Chapter 39
Burns

Learning Objectives

• Describe the incidence, patterns, and sources of burn injury.
• Describe the pathophysiology of local and systemic responses to burn injury.
• Classify burn injury according to depth, extent, and severity based on established standards.
Learning Objectives

• Discuss the pathophysiology of burn shock as a basis for key signs and symptoms.
• Outline the physical examination of the burned patient.
• Describe the prehospital management of the patient who has sustained a burn injury.

Learning Objectives

• Discuss pathophysiology as a basis for key signs, symptoms, and management of the patient with an inhalation injury.
• Outline the general assessment and management of the patient who has a chemical injury.
• Describe specific complications and management techniques for selected chemical injuries.

Learning Objectives

• Describe the physiological effects of electrical injuries as they relate to each body system based on an understanding of key principles of electricity.
• Outline assessment and management of the patient with electrical injury.
• Describe the distinguishing features of radiation injury and considerations in the prehospital management of these patients.
Incidence and Patterns of Burn Injury

* Burns are devastating form of trauma
  - Associated with
    - High mortality rates
    - Lengthy rehabilitation
    - Cosmetic disfigurement
    - Permanent physical disabilities
  - Each year, more than 2 million Americans seek medical attention for burns
    - Of these, 40,000 persons are hospitalized and about 4,000 die as result of thermal injury or burn-related infection

Incidence and Patterns of Burn Injury

* Morbidity and mortality rates from burn injury follow significant patterns regarding gender, age, and socioeconomic status
  - 2/3 of all fire fatalities are men
  - Death rate from thermal injury is highest among children and older adults
  - 3/4 of all fire deaths occur in home, with highest incidence in lower-income households
  - Key part of professional role of paramedic is community education
    - Stress prevention as most effective management of these injuries

Major Sources of Burns

* Burn injury is caused by contact between energy and living cells
  - Sources of this energy
    - Thermal
    - Chemical
    - Electrical
    - Radiation
Thermal Burns

- Majority of burns are thermal
  - Commonly result from flames, scalds, or contact with hot substances
  - Studies have shown that surface temperatures of 44°C (111°F) do not produce burns unless exposure time exceeds 6 hours

Thermal Burns

- At temperatures between 44°C and 51°C (111°F and 124°F), rate of epidermal necrosis approximately doubles with each degree of temperature rise
  - At 70°C (185°F) or greater, exposure time required to cause transepidermal necrosis is less than 1 second
  - Degree of tissue destruction depends on temperature and duration of exposure

Thermal Burns

- Factors that influence ability of body to resist burn injury
  - Water content of skin tissue
  - Thickness and pigmentation of skin
  - Presence or absence of insulating substances such as skin oils or hair
  - Peripheral circulation of skin, which affects dissipation of heat
If electrical energy is transformed to heat, causing tissue damage in a human, why doesn’t an electrical cord feel hot when you touch it?

Chemical Burns

• Caused by substance capable of producing chemical changes in skin
  – Disrupt protein structure of skin, with or without production of heat
  – Heat may be generated during burning process
    • Chemical changes in skin, not heat, produce greatest injury

Chemical Burns

• Differ from thermal burns
  – With chemical burns, topical agent usually adheres to skin for prolonged periods, producing continuous tissue destruction
  – Severity of chemical injury related to
    • Tissue affected
    • Type of agent
    • Its concentration and volume
    • Duration of contact
Chemical Burns
• Chemical agents that often cause burn injury include acids and alkalis
  – Found in many household cleaning products and organic compounds
  – Chemical burns are associated with high morbidity
    • Especially when they involve eyes
    • Inhalation injury may also result from thermal and/or chemical exposure

Electrical Burns
• Result from direct contact with electrical current
  – Can also result from arcing of electricity between two contact points near skin
  – In direct contact injury, current itself is not considered to have any thermal properties
  – Potential energy of current is changed into thermal energy

• Transformation occurs when electricity meets electrical resistance of biological tissue
  interposed between entrance and exit sites
  – Arc injuries are localized at termination of current flow
  – Caused by intense heat or flash that occurs when current “jumps,” making contact with skin
  – Flame burn also may occur as result of arcing if heat generated ignites clothing or other fuel source near patient
Based on these facts and your knowledge of life span development, who would you predict would have a deeper burn from the same energy source, an 18-year-old or a 75-year-old? Why?

Radiation Burns

- Caused by ionizing and nonionizing radiation
  - Burns may result from high level of radiation exposure to specific body area
  - Make up small percentage of burn injuries

Burn Injury Local Response

- Burn injury immediately destroys cells or so fully disrupts their metabolic functions that cellular death ensues
  - Cellular damage is distributed over spectrum of injury
    - Some cells are destroyed instantly
    - Others are irreversibly injured
    - Some injured cells may survive if rapid and appropriate intervention is provided in prehospital setting and in-hospital care
Burn Injury Local Response

• Major thermal burns have three distinct zones of injury (Jackson’s thermal wound theory)
  – Usually appear in bull’s-eye pattern
  – Central area of burn wound, which has sustained most intense contact with thermal source, is zone of coagulation
    • In this area, coagulation necrosis of cells has occurred, and tissue is nonviable

Burn Injury Local Response

• Zone of stasis surrounds critically injured area
  – Consists of potentially viable tissue despite serious thermal injury
  – Cells are ischemic because of clotting and vasoconstriction
  – Cells die within 24 to 48 hours after injury if no supportive measures are undertaken
Burn Injury Local Response

- At periphery of zone of stasis is zone of hyperemia
  - Has increased blood flow as result of normal inflammatory response
  - Tissues in this area recover in 7 to 10 days if infection or profound shock does not develop

- Tissue damage from burns depends on degree of heat and on duration of exposure to thermal source
  - As a rule, burn wound swells rapidly because of release of chemical mediators
    - Causes increase in capillary permeability and fluid shift from intravascular space into injured tissues

- Increased permeability is accentuated by injury to sodium pump in cell walls
  - As sodium moves into injured cells, it causes increase in osmotic pressure
  - This increase in osmotic pressure increases inflow of vascular fluid into wound
  - Normal process of evaporative loss of water to environment is accelerated (5 to 15 times that of normal skin) through burned tissue
Burn Injury Local Response

- In small wound, these physiological alterations produce classic local inflammatory response (pain, redness, swelling) without major systemic effects
- If wound covers large area, local tissue responses can produce effects throughout body and life-threatening hypovolemia

Systemic Response to Burn injury

- As local events occur at injury site, other organ systems become involved in general response to stress caused by burn
  - One of earliest manifestations of systemic effects of large thermal injury is hypovolemic shock
    - Known as burn shock

Systemic Response to Burn injury

- Burn shock is associated with
  - Decrease in venous return
  - Decreased cardiac output
  - Increased vascular resistance
  - Can lead to renal failure
Burn Injury Classifications

• Burns must be assessed and classified (body surface area involvement and depth) as correctly as possible in field
  – Help to ensure proper treatment and transport to proper facility
  – Will help to monitor progression of tissue damage
  – Usually is not possible in prehospital setting because of progressive nature of injury
  – Amount of tissue damage may not be evident for hours or even days after burn injury

Depth of Burn Injury

• Burns are classified in terms of depth
  – Superficial
  – Partial-thickness
  – Full-thickness
• Superficial and partial-thickness burns usually heal without surgery if burns are uncomplicated by infection or shock
• Full-thickness burns usually require skin grafts

Superficial Burns

• Also known as first-degree burns
  – Characteristically painful, red, and dry and blanch with pressure
  – Usually occur after prolonged exposure to low-intensity heat or short-duration flash exposure to heat source
Superficial Burns

- Only superficial layer of epidermal cells is destroyed
  - Cells slough (peel away from healthy tissue underneath wound) without residual scarring
  - Usually heal within 2 to 3 days
  - Example: sunburn

Partial-Thickness Burns

- Also known as second-degree burns
  - May be divided into two groups: superficial partial-thickness and deep partial-thickness wounds
    - Superficial partial-thickness injury is characterized by blisters
    - Often is caused by skin contact with hot but not boiling water or other hot liquids, explosions producing flash burns, hot grease, flame
Partial-Thickness Burns

- In superficial partial-thickness and deep partial-thickness burns, injury extends through epidermis to dermis
  - Basal layers of skin are not destroyed, and skin regenerates within few days to week
  - Edematous fluid infiltrates dermal-epidermal junction, creating blisters characteristic of this depth of wound

Partial-Thickness Burns

- Intact blisters provide seal
  - Protects wound from infection and excessive fluid loss
    - Blisters should not be broken in prehospital setting unless it is chemical burn
  - Injured area usually is red, wet, painful and may blanch when tissue around injury is compressed
  - In absence of infection, these wounds heal without scarring, usually within 14 days
Partial-Thickness Burns

- If depth of partial-thickness burn involves basal layer of dermis, burn is considered deep partial-thickness burn
  - Edema forms at epidermal-dermal junction
  - Sensation in and around wound may be diminished because of destruction of basal-layer nerve endings
  - Injury may appear red and wet or white and dry

Partial-Thickness Burns

- Appearance depends on degree of vascular injury
  - Wound infection and subsequent sepsis and fluid loss are major complications of these injuries
  - If uncomplicated, deep partial-thickness burns generally heal within 3 to 4 weeks
  - Skin grafting may be needed to promote timely healing and minimize thick scar tissue formation
  - Formation of thick scar tissue may severely restrict joint movements and may cause persistent pain and disfigurement
Full-Thickness Burns

• Also known as third-degree burns
  – Entire thickness of epidermis and dermis is destroyed
    • Skin grafts are necessary for timely and proper healing
  – Wound is characterized by coagulation necrosis of cells
    • Appears pearly white, charred, leathery
    • Definitive sign is translucent surface in depths of which thrombosed veins are visible
    • Eschar, tough, nonelastic coagulated collagen of dermis is present in these injuries

• Sensation and capillary refill are absent in full-thickness burns because small blood vessels and nerve endings are destroyed
  – Often results in large plasma volume loss, infection, sepsis
  – Natural wound healing may produce contracture deformity
    • Fixed tightening of muscles, bones, ligaments, skin that prevents normal movement
  – Severe scarring also may develop
    • Surgical intervention with skin grafting is necessary to close full-thickness wounds, minimize complications, allow restoration of maximal function
Full-Thickness Burns

- Some burn classifications also describe full-thickness injury (sometimes called fourth-degree burn) that penetrates subcutaneous tissue, muscle, fascia, periosteum, or bone
  - Often result from incineration-type exposure and electrical burns in which heat is great enough to destroy tissues below skin

Extent and Severity of Burn Injury

- Two common methods to evaluate extent of burn injury
  - Rule of nines
  - Lund and Browder chart
- Use method for determining extent of burn injury approved by medical direction
  - Use of any method to evaluate burn injury should never delay patient care or transport

Rule of Nines

- Commonly used in prehospital setting
  - Measurement divides total body surface area (TBSA) into segments that are multiples of 9 percent
  - Method provides rough estimate of burn injury size and is most accurate for adults and children over 10 years of age
Why is the calculation of body surface area different for children younger than 10 years of age?

Rule of Nines

- If burn is irregularly shaped or has scattered distribution throughout body, rule of nines is difficult to apply
  - In these cases, burn size can be estimated by visualizing patient’s palm as an indicator of percentage (rule of palms)
  - Surface of patient’s palm = about 1 percent of TBSA
Lund and Browder Chart

- More accurate method of determining area of burn injury because it assigns specific numbers to each body part
  - Allows for developmental changes in percentages of body surface area
    - Adult head is 9 percent of TBSA, but newborn head is 18 percent of TBSA

American Burn Association Categorization

- Devised method of categorizing burns to determine severity
  - Based on
    - Extent, depth, location of burn injury
    - Age of patient
    - Etiological agents involved
    - Presence of inhalation injury
    - Coexisting injuries or preexisting illness
  - Using these criteria, burn injuries are categorized as
    - Major
    - Moderate
    - Minor
American Burn Association Categorization

- In determining severity, must consider factors such as
  - Patient’s age
  - Presence of concurrent medical or surgical problems
  - Complications that accompany certain types of burns
    - Those of face and neck, hands and feet, and genitalia

Burn Center Referral Criteria

- Many EMS services use categories or other criteria determined by medical direction as basis for determining which patients need transport to specialized burn centers
- Burn injuries usually requiring referral to burn center
  - Partial-thickness burns greater than 10 percent of TBSA
  - Burns that involve face, hands, feet, genitalia, perineum, major joints
  - Third-degree burns in any age group

Burn Center Referral Criteria

- Burn injuries usually requiring referral to burn center
  - 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
**Burn Center Referral Criteria**

- Burn injuries usually requiring referral to burn center
  - Any patients with burns and concomitant trauma (such as fractures) in which burn injury poses greatest risk of morbidity or mortality
  - If trauma poses greater immediate risk, patient may be initially stabilized in trauma center before being transferred to burn unit
  - Physician judgment will be necessary in such situations and should be in concert with regional medical control plan and triage protocols

**Burn Center Referral Criteria**

- Burn injuries usually requiring referral to burn center
  - Burned children in hospitals without qualified personnel or equipment for care of children
  - Burn injury in patients who will require special social, emotional, or long-term rehabilitative intervention

**Burn Shock Pathophysiology**

- Shock can occur from large body surface area burns
  - Burn shock results from local and systemic responses to thermal trauma
  - Trauma leads to edema and accumulation of vascular fluid in tissues in area of injury
  - Locally, brief initial decrease in blood flow to area occurs (this is emergent phase)
  - Followed by considerable increase in arteriolar vasodilation
Burn Shock Pathophysiology

- Concurrent release of vasoactive substances from burned tissue causes increased capillary permeability
  - Produces intravascular fluid loss and wound edema (fluid shift phase)
  - Fluid shifts cause cardiovascular changes
    - Compromised cardiac output
    - Increased systemic vascular resistance
    - Reduced peripheral blood flow

Burn Shock Pathophysiology

- Hypovolemia results from fluid loss in injured tissues and fluid that evaporates from body because of loss of skin
  - Despite compensatory effort of body to retain sodium and water, sodium is lost and potassium is released into extracellular fluid
    - Blood becomes concentrated
    - In severe burns, red blood cells may burst (hemolyze)

Burn Shock Pathophysiology

- When combined with hemolysis, rhabdomyolysis, and subsequent hemoglobinuria and myoglobinuria seen with major burns and electrical injury, hypovolemic state can lead to renal failure
  - Impaired peripheral blood flow can damage tissue further and can result in metabolic acidosis
Burn Shock Pathophysiology

- Greatest loss of intravascular fluid occurs in first 8 to 12 hours
  - Loss is followed by continued, moderate loss over next 12 to 16 hours
  - At some point within 24 hours, leaking of fluid from cells greatly diminishes (this is resolution phase)
  - At this point, balance between intravascular space and interstitial space is reached

- Peripheral vascular resistance will increase in response to hypovolemia and resulting decrease in cardiac output
  - With volume replacement, cardiac output can increase to levels above normal (hypermetabolic phase of thermal injury)
Fluid Replacement

• Within minutes of major burn injury, all capillaries in circulatory system (not just those in area of burn) lose ability to retain fluid
  – This increase in capillary permeability prevents creation of osmotic gradient between intravascular and extravascular space
  • Allows colloid solutions to equilibrate quickly across capillaries and into surrounding tissue

Fluid Replacement

• Process of burn shock continues for about 24 hours
  – Normal capillary permeability is restored
  – Therapy for burn shock is aimed at supporting patient’s vital organ function through period of hypovolemic shock
  • Crystalloid solution (e.g., lactated Ringer’s solution or normal saline) usually is considered fluid of choice in initial resuscitation

Fluid Replacement

• Several fluid resuscitation formulae consider body size and extent of burned body surface area
  – Formulae have proved clinically useful in replacing fluids
    • Two most common formulae for estimating fluid replacement are Parkland formula and modified Brooke formula
    • Have been combined into consensus formula
Fluid Replacement

- All three formulae call for half of total calculated amount of fluid to be infused over first 8 hours from time of injury
  - Second half is to be infused over following 16 hours
  - Fluid resuscitation must be guided by regular monitoring of measures of hemodynamic function
    - Vital signs
    - Respiratory rate
    - Lung sounds
    - Capillary refill
    - In some cases, urinary output

Consensus Formula

- Consensus formula is applied as follows
  - First 24 hours: 4 mL/kg lactated Ringer’s solution or normal saline multiplied by percent of TBSA burned
    - 50 percent of calculated amount infused in first 8 hours
    - 25 percent of calculated amount infused in second 8 hours
    - 25 percent of calculated amount infused in third 8 hours

Consensus Formula

- Amount and type of fluids required after first 24 hours are vastly different from those administered during first 24 hours
  - Fluid replacement is dictated by patient’s response to burn and treatment regimen
Assessment of the Burn Patient

- Emergency care for burn patient begins with scene safety and primary survey
  - Paramedic should recognize and treat injuries that pose threat to life
    - In burn patients, dramatic appearance of burns, patient’s intense pain, and characteristic odor of burnt flesh may distract from life-threatening problems
    - Confident assessment by paramedic and direction of efforts away from burn wound and toward patient as whole are crucial

Primary Survey

- Evaluation of patient’s airway is major concern, particularly for patient with inhalation injury
  - Observe for
    - Stridor (ominous sign of airway narrowing)
    - Facial burns
    - Soot in nose or mouth
    - Singed facial or nasal hair
    - Edema of lips and oral cavity
    - Coughing
    - Inability to swallow secretions in pharynx
    - Hoarse voice
    - Circumferential burns around neck or thorax
  - Airway management should be aggressive
What life- or limb-threatening problems can develop from this swelling?

Primary Survey
- Evaluate breathing for rate, depth, and presence of wheezes, crackles, rhonchi
  - Circulatory status is evaluated by assessing
    - Presence, rate, character, rhythm of pulses
    - Capillary refill
    - Skin color and temperature
    - Pulse oximetry, which may be inaccurate in presence of carbon monoxide
    - Obvious arterial bleeding

Primary Survey
- Determine patient’s neurological status by using AVPU scale or similar method
  - Evaluate carefully any deviations from normal for underlying cause
  - Possible abnormalities
    - Hypoxia
    - Decreased cerebral perfusion from hypovolemia
    - Cerebral injury resulting from head trauma
  - After primary survey, history of event should be obtained while performing secondary assessment
Primary Survey

- Accurate history from patient or bystanders can help determine potential for
  - Inhalation injury
  - Concomitant trauma
  - Preexisting conditions that may influence physical examination or patient outcome

Primary Survey

- Patient history
  - What is the patient’s chief complaint (e.g., pain or dyspnea)?
  - What were the circumstances of the injury?
    - Did the injury occur in an enclosed space?
    - Were explosive forces involved?
    - Were hazardous chemicals involved?
    - Is there related trauma?
  - What is the status of tetanus immunization?

Primary Survey

- Patient history
  - What was the source of the burning agent (e.g., flame, metal, liquid, or chemical)?
  - Does the patient have any significant medical history?
  - What medications does the patient take (including recent ingestion of illegal drugs or alcohol)?
  - Did the patient lose consciousness at any time? (suspect inhalation injury)
  - What is the status of tetanus immunization?
Physical Examination

- At start of physical exam, obtain full set of vital signs
  - Obtain BP in unburned extremity, if available
  - If all extremities are burned, place sterile gauze under BP cuff and attempt to auscultate BP
  - Patients with severe burns or preexisting cardiac or medical illness should be monitored with pulse oximetry and ECG
    - Lead placement may need to be modified to avoid placing electrodes over burned areas
  - Field care and hospital destination are determined by depth, size, location, extent of burned tissue and presence of associated illness or injury

General Principles in Burn Management

- Goals for management of severely burned patient
  - Preventing further tissue injury
  - Maintaining airway
  - Administering oxygen and ventilatory support
  - Pain management
  - Providing fluid resuscitation (per protocol)
  - Providing rapid transport
  - Using clean technique to minimize patient’s exposure to infectious agents
  - Providing psychological and emotional support

General Principles in Burn Management

- Patients with burns also should be evaluated for other types of trauma that pose threat to life
  - Some will have additional injuries associated with burn event
    - Blunt or penetrating trauma sustained in automobile crashes
    - Blast injury
    - Skeletal or spinal injury from attempts to escape thermal source or contact with electrical current
Stopping the Burning Process

• First step in managing any burn is to stop burning process
  – Step must be achieved with safety of emergency crew in mind because it often occurs in proximity to source that caused burn
  – With superficial burns, burning process can be terminated by cooling local area with cool tap water
    • Ice-cold water, ice, snow, or ointments should not be applied to burn
    • May increase depth and severity of thermal injury
    • In addition, ointments may impair or delay assessment of injury when patient arrives in emergency department

Stopping the Burning Process

• In cases of severe burns, paramedic should move patient rapidly and safely from burning source to area of safety if possible
  – Person whose clothing is in flames or smoldering should be placed on floor or ground and rolled in blanket to smother flames or should be doused with large quantities of cleanest available water
    • Cool water to decrease skin temperature rapidly is preferred

Stopping the Burning Process

• Contaminated water sources, such as lakes or rivers, should be avoided
  – These patients should never be allowed to run or remain standing
  – Running may fan flame, and upright position may increase likelihood of patient’s hair being ignited
Stopping the Burning Process

- Remove patient’s clothing completely while cooling burn so that heat is not trapped under smoldering cloth
  - If pieces of smoldering cloth have adhered to skin, paramedic should cut, not pull, clothing and gently remove it
  - Melted synthetic fabrics that cannot be removed should be soaked in cold water to stop burning process
  - After burn is cooled, patient with large body surface area injury should be covered with clean, preferably sterile sheet to prevent hypothermia

Stopping the Burning Process

- Blankets may be placed over sheet when ambient temperatures are low
  - Duration of cooling is controversial
    - Cooling should continue at least until pain is relieved and probably for total duration of 15 to 30 minutes
    - Local cooling of less than 9 percent TBSA can be continued longer than 30 minutes to relieve pain

Airway, Oxygen, and Ventilation

- Evaluate adequacy of airway and breathing in all burn patients
  - Humidified high-concentration oxygen (if available) should be given to any patient with severe burns
  - Breathing should be assisted as needed
  - Use of continuous pulse oximetry is indicated in these patients
  - If inhalation injury is suspected, observe patient closely for signs of impending airway obstruction
Airway, Oxygen, and Ventilation

- Life-threatening laryngeal edema may be progressive and may make tracheal intubation difficult if not impossible
  - Decision to intubate these patients should not be delayed
  - Make every attempt to intubate patient’s lungs with normal (not smaller) size endotracheal tube

Airway, Oxygen, and Ventilation

- Patients often are difficult to ventilate, even with appropriately sized tube
  - Decision to intubate in field should be guided by transport time to receiving hospital and indications of impending airway obstruction

Circulation

- Need for fluid resuscitation based on
  - Severity of injury
  - Patient’s vital signs
  - Transport time to receiving hospital
- Some authorities contend that prompt intervention of IV therapy in critically burned patients is essential to prevent long-term complications such as burn shock and renal failure
  - Consult with medical direction and follow local protocol regarding fluid replacement via IV or IO route
Circulation

- If IV therapy is performed, it should be initiated with large-bore catheter in peripheral vein in unburned extremity
  - Arm is the preferred site
  - If unburned site is not available, insert catheter through burned tissue, although risk of subsequent infection is greater
  - Care should be taken to secure catheter with dressing
    - Tape may not adhere to injured area as tissue begins to leak fluid

Circulation

- Administration of pain medication is an early intervention
  - Medical direction may recommend patients with painful burns be given IV morphine or fentanyl, or other analgesic agents (e.g., nitrous oxide)
  - Some of these medications can cause vasodilation and respiratory depression

Circulation

- Fluid resuscitation and ventilation support must be adequate
  - Other pharmacological therapy that may be given after arrival in emergency department
    - Topical applications (e.g., silver sulfadiazine or special synthetic dressings)
    - Oral analgesics
    - Tetanus immunization
Why should you perform frequent reassessments of the airway of a patient who has a large burn when your initial assessment reveals that the airway is patent?

Circulation

- At times, transport of burn patient is delayed
  - Lengthy interfacility transport may be anticipated
  - In either case, other patient care procedures may be required
  - One such procedure includes placement of a nasogastric tube to prevent gastric distention or vomiting
  - Another procedure is placement of indwelling urinary catheter
    - Will measure urine output and maintain patency of urethra in patients with burns to genitalia

Special Considerations

- All burn injuries warrant good patient assessment and care
  - Burns of specific body regions require special consideration
    - Burns to face and extremities
    - Circumferential burns
Special Considerations

• Burns of face swell rapidly
  – May be associated with airway problems
  – Head of ambulance stretcher should be elevated at least 30 degrees, if not contraindicated by spinal trauma, to minimize edema
  – If patient’s ears are burned, avoid use of pillow to minimize additional injury to area

Special Considerations

• If burns involve extremities or large areas of body, remove all rings, watches, other jewelry as soon as possible
  – Will help to prevent vascular compromise with increased wound edema
  – Peripheral pulses should be assessed frequently and burned limbs should be elevated above patient’s heart if possible

How should you administer pain medicine to a patient with a large burn? Why would you choose this route?
Special Considerations

- Burn injuries that encircle body regions can pose threat to patient’s life or limbs
  - Circumferential burns that occur to extremity may produce tourniquet-like effect that may quickly compromise circulation
    • Effect can cause irreversible damage to limb
    • Circumferential burns of chest can severely restrict movement of thorax
    • These burns may impair chest wall compliance significantly

Special Considerations

- If this occurs
  - Depth of respirations is reduced
  - Tidal volume is decreased
  - Patient’s lungs may become difficult to ventilate, even by mechanical means
  - Definitive treatment for circumferential burns involves in-hospital escharotomy to reduce compartment pressure and allow adequate blood volume to flow to and from affected limb or thorax

Inhalation Burn Injury

- Smoke inhalation injury affects 5 to 35 percent of all patients admitted to hospitals
  - Presence of inhalation injury increases mortality from burns by 20 percent, and when combined with pneumonia by 60 percent
  - Prehospital considerations in caring for patients with inhalation injury
    • Recognition of dangers inherent in fire environment
    • Pathophysiology of inhalation injury
    • Early detection and treatment of impending airway or respiratory problems
Inhalation Burn Injury

- Smoke inhalation most often occurs in closed environment such as building, vehicle, or airplane
  - Such injury is caused by accumulation of toxic byproducts of combustion
  - Inhalation injury also can occur in open space.
  - All burn victims should be evaluated for this injury

Inhalation Burn Injury

- Dangers that contribute to inhalation injury in a fire environment
  - Heat
  - Consumption of oxygen by fire
  - Production of carbon monoxide
  - Production of other toxic gases such as cyanide and hydrogen sulfide
  - Inhalation injury also may occur in absence of significant thermal injury from exposure to toxic gases

Pathophysiology

- Smoke inhalation and inhalation injury can produce large number of complications
  - Carbon monoxide poisoning
  - Inhalation injury above glottis (supraglottic)
  - Inhalation injury below glottis (infraglottic)
Carbon Monoxide Poisoning

• Colorless, odorless, tasteless gas produced by incomplete burning of carbon-containing fuels
  – Does not harm lung tissue physically
  – Displaces oxygen off hemoglobin molecule, forming carboxyhemoglobin
    • Result is low circulating volumes of oxygen despite normal partial pressures
    • Presence of carboxyhemoglobin requires that tissues be hypoxic before oxygen is released from hemoglobin to fuel cells
    • This condition is reversible

• Has about 250 times attraction to hemoglobin that oxygen has
  – Small concentrations in inspired air can result in severe physiological impairments, including:
    • Tissue hypoxia
    • Inadequate cellular oxygenation
    • Inadequate cellular and organ function
    • Eventually death
  – Physical effects of carbon monoxide poisoning are related to level of carboxyhemoglobin in blood

• Prehospital care
  – Ensuring patent airway, providing adequate ventilation
  – Administering high-concentration oxygen
    • Half-life of carbon monoxide at room air is about 4 hours
    • Can be reduced to 30 to 90 minutes if 100 percent oxygen and adequate ventilation are provided
Carbon Monoxide Poisoning

- Use of hyperbaric oxygen therapy may be recommended in treating carbon monoxide poisoning
  - Promotes increased oxygen uptake by hemoglobin molecules that have not yet been bound to carbon monoxide
  - Follow local protocol

Carbon Monoxide Poisoning

- Other gases (e.g., cyanide and hydrogen sulfide) may be released when some materials are burned
  - Inhalation of these toxic gases can result in inhalation
    - May require pharmacological therapy (e.g., cyanide antidote kit)

Can carbon monoxide poisoning be ruled out if the patient does not have these signs or symptoms?
Inhalation Injury Above Glottis

• Structure and function of airway superior to glottis makes it susceptible to injury if exposed to high temperatures
  – Upper airway is vascular and has large surface area
    • Allows upper airway to normalize temperatures of inspired air
    • Because of this design, actual thermal injury to lower airway is rare
    • Upper airway sustains impact of injury when environmental air is superheated

Inhalation Injury Above Glottis

• Thermal injury to airway can result in immediate edema of pharynx and larynx (above level of true vocal cords)
  – Can progress rapidly to complete airway obstruction

Inhalation Injury Above Glottis

• Signs and symptoms of upper airway inhalation injury
  – Facial burns
  – Singed nasal or facial hairs
  – Carbonaceous sputum
  – Edema of the face, oropharyngeal cavity, or both
  – Signs of hypoxemia
  – Hoarse voice
  – Stridor
  – Brassy cough
  – Grunting respirations
Inhalation Injury Above Glottis

• Prompt assessment of airway is critical
  – Establish and protect airway
  – If impending airway obstruction is suspected, early nasotracheal or orotracheal intubation may be warranted because progressive edema can make intubation hazardous if not impossible

Inhalation Injury Below Glottis

• Two main mechanisms of direct injury to lung tissue are heat and toxic material inhalation
  – Thermal injury to lower airway is rare
  – Causes
    • Inhalation of superheated steam (steam has 4,000 times heat-carrying capacity of dry air)
    • Aspiration of scalding liquids
    • Explosions
  – Injuries occur as patient is breathing high concentrations of oxygen under pressure
Inhalation Injury Below Glottis

- Most lower airway injuries in fires result from inhalation of toxic chemicals
  - Such chemicals include gaseous byproducts of burning materials
  - Signs and symptoms of lower airway injury may be immediate but more often are delayed

Inhalation Injury Below Glottis

- Signs and symptoms
  - Wheezes
  - Crackles or rhonchi
  - Productive cough
  - Signs of hypoxemia
  - Spasm of bronchi and bronchioles
- May begin several hours after exposure

Inhalation Injury Below Glottis

- Prehospital care
  - Directed at maintaining patent airway
  - Providing high-concentration oxygen
  - Ventilatory support
  - Specific airway and ventilatory management should be guided by on-line/direct medical direction
    - May include nasal or oral tracheal intubation and drug therapy with bronchodilators
Chemical Burn Injury

- Caustic chemicals often are present in home and workplace
  - Unintentional exposure is common
  - Three types of caustic agents often associated with burn injuries
    - Alkalis
    - Acids
    - Organic compounds
  - Alkalis are strong bases with high pH
    - Include hydroxides and carbonates of sodium, potassium, ammonium, lithium, barium, calcium

- Commonly found in
  - Oven cleaners
  - Household drain cleaners
  - Fertilizers
  - Heavy industrial cleaners
  - Structural bonds of cement and concrete
  - Strong acids are in many household cleaners, such as rust removers, bathroom cleaners, swimming pool acidifiers
Chemical Burn Injury

- Organic compounds are chemicals that contain carbon
  - Most are harmless chemicals
  - Several produce caustic injury to human tissue
    - Phenols and creosote
    - Petroleum products such as gasoline
  - Organic compounds may be absorbed by skin
    - May cause serious systemic effects
  - Severity of chemical injury is related to
    - Chemical agent
    - Concentration and volume of chemical
    - Duration of contact

Chemical Burn Assessment

- While obtaining patient history, collect facts regarding exposure factors
- When dealing with chemical exposure, paramedic should determine
  - Type of chemical substance
    - If container is available and can be transported safely, should be taken to medical facility

Chemical Burn Assessment

- When dealing with chemical exposure, paramedic should determine
  - Concentration of chemical substance
  - Volume of chemical substance
  - Mechanism of injury (local immersion of a body part, injection, splash)
  - Time of contamination
  - First aid administered before EMS arrival
  - Appearance (chemical burns vary in color)
  - Pain
Chemical Burn Management

• Safety of rescuers must be first priority in managing victim of chemical injury
  – Consider use of protective gear before entering scene
  – Depending on scene and chemical agent(s), decontamination may be required
  – Personal protection may include
    • Gloves
    • Eye shields
    • Protective garments
    • Appropriate breathing apparatus

Chemical Burn Management

• Response to hazardous materials incident requires special safety considerations and trained rescue personnel
  – Treatment of chemical injuries varies little from that of thermal burns during primary survey
    • Directed at stopping burning process

Chemical Burn Management

• Stopping burning process:
  – Remove all clothing, including shoes
    • These can trap concentrated chemicals
  – Brush off powdered chemicals
    • Break open and irrigate under blisters that may contain chemical
Chemical Burn Management

• Stopping burning process
  – Irrigate affected area with vast amounts of water
  • In otherwise stable patients, irrigation takes priority over transport
    – Unless irrigation can be continued en route to emergency department
  • If large body surface area is involved, shower should be used for irrigation, if available

Chemical Burn Injury to Eyes

• Chemical exposure to eyes (e.g., from mace, pepper spray, or other irritants) may cause damage ranging from superficial inflammation (chemical conjunctivitis) to severe burns
• Patients with these conditions have
  – Local pain
  – Visual disturbance
  – Lacrimation (tearing)
  – Edema
  – Redness of surrounding tissues

• Management guidelines include flushing eyes with water
• Can be done by using mild flow from hose, IV tubing, or water from container
  – Affected eye should be irrigated from medial to lateral aspect
  – Will help to avoid flushing chemical into unaffected eye
Chemical Burn Injury to Eyes

- Irrigation should be continued during transport
  - If contact lenses are present, should be removed
  - When retracting lids to irrigate eyes, take care to apply pressure only to bony structures surrounding eye
  - Pressure on globe should be avoided

Chemical Burn Injury to Eyes

- Some EMS services use nasal cannulas to irrigate both eyes at same time
  - Cannula is placed over bridge of nose
  - Nasal prongs are pointing down toward eyes
  - Cannula is attached to IV administration set using normal saline or lactated Ringer’s solution
  - Fluid is run continually into both eyes
Chemical Burn Injury to Eyes

• Irrigation lenses may be useful for prolonged eye irrigation in adults, provided
  – Edema is absent
  – No lacerations or penetrating wounds of globe or eyelids
• Use of these devices in prehospital setting is controversial
  – Requires special training and authorization from medical direction

Chemical Burn Injury to Eyes

• Can be frightening for patient
  – Patient may fear loss of sight from injury
  – Attempt to calm patient
  – Explain importance of thorough eye irrigation, which may be uncomfortable
    • Improves the patient’s cooperation
Use of Antidotes or Neutralizing Agents

• According to American Burn Association, no agent has been found to be superior to water for treating most chemical burns
  – Use of antidotes or neutralizing agents should be avoided in initial prehospital management of most burn injuries
  – Many neutralizing agents produce heat
  – May increase injury when applied to wound

Use of Antidotes or Neutralizing Agents

• In special circumstances, medical direction may elect to have EMS stock neutralizer with specific antidote
  – When industrial complex within response area is known to use chemical agent
  – In this case, paramedics should receive special training on indications, contraindications, use, side effects of these agents

Specific Chemical Injuries

• Main treatment for most chemical burns is copious irrigation with water
  – Personal safety is priority when working around any of these chemicals
    • Petroleum
    • Hydrofluoric acid
    • Phenols
    • Ammonia
    • Alkali metals
Petroleum

- In absence of flame, products such as gasoline and diesel fuel can cause significant chemical burns if prolonged contact occurs
  - At first, injury may appear to be only superficial or partial-thickness burn
    - May be full-thickness injury
  - Systemic effects such as CNS depression, organ failure, death may result from absorption of various hydrocarbons
  - Lead toxicity can occur if exposure was from gasoline that contained tetraethyl lead

Hydrofluoric Acid

- One of most corrosive materials known
  - Acid is used in industry for
    - Cleaning fabrics and metals
    - Glass etching
    - Manufacture of silicone chips for electronic equipment
  - Hydrogen ion and fluoride ion are damaging to tissue
  - Fluoride hinders several chemical reactions required for cell survival
    - Continues to penetrate and kill cells even when it is neutralized by binding to calcium or magnesium

Hydrofluoric Acid

- Endogenous or exogenous hydrofluoric acid has potential to produce deep, painful, and severe injuries
  - If large body surface areas are involved, patient may experience severe hypocalcemia and even death
  - True with exposure to high concentrations of acid also
  - Even most minor-appearing wounds that involve hydrofluoric acid should be evaluated at proper medical facility
**Hydrofluoric Acid**

- Irrigation of exposed area with large amounts of water should be started immediately
  - On arrival in emergency department, treatment may include subcutaneous injection of 10 percent calcium gluconate directly into burn site

**Phenol**

- Phenol (carbolic acid) is aromatic hydrocarbon
  - Derived from coal tar and used widely in industry as disinfectant in cleaning agents
  - Used in manufacture of
    - Plastics
    - Dyes
    - Fertilizers
    - Explosives
  - Skin contact with phenol can result in local tissue coagulation and systemic toxicity if agent is absorbed

**Phenol**

- Soft tissue injury from phenol exposure may be painless because of anesthetic properties of agent
  - Minor exposures may cause CNS depression and dysrhythmias
  - Patients with significant exposures (10 to 15 percent TBSA) may require systemic support
  - Patients should be observed carefully for signs of respiratory failure
Phenol

• Wounds should be irrigated with large volumes of water
  – After irrigation, medical direction may advise that wound be swabbed with suitable solvent to bind phenol and prevent its systemic absorption
    • Glycerol
    • Vegetable oil
    • Soap and water

Ammonia

• Noxious, irritating gas
  – Strong alkali that is very soluble in water
  – Hazardous if introduced into eye
  – May result in tissue necrosis and blindness
  – Ammonia burn to eye probably will have swelling or spasm of eyelids
  – Injuries must be irrigated with water or balanced salt solution for up to 24 hours

Ammonia

• Respiratory injury from ammonia vapors depends on
  – Concentration
  – Duration of exposure
  – Example
    • Short-term, high-concentration exposure usually results in upper airway edema
    • Long-term, low-concentration exposure may damage lower respiratory tract
  – Initial care for patients with respiratory injury
    • High-concentration oxygen administration
    • Ventilatory support as needed
    • Rapid transport
Alkali Metals

• Sodium and potassium are highly reactive metals
  – Can ignite spontaneously
  – Water generally is contraindicated when these metals are imbedded in skin
    • React with water and produce large amounts of heat
    • Physically removing metal or covering it with oil minimizes thermal injury

Electrical Burn Injuries

• Account for 4 to 6.5 percent of admissions to burn centers and are responsible for about 500 deaths each year
  – Good patient care and personal safety at scene of electrocution depends on understanding how electricity flows (current) through body

Types of Electrical Injury

• Three basic types of injury may occur as a result of contact with electric current
  – Direct contact burns
    • Occur when electric current directly penetrates resistance of skin and underlying tissues
    • Hand and wrist are common entrance sites
    • Foot is common exit site
  – Arc injuries
  – Flash burns
Types of Electrical Injury

• Although skin may initially resist current flow, continued contact with source lessens resistance and permits increased current flow
  – Greatest tissue damage occurs directly under and adjacent to contact points and may include
    • Fat
    • Fascia
    • Muscle
    • Bone

• Although skin may initially resist current flow, continued contact with source lessens resistance and permits increased current flow
  – Tissue destruction may be massive at entrance and exit sites
    • Injury to area between these wounds is what poses greatest threat to patient’s life
Types of Electrical Injury

• Arc injuries
  – Occur when person is close enough to high-voltage source that current between two contact points near skin overcomes resistance in air
    • Passes current flow through air to bystander
  – Temperatures generated by these sources can be as high as 2,000°C to 4,000°C (3,632°F to 7,232°F)
  – Arc may jump as far as 10 feet

Types of Electrical Injury

• Flame and flash burn injuries can occur when heat of electrical current ignites nearby combustible source
  – Common injury sites include face and eyes (welder’s flash)
  – Flash burns may ignite person’s clothing or cause fire in surrounding environment
  – No electrical current passes through body in this type of burn

Effects of Electrical Injury

• Skin is almost always first point of contact with electrical current
  – Direct contact and passage of current through tissue may cause wide areas of coagulation necrosis
    • Entrance site is often bull’s-eye wound
    • Site may appear dry, leathery, charred, or depressed
    • Exit wound may be ulcerated and appear exploded
    • Areas of tissue may be missing
Effects of Electrical Injury

• Oral burns often are seen in children under 2 years of age
  – Wounds usually are caused by chewing or sucking on low-tension electrical cord
  – Associated with injury to tongue, palate, face

Effects of Electrical Injury

• Hypertension and tachycardia associated with large release of catecholamines is common
  – Electrical current also may cause significant dysrhythmias (including ventricular fibrillation and asystole)
  – Damages myocardium as it passes through body
  – Patient may have suffered cardiac arrest
  – If early rescue and resuscitation can be initiated, success rates are high

Effects of Electrical Injury

• Nerve tissue is good conductor of electrical current
  – Nerve tissue often may be affected in electrical injuries
  – CNS damage may result in seizures or coma with or without focal neurological findings
  – Peripheral nerve injury may lead to motor or sensory deficits
    • Deficits may be permanent
Effects of Electrical Injury

• Nerve tissue is good conductor of electrical current
  – If current passes through brainstem
    • Respiratory arrest or depression
    • Cerebral edema
    • Hemorrhage
    • May rapidly lead to death

Effects of Electrical Injury

• Can cause extensive necrosis of blood vessels
  – May not be evident upon arrival of EMS
  – Such injuries can cause
    • Immediate or delayed internal hemorrhage
    • Arterial or venous thrombosis
    • Embolism with subsequent complications

Effects of Electrical Injury

• Damage within extremities after an electrical burn is similar to crush injury
  – Severe muscle necrosis releases myoglobin
  – Bursting of red blood cells (hemolysis) releases hemoglobin
  – Both of these large molecules can precipitate in renal tubules
    • Produces acute renal failure
  – Some patients may require amputation of affected extremity
**Effects of Electrical Injury**

- Results from decreased circulation and compartment syndrome
  - In electrocuted patient, severe muscle spasms can produce bony fractures
  - Spasms also may produce dislocations, even of major joints
  - Patient may fall after electrical shock and sustain skeletal trauma

**Effects of Electrical Injury**

- Acute renal failure
  - Can be serious complication from significant direct-contact electrical injuries
  - May result from
    - Combination of myoglobin or hemoglobin sludging in renal tubules
    - Disseminated intravascular coagulation caused by tissue damage
    - Hypovolemic shock
    - Direct current damage
  - Not of immediate consequence in prehospital setting
    - Prompt fluid resuscitation and management of shock may have positive impact on patients

**Effects of Electrical Injury**

- Ventilation may be impaired when electrical burns produce CNS injury or chest wall dysfunction
  - If respiratory center is disrupted, hypoventilation can lead to immediate patient death
  - Contact with any alternating current sources known to produce respiratory arrest and death from tetany of muscles of respiration
Effects of Electrical Injury

- Findings in some electrical injuries
  - Conjunctival and corneal burns
  - Tympanic membranes
  - Cataracts and hearing loss also may appear as late as 1 year after event

- Other internal structures that may be damaged from electrical injury
  - Abdominal organs
  - Urinary bladder
  - Submucosal hemorrhage may occur in bowel
    - Various forms of ulceration are possible
  - Each patient requires thorough physical assessment and high degree of suspicion for associated trauma

Assessment and Management

- Should begin by ensuring that no hazards exist for rescuers or bystanders
  - If patient is still in contact with electrical source, summon electric company, fire department, or other specially trained personnel before approaching patient
    - Once scene is safe, patient intervention may begin
What would you do if you responded to a scene and there was a child still in contact with an electrical current having tetanic movements, with a large crowd gathered around and screaming at you to help? The fire department is 3 minutes away. How will you feel?

Primary Survey

- Should proceed as it does for all other trauma patients
  - Take care to immobilize cervical spine
  - If patient is not breathing, begin assisted ventilation immediately
  - Perform intubation as soon as possible as apnea may persist for lengthy periods
  - Patient who is breathing should have patent airway maintained
  - Respirations should be supported with supplemental high-concentration oxygen
  - If patient is in cardiac arrest, initiate resuscitation efforts according to protocol

Primary Survey

- History of event should be obtained that includes
  - Patient’s chief complaint (e.g., injury or disorientation)
  - Source, voltage, and amperage of electrical injury
  - Duration of contact
  - Level of consciousness before and after injury
  - Significant medical history
Physical Examination

• Should be thorough
  – Search for entrance and exit wounds for trauma caused by tetany or fall
  – May have multiple pathways of current, resulting in multiple wounds
  – Remove all patient's clothing and jewelry and examine areas between fingers and toes for sites of entry or exit

Physical Examination

• Assess
  – Distal pulses
  – Motor function
  – Sensation in all extremities
• Monitor for possible development of compartment syndrome
  – Cover entrance and exit wounds with sterile dressings
  – Manage any associated trauma appropriately
  – Document all findings

Physical Examination

• Internal damage may be much more significant than external wounds
  – Frequent reassessment is necessary because of progressive nature of electrical injury
  – ECK monitoring should be implemented at scene and continued during patient transport
  – Electrical injury may cause variety of dysrhythmias, some of which can be lethal
### Electrical Burn Management

- Early administration of fluids is critical
  - Helps to prevent hypovolemia and subsequent renal failure
  - If possible, establish two large-bore IV lines
    - Should be in extremity without entry or exit wounds
    - Fluid of choice generally is lactated Ringer’s solution or normal saline without glucose
    - Flow rate should be determined by patient’s clinical status

- In emergency department or during interhospital transfer, patient’s IV fluid rates will be regulated to maintain urine output of 1 to 1.5 mL/kg/hr
  - Rate decreases potential for renal damage caused by myoglobin
  - Emergency department management may include
    - Administration of sodium bicarbonate to help maintain alkaline urine
      - Alkalinity increases solubility of hemoglobin and myoglobin and decreases risk of renal failure

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### Lightning Injury

- Lightning strikes produce tissue injuries that differ from other types of electrical injury
  - Because pathway of tissue damage often is over rather than through skin
  - Duration of lightning is short (1/100 to 1/1000 second)
  - Skin burns are less severe than those seen with other high-voltage current (full-thickness burns are rare)
Lightning Injury

- Lightning strikes produce tissue injuries that differ from other types of electrical injury
  - Common lightning burns are
    - Linear
    - Feathered
    - Punctate (pinpoint)
  - Depending on severity of strike, 30 percent of those struck by lightning suffer cardiac and respiratory arrest

Lightning Injury

- Lightning injuries may be classified as minor, moderate, or severe
  - Patients with minor lightning injuries usually are conscious
  - Patients often are confused and amnesic
  - Burns or other signs of injury are rare
  - Vital signs of these patients usually are stable
Lightning Injury

- Patients with moderate injury may be combative or comatose
  - May have associated injuries from impact of lightning strike
  - Superficial and partial-thickness burns are common
    - Typanic membrane rupture
  - Patients may have serious internal organ damage
    - Observe carefully for signs and symptoms of cardiorespiratory dysfunction

Lightning Injury

- Severe lightning injuries include those that cause immediate
  - Brain damage
  - Seizures
  - Respiratory paralysis
  - Cardiac arrest
- Prehospital care
  - Directed at basic and advanced life support measures
  - Rapid transport

Assessment and Management

- Scene safety is first priority
  - If electrical storm is still in progress, all patient care should take place in sheltered area
  - To prevent injury from subsequent lightning strikes, stay away from objects that project from ground
    - Trees
    - Fences
    - High buildings
  - Avoid areas of open water
  - If rescue attempts in open area are necessary, stay low to ground
Assessment and Management

• Same as for other severe electrical injuries, directed at
  – Airway and ventilatory support
  – Basic and advanced life support
  – Patient immobilization
  – Fluid resuscitation to prevent hypovolemia and renal failure
  – Pharmacological therapy (per protocol)
    • Manage seizures (if present)
    • Promote excretion of myoglobin
    • Treat dysrhythmias
  – Wound care
  – Rapid transport

Radiation Exposure

• Most common incidents involve sealed radioactive sources used in industrial radiography and nondestructive testing
  – Victims of these types of incidents rarely require emergency care
  – EMS may be called to building fires and crashes that may involve radioactive materials
  – Understanding of hazards of radiation exposure is important
  – Paramedic crew should never enter scene until it has been made safe by proper authorities

Radiation Exposure

• Safety issues regarding radiation have been excellent overall throughout world
  – Hazards associated with radiation became well known as result of two incidents
    • Serious potential for disaster occurred at Three Mile Island in Pennsylvania in 1979
    • Disastrous incident occurred at Chernobyl Nuclear Power Station in Soviet Union in 1986
What industries in your area use radioactive materials? Is there a preplan for accidents at that site?

Characteristics of Radioactive Particles

- Radioactive particles generally are classified into three types
  - Alpha
  - Beta
  - Gamma

Characteristics of Radioactive Particles

- Alpha particles are large
  - Travel only few millimeters
  - Have little penetrating ability
  - In fact, alpha particles may be stopped by paper, clothing, or skin
  - Considered least dangerous external radiation source
Characteristics of Radioactive Particles

• If alpha particles enter body through inhalation, ingestion, or absorption
  – Can damage internal organs and interfere with chemical functions of body
  – Alpha radiation is considered most dangerous form of internal radiation exposure

Characteristics of Radioactive Particles

• Beta particles
  – One seven thousandth size of alpha particles
  – Have much more energy and penetrating power
  – Can penetrate subcutaneous tissue
  – Usually enter body through damaged skin, ingestion, inhalation
  – Protection from alpha and beta radiation requires full protective clothing, including positive-pressure self-contained breathing apparatus

Characteristics of Radioactive Particles

• Gamma rays and x-rays are most dangerous forms of penetrating radiation
  – Require lead shields for protection
  – Gamma rays have 10,000 times penetrating power of alpha particles
  – Have 100 times penetrating power of beta particles
  – Protective clothing does not stop gamma rays
    • Pose internal and external hazards
    • May produce localized skin burns and extensive internal damage
Harmful Effects from Radiation Exposure

- Nonionizing radiation
  - Includes radio waves and microwaves
  - Usually is not thought to be dangerous
  - Ionizing radiation is produced by
    - Nuclear weapons
    - Reactors
    - Radioactive material
    - X-ray machines
  - Although rare, exposure to ionizing radiation poses threat to victims and rescue workers

Harmful Effects from Radiation Exposure

- Amount of emitted radiation is expressed in roentgens and indicates ionization produced in air by gamma or x-ray radiation
  - Other units used to measure radiation
    - Rad (radiation absorbed dose)
    - Rem (roentgen equivalent man)

Harmful Effects from Radiation Exposure

- Amount of emitted radiation is expressed in roentgens and indicates ionization produced in air by gamma or x-ray radiation
  - Rad is measure of amount of ionized radiation being emitted and amount that has been absorbed and active within body tissues
  - Rem is used to assess biological effects of the various types of radiation
  - For emergency purposes, assume that 1 roentgen = 1 rad = 1 rem
### Harmful Effects from Radiation Exposure

- **Doses of less than 100 rem usually do not cause significant acute problems**
- **Doses from 100 to 200 rem may cause symptoms**
  - Doses are not life threatening
- **When exposure of 200 rem is neared, nausea, vomiting, and diarrhea begin within 2 to 4 hours**

### Harmful Effects from Radiation Exposure

- **After exposure of 450 rem, 50 percent mortality can be expected within 30 days if no medical care is given**
  - Victims of radiation rarely show immediate signs or symptoms of exposure
  - Possible exposure should be presumed to have radiation injury until proved otherwise

### Emergency Response to Radiation Accidents

- **If EMS crew has been advised that radioactive materials are present at scene, approach site with caution**
  - Should not enter scene until it has been secured by proper authorities
  - Rescue personnel, emergency vehicles, and command post should be positioned 200 to 300 feet upwind of site
Emergency Response to Radiation Accidents

- Do not eat, drink, or smoke at site or in any rescue vehicle
  - Proper local authorities should be contacted (state radiological health office, local specialists)
  - Medical direction should be notified
  - Protective clothing suitable for other hazardous material releases should be worn by all emergency workers
  - Dose meters should be available for all rescue personnel
  - Self-contained breathing apparatus should be used if fire, smoke, or gas is present

Personal Protection from Radiation

- Federal Emergency Management Agency (FEMA) recommends that basic radiation protection for rescuer and patient include
  - Time
    - Less time spent in radiation field, less radiation exposure
    - If adequate personnel are available, rotating team approach can be used to keep individual radiation exposure to minimum
  - Distance
    - Farther person is from source of radiation, lower radiation dose
    - Even moving several feet away from radioactive source greatly reduces level of exposure

Personal Protection from Radiation

- FEMA recommends that basic radiation protection for rescuer and patient include
  - Shielding
    - General principle of shielding is that denser the material, greater its ability to stop passage of radiation
    - Lead shields provide best protection from exposure
    - Vehicles, mounds of dirt, and pieces of heavy equipment placed between radiation source and rescuer and victim also can diminish exposure levels
Personal Protection from Radiation

• FEMA recommends that basic radiation protection for rescuer and patient include
  – Shielding
    • Protective clothing and self-contained breathing apparatus may provide adequate protection from all alpha and some beta radiation: does not prevent penetration of gamma rays
    • If adequate shielding is not readily available, rescuers should use time and distance factors to reduce radiation exposure

Personal Protection from Radiation

• FEMA recommends that basic radiation protection for rescuer and patient include
  – Quantity
    • Limiting amount of radioactive material in specific area lessens radiation exposure
    • Examples include removing contaminated clothing, bagging all contaminated items, moving containers of radioactive material from area

Emergency Care for Victims of Radiation Exposure

• Patient who has been irradiated is not radioactive
  – When external contamination occurs and radioactive material remains on patient’s clothing and skin or in open wounds, consult with medical direction and follow agency protocol
  – Effects of radiation exposure may be instant (burns) or delayed
### Emergency Care for Victims of Radiation Exposure

- With exception of dealing with contaminants and containing their spread, no emergency care procedures specific to radiation injury
  - Control all external bleeding
  - Immobilize spine
  - Cover open wounds
  - Stabilize fractures
  - Move patient away from source of radiation as soon as possible

### Emergency Care for Victims of Radiation Exposure

- Lifesaving care should not be delayed for patient transfer or decontamination procedures
  - IV fluid replacement should be initiated if indicated
    - Use strict aseptic technique
    - If IV line is not needed for specific therapy, its use should be avoided to prevent introducing contaminants into body

### Radiation Decontamination Procedures

- Radiation emergencies involving patients may be defined in two ways: clean and dirty
  - Clean means patient was exposed but not contaminated
  - Dirty means patient was contaminated
  - Only properly trained personnel should attempt to decontaminate radiation victims at scene
  - Patient to be transported to hospital for decontamination should be isolated from environment
  - All patient effects should be transported with patient
Summary

• Each year more than 2 million Americans seek medical attention for burns
  – Morbidity and mortality rates from burn injury follow significant patterns regarding gender, age, and socioeconomic status
  – Burn injury is caused by an interaction between thermal, chemical, electrical, or radiation energy and biological matter

Summary

• Tissue damage from burns depends on the degree of heat and on duration of exposure to thermal source
  – As local events occur at the injury site, other organ systems become involved in general response to stress caused by burn

Summary

• Burns are classified in terms of depth as superficial, partial-thickness, and full-thickness
  – Rule of nines provides a rough estimate of burn injury size (extent) and is most accurate for adults and for children older than age 10
  – Lund and Browder chart is a more accurate method of determining area of burn injury
  – Severity of burn injury and burn center referral guidelines are based on standards that take into account the depth, extent, and severity of the burn wound; the source of injury; patient age; presence of concurrent medical or surgical problems; body region burned
Summary

• Shock after thermal injury results from edema and accumulation of vascular fluid
  – Tissue changes occur in area of injury and can produce systemic hypovolemia if burn area is large
• Emergency care for burn patients begins with initial assessment
  – Goal is to recognize and treat life-threatening injuries

Summary

• Goals for prehospital management of severely burned patient include preventing further tissue injury, maintaining airway, administering oxygen and ventilatory support, providing fluid resuscitation, providing rapid transport to an appropriate medical facility, using aseptic (clean) technique to minimize patient’s exposure to infectious agents, managing pain, and providing psychological and emotional support

Summary

• Prehospital considerations in caring for patients with inhalation injury include recognition of dangers inherent in fire environment, pathophysiology of inhalation injury, and early detection and treatment of impending airway or respiratory problems
• Severity of chemical injury is related to three things: chemical agent, concentration and volume of chemical, and duration of contact
  – Treatment is directed at stopping burning process by using copious irrigation
Summary

• Three types of injury may occur as a result of contact with electrical current: direct contact burns, arc injuries, and flash burns
  – Once scene is safe, patient intervention may begin
  – Internal damage from electrical current may be much more significant than external wounds

Summary

• Persons who are injured by radiation rarely require emergency care
  – Radioactive particles are classified into three types: alpha, beta, and gamma
  – FEMA recommends that basic radiation protection for rescuer and patient include four factors: minimize time in radiation field; maintain safe distance from source; place shielding between rescuers and source; and limit amount of radioactive material in specific area

Questions?