettes sold in every state to be fire-safe cigarettes.

Approximately 45,000 people are hospitalized for burn injuries each year and will benefit most from the knowledge gained in the Advanced Burn Life Support Provider Course.

Below are a few interesting facts regarding burn injuries in the U.S. These statistics are for patients admitted to burn centers and based on the ABA’s National Burn Repository Report of Data from 1999-2008.

- Nearly 71% of patients with burns were men.
- Children under the age of 5 accounted for 17% of the cases.
- Sixty-seven percent of the reported cases suffered burns of less than 10% TBSA.

- Sixty-five percent of the reported patients were burned in the home.
- During this 10-year period, the average length of burn center stay declined from roughly 11 days to 9 days.
- Four percent of the patients died from their injuries.
- *Ninety-six percent of the patients treated in burn centers survived!*

## **II. Course Objectives**

The quality of care during the first hours after a burn injury has a major impact on long-term outcome; however, most initial burn care is provided outside of the burn center environment. Understanding the dynamics of Advanced Burn Life Support (ABLS) is crucial to providing the best possible outcome for the patient. The ABLIS Provider Course is an eight hour course designed to provide physicians, nurses, nurse practitioners, physician assistants, paramedics, and EMTs 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 the initial primary treatment to those who have sustained burn injuries and manage common complications that occur 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, monitor and adjust 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 patient with burns.
- Identify priority of care for patients with burns in a burn mass casualty incident.

## **III. CE and CME Credits**

The American Burn Association is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing

medical education for physicians. The American Burn Association designates this education activity for a maximum of 7.25 credits AMA PRA Category 1 Credit(s)<sup>™</sup>. Physicians should only claim credit commensurate with the extent of their participation in the activity.

This program has been approved by the American Association of Critical Care Nurses (AACN) for 7 contact hours, Synergy CERP Category A, File number 00017581 for 2012. Please consult the ABA website ABLIS Course description for accreditation information in future years.

## **IV. Course Content**

Burn care is multidisciplinary. Therefore, the ABLIS Course is designed in a multidisciplinary format applicable to all levels of care providers and is based on the guidelines for initial burn care developed by the American Burn Association. The ABLIS 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, transfer and transport principles and burn disaster management. Participants then apply these concepts during small group case study discussions.

Participants are also given the opportunity to work with a simulated burn patient, to reinforce the assessment and stabilization principles and also 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.

## **V. Summary**

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 specialty care burn centers. The regionalization of burn care at such centers has optimized the long-term outcomes of these 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 ABLIS Course is to provide the information that will increase the knowledge, competence and confidence of healthcare providers who care for patients with burns in the first 24 hours post-burn injury.

## VI. Select References

American College of Surgeons—Committee on Trauma. Resources for Optimal Care of the Injured Patient. Chicago, IL: American College of Surgeons, 2006 (*Describes Burn and Trauma Care Program Requirements.*)

Sheridan RL, Hinson MI, Liang MH, et al. Long-term outcome of children surviving massive burns. JAMA 2000; 283:69-73. (*Demonstrates that quality of long term outcome after burns is favorably influenced by care in a multidisciplinary burn care environment.*)

Sheridan RL, 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. 2000; 20:347-50. (*Demonstrates that delay in transfer of seriously burned patients compromises outcome, increases length of hospitalization and increases costs.*)

National Burn Repository Report of Data from 1999-2008. American Burn Association. 2009 Version 5.0.

Burn Incidence and Treatment in the US: 2011 Fact Sheet. American Burn Association, available at [www.ameriburn.org](http://www.ameriburn.org). Accessed November 2011.



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## Ch. 2. Initial Assessment and Management

### Objectives:

Upon completion of this lecture 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.
- Identify the ABLIS Advisory Committee recommendations for initial fluid resuscitation calculations.
- List lab tests that should be performed on patients with burns.
- State the ABA Burn Center Referral Criteria.

### I. Introduction

The initial assessment and management of patients with major thermal injuries is of utmost importance in obtaining the best possible outcomes. The early identification of airway and breathing problems may prevent early mortalities and the initiation of early and appropriate fluid resuscitation may alleviate complications. Furthermore, it is vital to identify and treat actual or potential life/limb threatening problems and to recognize and ensure transfer for patients that require early transfer to a burn center in order to improve the outcomes of these individuals. It is the early and systematic approach in the assessment and management of these patients that has provided the foundation that allows those admitted to burn centers to have a 96% survival rate.

### II. Body Substance Isolation

Prior to initiating care of the patient with burns, it is critical that healthcare providers take measures to reduce their own risk of exposure to potentially infectious substances and/or chemical contamination. Body Substance Isolation (BSI) is the most effective way to do this. Body isolation devices include gloves, eyewear, gowns and respiratory

protection. The level of protection utilized will be determined by patient presentation, risk of exposure to body fluids and airborne pathogens, and/or chemical exposure.

Patients with burns are at high risk for infection. The use of BSI devices also helps to protect the patient from potential cross contamination from caregivers.

### III. Primary Survey

The initial assessment of the burn patient is like that of any trauma patient --- recognizing and treating life/limb-threatening injuries. Many patients with burns also have associated trauma. **Do not let the appearance of the burn overwhelm you!** Initially assess and treat these patients as you would any other 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.

The primary survey consists of the following:

**A**irway maintenance with cervical spine protection

**B**reathing and ventilation

**C**irculation and Cardiac Status with hemorrhage control

**D**isability, Neurological Deficit and Gross Deformity

**E**xposure (Completely undress the patient, **E**xamine for major associated injuries and maintain a warm **E**nvironment.)

#### A. Airway Maintenance with Cervical Spine Protection

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 the primary survey, 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. In the event of airway compromise, immediate intubation is indicated as discussed in Chapter 3, *Airway Management and Inhalation Injury*.

## **B. Breathing and Ventilation**

Ventilation, the movement of air, 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 and that they are equal.
- Assess the adequacy of rate and depth of respiration.
- High flow oxygen is started on each patient at 15 L (100%), using a non-rebreather mask.
- Circumferential full-thickness burns of the trunk and neck may impair ventilation and must be closely monitored.

It is important to recognize that respiratory distress may be due to a non-burn condition such as a pre-existing medical condition or a pneumothorax from an associated injury.

## **C. Circulation and Cardiac Status**

Assessment of the adequacy of circulation includes evaluation of blood pressure, pulse rate, and skin color (of unburned skin). Application of a cardiac monitor and pulse oximeter on an unburned extremity or ear will facilitate ease of continuous monitoring.

During the primary survey, insert a large bore intravenous catheter (through unburned skin, if possible) to begin fluid administration. Burns greater than 30% will require 2 large bore, indwelling venous catheters for adequate fluid administration. In the pre-hospital and early hospital settings, prior to calculating the Total Body Surface Area (TBSA) burned, the following guidelines are recommended as starting points for fluid resuscitation rates:

- 5 years old and younger: 125 ml Lactated Ringers (LR) per hour
- 6 – 13 years old: 250 ml LR per hour
- 14 years and older: 500 ml LR per hour

More definitive calculation of hourly fluid rates is performed during the secondary survey.

The circulation in a limb with a circumferential or nearly circumferential full-thickness burn may be impaired as a result of subeschar edema formation. Normal physical indicators of peripheral circulatory

compromise, the 5 P's (pain, pallor, pulselessness, progressive paresthesia and paralysis) should be evaluated but may not be reliable assessment tools in a burned extremity. Doppler examination can also be used to determine whether there is a circulation deficit in a circumferentially burned extremity. Placement of a pulse oximeter on the burned extremity is useful in monitoring progressive changes if it compares oxygenation of the burned area to readings in an unburned area.

Initial vital signs are evaluated in the primary survey. Due to the increased circulating catecholamines and hypermetabolism associated with burn injuries, a normal heart rate for an adult patient with burns is 100 – 120 bpm. Heart rates above this level may indicate hypovolemia from an associated trauma, inadequate oxygenation, unrelieved pain or anxiety. Heart rates below this level may indicate an underlying cardiac abnormality. The blood pressure in the early stages of burn resuscitation should be the individual's pre-injury BP. Absence of a radial pulse in the presence of a full-thickness circumferential burn is not indicative of hypotension. It is important to identify and treat the underlying cause for any abnormal physiological response.

Although elevated heart rates are normal, dysrhythmias are not. Dysrhythmias may be due to electrical injuries, underlying cardiac abnormalities or electrolyte imbalances.

Initially, burns do not bleed! If there is bleeding, there is an associated injury – find and treat the cause as you would with any other trauma patient.

#### **D. Disability, Neurologic Deficit, and Gross Deformity**

Typically, the patient with burns 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 **p**ainful stimuli

**U** – Unresponsive

The Glasgow Coma Scale (GCS) is a more definitive tool used to assess the depth and duration of coma and should be used to follow the patient's level of consciousness. Appendix I provides additional information on the GCS.

## **E. Exposure and Environmental Control**

**Expose** and completely undress the patient, **Examine** for major associated injuries and maintain a warm **Environment**.

The burning process must be stopped during the primary survey. Cool the burn briefly (3 – 5 minutes) for thermal burns, with cool, but not cold water. Never use ice or cold water. Application of cold results in systemic and localized hypothermia that may compromise acute and long-term burn recovery. This is especially true in a pediatric patient who has limited ability to maintain core body temperature. If the patient, someone else at the scene or EMS, has already cooled the burns immediately remove all wet dressings and cover with a clean, dry covering. Apply blankets to start re-warming the patient.

Tar and asphalt burns are an exception to brief cooling. These products must be thoroughly cooled with copious amounts of cool water. Additional information on caring for tar and asphalt burns is provided in Chapter 5, *Burn Wound Management*.

For chemical burns, brush dry chemicals off the patient and then flush with copious amounts of running water. Immediate irrigation at the scene decreases morbidity and mortality. Detailed information on caring for patients with chemical burns is discussed in Chapter 7, *Chemical Injury*.

Remove all clothing, jewelry/body piercings, shoes, and diapers to complete the primary survey. If any material is adherent to the skin, stop the burning process by cooling the adherent material, cutting around it and removing as much as possible.

Patients who are wearing contact lenses, with or without facial burns, should have the lenses removed. Contact lenses need to be removed before facial and periorbital edema develops. Chemicals may also adhere to the lenses and present further problems.

Localized hypothermia causes vasoconstriction to the damaged area, reducing blood flow and tissue oxygenation and may deepen the injury. Systemic hypothermia (core temperature less than 95° F. / 35° C) induces

peripheral vasoconstriction that may increase the depth of the burn injury, decrease enzymatic activity, depress muscle reflexes, interfere with clotting mechanisms and respiration, and cause cardiac arrhythmias and death.

Re-warming of a burn area that has been excessively cooled can result in excruciating, avoidable pain.

Maintaining the patient's core body temperature is a priority. The EMS transport vehicles and treatment room should be warmed and, as soon as the primary survey is complete, 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.

## **IV. 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:

- History
  - Circumstances surrounding the incident
  - Medical history
- Obtain an accurate weight of the patient prior to the burn or fluid resuscitation
- Complete head-to-toe evaluation of the patient
- Determination of percent Total Body Surface Area burned
- Insertion of lines and tubes
- Initiation of resuscitation fluids based upon the ABLS 2010 Fluid Resuscitation Formulas
- Obtaining necessary labs and X-rays
- Monitoring of fluid resuscitation
- Pain and anxiety management
- Psychosocial support
- Wound care

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

The circumstances surrounding the injury can be very important to the initial and ongoing care of the patient with burns. Family members, co-workers and Emergency Medical Services personnel can all provide information regarding the scene of the incident and the circumstances surrounding the injury. Document as much detail as possible.

Every attempt should be made to obtain as much information from the patient as possible prior to intubation. 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: Flame Burns

- How did the burn occur?
- Did the fire occur inside or outside?
- 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 did he/she jump?
- Were others killed at the scene?
- 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 the patient unconscious at the scene?
- Was there a motor vehicle crash?
  - What was the mechanism of injury (T-bone, head-on, roll-over, other)
  - How badly was the car damaged?
  - Was there a car fire?
  - Are there other injuries?
  - Was the patient trapped in the burning vehicle?
  - How long was he/she trapped?
- Is there any evidence of fuel or chemical spill that could result in a chemical burn as well as thermal injury?
- Are the purported circumstances of the injury consistent with the burn characteristics (i.e., is abuse a possibility)?

## 2. Circumstances of Injury: Scald Injuries

Scalding is a frequent cause of child abuse especially in children under the age of four years. In addition to obtaining the patient history, it is helpful to ask EMS or other prehospital providers what they observed at the scene. More details on child abuse by burning are included in Chapter 8, *Pediatric Burn Injuries*.

- How did the burn occur?
- What was the temperature of the liquid?
- What was the liquid?
- How much liquid was involved?
- What was the thermostat setting of the water heater?
- Was the patient wearing clothes?
- How quickly were the patient's clothes removed?
- Was the burned area cooled? With what? How long?
- 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)?

## 3. Circumstances of Injury: Chemical Injuries

- What was the agent(s)?
- How did the exposure occur?
- What was the duration of contact?
- What decontamination occurred?
- Is there a Material Safety Data Sheet (MSDS) available?
- Is there any evidence of ocular involvement?
- Is there any evidence of illegal activity?

## 4. Circumstances of Injury: Electrical Injuries

- What kind of electricity was involved – high voltage/low voltage, AC/DC?
- What was the duration of contact?
- Was the patient thrown or did he or she fall?
- Was there loss of consciousness?
- Was CPR administered at the scene?

## B. Medical History

An easy aid in obtaining the medical history needed is by using the mnemonic, “AMPLET”:

- A:** Allergies. Drug and/or environmental
- M:** Medications. Prescription, over-the-counter, herbal, illicit, alcohol.
- P:** Previous illness (diabetes, hypertension, cardiac or renal disease, seizure disorder, mental illness) or injury, **p**ast medical history, **p**regnancy
- L:** Last meal or drink
- E:** Events/**e**nvironment related to the injury
- T:** Tetanus and childhood immunizations

Tetanus is current if given within five years for patients with burns. More information on recommendations for administration of tetanus is provided in Appendix II Tetanus Prophylaxis.

If the patient is a child, is he/she is up-to-date on the childhood immunizations?

## C. Preburn weight

Fluid resuscitation formulas should be based on the pre-burn weight of the patient. If the patient has received a large volume of fluid prior to calculating the hourly fluids, obtain an estimate of the patient’s pre-injury weight from the patient or family member if possible.

## D. Complete Physical Examination

### “Head to Toe” Examination

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

## **E. Determining the Severity of a Burn**

Physiologically, the severity of a burn injury is determined primarily by the extent of the body surface area involved and 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 functional and cosmetic areas such as the face, hands, feet, major joints, and genitalia must be considered. Compounding circumstances including pre-existing health conditions and/or associated injuries also impact morbidity and mortality.

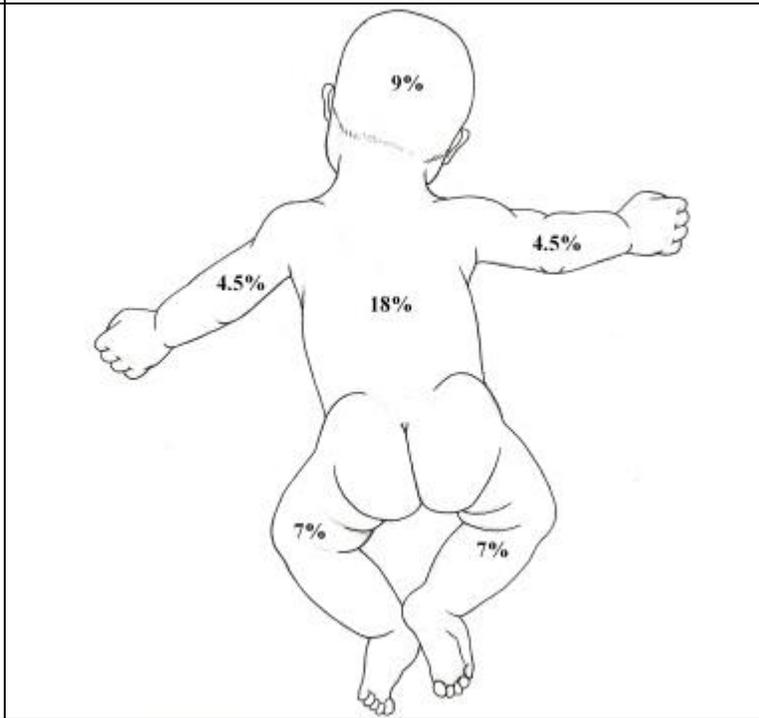
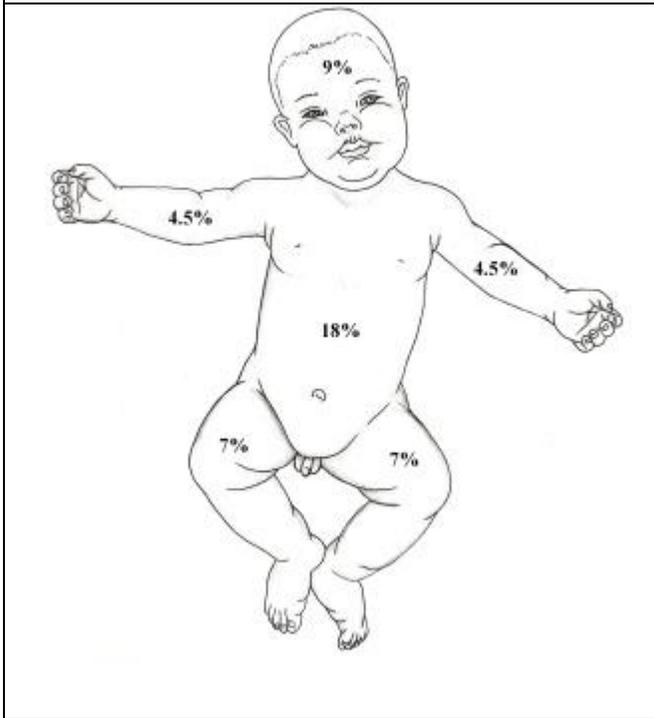
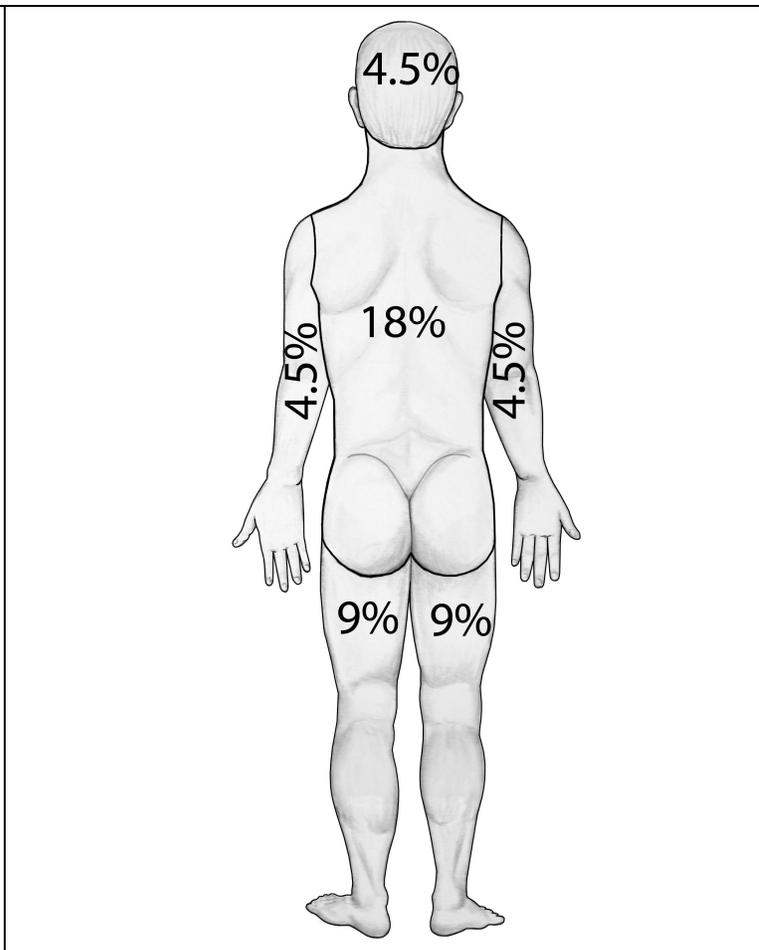
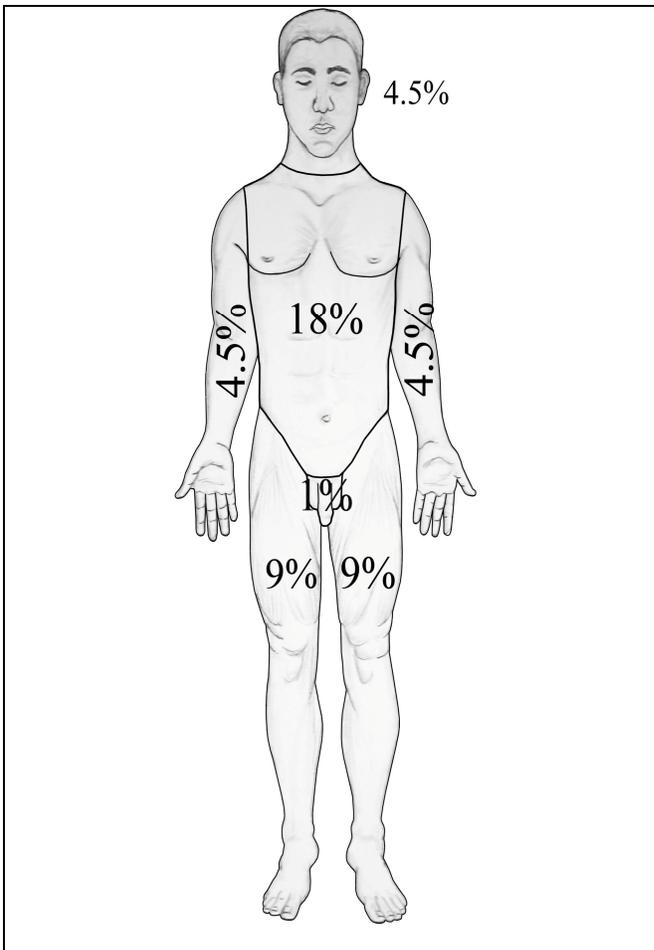
Even a small burn can have a huge impact on the quality of life of a burn survivor. For example, a 1% hand burn to a young athlete can have a devastating effect on his or her plans for the future. Individual emotional and physiological responses to a burn vary and should be taken into consideration when determining the long-term severity of injury in relationship to the survivor's perception of their own quality of life post-burn.

## **F. Extent of Burn**

The most commonly used guide for making an initial estimate of burn extent in second and third/fourth degree burns (referred to as third degree for the remainder of the course) is the "Rule of Nines." The "Rule of Nines," 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.)

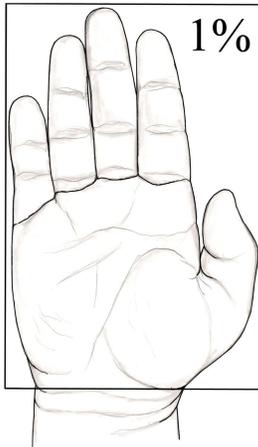
If only part of the anatomical area is burned, calculate the percent TBSA burned based only percentage of that site injured and not the value of the whole (i.e. if the arm is circumferentially burned from the hand to the elbow, only half the arm is burned for a total of approximately 4.5%).

Burn centers typically use the Lund-Browder Chart for a more accurate determination of percent TBSA burn. A copy of this chart is included at the end of this chapter for your reference.



## 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.



### G. Depth of a Burn

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

- Temperature of the offending agent
- Duration of contact with the burning substance
- Thickness of the epidermis and dermis
- Blood supply to the area

Certain areas of the body such as the palms of the hands, soles of feet, and back can tolerate a higher temperature for a longer period of time without sustaining a full thickness injury. Other areas such as the eyelids have very thin skin and burn deeply very quickly. People with circulatory problems may sustain deeper burns more easily.

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. It is often very difficult to determine the depth of injury for 48 to 72 hours. Initially, the depth of burn does not determine treatment modalities outside of the burn center.

Throughout the ABLS course first- and second-degree burns will be referred to as partial-thickness burns or injuries. Third- and fourth-degree burns will be referred to as full-thickness burns or injuries.

Definitions of first, second, and third degree burns are found in Chapter 5, *Burn Wound Management*.

## H. Management Principles and 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. Fluid Resuscitation

**a. Adult:** Thermal and Chemical Burns: The ABLIS 2010 Fluid Resuscitation Formula for the first 24 hours post burn for adult patients with thermal or chemical burns is:

2 ml LR x patient's body weight in kg x % TBSA second and third degree burns.

**Research indicates that resuscitation based upon using 4 ml LR per kg per %TBSA burn commonly results in excessive edema formation and over-resuscitation.**

**b. Pediatric Patients** (14 years and under and less than 40 kgs): The ABLIS 2010 Fluid Resuscitation Formula is:

3 ml LR x child's weight in kg x % TBSA second and third degree burns.

**c. Adult Patients with High Voltage Electrical Injuries:** If there is evidence of deep tissue injury or hemochromogens (red pigments) are present in the urine, begin fluid resuscitation using:

4 ml LR x patient's weight in kg x % TBSA second and third degree burns.

**d. For pediatric patients with high voltage injuries, consult a Burn Center immediately for guidance.**

The most critical consideration when determining the volume of fluid to administer is the patient's urinary output and physiological response. It is better to increase fluids based on response than to attempt to remove excess fluids once given.

Some patients including those with a delayed start of fluid resuscitation, prior dehydration, chronic or acute alcohol use or abuse, methamphetamine

lab injuries, high voltage electrical injuries, or inhalation injuries may require more than the estimated fluids. Again, the rate of fluid administration is based on patient response.

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. The IV rate should be adjusted as needed to maintain adequate urine output. This is discussed in more detail in Chapter 4, *Shock and Fluid Resuscitation*.

**2. Vital Signs** Vital signs should be monitored at frequent intervals.

**3. Insertion of Nasogastric Tube** Patients with burns of more than 20% TBSA are prone to gastric distention that may cause nausea and vomiting. In these patients a nasogastric tube should be inserted to decompress the stomach to prevent vomiting and aspiration.

Consider insertion of a nasogastric tube for the following patients:

- Adult and pediatric patients with burns > 20% TBSA
- Intubated patients
- Patients with associated trauma

#### **4. 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 in a patient with normal renal function. In general, all patients with burns greater than 20% TBSA or with burns to the genitalia should have a urinary catheter inserted.

#### **5. 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 flows are markedly reduced, ischemia and necrosis may result. Early signs and symptoms include the 5 P's: pain, pallor, decreasing pulse or pulselessness, progressive parasthesia and paralysis in the extremity.

When compartment pressure in an extremity is elevated, an escharotomy is indicated to restore adequate circulation. An escharotomy is a releasing incision made in a longitudinal fashion through the burned skin (eschar) to

allow the subcutaneous tissue to be decompressed. Escharotomy procedures are discussed in Chapter 5, *Burn Wound Management*.

## 6. Continued Ventilatory Assessment and Support

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. Escharotomy procedures are discussed in Chapter 5, *Burn Wound Management*.

## 7. Pain and Anxiety Management

Burn pain may be excruciating and must be managed. It must be determined early on in the care of the patient whether the pain is due to the burn injury or caused by associated trauma or other cause. Control of burn pain must begin upon determination of cause and initiation of medical care. Morphine or other narcotics are indicated for control of the pain associated with burns.

Pain should be differentiated from anxiety. Benzodiazepines may also be indicated to relieve the anxiety associated with the burn injury.

These drugs should be titrated by giving small, frequent doses IV (never IM) to attain the desired effect. It is not unusual for the narcotic dose to exceed the standard weight based recommendations. Respiratory status should be constantly evaluated as large dosages may be required to alleviate pain and anxiety. Remember, paralytic agents given for intubation do not relieve pain or anxiety! Narcotics and anxiolytics must be given in conjunction with these paralytic agents.

Changes in fluid volume and tissue blood flow make absorption of any drug given intramuscularly or subcutaneously unpredictable. The intra-muscular 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. Tetanus immunization is the only medication given IM to a patient with burns.

## **8. Elevate the Patient's Head and Extremities**

Unless contraindicated by the patient's medical condition or associated trauma, the patient's head should be elevated 30 degrees. This will help to minimize facial and airway edema and to prevent possible aspiration.

Burned extremities should be elevated above the level of the heart to minimize edema. This simple action helps to decrease the pain associated with increased swelling.

## **9. Psychosocial Assessment and Support**

Patients with burns should initially be alert and oriented. As such, even patients with major burns are likely to remember the first several hours post injury. Provide emotional support by talking to the patient and avoiding comments not intended for the patient to hear.

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 and psychiatric consultation should be obtained.

In order for a burn survivor to reach optimal recovery and reintegration into family life, school, work, social and recreational activities, the psychosocial needs of the survivor and family must be met during and following hospitalization and rehabilitation. Located on the ABA website, [www.ameriburn.org](http://www.ameriburn.org), Psychosocial and Emotional Support for the Patient and Loved Ones, Aftercare and Reintegration of Burn Survivors, provides excellent information and resources. The ABLIS Advisory Committee encourages you to review this important information.

## **V. 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:

- Complete Blood Count (CBC)
- Serum chemistries/electrolytes (e.g., Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>)
- Blood urea nitrogen

- Glucose levels, especially in children and diabetics
- Urinalysis
- Chest roentgenogram (X-Rays)

Where special circumstances exist, additional specialized tests, such as the following, may be appropriate:

- Arterial blood gases with Carboxyhemoglobin (Carbon Monoxide) level should be drawn if inhalation injury is suspected
- ECG —With all electrical burns or pre-existing cardiac problems
- Type and screen or cross for associated injuries
- X-Rays for associated trauma or suspected child abuse

## VI. Special Considerations

### A. Associated Trauma

Patients with burns frequently have minor to life-threatening associated injuries depending on the mechanism of injury (i.e. motor vehicle crash, explosions, crush injuries due to building collapse, falls or assaults, etc.) Associated trauma is more common in adults than children except when child abuse occurs. Knowing the mechanism of injury helps predict the type of traumatic injury that may be present. Associated trauma may delay or prevent escape from a fire situation resulting in larger TBSA burns or more severe inhalation injury.

Delay in diagnosing associated injuries leads to an increase in morbidity and mortality, increasing the length of stay and cost of care. Do not let the appearance of the burn delay your total trauma assessment and management of serious associated trauma.

### B. The Pregnant Patient with Burns

Burn injuries during pregnancy are rare but can be problematic in this high-risk group of patients. Although some studies show a maternal mortality rate greater than 60% for burns of 25-50% TBSA, a more recent study showed 100% survival with aggressive fluid resuscitation, the utilization of supplemental oxygen and mechanical ventilation, early delivery of the fetus if in the third trimester, and a high suspicion for and aggressive treatment of DVT and sepsis.

### C. Blast Injuries and Burns

Blast injuries include the entire spectrum of injuries that can result from exposure to an explosion. Blast injuries are becoming a common mechanism of trauma in many parts of the world and such high explosive events have the potential to produce mass casualties with multi-system injuries, including burns. The severity of the injuries depends upon the amount and composition of the explosive material, the environment in which the blast occurs, the distance between the explosion and the injured, and the delivery mechanism. The use of radioactive materials and chemicals must also be considered in unintentional injuries as well as in acts of terrorism and war.

Blast injuries are considered to be one of five types or combinations:

- 1. Primary:** Primary blast injuries are due to the direct effect of the blast (blast wave) impacting the body surface. Injuries include tympanic membrane rupture, pulmonary damage, and hollow viscous injury.
- 2. Secondary:** Secondary blast injuries result when projectiles from the explosion such as flying debris hit the body. The result is penetrating and blunt trauma.
- 3. Tertiary:** Tertiary blast injuries are due to the victim flying through the air as the result of the blast. Blunt and penetrating trauma, fractures and traumatic amputations are types of tertiary injuries.
- 4. Quaternary:** Quaternary blast injuries include all other types of injuries from the blast (heat, light, and/or toxic gases). The fireball may cause flash burns to exposed body parts (hands, neck, head) or may ignite clothing. Other injuries include crush injuries, inhalation injury, asphyxiation and toxic exposures.
- 5. Quinary:** Quinary blast injuries are the clinical result of post-detonation environmental contaminants including bacteria, radiation (dirty bombs), and tissue reactions to the contaminants.

Blast injuries are due to over-pressurization and are common within the lungs, ears, abdomen and brain. The blast effect to the lungs is the most common fatal injury to those who survive the initial insult. The chest X-ray may have a butterfly pattern and dyspnea, cough, hemoptysis and chest pain are all-important indicators of such barotraumas. These injuries are often associated with the triad of apnea, bradycardia, and hypotension. Prophylactic chest tubes prior to operative intervention or

air transport is highly recommended. Gentle supportive ventilation is indicated in survivors until the lung heals. Inhalation injury can result from the explosion's extinction of the oxygen available in the immediate environment, creation of particulate matter, smoke and superheated gases and toxic by-products. The patient may demonstrate clinical symptoms of blast lung injury immediately or clinical problems may not present for 24-48 hours post explosion.

Another commonly injured organ is the tympanic membrane, which ruptures from significant overpressure; treatment here is also supportive. Intra-abdominal organs can receive injury from the pressure wave, and should be treated as any blunt abdominal injury. Bowel ischemia and/or rupture should be considered. Lastly, brain injury is thought to be common in blast over pressure situations, but this entity has not been completely defined yet. Those with suspected injury should undergo imaging by computed tomography or magnetic resonance, and treated appropriately. Those without anatomic injury should be treated in a fashion similar to that for mild to moderate traumatic brain injury, which is mostly supportive with cognitive function testing during recovery.

Burns associated with blast injuries should be treated as thermal injuries without significant caveats other than some crush component, which may compound the injury. Burns are a common manifestation of significant blast injuries to those that survive; these injuries are associated with the ball of flame emanating from most explosive devices with a potential for clothing ignition to extend the injury.

#### **D. Radiation Injury**

Serious radiation injuries are a rare cause of serious burns. Appendix 3, *Radiation Injury*, provides basic information on radiation burns and their management.

#### **E. Cold Injuries**

Cold injuries are frequently treated in a burn center. Additional information is provided in Appendix 4, *Cold Injuries*.

## **VII. Initial Care of the Burn Wound**

### **A. Thermal Burns**

After the burning process has stopped cover the burn area with a clean, dry sheet. Covering all burn wounds prevents air currents from causing

pain in partial thickness burns. It is important to remember that although cool water may be used to cool the burn for 3-5 minutes, ice should never be applied directly to the burn. Ice may induce a localized hypothermia and the resultant complications discussed earlier. During all other phases of burn care, the patient should be kept warm and dry.

## **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. Patients with a history of loss of consciousness or documented dysrhythmias either before or after admission to the emergency department, or those with documented ECG abnormalities should be admitted for (continuous) cardiac monitoring. Patients with low voltage injuries and normal EKGs may be discharged with burn center follow-up, unless wound issues dictate otherwise.

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 6, *Electrical Injury*.

## **C. Chemical Burns**

All contaminated clothing and shoes should be removed. Dry and powdered chemicals should be brushed from the skin prior to flushing the affected areas. Immediate irrigation with copious amounts of running water should then be performed. Continue to flush for a minimum of 20-30 minutes. If the patient continues to complain of a burning sensation, continue to irrigate. Exceptions to these guidelines (i.e. Hydrofluoric Acid) are discussed in Chapter 7, *Chemical Burns*.

Chemical eye injuries require continuous irrigation until instructed otherwise by a burn physician or ophthalmologist. A discussion of the management of these patients is discussed further in Chapter 7, *Chemical Burns*. Contact lenses must be removed. Emergency team members must also be appropriately protected from chemical exposure by the use of appropriate Body Substance Isolation measures.

## VIII. Burn Center Referral Criteria

### A. Burn Center Characteristics

A burn center is a service capability based in a hospital that has made the institutional commitment to care for burn patients. A multidisciplinary team of professionals staffs the burn center 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 should be referred 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 center 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 stabilized initially in a trauma center before being transferred to a burn center. 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 rehabilitative intervention.

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

## **IX. 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.

## **X. Additional Information**

The following three documents found at the end of this chapter will assist ABLIS participants long after the course is complete. These pages may be useful in your workplace as quick references.

ABLS Initial Assessment and Management Review, pages 28, 29

Lund and Browder Chart, page 29

ABA Burn Center Referral Criteria, page 30

## XI. SELECT REFERENCES

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## ABLS Initial Assessment and Management Summary

### Body Substance Isolation

#### Primary Survey: A through E

##### Assess and manage life- and limb-threatening conditions

- **A**irway maintenance with cervical spine protection
- In-line cervical immobilization
- **B**reathing and ventilation
- Assess rate, depth and quality
- 100% Oxygen per nonrebreather mask while waiting for intubation (if indicated)
  - Assist with bag-valve-mask if indicated
- If you are going to intubate – get history here
- Intubate if indicated
- If there are difficulties with ventilation, check for:
  - Circumferential torso burns
  - Correct tube placement
  - Need for suction
  - Associated injury
- **C**irculation with hemorrhage control, **C**ardiac Status, **C**ardiac Monitor, **C**-spine if you didn't do it before
- Burns do not bleed! If there is bleeding, identify and treat the cause
- Assess peripheral perfusion
- Identify circumferential burns (use Doppler if necessary)
- Initiate monitoring of vital signs
  - Normal adult HR 110 – 120 BPM
  - BP should be initially normal
  - If abnormal HR or BP – find out why!
- IV – insert large bore IV and initiate fluid resuscitation using Lactated Ringer's Solution (LR) – for burns >30% TBSA, insert 2 large bore IVs
  - Rates during pre-hospital management and primary survey in the hospital
    - 5 years old and younger: 125 ml LR per hour
    - 6 – 13 years old: 250 ml LR per hour
    - 14 years and older: 500 ml LR per hour
    - Resuscitation rates will be fine tuned during the secondary survey when the weight has been obtained and %TBSA burn has been determined
- **D**isability, Neurological **D**eficit, Gross **D**eformity

- Assess level of consciousness using AVPU
- Identify any gross deformity/serious associated injuries
- **E**xposure / **E**xamine / **E**nvironment Control
- Stop the burning process
- Remove all clothing, jewelry, metal, diapers, shoes
- Log roll patient to remove clothing from back, check for burns and associated injuries
- Keep warm – apply clean dry sheet and blankets, maintain warm environment

<b>Lund and Browder Chart</b>
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<b>Estimate of % Total Body Surface Area (TBSA) Burn</b>
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AREA	BIRTH - 1 YEAR	1 - 4 YEARS	5 - 9 YEARS	10 - 14 YEARS	15 YEARS	ADULT	TOTAL
<b>Head</b>	<b>19</b>	<b>17</b>	<b>13</b>	<b>11</b>	<b>9</b>	<b>7</b>	
Neck	2	2	2	2	2	2	
Anterior trunk	13	13	13	13	13	13	
Posterior trunk	13	13	13	13	13	13	
Right buttock	2.5	2.5	2.5	2.5	2.5	2.5	
Left buttock	2.5	2.5	2.5	2.5	2.5	2.5	
Genitalia	1	1	1	1	1	1	
Right upper arm	4	4	4	4	4	4	
Left upper arm	4	4	4	4	4	4	
Right lower arm	3	3	3	3	3	3	
Left lower arm	3	3	3	3	3	3	
Right hand	2.5	2.5	2.5	2.5	2.5	2.5	
Left hand	2.5	2.5	2.5	2.5	2.5	2.5	
<b>Right thigh</b>	<b>5.5</b>	<b>6.5</b>	<b>8</b>	<b>8.5</b>	<b>9</b>	<b>9.5</b>	
<b>Left thigh</b>	<b>5.5</b>	<b>6.5</b>	<b>8</b>	<b>8.5</b>	<b>9</b>	<b>9.5</b>	
<b>Right lower leg</b>	<b>5</b>	<b>5</b>	<b>5.5</b>	<b>6</b>	<b>6.5</b>	<b>7</b>	
<b>Left lower leg</b>	<b>5</b>	<b>5</b>	<b>5.5</b>	<b>6</b>	<b>6.5</b>	<b>7</b>	
Right foot	3.5	3.5	3.5	3.5	3.5	3.5	
Left foot	3.5	3.5	3.5	3.5	3.5	3.5	
Total							

Rows in **bold italics** indicate areas of difference between adult and pediatric patients. All other areas are the same for adults and children.

**ABA Burn Center Referral Criteria**

[www.ameriburn.org](http://www.ameriburn.org)

Burn injuries that should be referred to a burn center 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 stabilized initially in a trauma center before being transferred to a burn center. 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 rehabilitative intervention.



## Ch. 3. Airway Management and Smoke Inhalation Injury

### Objectives:

Upon completion of this lecture, 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 defined as aspiration of superheated gasses, steam, hot liquids or noxious products of incomplete combustion. The severity of the injury is related to the temperature, composition and length of exposure to the agent(s). Inhalation injuries are only present in 6% - 30% percent of the patients admitted to burn centers but greatly increase mortality. Although an inhalation injury can occur without a cutaneous burn, it is far more common for both to be present.

Carbon monoxide (CO) and/or cyanide poisoning, hypoxia, and upper airway edema often complicate the early clinical course of inhalation injury. In the patient with a cutaneous burn, fluid resuscitation may worsen the upper airway edema and cause early respiratory distress and asphyxiation. Prophylactic intubation to maintain a patent airway in these cases is required. Inhalation injury is a predictor of prolonged ventilator dependency and death.

There are three types of inhalation injury:

- Injury caused by exposure to toxic gases including carbon monoxide and/or cyanide
- Supraglottic (above the vocal cords) injury, due to direct heat or chemicals, causing severe edema

- Subglottic or tracheobronchial (below the vocal cords) injury causing parenchymal pulmonary edema, atelectasis and pneumonia as late effects of inflammation.

It is important to note that respiratory distress in a patient with burns may be due to a problem other than smoke inhalation. Always consider the mechanism of injury and assess for the possibility of another traumatic or medical cause.

## **II. Pathophysiology**

### **A. Poisonous Gasses**

#### **1. 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 carbon monoxide is bound to hemoglobin, tissue hypoxia will occur.

The most immediate threat is to hypoxia-sensitive organs such as the brain. 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. At levels between 15 and 40 percent, the patient may present with various changes in central nervous system function, complaints of headache, flu-like symptoms, nausea and vomiting. At levels greater than 40%, the patient may have loss of consciousness, seizures, Cheyne-Stokes respirations and death. A more concise breakdown of symptoms can be found on the following table.

(next page)

## Effects of Carboxyhemoglobin (COHb) Saturation

Carboxyhemoglobin Saturation (%)	Symptoms
0 – 9	None
10 – 20	Tension in forehead and dilation of skin vessels
20 – 30	Headaches and pulsating temples
30 – 40	Severe headache, weakened sight, nausea, vomiting and prostration
40 – 50	Same as above, plus increase respiratory and heart rates. Asphyxiation
50 – 60	Same as above plus coma, seizures and Cheyne-Stokes respirations
>60	Coma, seizures, weak respirations and pulse. Death is possible.

A cherry red coloration of the skin is said to be associated with high carboxyhemoglobin levels but is rarely seen in patients with cutaneous burns or inhalation injury associated with fire. 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 CO<sub>2</sub> removal is not affected. Although the O<sub>2</sub> content of blood is reduced, the amount of oxygen dissolved in the plasma (PaO<sub>2</sub>) is unaffected by carbon monoxide poisoning. Blood gas analysis is normal except for an elevated carboxyhemoglobin level. Oxygen saturation is also usually normal because an oximeter detects the color of hemoglobin and *does not measure* carbon monoxide. CO turns hemoglobin bright red. Due to the variability of symptoms, it is essential to determine the carboxy-hemoglobin level in patients exposed to carbon monoxide.

Late effects of CO poisoning include increased cerebral edema that may result in cerebral herniation.

## 2. Cyanide Poisoning

Cyanide is another product of incomplete combustion than may be inhaled by those injured in enclosed space fires. It occurs primarily from the combustion of synthetic products such as carpeting, plastics, upholstered furniture, and draperies. Symptoms include changes in respiratory rate,

shortness of breath, headache, CNS excitement, irritation of the eyes and mucus membranes.

## **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 airway above the glottis (the supraglottic region) including the 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. Prophylactic intubation is often preferred because the ensuing edema obliterates the landmarks needed for successful intubation. Supraglottic edema may occur without direct thermal injury to the airway but secondary to the fluid shifts associated with the burn injury and resuscitation.

## **C. Inhalation Injury Below the Glottis**

Inhalation injury supra-glottis can be thermal or chemical; sub-glottis is almost always chemical. Noxious chemicals (e.g. aldehydes, sulfur oxides, phosgenes) are predominantly adherent to smoke particles and cause damage to the epithelium of the large airways. Smaller airways and terminal bronchi are usually affected by prolonged smoke exposure.

Pathophysiology changes associated with injury below the glottis include:

- Sloughing of the epithelial lining of the airway
- Mucus hyper secretion
- Impaired ciliary activity
- Inflammation
- Surfactant inactivation
- Pulmonary edema
- Ventilation/perfusion mismatch
- 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 inhalation injury markedly worsens prognosis of cutaneous burns, 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.

Several studies have shown that inhalation injury increases the fluid requirements in patients with cutaneous burns. Therefore, careful monitoring and appropriate resuscitation are required in this condition. Neither the presence nor the absence of colloid in resuscitation fluids has been correlated with better outcomes after inhalation injury.

### **III. Initial Management**

#### **A. Oxygen Therapy and Initial Management of the Airway**

The goals of airway management during the first 24 hours are to prevent suffocation by ensuring airway patency, to ensure adequate oxygenation and ventilation, to forgo the use of agents that may complicate subsequent care, and to avoid ventilator-induced lung injury.

Any patient with suspected carbon monoxide or cyanide poisoning and/or inhalation injury should immediately receive humidified 100% oxygen through a non-rebreather mask until carboxyhemoglobin approaches normal levels (under 10) or unless other conditions necessitate an increased FiO<sub>2</sub>.

Anyone with an inhalation injury is subject to increased respiratory secretions and may have a large amount of carbonaceous debris in his/her respiratory tract. Frequent and adequate suctioning is necessary to prevent occlusion of the airway and endotracheal tube.

## **B. Factors to Consider When Deciding Whether or Not to Intubate a Patient with Burns**

Prophylactic intubation is not indicated for a diagnosis of inhalation injury alone. However, if there is concern over progressive edema during transport to a burn center, intubation should be strongly considered. Intubation is indicated if upper airway patency is threatened, gas exchange or compliance mandate mechanical ventilatory support, or mental status is inadequate for airway protection.

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. In adults, if possible, the ET tube should be a size 7.5 or greater to allow maximization of pulmonary toilet and a conduit for diagnostic and therapeutic bronchoscopy following transfer to the burn center. The cervical spine needs to be stabilized during intubation in this circumstance as the potential for airway obstruction mandates the need for immediate control of the airway. In impending airway obstruction, X-ray clearance of the cervical spine, if indicated by the mechanism of injury, should not occur until after intubation.

### Indications for early intubation include:

- Hoarseness
- Stridor
- Extent of the burn (TBSA burn > 40-50%)
- Extensive facial burns
- Burns inside the mouth
- Significant edema or risk for edema
- Signs of airway obstruction
- Difficulty swallowing
- Significant changes in the voice
- Use of accessory respiratory muscles
- Need for pulmonary toilet
- Inability to handle secretions
- Signs of respiratory fatigue
- Poor oxygenation or ventilation
- Need for large doses of narcotics
- Level of consciousness is such that airway protective reflexes are impaired
- NOT singed nasal hair

After ascertaining that the endotracheal tube is in the proper position by auscultation and X-Ray confirmation, the tube must 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 ties passed around the head. Do not place ties over the ears in order to prevent additional tissue damage and potential loss of cartilage.

Because facial swelling and edema may distort the normal upper airway anatomy, intubation may be difficult and should be performed by the most experienced individual available. If time permits, a nasogastric tube should be inserted before intubation. Rarely, emergency cricothyroidotomy is required.

## IV. Assessment and Management

### A. General Assessment Findings

Early diagnosis of inhalation injury is an important element in transfer decisions. Normal oxygenation or chest radiographs do not exclude the diagnosis. After adequate airway, ventilation, and oxygenation are assured, assessment may proceed with less urgency.

### History of Event

**Historical facts** most important in evaluation are:

- Did injury occur in an enclosed 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.
- Is there a history of loss of consciousness?
- Were noxious chemicals involved?
- Is there a history of associated blunt or penetrating trauma such as an explosion, motor vehicle crash or fall?

### Physical Findings

Physical findings that suggest respiratory tract injury include the following:

- Carbonaceous sputum
- Deep facial burns
- Agitation, anxiety, stupor, cyanosis, or other general signs of hypoxia
- 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

## **B. Treatment for Each Type of Inhalation Injury**

### **Poisonous gases**

#### **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 10 percent are achieved unless other conditions necessitate an increased  $FiO_2$ . Hyperbaric oxygen for carbon monoxide poisoning has not been shown to improve survival rates. Transfer to a burn center should not be delayed by efforts to institute hyperbaric oxygen therapy.

#### **2. Cyanide Poisoning**

The levels of cyanide seen in well-resuscitated burn patients can usually be rapidly detoxified and additional treatment is not required. In patients that do not respond to 100% oxygen and resuscitative efforts, therapy can be provided without undo risk using a commercially available cyanide antidote kit. Cyanide levels may be drawn but are usually sent out to regional labs, even in large centers, and not immediately available. Therefore, treatment must be initiated without levels when clinically indicated.

#### **3. 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. Neither blood gas monitoring nor pulse oximetry is useful in determining when intubation is required. Reliance should be placed on physical findings of potential airway injury and the extent of the cutaneous burn.

#### **4. 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 chiefly impairs 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.

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.

### **5. 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 and to ensure that it is well secured in an appropriate position.

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:

- Poisonous gases such as carbon monoxide and cyanide 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 non-rebreather mask.

Prophylactic use of antibiotics and steroids are not indicated in patients with inhalation injuries.

Burn patients with inhalation injuries will require burn center admission. The burn center should be contacted early to assist in coordinating the care prior to transfer.

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## Ch. 4. Shock and Fluid Resuscitation

### Objectives:

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

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

### I. Introduction

Burns greater than 20-25% TBSA are associated with increased capillary permeability and intravascular volume deficits that are most severe in the first 24 hours post injury. Optimal fluid resuscitation aims to support organ perfusion with the least amount of fluid at the least physiological cost.

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 fluid loss associated with burn injuries is slow and progressive, unlike many other types of trauma. Thermal injury-induced hypovolemia consists of a steady loss of intravascular volume that requires sustained replacement to avoid end-organ hypoperfusion and ischemia. In other words, the goal of proper fluid resuscitation aims to prevent rather than treat hypovolemia. 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 support tissue perfusion and organ function while avoiding the complications of inadequate or excessive fluid therapy. Burn fluid resuscitation must be managed on an hour-by-hour, and in some cases, minute-by-minute basis to promote optimal outcomes.

#### **B. Complications 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. Over-resuscitation can also lead to elevated compartment pressures, acute respiratory distress syndrome and multiple organ dysfunction syndrome.

Patients sensitive to excessive fluids include:

- Children
- The elderly
- Patients with preexisting cardiac disease

The edema slowly resolves as evaporative water losses from the wound surface and renal excretion reduce the resuscitation related water and salt loading.

### **C. Complications 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. The fluid requirements are based only on second and third degree burns. Including first degree burns in the fluid resuscitation calculations increases the potential for grossly over-resuscitating the patient with resulting increase in morbidity and mortality.

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

### **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. Ringer's Lactate is the fluid of choice for burn resuscitation because it most closely mimics the normal intravascular fluid. RL treats both the hypovolemia and intracellular sodium deficits caused by thermal injury (PG).

## B. Infusion Rates

During the primary survey, insert a large bore intravenous catheter (through unburned skin, if possible) to begin fluid administration. In burns greater than 30% TBSA, two large bore catheters should be inserted. In the pre-hospital and early hospital settings, prior to calculating the percent Total Body Surface Area (TBSA) burned, the following guidelines based on the patient's age are recommended as starting points for fluid resuscitation rates:

- 5 years old and younger: 125 ml LR per hour
- 6 – 13 years old: 250 ml LR per hour
- 14 years and older: 500 ml LR per hour

Once the patient's weight in kg is obtained and the percent second and third degree burn is calculated in the secondary survey, the ABLIS 2010 Fluid Resuscitation Formulas are used to estimate hourly infusion rates. The ABLIS 2010 Fluid Resuscitation Formulas for the first 24 hours post burn are:

### **Adult Thermal and Chemical Burns:**

The ABLIS 2010 Fluid Resuscitation Formula for the first 24 hours post burn for adult patients with thermal or chemical burns is:

2 ml LR x patient's body weight in kg x % second and third degree burns.

Research indicates that resuscitation based upon using 4 ml LR per kg per %TBSA burn commonly results in excessive edema formation and over-resuscitation.

### **Pediatric Patients (14 years and under and less than 40 kgs):**

The ABLIS 2010 Fluid Resuscitation Formula is:

3 ml LR x child's weight in kg x % TBSA second and third degree burns.

### **Adult Patients with High Voltage Electrical Injuries:**

If there is evidence of deep tissue injury or hemochromogens (red pigments) are present in the urine, begin fluid resuscitation using:

4 ml LR x patient's weight in kg x % TBSA second and third degree burns.

**Pediatric Patients with High Voltage Injuries:** Consult a burn center immediately for guidance.

The most critical consideration when determining the volume of fluid to administer is the patient's urinary output and physiological response. It is better to increase fluids based on response than to attempt to remove excess fluids once given.

The infusion rate is regulated so that one-half of the estimated volume is administered in the first 8 hours post burn, calculated from the time of injury. 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 urinary output and clinical response.

Example:

An adult patient with a 50% TBSA second and third degree burn who weighs 70 kg:

$2 \text{ ml LR} \times 70 \text{ (kg)} \times 50 \text{ (\% TBSA burn)} = 7,000 \text{ ml LR}$  in the first 24 hours.  
3,500 ml (half) is given over the first 8 hours from the time of injury. 437 ml LR / hour for the first 8 hours.

If initial resuscitation is delayed, the first half of the volume is given over the number of hours remaining in the first 8 hours post burn.

**For example**, if the resuscitation is delayed for two hours, the first half is given over 6 hours.  $3500 / 6 \text{ hours} = 583 \text{ ml LR per hour}$

If resuscitation is delayed by more than two hours, initiate fluid resuscitation based on the ABLIS 2010 Fluid Resuscitation Formulas, monitor closely and consult the burn center.

These fluid rates are estimates only and the patient may have increased fluid needs due to associated trauma or decreased needs due to patient response.

The special fluid resuscitation requirements associated with high voltage electrical injuries are discussed in Chapter 6, *Electrical Injury*.

### **Fluid Resuscitation of Pediatric Patients with Burns**

Children have a greater surface area per unit body mass than adults and require 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, which makes the burned child more susceptible to fluid overload and hemodilution.

In addition to the resuscitation fluid noted above, infants and young children should also receive LR with 5% Dextrose at a maintenance rate. 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 or the hypermetabolism associated with burn injury. Therefore, it is important to monitor blood glucose levels and, if hypoglycemia develops, to continue resuscitation using glucose containing electrolyte solutions.

Liberal consultation with the burn center is advised when resuscitating infants and young children.

Additional information relating to pediatric fluid resuscitation will be addressed in Chapter 8, *Pediatric Burn Injuries*.

### **C. 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.

With appropriate fluid resuscitation, 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 respond 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.

## 1. 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 in patients with normal renal function.

**Adults:** Adults: 0.5 ml per kg per hour (or 30-50 ml/hour)  
Children weighing less than 40 kg: 1 ml per kg per hour

The fluid infusion rate should be increased or decreased based on urine output. The expected output should be based on ideal body weight, not actual pre-burn weight (i.e. the patient who weighs 200 kg does not need to have a urinary output of 100 ml per hour).

The fluid infusion rate should be increased or decreased by one-third if the urine output falls below or exceeds those limits by more than one-third for two consecutive hours.

### a. 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 to increase urine output. Once a diuretic has been administered, urinary output is no longer an accurate tool to monitor fluid resuscitation.

### b. Management of Hemochromogenuria (Red Pigmented Urine)

Patients with high voltage electrical injury, patients with associated soft tissue injury due to mechanical trauma and very deep burns 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.

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.

Persistence of red urine may indicate compartment syndrome.

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

## **2. Blood Pressure**

In the first few hours post burn, the patient should have a normal blood pressure. Early hypovolemia and hypotension are rarely associated with the burn and are usually a manifestation of associated trauma or cardiac abnormalities. It is important to find and treat the cause of the hypovolemia.

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.

## **3. Heart Rate**

Heart rate is also of limited usefulness in monitoring fluid therapy. A tachycardia of 100 to 120 beats 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 should be assessed on the basis of their age-related normal heart rate.

## **4. 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 mechanical trauma at the time of injury. In that case, transfusion of red cells should be individualized.

## 5. Serum Chemistries

Baseline serum chemistries should be obtained in patients with serious burns. 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 burn center physicians.

## V. Patients Requiring Increased Fluids

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. 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 (chronic or acute)
- Patients with very deep burns
- Patients burned as the result of a methamphetamine fire or explosion

## VI. Summary

Adults and children with burns greater than 20% TBSA should undergo fluid resuscitation using estimates based on body size and surface area burned. 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 formulas used for calculating resuscitation fluids for the first 24 hours are:

Adult Thermal and Chemical Burns:  $2 \text{ ml LR} \times \text{patient's weight in kg} \times \% \text{ TBSA second and third/fourth degree burn}$

Due to the underlying tissue destruction associated with high voltage electrical injuries, if there is evidence of deep tissue injury or the urine

shows any red or dark pigmentation, initiate fluid resuscitation using 4 ml LR x wt in kg x % TBSA visible burn.

Infants and children 14 years old and younger who weigh less than 40kg: initiate fluid resuscitation using 3 ml LR x weight in kg x % TBSA second and third degree burns. Children less than 10 kg should have their resuscitation with D5LR.

The infusion rate is regulated so that one-half of the estimated volume will be administered in the first eight hours post burn, calculated from the time of injury — 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 consecutive 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.
  - Adult thermal and chemical injuries: 30 – 50 ml per hour.
  - Pediatric patients: 1 ml per kg per hour.
  - Patients with high voltage electrical injuries: 75 – 100 ml per hour until urine clears.
- Frequent assessment of the patient's general condition, including mental status.
- Obtain baseline determination of hematocrit, hemoglobin, serum chemistries and arterial blood gases. Repeat studies as indicated.

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 the burn center regarding ongoing fluid requirements.*

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## **Ch. 5. Burn Wound Management**

### **Objectives:**

At the conclusion of this lecture, the participant will be able to:

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

### **I. Introduction**

The treatment of other life/limb threatening injuries always takes precedence over the treatment of the burn wound. 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

## **C. Burn Depth**

It is often difficult to determine the depth of injury during the first several days and the initial wound care is not dependant on the depth.

### **1. Partial Thickness Burns/First or Second Degree**

A first degree burn is a superficial injury limited to the epidermis and is characterized by redness, hypersensitivity and pain. Within a few days, the outer layer of injured cells peels away from the totally healed adjacent skin with no residual scarring. First degree burns are seldom medically significant and are not included when calculating the percent TBSA burn.

Second degree burns involve the epidermis and a variable portion of the dermis. The skin may be red and blistered, wet, weepy 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/Third or Fourth Degree**

Full-thickness burns (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.

Full-thickness burns (fourth degree burns) involve underlying fat, fascia, muscle and/or bone. The physiological impact of a burn is proportional to the extent of the body surface area involved with second and third/fourth degree burns. Superficial partial thickness burns do not result in scar formation. Deep partial thickness burns that heal by scar formation and full thickness burns even when grafted are likely to develop burn scar contractures. Burn depth determines the wound care required, the need for grafting, and the functional and cosmetic outcomes.

### 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 2<sup>nd</sup> and 3<sup>rd</sup> 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 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 are that improper wound care and inappropriate resuscitation may lead to more extensive injury. For large burns, *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. Localized or systemic hypothermia causing vasoconstriction may also extend the zone of coagulation increasing the size of the burn that requires surgical intervention and grafting.

## **B. Fluid Accumulation (Edema Formation)**

In addition to cellular damage, the thermal injury generates the classic inflammatory reaction with early and rapid accumulation of fluid (edema) in the burn wound. Following the burn, capillaries in the burn wound become highly permeable, leak fluid, electrolytes and proteins into the area of the wound. In patients with large burns, edema formation occurs in unburned tissues as well. This fluid 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 should be performed only after consultation with the burn center.

## **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), *do not* debride the burn or apply topical antimicrobial agents. Certain antimicrobial products such as silver sulfadiazine may change the appearance of the wound making it more difficult to accurately assess depth and severity upon arrival at the burn center. The burn wound should be covered with clean dry sheets prior to transfer.

After the initial 3-5 minutes of cooling the burn, wet dressings or sheets should not be used because evaporative heat loss and hypothermia may occur. To minimize heat loss, a thermal insulation blanket should be applied in the emergency department and during transfer.

If for any reason transfer to the burn center must be delayed beyond 24 hours, 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 cleaning with soap and water, followed by application of silver sulfadiazine cream or another alternative that is suitable with the receiving burn center. Any escharotomy incision should be treated the same way the rest of the burn wound is treated.

## **B. Escharotomies and Fasciotomies**

An escharotomy is an incision performed longitudinally through the burned tissue down to subcutaneous tissue over the entire involved area of full-thickness circumferential (or nearly circumferential) burns that are causing constriction and loss of peripheral perfusion or airway constriction. Prior to performing an escharotomy or fasciotomy, other causes of circulatory or ventilatory compromise (i.e. associated trauma, severe hypotension/shock, etc.) must be ruled out.

Escharotomies and fasciotomies are rarely indicated prior to transfer of a burn patient. Escharotomy can cause significant morbidity, and generally is not needed until several hours into the burn resuscitation. Therefore, in most cases, it can be delayed until the patient is transferred to a burn center familiar with performing these procedures. Certain patients, however, may require these procedures to allow normal ventilation and peripheral perfusion. Signs include:

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

### **1. 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. Signs that the patient is in need of a chest escharotomy include:

- Caregiver difficulty when assisting ventilation with a bag-valve-mask
- Increasing peak inspiratory pressures if the patient is on the ventilator
- Increasing restlessness or agitation
- Decreasing air exchange when listening to lung/breath sounds

When this problem is present, relief by escharotomy is indicated and may be life saving. Other causes of respiratory distress such as airway obstruction, pneumothorax, right mainstem intubation, 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**

During the primary survey of all burn patients, all rings, watches, and other jewelry must be removed from injured limbs to avoid distal 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.

In an extremity with tight unyielding circumferential eschar, edema formation in the tissues may produce significant vascular compromise in that limb. This sequela 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.

Use of an ultrasonic flowmeter is a 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, arterial or other associated injuries, and is compatible with the burn 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. Because the third degree burn is insensate, local anesthesia is rarely needed. However, small doses of intravenous narcotics or ketamine may be utilized for analgesia. The incision, which must avoid major nerves, 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 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 and is treated by fasciotomies, which should be performed in the operating room. The great majority of burn patients with circumferential burns of the extremities and decreased Doppler arterial flow, however, respond well to escharotomies and do not require fasciotomies.

## 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 across 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. Rapid, dramatic changes in appearance may result in the patient being unrecognizable even to those closest to him/her. Prepare visitors for this change prior to their first visit. It is not uncommon for the patient's eyes to swell closed for several days post burn. Prepare the patient for this frightening possibility and provide education and emotional support.

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 unless the patient is hypotensive or has a spinal injury that prohibits such positioning.

To avoid chemical conjunctivitis, only 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. Check for and remove contact lenses before swelling occurs. 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 7, *Chemical Burns*).

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 should be avoided.

### **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) may have sustained a 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 flow meter 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. Prior to and during transportation of the patient to the burn center, it is best to apply clean, loose coverings over the burn. This dressing should allow rapid evaluation of the circulatory status of the extremity and also prevent inadvertent constriction from the wraps. Monitor pulses every hour. 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. Tar and Asphalt Burns**

Hot tar and asphalt 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.

Roofing asphalt doesn't even become pliable until it reaches 180-200° F (82-93° C). The maximum storage temperature is 250° F (121° C) and is much hotter when being applied. These extreme temperatures combined with the thick viscosity result in very deep burns if not cooled immediately and adequately. Emergency treatment consists of cooling the molten material with cold water until the product is completely cooled. Physical removal of the tar is not an emergency. After cooling, adherent tar should be covered with a petrolatum-based ointment (such as white petrolatum jelly) and dressed to promote emulsification of the tar. Removal of the tar or asphalt may be delayed until arrival at the burn center.

## **VII. 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.

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## Ch. 6. Electrical Injury

### Objectives:

At the conclusion of this lecture the participant will be able to:

- 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 wounds may be associated with devastating internal injuries. Electrical injuries account for approximately 4% of all burn center admissions and cause around 1,000 deaths per year. Frequently these are work-related injuries and have a significant public health and economic impact. Electrical injuries are caused by direct or alternating current (DC or AC), and are arbitrarily divided into high or low voltage, the former being 1,000 volts or greater.

A century ago virtually all electrical injuries were caused by lightning, but today they are outnumbered tenfold by accidents associated with commercially generated electricity. Electricity may also be used during suicide attempts.

Electricity can cause injury by current flow, arc flash, or ignition of clothing. Understanding these mechanisms may help to predict the severity of the injury and the potential sequelae.

## II. Pathophysiology

### A. Terms to Describe Electricity

In physics, the flow of electricity in an electrical circuit is described to be like water in a garden hose. The smaller the wire, the higher the resistance (measured in Ohms) and the less the current flows for any given pressure (measured in Volts). 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):  $I = V/R$ . Further equations describe the creation of heat (J) by the Joule Effect ( $J = I^2 \times R \times T$ ) indicating the importance of current, contact time and tissue resistance.

*These concepts are inadequate to completely describe the effects seen on living tissue. While it is true that Joule heating contributes to the damage of tissue, this does not explain the clinical findings of electrical injury. It is now apparent that besides the production of heat, other processes such as electroporation may damage the tissue. Such processes cause damage that is not immediately apparent on physical exam and leads to progressive cellular damage and tissue death. In addition, other factors are involved besides time of contact, resistance and current. For example, the position of the limb to the direction of current flow (e.g. flexed vs. extended) can change the dynamics of tissue damage. Since body tissue is not homogeneous, the resistance of the body is not homogeneous. Generally speaking, skin and bone are high resistance while nerves, muscle and blood vessels have the least resistance. Therefore, looking at our body as a simple conductor whose resistance is simply proportional to cross-sectional area is an oversimplification. Dry skin has a resistance as high as 100,000 Ohms. Once this resistance is overcome current flows through the underlying tissue, especially muscles, following a highly unpredictable path. Consequently, deep tissues may be severely injured even when superficial tissues appear normal or uninjured. Due to this unpredictability, one must be very suspicious examining the patient exposed to electrical current. Contact points may be in unexpected locations and the external findings may be innocuous and not reflective of a severe underlying injury that may threaten limb loss or loss of life.*

In some cases, the contact time becomes even more important than the other variables. When exposed to a threshold current, the victim may experience the inability to "let go" of the electrical contact due to the tetanic contraction of the flexor muscles that overwhelm the extensor muscles.

This can lead to extraordinarily long contact times and resulting extensive tissue damage similar to a high voltage injury even with relatively low voltage. Similar injuries can be found if the patient becomes unconscious in contact with the source of electricity.

Patients who receive electrical injury are sometimes described as being “electrocuted”. Electrocution means “to kill by shock of electricity”. Unless the patient is dead, the term electrocution is not appropriate.

Findings that suggest electrical conduction injury include the following:

- Loss of consciousness
- Paralysis or mummified extremity
- Loss of peripheral pulse
- Flexor surface contact injury (antecubital, axillary, inguinal or popliteal burns)
- Myoglobinuria (red or black urine)

## **B. Direct Current (DC) Versus Alternating Current (AC) Conduction Injuries**

Direct current (DC) injuries are commonly caused by lightning and occasionally by car batteries (including hybrid cars). Car batteries produce low voltage electricity and cause injuries if a metal object like a watch band or ring becomes fused to the frame. The current flow heats the metal, causing a circumferential contact burn.

In contrast, lightning involves very high voltage and amperage current. Lightning can strike a person directly, causing massive injuries, or travel through a nearby object to the victim, dissipating much of the energy.

Commercially generated alternating current (AC) is used to power most appliances and household items. It is most efficiently transmitted across large distances at high voltage. Even low voltage AC is extremely dangerous to the human body, readily causing death from cardiac fibrillation or respiratory arrest.

In North America, the 60 cycle current used means that the current changes direction 60 times per second. With a contact time of even a fraction of a second, the current may have changed direction several times. Unlike the terminology for gunshot wounds, there are no entrance and exit sites. Direct current (DC) travels in one direction and entrance and exit sites may be possible. However, even with DC current, more than two sites may be evident. It is generally more appropriate to use

the term “contact point” when describing the wounds seen with electrical injury and to reserve the terms of entrance and exit wounds for gunshot wounds.

Regardless of whether the electrical injury comes from AC or DC current, it is not truly identical to other thermal injuries. In some cases, the appearance of the electrical contact point is different than what one expects from burn injury. Electrical contact points often are blackened, dark and dry but with a hole in the skin leading to the erroneous term “entrance wound”. The cellular damage and ultimate prognosis is also quite different. The details of this are beyond the scope of this course. Suffice it to say that the term “electrical burn” is a misnomer when referring to a true conduction injury. It is more appropriate to say “electrical injury” than to say “electrical burn”.

## **C. Types of Injury, Based on Mechanism**

### **1. Body Conduction**

When electrical current flows in a person, the muscles contract powerfully, causing the victim’s hands to clench often maintaining contact with the electrical source. Low voltage electricity may cause few physical findings, but delayed onset of migratory pains and psychological effects can be very debilitating. Referral for burn center evaluation is recommended even for minor electrical injuries. This is due to the electrical nature of nerve and muscle that allows function of the central nervous system and the heart. Low voltage current rarely causes significant muscle damage, but wet skin has a lowered electrical resistance and *even low voltage current can cause fatal cardiac arrhythmias*. Cutaneous contact points have concentrated current flow, causing the cratered skin wounds that are diagnostic of electrical conduction injury. High voltage current heats tissue immediately, causing deep tissue necrosis, which may not be externally visible except for the charred contact points.

### **2. Arc Flash and Arc Blast Injuries**

When electrical current travels through the air between two conductors, the resulting arc has a temperature of up to 4000°C. The heat released can cause flash burns to exposed skin and even ignition of clothing or surrounding objects. The explosive force of the superheated air may cause associated blunt trauma from a fall. The blast wave may create enough pressure to rupture eardrums and/or collapse lungs.

### **3. Secondary Ignition**

An arc flash releases sufficient energy as radiant heat to ignite clothing or surrounding flammable materials. A severe flame burn can result even in the absence of electrical conduction injury.

### **4. Thermal Contact Burns**

As the electrical current passes through the body, heat is generated. Any metal, such as jewelry, body piercings, zippers, metal in shoes, etc, may be superheated by conducting electricity, resulting in small, but deep contact burns.

### **5. Associated Injuries**

Many people working with electricity are working off the ground on power poles, in truck “buckets”, on roofs or ladders and suffer falls. The electrical current itself causes tetanic contraction of muscles that can result in dislocations of major joints and fractures of vertebral and/or long bones. Every victim of electric shock should be assessed and managed as a trauma patient until associated injuries are ruled out.

*It cannot be overemphasized that the appearances of electrical injury can be deceiving. Even if the exam looks as if the patient has a simple thermal injury, it may really be a conduction injury. Electrical injury can confuse even the most experienced burn surgeon.*

## **D. Lightning Strike**

Lightning occurs chiefly in the summer months. The risk of being struck by lightning is about one per million per year in the U.S. Lightning kills 80 to 100 people in the U.S. annually and injures another 300 per year. Up to 70% of survivors suffer serious complications.

Lightning is direct electrical current and a typical strike may carry 100,000 volts and 10,000 amps. A direct cloud-to-ground lightning strike, which hits you or something you are holding, is usually fatal. Most injuries occur indirectly from a side flash, when lightning current discharges from a nearby object (e.g. a tree or building) and travels through the air to the victim. The current may also strike the ground close to the victim (considered the strike point) and travel through the ground to the person, (the strike point potential). One may also be injured by a surge voltage, which occurs when lightning strikes the source of power or network the individual is using (electrical appliance or telephone) and the person receives a shock.

The presentation of a lightning injury varies widely, even within groups of people struck at the same time. The lightning current causes immediate depolarization of the entire myocardium, much like a defibrillator machine, which can produce asystole. Respiratory arrest is more common, since electrical current can temporarily inactivate the respiratory center of the brain. Immediate CPR is lifesaving. Survivors often have reddened areas of the body where the current flowed over the moist skin. A characteristic temporary ferning pattern on the skin called Lichtenberg figures is pathognomonic for electrical injury. These usually occur within an hour of the injury and persist for up to 36 hours and are not associated with any pathological changes in the epidermis or dermis.

### III. MANAGEMENT

**STOP! Confirm that the scene is safe from electrical current. Do not become the next victim.**

Subsequent evaluation of the patient with electrical injury is similar to other burn injury. Extra effort must be taken to find all contact points and to detect evidence of blunt trauma or other associated trauma. In addition, cardiac monitoring should be initiated as soon as possible due to the high possibility of arrhythmia.

#### A. Primary Survey

The primary survey is the same as discussed in Chapter 2, *Initial Assessment and Management*.

**1. Airway maintenance** with cervical spine protection is indicated if a fall or blunt force trauma is suspected. Due to the high potential for associated injury or vertebral injury as the result of muscle contraction, a c-collar should be applied.

**2. Breathing and ventilation.** Administer 100% oxygen per non-rebreather mask.

**3. Circulation and cardiac status.** *Apply cardiac monitor and monitor for cardiac dysrhythmias.* Insert two large bore IVs and initiate fluid resuscitation based on age. Assess peripheral perfusion and examine for circumferential burns. Obtain initial vital signs.

**4. Disability, Neurological Deficit, Gross Disability**

Assess level of consciousness

Assess neurological status and any gross deformity

**5. Exposure and Environmental Control**

Stop the burning process, remove all clothing and metal and protect the patient from hypothermia

**B. Secondary Survey**

- Obtain patient history using AMPLET
- Perform a head-to-toe physical examination
- Identify all contact points. Carefully check hands, feet, and scalp (hair may obscure wounds).
- Determine burn severity. Calculate % TBSA burn. Assess depth of injury
- Perform a detailed motor and sensory neurological examination and document changes with time. This is even more important in electrical injury due to the greater possibility of nerve damage and compartment syndrome with even minimal cutaneous injury.
- Continually monitor for fractures/dislocations, occult internal injury, and evidence of compartment syndrome.
- Administer medications for pain and anxiety.

**C. Resuscitation**

Prompt initiation of fluid resuscitation to maintain a high urine volume is important when hemochromogens are evident in the urine. Initiate fluid resuscitation using LR based on the ABLIS 2010 Fluid Resuscitation Formula sufficient to treat the visible surface burns. This volume of fluid may be inadequate if muscle injury or other associated injuries are present.

- Insert a urinary catheter.
- Infuse additional Ringer's Lactate at a rate sufficient to maintain a urine output of 75-100 ml per hour in an adult or 1 ml/kg/hour in a child.
- If there is evidence of hemochromogens such as myoglobin, the urine output should be maintained between 75-100 ml per hour until the urine grossly clears.

## **D. Cardiac Monitoring**

Electrical injuries can result in potentially fatal cardiac dysrhythmias. An electrocardiogram (ECG) should be performed on all patients who sustain high or low voltage electrical injuries. A 12-lead ECG will help detect any cardiac rhythm changes that require ongoing monitoring. Maintain continuous cardiac monitoring if dysrhythmias or ectopy are found.

Prolonged monitoring is not required if there is a normal ECG, and no history of unconsciousness, cardiac arrest, or abnormal rate or rhythm.

## **E. Maintenance of Peripheral Circulation**

All rings, watches and other jewelry must be removed from injured limbs, otherwise a “tourniquet-like” effect may cause distal vascular ischemia.

Skin color, sensation, capillary refill and peripheral pulses must be assessed hourly in any extremity with a circumferential cutaneous burn, an electrical contact site, or abnormal neurologic exam.

Decreased blood flow suggests the development of a compartment syndrome. Compartment syndrome can occur with circumferential third degree burns requiring surgical escharotomy at the burn center. High voltage electrical burns frequently injure deep muscles that swell within the muscle fascia and interrupt blood flow to the extremity. Surgical fasciotomy by an experienced surgeon is required at the burn center.

## **F. Special Situations: Cardiac and/or Respiratory Arrest**

**STOP. Assess the risk that current may be flowing at the accident scene. Do not become the second victim.**

Ventricular fibrillation, asystole, and other life-threatening arrhythmias are treated as outlined by the Advanced Cardiac Life Support course.

Endotracheal intubation may be necessary if the patient has had a respiratory arrest, a head injury from a fall or if there are burns involving the head, face, or neck.

*Patients with a history of loss of consciousness or documented dysrhythmias either before or after admission to the emergency department, or those with documented ECG abnormalities should be*

*admitted for (continuous) cardiac monitoring. Patients with low voltage injuries and normal ECGs may be discharged unless wound issues dictate otherwise.*

High voltage injuries can result in extreme injuries resulting in loss of limb(s). Fortunately, with the advances in prosthetics and rehabilitation, many of the survivors are able to return to pre-burn functional and emotional status.

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## Ch. 7. Chemical Burns

### Objectives:

Upon completion of this lecture, 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.

### 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 injuries accounted for 3% of all burn center admissions (1999-2008). Most chemical burns are unintentional injuries but chemicals can also be used as a form of assault, abuse or during a suicide attempt.

Injurious chemicals react with the skin, may not be easily removed, and thereby continue to cause injury for an extended time. The severity of a chemical burn is reduced by prompt recognition and rapid treatment.

Chemicals cause injury in four ways:

- Absorption through the skin and mucous membranes
- Ingestion
- Inhalation
- Or as a combination of any of the three (i.e. a scald burn with chemicals in the water)

Chemical burns are progressive injuries and it is often very difficult to determine the severity early in the course of treatment. The initial appearance of a chemical burn can be deceptively superficial and any patient with a serious chemical burn injury should be referred to a burn center for evaluation and definitive management.

## II. Classification

The most common chemicals that cause cutaneous burns fall into three categories: alkalis (bases), acids, and various organic compounds. Alkalis and acids are used in cleaning agents, at home and at work. Organic compounds, including petroleum products, can be topically irritating and systemically toxic.

### A. Alkalis (AKA Bases. pH >7)

Alkalis, including lye and other caustic sodas, may contain the hydroxides, or carbonates of sodium, potassium, ammonium, lithium, barium and calcium. They are commonly found in oven cleaners, drain and toilet bowl cleaners, fertilizers and heavy industrial cleansers like stripping agents. Hydrated calcium hydroxide forms the structural bond in cement and concrete. Wet cement, with a pH of approximately 12, can cause a severe alkali chemical burn. Anhydrous ammonia is used as a fertilizer and in methamphetamine manufacture. Alkalis damage tissue by liquefaction necrosis and protein denaturation. This process allows deeper spread of the chemical and progression of the burn.

### B. Acids (pH <7)

Acids are likewise prevalent in the home and in industry. They may be found in many household products. Hydrochloric acid, oxalic acid, or hydrofluoric acid may be found in bathroom cleansers and calcium or rust removers. Concentrated hydrochloric (muriatic) acid is the major acidifier for home swimming pools and is used to clean masonry and brick. Concentrated sulfuric acid is utilized in industrial drain cleaners and car batteries. Leather is produced by the action of a weak acid on animal dermis (rawhide) in a process called tanning. Acids damage human tissue by coagulation necrosis and protein precipitation, causing a thick leathery eschar. The exception is hydrofluoric acid, which is discussed later.

### C. Organic Compounds

Many organic compounds, including phenols, creosote, and petroleum products, produce contact chemical burns and systemic toxicity. Phenols

are prevalent in a variety of chemical disinfectants. Petroleum, including creosote, kerosene, and gasoline, is commonly used in the home, in industry, and in recreation. Organic compounds cause cutaneous damage due to their solvent action on the fat in cell membranes. Once absorbed, they can produce harmful effects on the kidneys and liver.

### **III. Factors That Determine Severity**

#### **A. Severity of Chemical Injury**

The severity of a chemical injury is related to:

- Chemical composition of the agent and the mechanism of action
- Starting concentration
- Starting temperature of the agent
- Volume or quantity of the agent
- Duration of contact

The concentration and duration of contact of the chemical influences the depth of injury, and the volume of the chemical affects the extent of body surface involved. The temperature affects the rate at which the chemical reacts with the tissue. Dry chemicals should be brushed from the patient's clothing and skin prior to irrigation. Immediate irrigation with water decreases the concentration and duration of contact, thereby reducing the severity of the injury. Water should be used liberally to remove almost any chemical substance exposed to the body.

Delay in removal of the agent and any contaminated clothing permits continued tissue damage. Prompt irrigation to remove and dilute the chemical is vital to minimize tissue injury. Delay in implementation of resuscitation contributes significantly to major disability.

#### **B. Pediatric Chemical Burns**

Pediatric patients are more likely to ingest chemicals than adults. Children are less able to process and eliminate chemicals and the developing brain and organs may be more susceptible to damage associated with chemical injuries.

## IV. Treatment

Body Substance Isolation must 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. Remember that patient's clothing often contain remnants of the injurious agent. Failure to take simple precautions can lead to significant provider injury. **Don't become a victim!**

Decontamination is the process of removing or neutralizing a hazard from the victim to prevent further harm and enhance the potential for full clinical recovery. For every chemical burn, immediate removal of the contaminated clothing (including underwear, gloves, shoes, jewelry and belongings) is critical. All contaminated clothing and belongings should be disposed of according to organizational/institutional protocols to prevent secondary contamination to others.

Immediately brush any powdered chemical from the skin and begin continuous irrigation of 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 (an exothermic reaction), which could contribute to further tissue destruction. Irrigation in the hospital 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.

If the chemical exposure is to a large body surface area, caution must be taken to avoid hypothermia. Use warm water for irrigation if it is available and maintain a warm environment if possible.

Support the "ABCs" (airway, breathing, circulation): volatile chemical agents like ammonia can have profound respiratory effects. It is important to continually evaluate the patient's airway status and to address promptly any evidence of airway compromise. Intravenous access should be obtained for all significant chemical injuries.

Patients who are wearing contact lenses, with or without facial burns, should have the lenses removed. Contact lenses need to be removed prior to development of facial and periorbital edema. Chemicals may also adhere to the lenses, prolonging exposure to the chemical and presenting further problems.

After initial therapy has begun, it is helpful to identify the causative agent and any associated medical risks, including potential systemic 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 (1-800-222-1222).

## V. Specific Chemical Burns

### A. Chemical Injuries to the Eye

Alkalis cause chemical eye injuries twice as frequently as acids 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 the 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 adequately irrigate 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 catheter (Morgan lens) may be fitted over the globe. Extreme caution should be used when employing this irrigating modality to prevent additional injury to the eye and a topical ophthalmic analgesic should be utilized.

Continue irrigation until the patient has been fully evaluated by a qualified professional. An ophthalmologist in consultation with the burn center should see all alkali injuries to the eye.

### B. Anhydrous Ammonia

Anhydrous ammonia is commonly used as a fertilizer, industrial refrigerant and in the manufacture of illicit methamphetamine. It is a strong base (pH 12) with the penetrating odor of smelling salts. Anhydrous ammonia, reacting with body moisture on contact is corrosive to body tissues. Moist or sweaty areas of the body such as the axilla or groin are frequent sites of serious injury.

**1. Skin Exposure:** Exposure causes blistering of the skin. Contact with vaporizing liquid anhydrous ammonia may cause frostbite due to rapid evaporative cooling.

**2. Eye Irritant:** Eye injuries are also common. Anhydrous ammonia is an eye irritant that may cause severe eye irritation with corneal injury and permanent vision impairment. Eye injuries require prolonged irrigation of the eye and need to be evaluated by an ophthalmologist.

**3. Respiratory Effects:** Inhalation of anhydrous ammonia may result in serious injury to the entire respiratory tract. Delayed effects may include potentially life-threatening edema of the upper and lower airway. Chemical pneumonitis and pulmonary edema may develop several hours after exposure. At high concentrations, laryngeal spasm may occur resulting in rapid asphyxiation. Effects are more pronounced at lower concentrations in children, the elderly, and persons with impaired lung function. Inhalation injuries with hypoxemia and copious secretions may require ventilator support.

Immediately after exposure, all clothing (including undergarments), shoes, and jewelry should be removed and disposed of according to organizational protocols. The eyes and affected areas should be flooded with water for at least 30 minutes. A desired endpoint is to completely remove the smell of ammonia. Such an aggressive irrigation may prevent the need for subsequent skin grafts.

### **C. Hydrofluoric Acid (HF)**

Hydrofluoric acid is a corrosive agent used in industry to etch glass, make Teflon, cleanse conductors and for a variety of other uses. It is used in home and industrial cleaners as a rust remover and is often combined with other agents in these products. HF may cause skin damage and burns, eye damage, and, when inhaled, severe respiratory problems.

Although it is a weak acid, the fluoride ion is very toxic. Exposure to low concentrations (less than 10 percent) causes severe pain, which does not appear for 6- 8 hours. Higher concentrations cause immediate intense pain and tissue necrosis. Death can occur from hypocalcemia as the fluoride rapidly binds free calcium in the blood. Cardiac dysrhythmias may occur.

After hydrofluoric acid exposure, all clothing including undergarments should be removed and disposed of appropriately. The affected areas should be flooded with water at the scene for at least 30 minutes.

Once in an appropriate facility, topical calcium gel may be used to neutralize the fluoride (one amp calcium gluconate and 100 gm of water soluble lubricating jelly). *This is one of the rare exceptions of a direct neutralizing agent being used to acutely treat a chemical exposure.* The gel is applied with the gloved hand to avoid spread of the fluoride to other body parts or to medical personnel. This calcium mixture can be placed inside a surgical glove worn by the patient to treat injuries of the hand. Patients who have persistent pain may require intra-arterial infusion of calcium at a regional burn center and require careful monitoring.

Severe pain indicates exposure to a high concentration, which may cause life-threatening hypocalcemia. 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 aggressive calcium infusion and early excision of the wound may be lifesaving.

#### **D. Phenol Burns**

Phenol, an acidic alcohol with poor solubility in water, is frequently used in disinfectants, chemical solvents, and wood and plastic processing. It damages tissue by causing coagulation necrosis of dermal proteins. Initial treatment consists of copious water irrigation followed by cleansing with 50% polyethyleneglycol (PEG) or ethyl alcohol, which increases the solubility of the phenol in water 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.

#### **E. Petroleum Injuries (Not Flame Burns)**

Gasoline and diesel fuel are petroleum products that may cause severe 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 crashes 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 crash 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. Patients with these injuries require immediate transfer to a burn center.

It is important to remember that clothing and belongings that have been exposed to the fuel are potentially flammable, must be kept away from any ignition source and disposed of appropriately.

### **F. Burns Associated with Methamphetamine Fires and/or Explosions**

Burns associated with methamphetamine (meth) lab explosions pose additional hazards to all healthcare providers. There are many hazardous chemicals involved in the production of methamphetamine (pseudoephedrine, iodine, red phosphorous, ether, hydrochloric acid, sodium hydroxide, methanol).

Patients involved in these incidents are often less than truthful about the circumstances of injury, reporting that he/she was involved in a "fire" of some type. Upon evaluation, the pattern of burn injury is inconsistent with the history being reported. Often times EMS has not been called to the scene and the patient arrives at the hospital via private vehicle. The patient may present with serious burns that appear to be thermal/flame burns in appearance but in actuality are a combination of flame and chemical injuries. The patient may be tachycardic (greater than expected with a similar size burn), hyperthermic, and appear extremely agitated or paranoid.

If there is any possibility the patient may have been involved in a meth lab explosion, treatment must include the use of appropriate protective clothing by healthcare providers, decontamination of the skin and eyes, proper disposal of contaminated clothing and belongings, and treatment of the thermal injuries.

### **G. 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, Lewisite and chlorine gas, 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: use of Body Substance Isolation apparel, removal of all clothing, shoes and jewelry, and copious irrigation with water. Patients with respiratory compromise should be intubated if necessary. In order to avoid provider injury from environmental contamination in cases involving large numbers of victims, particular care should be taken to establish a single area for isolation of contaminated clothing and equipment. Agents used in chemical attacks frequently have both short and long-term morbidity and toxicity. Contact the Poison Control Hotline at 800-222-1222 for specific treatment for these chemical agents.

## **VI. Summary**

Chemical burns constitute a special group of injuries and require referral 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 and contaminated clothing, 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. Ammonia, 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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## Ch. 8. Pediatric Burn Injuries

### Objectives

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

- Describe how children differ from adults with respect to size, body surface area and skin thickness.
- Identify how the differences in pediatric pathophysiology impact burn treatment.
- Discuss principles of airway management for children with inhalation injury.
- Describe fluid resuscitation requirements for the child with a burn injury.
- List signs of child abuse.

### I. Introduction

Children, for ABLS purposes, are defined as those between the age of birth and 14 years. Each year, up to 1,000 children die from fire and burn injuries in the United States. Fires and burns are the leading cause of unintentional death *in the home* for children. Children under 5 years of age are at the greatest risk for home fire death and injury; their death rate is twice the national average. The leading cause of fire death to children under 5 years old is children (self or another child) misusing fire.

An average of 116,000 children under the age of 14 are burned seriously enough each year to require medical attention. In the United States scald burns from tap water or food/beverages are the most common thermal injuries in children under the age of three. Scald burns are also prevalent in cases of child abuse. Flame burns are more commonly seen in older children.

## II. Pathophysiology

### A. Body Surface Area

Infants and young children 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 area of the adult. The relatively large body surface area of children results in greater contact with the environment and evaporative water loss per unit of weight than the adult. Therefore, children require more fluid per unit of body weight during resuscitation than adults. Relationships between surface and weight are established by 15 years of age (same as an adult).

Because the total body surface areas are different, a cup of water or a clothes iron will produce much greater TBSA burns in a child than in an adult.

### B. Temperature Regulation

Temperature regulation in the infant and child is also influenced by the child's relatively greater body surface area. More body surface area is exposed per unit body weight after burn injury in a child, and body heat is rapidly lost from these areas. Intrinsic heat generation by shivering is hampered by a relatively small muscle mass in a child. Temperature regulation in infants less than 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 and Depth of Burn

Children under age 2 years have thinner skin than adults and are prone to full-thickness burns at lower temperatures and shorter duration of contact than adults. Exposure of tissue to temperatures at or below 111° F (43.5° 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 a full thickness injury. At 140°F (60°C), a common setting for home water heaters, tissue destruction occurs in five seconds in adults and 3 seconds 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.

## Approximate Time and Temperature Relationship to Severe Burns in Children

Water Temperature	Time for a third degree burn to occur	
100° F	37° C	Safe temperature for bathing
120° F	48° C	5 minutes
124° F	51° C	3 minutes
127° F	52° C	1 minute
133° F	56° C	15 seconds
140° F	60° C	5 seconds
148° F	64° C	2 seconds
155° F	68° C	1 second

Approximate temperatures for frequently encountered hot liquids		
102-104° F	38.9-40° C	Spa/Jacuzzi
119° F	48.3° C	First adult pain
120° F	48.9° C	Recommended water heater setting
175-185° F	79.4-85° C	Holding temperature fast food coffee
212° F	100° C	Boiling water
300-500° F	148.9- 260° C	Grease - frying

### III. Initial Assessment and Management

#### A. Primary/Secondary Survey and Management

Primary and secondary surveys for pediatric patients follow the same format as for an adult (described in Chapter 2, *Initial Assessment & Management*). Pediatric patients do have special considerations that will be covered in this chapter.

##### 1. Airway with Cervical Spine Protection

Fundamental considerations of airway thermal injuries have been discussed in Chapter 3, *Airway Management and Smoke Inhalation Injury*. Edema leading to airway obstruction is the major concern. Since a small child's airway is smaller than an adult's, less edema is needed to develop obstruction. Subtle signs include hoarseness, increased work of breathing, tachypnea, and ultimately use of accessory muscles. 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 due to the smaller diameter of the child's airway and the need for significant fluid volumes during resuscitation. Face burns also increase the risk for airway edema.

Intubation should be undertaken by someone experienced in managing the child's airway due to the anatomic differences between adults and children. The infant's larynx is located more cephalad (anterior) and the glottis is more angulated and located more anteriorly than the adult's. These anatomical differences make intubation by the inexperienced more difficult. The diameter of the child's nares or small finger may be used to gauge the size of the endotracheal tube. An alternative method of estimating the proper endotracheal tube size is to use the equation  $(16 + \text{age in years}) / 4$ . Remember that the narrowest point of the pediatric airway is at the cricoid and not at the glottis. After intubating the child it is helpful to listen for an air leak and also to ensure that the endotracheal tube is in the correct location and both lung fields are being ventilated.

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. After intubation, placement of a nasogastric tube is advisable. Infants and children often swallow air when crying, resulting in gastric distension, which can impair ventilation. Nasogastric tube decompression will be helpful in eliminating the swallowed air.

**Airway Diameter Comparison  
(Resistance  $\propto 1/\text{radius}^4$ )**

**Infant:**

Airway Diameter 4 mm

- 1 mm edema = resistance increase 16X
- 75% decrease in airway diameter
  - Like an adult trying to breathe through a coffee stirrer with nose plugged
  - Crying makes this worse.

**Adult:**

Airway diameter 8 mm

- 1 mm edema = resistance increase of only 3X
  - Like an adult trying to breathe through a straw with nose plugged

## 2. Breathing and Ventilation

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. In addition, children have more compliant chests and tend to use the abdominal muscles for breathing when compared to adults. It is essential that the practitioner listen for bilateral breath sounds (and

preferably obtain a chest x-ray) to confirm proper positioning of the endotracheal tube. It is critical that the ET tube and NG tube are secured well.

A child should have the head of the bed elevated 30 degrees unless contraindicated by an associated injury or medical condition. Elevation helps open the airway and decreases cerebral edema.

### **3. Circulation and Cardiac Status**

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

As with adult patients with burns, LR is the resuscitation fluid of choice, except in those < 10 kg, D<sub>5</sub>LR is the preferred fluid in this size infant. Intravenous cannulae are inserted. During prehospital care and the primary survey in the hospital, until the percent total body surface area burned is calculated and the patient's weight in kg is obtained in the secondary survey, fluid resuscitation rates are started as follows:

- 5 years old and younger: 125 ml LR per hour
- 6 – 14 years old: 250 ml LR per hour

Intravenous cannulae may be inserted percutaneously or by cutdown. The earlier the line is attempted the easier it is to place. Once shock occurs, finding a vein may be quite difficult. Since the cutdown eliminates future IV access, it should be the last choice for intravenous access. 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 (IO) infusion may be lifesaving in the severely burned infant, but is indicated only when intravenous line placement has been unsuccessful prior to interhospital transfer. Compartment syndromes in the extremity have resulted from misplaced IO lines; furthermore, IO lines should be removed as soon as IV cannulation is established.

## 4. Disability, Neurological Deficit, and Gross Deformity

All children need to be assessed for changes in level of consciousness and neurological status as described in Chapter 2, *Initial Assessment & Management*. Hypoglycemia and hypoxia often present as agitation and confusion in children. It is important to identify and treat the cause of any change. Remember that changes may be due to something other than the burn injury.

## 5. Exposure, Examine and Environment Control

Management of the burn wound should include stopping the burning process, removing all clothing, diapers, jewelry, shoes and socks to examine the entire body to determine the extent of the burn injury. The child should also be examined to assess for any associated or pre-existing injuries.

Cover the burned areas with clean, dry linens. Topical antimicrobial dressings are not indicated prior to transfer. During treatment and transfer, measures to conserve body heat, including thermal blankets, are essential for the infant and young child. Due to the large surface area of an infant or young child's head, the head should be covered to conserve body temperature during treatment and transport of children with large TBSA burns.

### B. 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:

#### 1. History

- Circumstances of the accident and first aid administered
- Even young female patients may need to be tested for pregnancy depending on circumstances
- Exposure to communicable diseases needs to be determined. Communicable diseases such as chickenpox may complicate recovery and pose a hazard to other patients and healthcare providers.
- Complete head-to-toe evaluation of the patient
- Determination of percent TBSA burned
- Fluid calculations using the ABLIS 2010 Fluid Resuscitation Formula
- Insertion of lines and tubes
- Lab and X-rays

- Monitoring of fluid resuscitation
- Pain and anxiety management
- Psychosocial support
- Wound care

Use the same mnemonic, AMPLET, discussed in Chapter 2, *Initial Assessment and Management*, to obtain a history about the child. Special considerations need to be given to the following: the events leading to the thermal injury and the past medical history. These are extremely important in the initial evaluation of an infant and child. One must rely on the caregiver to provide a history, since the child may not be able to. In addition to checking the child's tetanus status, review the health history to determine the immunization status and potential exposure to communicable diseases such as chicken pox.

The potential for child abuse must always be considered, particularly in children less than 4 years of age. The key strategy is to match the burn pattern with the description of how the burn occurred.

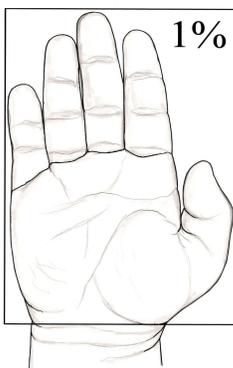
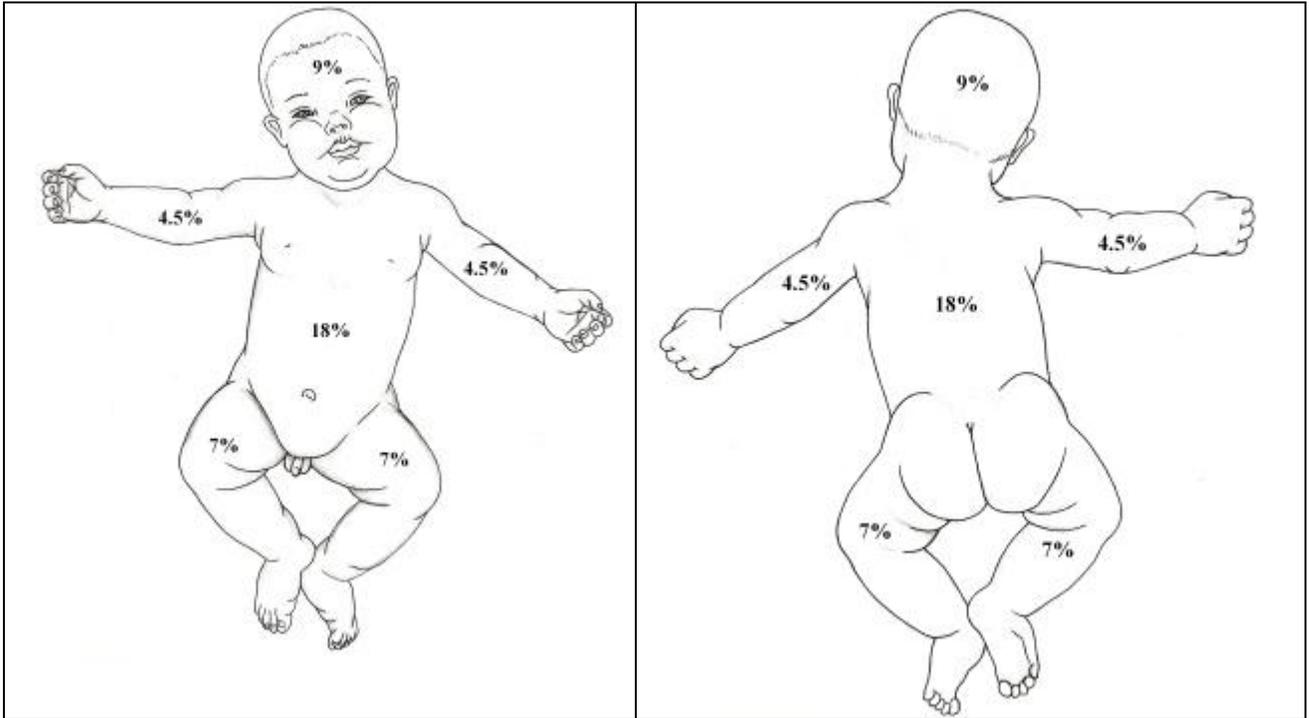
Another important aspect of the history of injury in a child is to match the burn with the developmental age of the child. Infants are unable to escape a hot source and thus develop deep and often massive injuries. Toddlers tend to explore their environment with their hands and mouths. The reflex to pull away after contacting a hot surface has not yet been developed, so they tend to sustain burns to the palm and fingers as they grab or touch items. Toddlers may also sustain burns to the oral commissure when they chew on electric cords. The period of toilet training is the period of high risk for "dip" burns associated with child abuse. As some boys mature they increase their high-risk behavior and thus tend to suffer flame burns as they play with matches, lighters and/or accelerants. Some teenagers are at risk for burns from peer pressures, and this is the age that suicide attempts increase.

## **2. Calculate the Percent TBSA Burned**

The "Rule of Nines" is of less value in estimating the size of burn in the young child since the head is relatively larger and the legs smaller. The head and neck represent 18 percent TBSA, twice that of an adult. Each lower extremity represents 14 percent TBSA in the infant. As the child ages, each year and a half on the average, subtract 1% from the head and add half to each leg. By the time the child reaches 15 years old, he or she has the same surface and weight ratios as an adult. A Lund and Browder Chart is helpful in detailing the extent of burn and in calculating the percentage of

body at different stages. A copy of the Lund and Browder Chart can be found at the end of Chapter 2, “Initial Assessment and Management.”

Only second and third degree burns are used in the calculations for fluid requirements.



### 3. 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, the patient’s hand-size can be used as a guideline to estimate the extent of irregularly scattered burns.

### 4. Fluid Resuscitation

In infants, hypoglycemia may develop due to limited glycogen reserves; therefore, blood glucose levels should be closely monitored. Infants weighing less than 10 kg should receive D<sub>5</sub>LR as their resuscitation.

Estimated fluid requirements used in the ABLIS 2010 Fluid Resuscitation Formula for burned children are similar to adult calculations, with one exception: use 3 ml x kg x % TBSA burn. Resuscitation fluids are the fluids needed to replace fluids being lost as the result of the burn injury. This is the fluid that is adjusted during the resuscitation period.

Starting intravenous resuscitation fluid rate in the infant and child can be calculated using the following formula:

**a. Estimated Fluid Resuscitation Rate:**

Total volume (ml) to be given over the first 24 hours post burn is 3 ml LR x weight (kg) x total body surface area (TBSA) second and third degree burns

- Half of the total should be administered in the first 8 hours
- Therefore, first 8 hour total fluid volume = [3 ml x weight (kg) x TBSA] divided by 2
- Starting fluid rate/hour for the first 8 hours (divide by 8)
- Subsequent 16 hours give one half initial hourly rate

Example Pediatric Fluid Calculation:

Initial fluid requirements in a 23 kg child with a 20% TBSA full thickness burn:

- Resuscitation Fluid: LR
- Total resuscitation volume to be given over first 24 hours post burn:  
3 ml x 23 kg x 20 (TBSA) = 1380 ml (as Ringer's Lactate)
- Half of total in first 8 hours: 1380 ml / 2 = 690 ml
- Starting resuscitative fluid rate per hour (divide by 8):  
690/8 = 86.25 ml/hr
- Titrate this fluid to maintain a urinary output of 1ml/kg/hour

It is important to remember that the resuscitation formulas are *estimates*. The response to fluid therapy will determine the rate and volume of fluid administration. A urinary catheter is needed to monitor the effectiveness of fluid resuscitation. In children weighing less than 40kg, adequate fluid resuscitation results in an average urinary output of 1 ml/kg/hr. In children over 40 kg, adequate fluid resuscitation is assumed with a urinary output of ½ ml/kg/hr. Urine volumes less than or greater than this require adjustment in fluid resuscitation rates.

Only second and third degree burns should be considered in the calculation. Adjuncts to monitoring urine output include monitoring the sensorium, the blood pH, and the peripheral circulation. Delays in initiating resuscitation, underestimation of fluid requirements, and overestimation of fluid requirements may result in increased mortality. After starting fluids, consult with the burn center regarding ongoing fluid requirements.

## IV. Escharotomy

Escharotomy in a child with burns may be necessary to relieve compartment syndrome of the extremities, chest, or abdomen. However, they are rarely required prior to burn center transfer, (the technique of escharotomy is described in Chapter 5, *Burn Wound Management*). Vascular impairment occurs with circumferential burns of the limbs. Deep tissue pain, paresthesia, pallor, and pulselessness are classic manifestations, but are frequently late in appearance. It is wise to consult the burn center when escharotomy is being considered. In addition to escharotomy, fasciotomy is sometimes necessary due to the relatively small size of the pediatric patient's compartments in each extremity, but should be performed only after consultation with the burn center.

The chest wall is more compliant in children than in adults. Consequently, edema and restrictive effects of a circumferential chest wall burn may rapidly exhaust the child. If such occurs, chest wall escharotomy is required. Incisions along the anterior axillary lines must extend well on to the abdominal wall and be accompanied by a transverse costal margin bridging incision. Abdominal compartment syndrome may also occur in the child. This syndrome is recognized by decreasing urine output despite aggressive resuscitation, and occurs in the face of hemodynamic instability and increased peak inspiratory pressures. Contact the burn center if you are concerned about this problem.

## V. Child Abuse by Burning

Burned children, particularly those under the age of four, should be evaluated for child abuse and neglect. Although scald injuries are the most frequent cause of child abuse by burning, children are also intentionally injured by contact with hot objects or flames. Scald burns may be due to immersion into hot liquids such as a bathtub or hot liquids may be deliberately poured onto a child.

Documentation, including photographs, is essential.

If child abuse or neglect is suspected, the child's pediatrician and/or primary caregiver should be consulted to determine an accurate health history. Question the pre-hospital care providers about scene observations if possible. Reporting of suspected child abuse is mandatory in every state in the U.S. Even if the child is being transferred to a burn center, the initial hospital should initiate the reporting process.

In order to detect such an event, the examining physician and staff must have a high level of suspicion, which should be triggered when:

- The pattern of injury is not compatible with the history given.
- The "story" changes between individuals or over time.
- A young sibling is blamed for the burn.
- The caregiver was absent at the time of injury.
- 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.
- The caregivers are more concerned about themselves than the child.
- The child appears unusually passive when subjected to painful procedures.
- There are burns of different ages.
- There are other forms of injury.
- The siblings have similar injuries.
- The child has signs of neglect such as lack of cleanliness, malnutrition, poor dentition.
- There is a history of previous Child Protective Services reports.

## VI. Preventing Pediatric Burns

Almost every pediatric burn can be prevented! Although the ABLS course does not teach fire safety and burn prevention, the ABA believes that all healthcare providers play a role in mitigating fire and burn injuries and deaths.

Prevention topics include:

- Scald Prevention
- Tap Water Scalds
- Food and Beverage Scalds
- Children's Sleepwear Flammability

- Youth/Juvenile Fire-setting
- Smoke Alarms and Fire Escape Planning for the Family

Fire safety and burn prevention materials are available for all members of your family and can be found at <http://www.ameriburn.org/prevention.php>. These prevention programs were developed for community education and outreach initiatives with the support of a grant from the US Fire Administration, Federal Emergency Management Agency, Department of Homeland Security, with funds appropriated by the US Congress under the Assistance to Firefighters Act (Fire Prevention and Safety Grants). There are six comprehensive campaigns (including PowerPoint presentations) available for download on topics including:

- Scald Injury Prevention
- Electrical Safety
- Fire/Burn Safety for Older Adults
- Leaving Home Safely
- Gasoline Safety
- Summer Burn Safety

## VII. Transfer Criteria

Infants and children with full-thickness 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 9, *Stabilization, Transfer and Transport*).

## VIII. 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. 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

- Decreased glycogen stores, which may be associated with hypoglycemia
- Possibility of child abuse/neglect

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## Ch. 9. Stabilization, Transfer and Transport

### Objectives

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

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

### I. Introduction

The patient with a compromised airway, electrical, chemical or major thermal injury requires immediate assessment and stabilization at the closest appropriate hospital. Hospital personnel must complete a primary and secondary survey and evaluate the patient for potential transfer to a burn center. 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 flowsheet. Transfer agreements should exist to ensure orderly transfers.

### II. ABA Burn Center Referral Criteria

The American Burn Association (ABA) has identified the following injuries as those requiring referral to a burn center. A burn center may treat adults or children or both. Burn injuries that should be referred to a burn center include the following:

- Partial thickness burns of greater than 10% total body surface area.
- Burns that involve the face, hands, feet, genitalia, perineum, or major joints.
- Third-degree burns in any age group.
- Electrical burns, including lightning injury.

- Chemical burns.
- Inhalation injury.
- Burn injury in patients with preexisting medical disorders that could complicate management, prolong recovery, or affect mortality.
- 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's condition may be stabilized initially in a trauma center before transfer to a burn center. Physician judgment will be necessary in such situations and should be in concert with the regional medical control plan and triage protocols.
- Burned children in hospitals without qualified personnel or equipment for the care of children.
- Burn injury in patients who will require special social, emotional or rehabilitative intervention.

Patients at the age extremes are subject to variable physiologic response to thermal injury. Infants and elderly patients are less tolerant of burn 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 To A Burn Center**

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 survey in the following manner.

#### **A. Body Substance Isolation**

Prior to initiating care of the patient with burns, it is critical that healthcare providers take measures to reduce their own risk of exposure to potentially infectious substances and/or chemical contamination. Body isolation devices include gloves, eyewear, gowns and respiratory protection. The level of protection utilized will be determined by patient presentation, risk of exposure to body fluids and airborne pathogens, and/or chemical exposure.

## **B. Primary Survey**

During the primary survey all life- and limb-threatening injuries should be identified and management initiated.

### **1. Airway Maintenance with Cervical Spine Protection**

The airway must be assessed and management initiated immediately. One hundred percent oxygen per non-rebreather mask should be applied to all patients with serious burns and/or suspected or confirmed inhalation injury. Intubation should be performed when indicated.

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.

### **2. Breathing and Ventilation**

Ventilation requires adequate functioning of the lungs, chest wall, and diaphragm. Circumferential full thickness burns of the trunk and neck, and the abdomen in children may impair ventilation and must be closely monitored. It is important to recognize that respiratory distress may be due to a non burn condition such as a preexisting medical condition or pneumothorax from associated trauma.

### **3. Circulation and Cardiac Status**

Major thermal injury results in a predictable shift of fluid from the intravascular space. Assessment of the adequacy of circulation includes evaluation of blood pressure, pulse rate, and skin color (of unburned skin). Baseline vital signs are obtained during the primary survey and are monitored throughout care and transport.

A large bore IV should be inserted and fluid resuscitation started using LR. In burns greater than 30% TBSA two catheters should be used. During the primary survey the fluid infusion rate should be based on patient age as follows:

- 5 years old and younger: 125 ml LR/hour
- 6 – 14 years old: 250 ml LR/hour
- 15 years and older: 500 ml LR/hour

Frequent assessment of the peripheral circulation, especially in areas of circumferential extremity burns, should be performed. Escharotomies may need to be performed.

#### **4. Disability, Neurological Deficit and Gross Deformity**

Typically, the patient with burns is initially alert and oriented. If not, consider associated injury, carbon monoxide/cyanide poisoning, substance abuse, hypoxia, or pre-existing medical conditions. Assess for any gross deformity that may be due to an associated trauma.

#### **5. Exposure and Environmental Control**

**Expose**, completely undress the patient and **Examine** the patient for major associated injuries and maintain a warm Environment.

The burning process must be stopped during the primary assessment. Cool the burn briefly (3 – 5 minutes) for thermal burns, with cool, not cold water. Remove all clothing, jewelry/body piercings, shoes, and diapers to complete the primary survey. If any material is adherent to the skin, stop the burning process by cooling the adherent material, cutting around it and removing as much as possible.

For chemical burns, remove all clothing and foot coverings, brush dry chemicals off the patient and then flush with copious amounts of running water.

Maintaining the patient's core body temperature is a priority. The EMS transport vehicles and treatment rooms should be warmed. As soon as the primary survey is completed, the patient should be covered with dry sheets and blankets to prevent hypothermia.

#### **C. Secondary Survey**

The secondary survey does not begin until the primary survey is completed and after resuscitative efforts are well established. The secondary survey entails:

- History
- Complete head-to-toe evaluation of the patient
- Determination of percent TBSA burned
- Fluid calculations using the ABLIS 2010 Fluid Resuscitation Formula
- Insertion of lines and tubes

- Lab and X-rays
- Monitoring of fluid resuscitation
- Pain and anxiety management
- Psychosocial support
- Wound care

## 1. History

Using the acronym AMPLET obtain the following history:

- A:** Allergies. Drugs and environmental
- M:** Medications: Prescription, over-the-counter, herbal and home remedies
- P:** Past medical history: **P**revious illnesses or injuries, potential for **p**regnancy
- L:** Last meal or drink
- E:** **E**vents/**e**nvironment relating to incident. Suspicion of abuse or neglect? Intentional or unintentional injury?
- T:** Tetanus and Childhood Immunizations

Tetanus is considered current if given within the past five years. It is also important to know if a child is up-to-date with his/her childhood immunizations.

## 2. Complete Physical Exam

### a. Determining the Severity of the Burn and Fluid Resuscitation

During the secondary survey the Total Body Surface Area (TBSA) burned is determined using the Rule of Nines.

- Adult thermal and chemical burns  
2ml LR x weight kg x % third/fourth degree burn
- Pediatric patients <14 years old or less than 40 kg  
3ml LR x weight kg x % third/fourth degree burn
- Pediatric high voltage electrical injuries: **consult the burn center immediately**
- High voltage electrical injuries (adult)only with evidence of deep tissue injury or presence of hemochromagens in the urine (red urine) **4ml LR x weight kg x % full thickness (third/fourth degree) burn**

In the first eight hours post injury, half of the calculated fluid 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. The IV rate should be adjusted as

needed to maintain adequate urine output. Administer LR based on the ABLIS 2010 Fluid Resuscitation Formula.

Insert urinary catheter and maintain an hourly urinary output of:

- Adult thermal and chemical burns: 30 – 50 ml urine/hour
- Pediatrics: 1 ml urine/kg/hour
- High voltage electrical (adult): 75 – 100 ml urine/hour

Adjust IV fluid rate hourly based on urinary output and physiologic response

### **3. Vital signs**

Vital signs should be monitored and documented at frequent intervals.

### **4. Insertion of Nasogastric Tube**

Patients with burns of more than 20% TBSA are prone to nausea and vomiting. A nasogastric tube may need to be inserted to prevent aspiration. Consider insertion of a nasogastric tube for the following patients:

- Adult and pediatric patients with burns > 20% TBSA
- Intubated patients
- Patients with associated trauma

### **5. Assessment of Extremity Perfusion and Ventilatory Status**

Frequently assess for the 5 Ps --- **p**ain, **p**allor, decreasing **p**ulse or **p**ulselessness, progressive **p**arathesia and **p**aralysis --- for signs of circulatory compromise. Doppler assessment may be necessary if pulses are difficult to palpate. Chest and abdomen excursion should also be monitored closely. Escharotomies may need to be performed.

### **6. Pain and Anxiety Management**

Burn pain may be excruciating and must be managed. Control of the pain must begin upon initiation of medical care. Morphine or another narcotic is indicated for control of the pain associated with burns. Small frequent doses should be administered through the IV route only.

## **7. Psychological 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.

## **8. 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.

## **9. 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 remains 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.

## **10. 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)

A copy of the patient's Advance Directives or Durable Power of Attorney for Healthcare should be sent to the burn center with the patient.

**Sample Transfer Information Form**

Today's date: \_\_\_\_\_ Time: \_\_\_\_\_

Information Obtained From: \_\_\_\_\_

Referring Agency: \_\_\_\_\_

Referring Physician: \_\_\_\_\_ Phone #: \_\_\_\_\_

Patient's Name: \_\_\_\_\_

Age: \_\_\_\_\_ Sex: \_\_\_\_\_ Wt: \_\_\_\_\_ Ht: \_\_\_\_\_

Date of Burn: \_\_\_\_\_ Time of Burn: \_\_\_\_\_

Source of Burn: \_\_\_\_\_ Estimated % TBSA: \_\_\_\_\_

Body Areas Burned: \_\_\_\_\_

Associated Injuries: \_\_\_\_\_

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

Allergies: \_\_\_\_\_

Current Meds: \_\_\_\_\_

Past Medical History: \_\_\_\_\_

Tetanus Given:

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 fluid intake since burn \_\_\_\_\_ ml

Output (Foley) \_\_\_\_\_ ml past hr. \_\_\_\_\_

Total output post burn \_\_\_\_\_ ml

Burn treatment: \_\_\_\_\_

Present status of pt: BP \_\_\_\_\_ P \_\_\_\_\_ R \_\_\_\_\_ Combative: Yes No

Please send copies of any lab, X-ray results and Advance Directives/Durable Power of Attorney for Health Care if applicable.

## 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 burn center and the referring physician, working in collaboration, should make the decision as to the means of transportation and the required stabilization measures. Personnel trained in burn resuscitation should conduct the actual transport. 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 compromised airways, electrical, chemical or thermal injuries that 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. Select References

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## Ch. 10. Burn Disaster Management

### Objectives:

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

- Define burn triage and how to sort burn casualties
- Identify patient treatment priorities in a burn disaster
- Describe priorities for transfer of patients to a burn center
- Describe why patients with burn injuries are best managed in burn centers

### I. INTRODUCTION

#### **A. Burn injuries are common in disasters and terrorist acts.**

Burn disasters can occur in any community. Most do not involve terrorism or terroristic attacks. They can occur anywhere people congregate: schools, churches, housing units, dormitories, workplaces and entertainment establishments. They can also occur as the result of natural disasters such as wild land fires, earthquakes, etc. Each community has its own high-risk locations. All healthcare providers should be aware of the potential for burn disasters and plan, prepare and practice community wide drills.

On September 11, 2001 terrorist attacks both in New York and Washington, DC, produced large numbers of patients with burn injuries in a short period of time. Burn Centers in New York and Washington, DC, almost immediately saw a capacity of patients and in the weeks that followed were challenged with the demands of ongoing care for those burn survivors. In addition to surface injuries, many of the patients also had inhalation injuries.

People with burn injuries due to disasters frequently have associated injuries, minor to severe inhalation injuries are common. In 2003 the Station Nightclub Fire, in Rhode Island, burned with over 400 people inside at the start of the fire. There were 96 dead at the scene and four died later

as the result of their injuries, and 215 people were injured. Forty-seven patients with burns were admitted to hospitals. Thirty-three of the 47 had burns less than 20% TBSA. Twenty-eight had inhalation injuries. In addition, some had associated trauma as the result of the rush to escape the fire.

Many disasters involve children and local disaster plans need to include treatment plans for large numbers of adults and children who have been burned.

### **B. 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, averaging one day of hospitalization per percent total body surface area burned, as compared to simple or even complex trauma patients. For example, for burn patients with 50% total body surface area burn (TBSA), the average length of stay in the ICU = 50 days.

### **C. Burn centers are not the same as trauma centers.**

While there are literally thousands of trauma centers in the United States, there are only 123 burn care centers throughout the country, representing 1754 burn beds nationwide. Approximately 60% of U.S. Burn beds are located in verified burn centers. Verification is a rigorous joint review program of the American Burn Association (ABA) and the American College of Surgeons (ACS) to assure the burn center has the resources for the provision of optimal care to burn patients from the time of injury through rehabilitation. To find the closest verified burn center in your area visit [http://ameriburn.org/verification\\_verifiedcenters.php](http://ameriburn.org/verification_verifiedcenters.php)

While most burn surgeons have the expertise and training to treat burns as well as trauma victims in the event of a mass casualty, the reverse is not necessarily true. Burn patients, as demonstrated in this course, have a unique pathophysiology and require different treatments than those provided a trauma patient.

## II. Burn Disasters: Definitions

### A. Burn Disasters

A mass casualty incident is any situation in which the needs of multiple victims exceed the abilities of the available medical resources to individually manage each patient. A disaster, specifically a medical disaster, is said to have occurred when imminent threat of widespread injury or loss of life has occurred as a result of a man-made or natural event that exceeds the capacity of a local agency which would normally respond to the event. When disasters or mass casualty incidents occur and include patients with burn injuries, in general terms, this is also referred to and for the purpose of this work, is known as a Burn Disaster.

A burn disaster can further be defined as any catastrophic event in which the number of burn victims exceeds the capacity of the local or regional 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.

### B. Burn Surge Capacity

Burn surge capacity is defined as 1.5 times more burn patients than the average daily census at the burn center. Surge capacity will be different for each burn center, may be seasonal, and will vary from week to week or possibly even day to day.

### C. Triage

Triage is, by definition, the process of sorting a group of patients in a disaster setting to determine the immediacy of an individual's need for treatment. The criteria for triage include: type of injury or illness, the condition's severity, and level of urgency involved, the availability of medical facilities, and the likelihood of survival. The goal of triage is to maximize survival for the greatest number of individuals utilizing available resources. Triage must be based on medical needs.

An organized process of establishing a triage system on site is critical to the survivability of the mass casualty patient. Many local jurisdictions and state EMS agencies have already adopted some form of an organized methodology for sorting the care needs of patients. It is imperative that everyone engaged in that system be familiar with how it works, how it is enacted and most of all what criteria will be utilized to make evaluative decisions. The first

exposure to the triage system should occur *before* a disaster, not *during* a disaster. Hospital personnel must have a working knowledge of the pre-hospital triage system including the triage tags used by EMS in the local jurisdiction.

### **1. Primary Triage**

Primary triage is triage that 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 the implementation actions of the Office for the Assistant Secretary for Preparedness and Response (ASPR) of the US Department of Health and Human Services (DHHS) recommends that state disaster plans incorporate burn centers into such plans.

### **2. Burn Triage**

In general:

- Patients with burns do not develop shock within 60 minutes from time of injury if left untreated unless there are associated injuries or medical conditions in addition to the burn.
- Patients older than two years old and younger than 50 years old will fare better.
- Those with inhalation injury will do worse than those without inhalation injury.
- Some patients are going to be treated as “expectant”. Definitive treatment must be delayed or withheld for expectant patients in order to adequately treat those with the best chance of survival.

## **III. Patient Triage**

### **A. Scene Safety**

The scene at a burn disaster is often hectic and seemingly out of control. The arrival of first responders is the first step in bringing order and control to the chaos. No hazard can ever be completely controlled, and occurrences on the scene may be unpredictable. The first priority of any responder must be for their own well being. Decisions pertaining to personal protective equipment and levels of care will be determined by the hazardous elements causing the problem. No one should ever place himself or herself in danger when there is little chance for improving the status of the situation. The Incident Management Team must conduct a risk management assessment

for the circumstances at hand and determine the level of risk to the responders upon arrival at the scene. It is imperative that everyone operating within the confines of the emergency understand the impact a foolhardy act may have upon others and the overall outcome on the incident. Preparation, practice and patience will often lead to a more successful outcome when dealing with unexpected situations.

## **B. Burn Survivability**

There are three critical factors in determining patient survivability:

- TBSA burn > 40%
- Age > 60 years
- Presence of inhalation injury

The burn size is the most readily identified factor in determining the potential survivability of patients with burns in a mass casualty situation. Accurate assessment of burn size is critical for appropriate application of triage criteria. Health care providers who are inexperienced with calculating Total Body Surface Area (TBSA) burn may wish to use one or more of the following strategies:

1. Two independent providers calculate the TBSA burn. If the difference is greater than 5%, recalculate.
2. Have one provider calculate the percent TBSA burned. A second person calculates the percent TBSA that is not burned (or has a superficial, first degree burn). If the two percents added are different than 95-100%, recalculate.
3. Designate one or two experienced people in a centralized area to calculate percent TBSA burns and have them assess every patient with burns.
4. Use digital photographs and consult with the burn center.

Other factors including presence of associated injuries and/or pre-existing health status have an impact on the resources (i.e. personnel, supplies, equipment and time) required to care for these individuals complicating the process of prioritizing patient care. (Triage Table is on next page.)

### Age/TBSA Survival Grid

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

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

### Benefit-to-Resource Ratio Based on 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 tem 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.

**EXPECTANT:** Survival less than 10% even with unlimited, aggressive treatment

## C. Triage System and Tags

Color-coded triage tags are a tool Emergency Medical Services use during a mass casualty incident to effectively and efficiently distribute the limited resources and provide immediate care until more help arrives or patients are transported to a hospital. Each state or jurisdiction has their own version but the basic principles are the same. Hospital personnel should be familiar with the triage tags used in your locale to facilitate understanding of the pre-hospital assessment and care provided prior to hospital arrival.

There are four triage categories: red, yellow, green and black. Extensive burns require vast amounts of resources (personnel, equipment and time). In mass casualty situations limited resources are used to care for patients with the highest likelihood of survival.

In general, the following guidelines may assist the pre-hospital and initial hospital personnel determine the priorities of care for patients with burns.

Immediate (red): immediate treatment needed to save life, limb, or sight (highest priority). These patients have a high probability of survival with immediate treatment. For patients with burns these include:

- Burns 20-60%TBSA with complications
- Burns to critical functional areas (i.e. face, hands, feet, genitalia, major joints)
- Circumferential burns of any sites
- Burns < 20% TBSA with serious associated injury and/or inhalation injury

Delayed (yellow): less urgent treatment required than immediate, but still potential for life or limb threatening issue. These patients are not in danger of going into immediate cardiac or respiratory arrest. Treatment can be delayed in order to care for critical patients. These include:

- Patients with burns of 20-60% TBSA *without* inhalation injury or major associated injuries. Burns with larger percent TBSA involvement obviously will require fluid resuscitation earlier than smaller TBSA burns
- Burns with simple fractures may be delayed

Minimal (green): outpatient treatment and returned to duty/home. These are patients who are ambulatory, alert and oriented and have no life- or limb-threatening injuries. These “walking wounded” may initially refuse care

at the scene then present at the local hospital for treatment. In general, patients with partial thickness burns of less than 10% TBSA burn in children or 20% TBSA burn in adults fall into this category.

Expectant (black): poor prognosis, even with treatment (lowest priority)  
 In mass casualty situations, limited resources must be used to first care for those patients with the highest likelihood of survival. Treatment may need to be denied to patients with severe injuries who are theoretically salvageable. In this way, the greatest number of patients benefit from the limited care available. Patients who may be triaged into the black category include the following:

- Patients who have no pulse or breathing (after airway positioning) on scene.
- Who are not candidates for resuscitation due to:
  - Severity of injury
  - Limited resources and large numbers of patients
  - Massive burns >60% TBSA
  - Critical inhalation injury when resources for ventilatory management are limited
  - Advanced age
  - Serious co-morbidities

CONTAMINATED

## FRONT

CONTAMINATED

**Personal Property Receipt/ Evidence Tag** \*1234567\*

Destination: \_\_\_\_\_ Via: \_\_\_\_\_

**TRIAS TAG** \*1234567\*

S  L  U  D  G  E  M  
First Last Initial Middle Initial Last

AUTO INJECTOR TYPE:  1  2  3  
 AUTO INJECTOR TYPE:  1  2  3

Type:  Primary  Secondary  
 Sex:  Male  Female

Blast Trauma  
 Blast  
 C-Spine  
 Gunshot  
 Crushing  
 Fracture  
 Laceration  
 Penetrating Injury

Other: \_\_\_\_\_

**VITAL SIGNS**

Time	S/P	Pulse	Respiration
Time	Drug Solution		Dose

EVIDENCE

## MORGUE

**IMMEDIATE** Life Threatening Injury \*1234567\*

**IMMEDIATE** Life Threatening Injury \*1234567\*

**DELAYED** Serious Non Life Threatening \*1234567\*

**DELAYED** Serious Non Life Threatening \*1234567\*

**MINOR** Walking Wounded \*1234567\*

**MINOR** Walking Wounded \*1234567\*

EVIDENCE

## BACK

CONTAMINATED

**Comments/Information**

Patient's Name: \_\_\_\_\_

**RESPIRATIONS**  Yes  No  
**R**

**PERFUSION**  + 2 Sec  - 2 Sec  
**P**

**MENTAL STATUS**  Can Do  Can't Do  
**M**

Move the Walking Wounded → **MINOR**  
 No Respiration After Hood Fit → **MORGUE**  
 Respiration - Over 30 → **IMMEDIATE**  
 Perfusion - Capillary Refill Over 2 Seconds → **IMMEDIATE**  
 Mental Status - Unable to Follow Simple Commands → **IMMEDIATE**  
 Otherwise → **DELAYED**

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**PERSONAL INFORMATION**

NAME: \_\_\_\_\_

ADDRESS: \_\_\_\_\_

CITY: \_\_\_\_\_ ST: \_\_\_\_\_ ZIP: \_\_\_\_\_

PHONE: \_\_\_\_\_

COMMENTS: \_\_\_\_\_ RED/GOLD PREF: \_\_\_\_\_

## D. Prioritizing Early Hospital Care and Patient Transfer to a Burn Center

### 1. Initial Hospital Triage Criteria and Care Plan

For all patients, ensure that the burning process has been stopped, all clothing/jewelry/shoes/etc. have been removed, and chemicals have been removed from the patient.

Major Burns: Triage Criteria	Plan of Care
<ul style="list-style-type: none"> <li>· 20-60% TBSA burn</li> <li>· Critical sites (i.e. face, hands, feet, genitalia, major joints)</li> <li>· With or without associated trauma</li> </ul>	<ul style="list-style-type: none"> <li>· Maintain open airway</li> <li>· Administer 100% O<sub>2</sub></li> <li>· Initiate fluid resuscitation and monitoring</li> <li>· Wound care: clean, dry covering</li> <li>· Keep warm and dry</li> <li>· IV pain and anxiety management</li> <li>· Tetanus prophylaxis</li> <li>· These patients have first priority for transfer to a burn center</li> </ul>

Minor Burns with Inhalation Injury or Associated Injuries	Plan of Care
	<ul style="list-style-type: none"> <li>· Administer 100% O<sub>2</sub></li> <li>· Measure CO level if possible</li> <li>· Intubate if condition warrants and resources are available</li> <li>· Mechanical ventilation if available</li> <li>· IV pain and anxiety management</li> <li>· Dry dressings</li> <li>· Immediate care of associated injuries</li> <li>· Tetanus prophylaxis</li> <li>· Second priority transfer to a burn center</li> </ul>

<b>Minor burns / non-critical sites</b>	<b>Plan of Care</b>
<p>&lt; 10% TBSA burn children &lt; 20% TBSA burn adults</p> <p>Consult burn center if these patients have full-thickness burns to critical body sites</p>	<ul style="list-style-type: none"> <li>• Dress wounds</li> <li>• Pain and anxiety management (may use oral methods initially)</li> <li>• Tetanus prophylaxis</li> <li>• Fluid resuscitation – oral               <ul style="list-style-type: none"> <li>○ Flavored sport drinks</li> <li>○ Monitor quantity and quality of urinary output</li> <li>○ Monitor for signs of dehydration (i.e. fever, nausea, vomiting, etc.)</li> </ul> </li> <li>• Outpatient and home care</li> <li>• Transfer to burn center after critical transfers</li> </ul>

<b>Expectant Burns</b>	<b>Plan of Care</b>
<p>60% or greater TBSA burn Severe inhalation injury Burns with major associated trauma Critical co-morbidities</p>	<ul style="list-style-type: none"> <li>• IVs at KVO/TKO for pain and anxiety management</li> <li>• Do not infuse large amounts of fluid</li> <li>• Psychological support for patient and family</li> <li>• Transfer to a burn center only after all other patients have been moved and in consultation with the family and the burn center</li> </ul>

## 2. **Prioritizing treatment:**

- Resources prioritized to care for immediate and delayed patients
- Expectant and minimal patients may need to wait for resource availability
- If equally compelling problems require emergent intervention, the one estimated to take less time should be done first

## IV. Primary and Secondary Survey and Management: Mass Casualty Considerations

### A. and B. Airway, Breathing and Ventilation

Inhalation injury alone jeopardizes survival. Airway edema increases significantly after fluids are started. Therefore it is critical that resources are available to assess and manage the airway prior to starting large volumes of fluid resuscitation. It is important for pre-hospital providers and transport teams to know the resources available at the receiving hospital(s). In many rural areas the number of available ventilators is severely limited. If more patients are paralyzed and intubated than there are ventilators, additional personnel will be required in order to maintain the airway and provide manual ventilation. Intubate patients based on assessment and need.

Patients placed in the expectant category should not be intubated. O<sub>2</sub> should be administered to aid comfort and prevent air hunger.

### C. Circulation and Cardiac Status

Fluid loss associated with burn injuries is slow and progressive, unlike many other types of trauma. As a general rule of thumb, patients with burns but without associated trauma do not develop shock within 60 minutes from time of injury if left untreated. Hypovolemic shock may be delayed by several hours but will occur if treatment is delayed for too long.

ABLIS teaches that ideally two large bore IVs should be inserted in patients with burns and resuscitation with LR initiated. In mass casualty incidents, one IV line should be inserted until it is determined that adequate resources are available for all patients. IV priority should be given to patients with burns > 20% TBSA and/or with associated trauma with blood loss. When supplies of LR are depleted, fluid resuscitation may continue using Normal Saline, ½ Normal Saline or colloids. Do not use fluids containing glucose. Unless blood loss has occurred or the patient is extremely anemic, packed red blood cells should not be given.

Oral resuscitation should be considered for awake and alert pediatric patients with burns < 10% TBSA and adult patients with burns < 20% TBSA using flavored sport drinks and/or an oral electrolyte maintenance solution. Have the patient or family monitor the quality and quantity of urinary output and watch for signs of dehydration. Consult the burn center for guidance.

For patients placed into the expectant category, IVs should be started for administration of medication to manage pain and anxiety. Do not administer large volumes of fluid. Excessive fluids will result in decreased circulation and increased pain due to edema and constriction of circumferential burns, increased respiratory effort due to airway edema and/or constriction of circumferential burns of the torso or neck, and changes in sensorium due to cerebral edema.

### **D. Disability, Neurological Deficit, and Gross Deformity**

Patients with burns are usually alert and oriented at the scene and at the first receiving hospital. Patient identification and history should be performed during this timeframe and definitely before intubation if required.

### **E. Exposure and Environmental Control**

Maintaining a warm environment and patient temperature in a mass casualty incident can be a challenge. When supplies of blankets are depleted, be creative. Raid your facility's kitchen. Patients can be wrapped in plastic wrap or kitchen aluminum foil for insulation and warmth.

Burns do not need to be dressed in sterile dressings. For patients who will not be transferred, or have delayed transfer (longer than 24 hours), to a burn center burn wounds can be easily dressed with clean, cotton diapers cut into appropriate size wraps. Clean cotton t-shirts provide excellent dressings for torso, shoulder, upper arm and axilla burns. White cotton gloves can serve as dressings for hand burns and socks work well to dress foot burns.

### **F. Pain Management**

Burn pain is excruciating and patients will require huge doses of narcotics and sedation. Patients with burns less than 20% TBSA can be managed with oral or IM narcotics and anxiolytics.

## **V. ABLIS Primary and Secondary Triage Policy**

### **A. ABLIS Primary Triage Policy for Patients with Burns**

Patients with burns should be triaged to a burn center within 24 hours of an incident to be cared for by burn surgeons and the specialized burn team.

The disaster site incident management team should call the nearest verified burn center regarding available capacity and alternate site burn center information if needed. Establishing contact information on a 24 hour basis and knowing who the decision makers are within the facility is critical. General phone lines and informational sources available to the public will be clogged due to the nature of the disaster. Direct access into the facility via two-way communication is imperative to providing a sufficient level of care. Resource data bases established at the local level should include a listing of at least the five closest burn centers. Appropriate field triage may depend upon the first-responders and hospital emergency room personnel knowledge of burn triage recommendations.

### **B. ABLIS Secondary Triage Policy for Patients with Burns**

Secondary triage is triage involving the transfer of patients with burns from one burn center to another upon reaching surge capacity (1.5 times the average daily census of the Burn Center) and is implemented by the Burn Center Director. 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. Secondary triage policy should be put in place at every burn center, with formal written transfer agreements in place.

During the entire triage process, basic level care is continued and advanced life support is initiated as needed.

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## Appendix 1. Glasgow Coma Scale

The Glasgow Coma Scale (GCS) is now considered to be a standard measure for patients with altered mental status. The scale relies upon the evaluation of 3 systems: Eye movement, response to verbal stimuli, and motor response. Falsely lowered initial GCS may be due to hypoxia, hypotension, and intoxication and in patients that are intubated, the inability to speak automatically lowers the verbal response to a score of 1. In addition, facial burns often have periorbital edema and the assessment of spontaneous eye movement may be difficult.

Response	Score	Significance
<b>Eye Opening</b>		
Spontaneously	4	Reticular activating system is intact; patient may not be aware
To verbal command	3	Opens eyes when told to do so
To pain	2	Opens eyes in response to pain
None	1	Does not open eyes to any stimuli
<b>Verbal Stimuli</b>		
Oriented, converses	5	Relatively intact CNS, aware of self and environment
Disoriented, converses	4	Well articulated, organized, but disoriented
Inappropriate words	3	Random, exclamatory words
Incomprehensible	2	Moaning, no recognizable words
No response	1	No response or intubated
<b>Motor Response</b>		
Obeys verbal commands	6	Readily moves limbs when told to
Localizes to painful stimuli	5	Moves limb in an effort to remove painful stimuli
Flexion withdrawal	4	Pulls away from pain in flexion
Abnormal flexion	3	Decorticate rigidity
Extension	2	Decerebrate rigidity
No response	1	Hypotonia, flaccid: suggests loss of medullary function or concomitant spinal cord injury

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The GCS is not only a tool to help establish the severity of a traumatic brain injury (TBI) but also to help determine if the condition is stable, improving or worsening. The scores for each response are totaled to give the proposed severity of the TBI. A score of 13-15, 9-12, and 3-8 represent mild, moderate, and severe injuries respectively.

## Appendix 2. Tetanus Prophylaxis

Burn injuries are considered tetanus prone and the Centers for Disease Control and Prevention (CDC) guidelines should be followed.

### CDC Guide to tetanus prophylaxis in routine wound management

HISTORY OF ADSORBED TETANUS TOXOID (DOSES)	CLEAN, MINOR WOUND		ALL OTHER WOUNDS*	
	TDAP,TD OR DTAP†	TIG	TDAP,TD OR DTAP†	TIG§
Unknown or <3	Yes	No	Yes	Yes
≥3¶	No**	No	No††	No

- Such as, but not limited to, wounds contaminated with dirt, feces, soil, and saliva; puncture wounds; avulsions; and wounds resulting from missiles, crushing, **burns** and frostbite.
- † Tdap is preferred to Td for adolescents and adults aged 11-64 years who have never received Tdap. Td is preferred to TT for adults who received Tdap previously, or when Tdap is not available. DTaP is indicated for children <7 years old.
- § Equine tetanus antitoxin should be used when TIG is not available.¶ If only 3 doses of fluid toxoid have been received, a fourth dose of toxoid, preferably an adsorbed toxoid, should be given.
- \*\* Yes, if >10 years since the last tetanus toxoid-containing vaccine dose.
- †† Yes, if >5 years since the last tetanus toxoid-containing vaccine dose.
- Source: <http://www.cdc.gov/travel/yellowbook/ch4/tetanus.aspx>

## **Appendix 3: Radiation Injury**

### **I. Introduction**

Every person is continuously exposed within the environment to low levels of radiation, called background radiation. Exposure is increased near sources of radiation, especially X-ray machines and CAT scanners used in diagnostic radiology. Those who use such equipment are required to wear monitoring devices called dosimeters.

Radiation injuries can result from exposure to any of these machine which transiently generates radiation. The radiation is produced only when the machine is powered up and, therefore, can cause internal or external contamination of a person during this time.

Many other radiotherapy devices used to treat cancer contain highly radioactive elements. If radioactive compounds used in nuclear medicine, nuclear power plants, nuclear weapons processing facilities, and research laboratories are released in the environment, contact with the body will cause a cumulative radiation injury. A “dirty” bomb containing radioactive material can produce combined radiation and traumatic injuries.

The primary duty of a first responder is to evaluate and treat traumatic injuries and assess the possibility of external contamination with radionuclides. It is best to begin the decontamination process as early and completely as possible, ideally before transport to the local health care facility. This will minimize environmental contamination of the EMT equipment and the receiving hospital facilities.

### **II. Definition**

Radiation injuries result from exposure to electromagnetic or particulate ionizing radiation. The electromagnetic radiation (EMR) spectrum includes non-ionizing wavelengths like visible light, infrared waves and radio waves, which lack the energy to remove electrons from atoms. Higher energy EMR, like ultraviolet light, x-rays and gamma rays, easily ionize molecules, which then react with local tissue and damage the cellular DNA. Ionizing particles released from natural decay of unstable atomic nuclei can include alpha particles (2 protons and 2 neutrons), or beta particles (high speed electrons). High speed protons, neutrons, and other energetic particles are produced by man-made devices like synchrotrons or thermonuclear bombs.

### III. Mechanism of Injury

Ionizing radiation causes tissue damage as energy is transmitted to living tissue. At low doses the primary effect is production of ionized free radicals that readily damage DNA. Sunburn is a radiation injury caused by ultraviolet light.

The body has efficient self-repair mechanisms, so that small doses of radiation over a prolonged period are much better tolerated than the same dose received acutely. Rapidly dividing cells in the hemopoietic system and the GI tract are most easily damaged, although maximum doses of radiation will disrupt the metabolic activity of all somatic cells.

### IV. Mechanisms of Exposure

There are three mechanisms of exposure to ionizing radiation that may occur alone or in combination.

1. External irradiation occurs if there is transient exposure to radiation but no physical contact with radionuclides. Tissue injury occurs only while in proximity to the radiation source, and no decontamination is needed. These patients represent no risk to others and only require transport to an appropriate medical facility.
2. Internal contamination can result from inhalation, ingestion or transdermal absorption of radioactive material. In many cases, low dose internal contamination is initially difficult to detect. Contamination of open wounds can result in rapid systemic absorption of radioactive elements, so early decontamination is indicated.
3. External contamination results from presence of radionuclide material on external body surfaces or clothing. This presents a continuous hazard to the patient and to all those who come in contact with him. Immediate decontamination procedures will minimize the radiation exposure to all involved.

### V. Radiation Detection

The most useful instrument following a radiation incident is a radiation survey meter commonly called a Geiger-Muller counter. This will readily detect sources of ionizing radiation including alpha, beta, or gamma energy released from radioactive elements. The Geiger counter can immediately detect contaminated sites and demonstrate the efficiency of

decontamination. However, it cannot determine the total dose of radiation received by an individual.

Personal dosimeters are used in medicine and in industry to quantify the accumulated radiation dose for those who frequently work near sources of radiation such as x-ray machines, medical radionuclides, and other radioactive materials used in research and industry. Electronic dosimeters provide a real time determination of radiation exposure, whereas film based dosimeters require processing after removal from the patient.

## VI. Initial evaluation and treatment

**STOP:** Do not become the next victim. Radiation contamination is a unique form of chemical injury (radionuclides are unstable chemical elements which damage tissue by emitting alpha, beta or gamma ionizing radiation). Use Personal Protective Equipment to prevent possible skin contamination with ANY radioisotope.

- Remove the victim from the vicinity of any possible radionuclide spill.
- If external contamination is suspected, begin IMMEDIATE field decontamination before transport to reduce the total radiation dose, and minimize contamination of you, your rig, your medical equipment and the medical facility that will receive the patient.
- Treat all patients as potentially contaminated until they are scanned with a Geiger-Mueller counter (available at most hospital Radiology suites). Patients with a NEGATIVE scintillation counter scan do not represent a danger to others and do not require external decontamination.

**a. History:** A careful history of potential radiation exposure is critical. For example, a release in a nuclear power plant or a spill while a medical worker is handling radioactive iodine suggests external contamination.

**b. Safety priorities:** When encountering a patient with suspected radiation injury, the priorities include rapid removal from any presumed source of ongoing radiation exposure, decontamination including removal of possibly contaminated clothing and thorough irrigation of the contaminated skin with water. Any wound to the skin should be presumed to be contaminated. Copious irrigation of the exposed tissue with water or saline will remove most of the contaminants. Irrigation is continued until a survey with a radiation detector indicates minimal residual radiation, or at least a steady state condition. Then transport the victim to the designated health care facility.

JCAHO requires hospitals to have a protocol for decontamination of radioactive or chemically contaminated patients. This includes radiation detectors, personal protective equipment to minimize direct contact with the radionuclide, plastic covered equipment to minimize environmental contamination, and a system for collection of the contaminated irrigation fluid. Consult your regional health care facility disaster plan for details of these protocols.

## **VII. Severity of Exposure**

**STOP** If a person is wearing a personal dosimeter, KEEP the device with the patient during and after decontamination. At Chernobyl, when the patients were undressed, all the dosimeters remained attached to the contaminated clothing, received additional radiation exposure, and were useless in determining the radiation exposure of individual victims.

Massive irradiation of a single body part is harmful but almost never fatal. Total body irradiation can produce acute radiation syndrome. Initially there is a sharp drop in the circulating leucocytes and platelets, followed by a drop in erythrocyte production. Over several days there is loss of the mucosa of the entire GI tract. Initially there is GI bleeding which may be lethal. This is followed by sepsis as bacteria enter the bloodstream. There is a prolonged depression of the bone marrow and death results from bleeding or septicemia.

## **VIII. Prognosis**

The prognosis is determined by the total body radiation dose, the presence of any trauma or co-morbid medical conditions, and the availability of sophisticated medical treatment facilities. Radiation syndrome is often fatal unless managed with all the resources of a major medical research facility. Bone marrow transplant is required in the most severe cases.

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## Appendix 4. Cold Injuries

### I. Introduction

Cold injury most commonly occurs after exposure to a cold environment without appropriate protection. Localized cold injuries (frostbite) can cause severe disabilities or amputations, but systemic hypothermia can be rapidly fatal, so local cold injuries are treated only after reversal of any associated hypothermia. The physiological changes associated with cold injuries are distinct from heat injury and require a unique therapeutic approach. Military personnel, winter sports enthusiasts, older adults, and homeless persons are most at risk for these injuries.

### II. Hypothermia

#### A. Incidence

**Primary** hypothermia due to frigid environmental exposure or cold water immersion is most common during the winter months, accounting for approximately 500 deaths per year in the United States. **Secondary** hypothermia occurs when a medical illness, injury or drug ingestion lowers the set point for body temperature. For example, older adults with severe hypothyroidism, sepsis or uncontrolled diabetes may develop hypothermia even indoors.

#### B. Pathophysiology

Heat flows down any temperature gradient. The mechanisms for heat transfer include conduction, convection, radiation and evaporation. As heat leaves the body, the body temperature drops and metabolism slows. Respirations and heart rate decrease. The patient experiences first a generalized cold sensation with uncontrollable shivering, followed by confusion, lethargy and impaired coordination of body movements. With a further decrease in core temperature, shivering stops and the patient becomes somnolent with depressed respirations and profound bradycardia. Death results from hypoventilation and asystolic cardiac arrest.

Even mild hypothermia induces diuresis and cold patients become rapidly hypovolemic. A brisk urine flow is not an indicator of adequate resuscitation. Metabolic acidosis and electrolyte imbalances are common. Secondary accidental hypothermia is a highly lethal illness where the core temperature is reduced to 32°C is almost always fatal.

## C. Signs and Symptoms of Hypothermia

Table 1. Findings in Hypothermia

Hypothermia Class	Core Temperature	Characteristics
Mild	32°C – 35°C (90°F – 95°F)	Vasoconstriction, shivering, cold sensations, coagulopathy
Moderate	28°C-32°C (82.4°F-90°F)	Bradycardia, confusion or agitation, metabolic acidosis, cold-induced diuresis
Severe	20°C-28°C (68°F-82.3°F)	Coma, respiratory depression, profound hypovolemia
Profound	Below 20°C (Below 68°F)	Apnea, asystolic arrest

Signs and symptoms of hypothermia are non-specific (see Table 1). An altered level of consciousness is present in 90% of patients with core temperatures less than 32°C and range from mood changes, poor judgment, and confusion to severe agitation and coma. Hypothermic patients in a confused state may undress outdoors and die quickly of exposure. Hypothermia can mimic other disease states, such as alcohol or drug intoxication, cerebral vascular ischemia, hypothyroidism, or diabetic coma.

## D. Diagnosis

Older clinical thermometers will not register below 93°F, so a digital thermometer or thermocouple must be used. A Foley catheter tipped with an integral thermocouple is more accurate than standard rectal temperature measurements to monitor core temperature in the hypothermic patient.

## E. Treatment

The effects of primary hypothermia are reversible with aggressive rewarming, fluid resuscitation and correction of metabolic imbalances. Measures to prevent further heat loss followed by prompt rewarming efforts are lifesaving. All wet clothes are removed when the patient is transported in a warm environment. An alert patient with mild to moderate hypothermia will respond to hot liquids p. o. and external warming methods including warm air via convective heating blankets. Shivering will generate body heat, albeit at a metabolic cost. Overhead radiant heat devices are inefficient, and only warm exposed skin which is then at risk for burns. Hypothermia induces diuresis so a brisk urine flow is not an indicator of adequate

resuscitation. Cold patients are hypovolemic and should receive warm intravenous fluids until body temperature is normal.

Severe hypothermia can be rapidly fatal and active rewarming measures are necessary. Active rewarming by immersion in a circulating water bath at 40°C is the most rapid conductive rewarming technique. To prevent even further temperature drop, cold extremities (even with frostbite) are wrapped in dry towels and not rewarmed until the core temperature reaches 35° C. As the core temperature rises, one cold extremity at a time is rewarmed by immersion in the bath. Contraindications to immersion include CPR requiring chest compressions or electrical defibrillation, active bleeding, open traumatic wounds, or unstable fractures.

If the patient is unconscious, endotracheal intubation may be necessary to protect the airway. Active core heating can be accomplished in unstable patients with pleural or peritoneal lavage. Usually two catheters are placed in the peritoneal cavity or the left pleural space to permit simultaneous infusion and drainage of warmed isotonic fluid (40-42° C). Cardiopulmonary bypass permits more rapid rewarming, and simultaneously supports the circulation. The potential complications of such invasive procedures must be weighed against the advantages, especially in patients with traumatic injuries. Newer methods of extracorporeal circulation or continuous arteriovenous hemodialysis may prove equally effective.

Hypothermic patients require frequent pH and electrolyte determinations, especially if systemic acidosis is present, and continuous electrocardiographic monitoring is necessary during rewarming. Hypotensive patients with a slow but detectable pulse require aggressive volume expansion with warmed fluids, but chest compressions, which may trigger intractable ventricular fibrillation, should be avoided. If documented asystole or ventricular fibrillation occurs, CPR is initiated and continued during aggressive rewarming efforts. Defibrillation is ineffective if the heart is cold; few patients will survive unless rapidly rewarmed and cardioverted.

Following rewarming, secondary assessment is performed to identify predisposing or contributing diseases, which may include septicemia, diabetes mellitus, cerebral ischemia, hypothyroidism, or alcoholism.

### **III. Local Cold Injury (Frostbite)**

#### **A. Pathophysiology**

If tissue is cooled very rapidly, ice crystals will form inside cells and rupture them. These flash freeze or cold contact injuries resemble thermal burns

except the tissue proteins are not denatured. Rewarming efforts will not restore the non-viable cells produced by these conditions.

But under ideal circumstances human skin can be frozen and remain viable, in a process called cryopreservation. Frostbite injuries can mimic this process. Following exposure to cold temperatures, exposed skin exhibits profound vasoconstriction as the body attempts to maintain a stable core temperature. As the tissue reaches  $-4^{\circ}\text{C}$ , ice crystals slowly form within the extracellular fluid. This concentrates the extracellular solutes, and this hyper-osmolar fluid dehydrates and shrinks the cells, which are less easily punctured by the enlarging ice crystals. There is sludging of the capillary beds and eventually blood flow stops in the exposed digits. The metabolic rate is so reduced that slowly frozen tissue can survive for a limited time. Rapid rewarming minimizes further cellular damage.

After thawing, blood flow returns but endothelial cells soon detach and embolize into the capillary bed, leaving a thrombogenic basement membrane. Progressive thrombosis of the digital vessels causes ischemic necrosis of the affected areas. It often takes several weeks to determine the full extent of injury.

## B. Signs and Symptoms

Initially the patient develops a cold, clumsy and ultimately insensate extremity which appears pale or mottled blue. Rapid rewarming produces intense burning pain and redness of the affected extremity. Edema and blisters may develop over the next 12-24 hours. It is difficult to determine the depth of injury on early examination; signs and symptoms of deep injury are found in Table 2. Hemorrhagic blisters indicate deep dermal injury and severely frostbitten skin eventually forms a black dry eschar. This progresses to mummification with a clear line of demarcation by 3 to 6 weeks. Time and patience often result in remarkable preservation of tissue.

Table 2 Signs and Symptoms Following Rewarming

<b>Mild Injury</b>	<b>Deep Injury</b>
Brief cold exposure, early rewarming	Prolonged exposure, delayed warming
Bright red or normal skin color	Mottled or purple skin
Warm digits	Cool digits
Sensation present	No sensation
Clear blisters	Hemorrhagic blisters
Blisters to digit tips	Proximal blisters only

## C. Treatment

The initial therapy for frostbite is rapid transport to a safe environment before attempts at rewarming. Constrictive or damp clothing is removed and replaced with dry, loose garments. The extremity should be padded, splinted and elevated, and should not be rubbed or massaged, which may exacerbate the injury. Fluid resuscitation is rarely required for isolated frostbite. Partial rewarming should be avoided and any re-freezing of the extremity is catastrophic. Care must be taken to diagnose and treat concomitant injuries, especially systemic hypothermia.

The affected areas are rewarmed by immersion in gently circulating water at 40–42° C for 15 to 30 minutes. Pain medication should be provided. Blisters are deflated and left in place. Tetanus prophylaxis should be administered. Oral ibuprofen is used to treat pain and may limit injury by blocking prostaglandin production. Preliminary published studies suggest that systemic thrombolytics administered within 12 hours of thawing a frostbitten extremity can limit the amount of tissue loss in highly selected patients. There are many contraindications; therefore, this therapy should be administered by an experienced burn team. Early amputation prior to definitive demarcation (which can take weeks or months to occur) is generally discouraged, as delay can often result in increased functional limb length.

## IV. Summary

Cold injuries can range from very mild local injury to possibly lethal systemic hypothermia. The severity of the exposure to cold and the associated injuries are easily underestimated. Consultation with a burn center is encouraged to optimize the management for these individuals.

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## **Appendix 5. Blast Injuries**

Blast injuries are a common mechanism of trauma in many parts of the world and such high explosive events have the potential to produce mass casualties with multi-system injuries, including burns. The severity of injury depends upon the amount and composition of the explosive material, the environment in which the blast occurs, the distance between the explosion and the injured, and the delivery mechanism. The Presence of radioactive materials and chemicals must be considered in non-intentional injuries as well as in acts of terrorism and war. Blast injuries are considered to be one of four types or combinations:

- 1°- direct organ damage from blast overpressure;
- 2°- blunt and penetrating injury from flying objects;
- 3°- blunt injury due to the patient flying through the air; and
- 4°- associated injuries such as burns and crush injuries.

Blast injuries are due to over-pressurization and occur most often within the lungs, ear, abdomen, and brain. The blast effect to the lungs is the most common injury causing delayed fatality to those who survive the initial insult. The chest x-ray has a butterfly pattern and dyspnea, cough, hemoptysis, and chest pain are indicators of this barotrauma. These injuries are often associated with the triad of apnea, bradycardia, and hypotension. Prophylactic chest tubes are recommended prior to operative intervention or air transport. Gentle supportive ventilation is indicated until the lung heals.

Another commonly injured organ is the tympanic membrane which ruptures with significant overpressure; treatment here is also supportive. The pressure wave can cause blunt abdominal injury, and bowel ischemia/rupture should be considered. Lastly, brain injury is thought to be common in blast overpressure situations, but this has not been completely defined as yet. Those with suspected injury should undergo computed tomography or magnetic resonance imaging and treated appropriately. Those without anatomic injury should be treated for mild to moderate traumatic brain injury, which is mostly supportive with cognitive function testing during recovery.

Burns should be treated as thermal injuries without significant caveats other than some crush component which may compound the injury. Burns are common with significant blast injuries. The ball of flame emanating from most explosive devices has a potential to ignite clothing and extend the injury.