AMERICAN COLLEGE OF EMERGENCY PHYSICIANS
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The Pediatric Burn Victim

Children with burn injuries are frequently brought to an emergency department for their initial medical care. The lecturer will discuss up-to-date emergency department evaluation and management of pediatric victims of minor and severe thermal and electrical burn injuries. Cases will be presented to illustrate specific issues, including airway management, fluid resuscitation, prevention of complications, burn center referral, and recognition of intentional injuries.

- Describe the main pathophysiologic concepts of both thermal and electrical burn injuries.
- Discuss a systemic approach to the emergency department evaluation and management of thermal and electrical burn injuries.
- Discuss specific issues relevant to pediatric patients, including airway management, fluid resuscitation, burn center referral, and recognition of abuse.

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FACULTY

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THE PEDIATRIC BURN VICTIM

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THERMAL BURN INJURY

Epidemiology

There are approximately 100,000 children hospitalized in the United States for bum injury, with 3,000 pediatric deaths secondary to bum injuries each year. Most severe burns are managed in the ED.

Scald burns result from contact with a hot liquid or gas. Most commonly seen in children less than 3 years of age. Child abuse is a well-documented cause of scald burns.

Flame burns result from ignition of clothing. These are most commonly seen in children (greater than 2 years of age) playing with fire, matches, or flammable materials.

Contact burns result from contact with hot objects.

Flash burns result from explosions and are usually uniform and partial thickness.

Pathophysiology

Burn wounds are described in terms of depth and size. These variables are a function of the burning agent, its temperature, and the duration of exposure.

Burn depth is described as first, second, or third degree.

First degree burns involve the only epidermal layer of the skin. The burned skin is red and painful, but there is no blister formation and heals without scarring.

Second degree burns, also known as *partial-thickness* burns, are subdivided into *superficial* and *deep.*

In superficial second degree burns, the epidermis and part of the dermis are involved, the deeper layers of the dermis are spared. The skin is red, hot, very painful, and with blister formation. There is usually minimal scar formation.

With deep second degree burns, the deeper layers of the dermis are involved, including damage to the hair follicles and sweat glands. Scarring is related to the extent and depth of the injury.

Third degree burns involve the entire thickness of the skin. All epidermal and dermal structures are destroyed. The skin is charred, pale, painless, and leathery. These injuries will not heal spontaneously and will require skin grafts. Scarring is significant.

Burn wounds are quantified as percentage of the total body surface area (TBSA). Approximating the TBSA can be accomplished in children with the Lund and Browder Chart.

Classification of Pediatric (~10 Years of Age) Burn Injury

Major burn injury - partial-thickness burns of greater than 20 percent TBSA; full-thickness burns of greater than 10 percent, burns involving the hands, face, feet, or perineum; burns crossing major joints; circumferential limb burns; burns with inhalation injury; burns complicated by fractures or other major trauma; burns in infants.

Moderate burn injury - partial-thickness burns of 10 to 20 percent TBSA; full-thickness burns of less than 10 percent.

Minor burn injury - partial-thickness burns of less than 10 percent; full thickness burns of less than 2 percent.

Systemic Effects of Major Burn Injury

Immunosuppression, muscle catabolism, infections, edema, myocardial depression, pulmonary injury, and decreased renal blood flow are all systemic effects of major burn injury.

Smoke Inhalation Injury

Smoke inhalation injury is a frequent complication of burn injury and double the mortality for burns of any size. Several types of injury are associated with smoke inhalation: carbon monoxide poisoning; cyanide poisoning; asphyxiation; and thermal injury of the upper respiratory tract.

Emergency Department Management of Major and Moderate Burns

ABCs - Primary ATLS Survey

Protection of the airway, 100% oxygen, intubation, ventilation.

Initiation of fluid resuscitation (20cc/kg).

Secondary ATLS Survey.

Assessment of burn injury (depth and size).

Sterile drapes of clean sheets to cover wounds.

Intravenous narcotics for analgesia.

Tetanus toxoid (0.5 IM) and tetanus immunoglobulin (250 units).

No antibiotics.

Labs - Electrolytes, BUN, creatinine, CBC, CPK, ABGs (with COHb level), CXR.

Nasogastric tube for potential ileus.

Foley catheter to measure urine output.

Fiberoptic bronchoscopy to assess thermal inhalation injury.

Wound debridement.

Fluid Resuscitation

Parkland formula: 4 cc/kg/TBSA given over 24 hours (one half given over the first 8 hours and one half given over the second 16 hours).

Maintain urine output of 1 cc/kg/hr.

Pulmonary edema and hypoxia can be exacerbated by overvigorous fluid administration, especially if the patient sustained significant pulmonary injury from smoke inhalation.

Escharotomy

Circumferential burns of limbs compromising circulation and circumferential burns to the chest compromising ventilation require escharotomy. Incisions are made on the lateral surface of the limbs to restore circulation and in a square pattern on the anterior chest to restore ventilation.

Admission Criteria for Pediatric Burn Injury

For older children (>10 years of age), partial-thickness burns greater than 15 percent TBSA or full-thickness burns greater than 5 percent TBSA.

For younger children (~10 years of age), partial-thickness burns greater than 10 percent TBSA or full-thickness burns greater than 3 percent TBSA.

Partial of full-thickness burns of the face, hands, feet, or perineum, or burns across major joints of circumferential limb burns.

Patients that are immunocompromised or have underlying medical problems.

Burns associated with other trauma.

Emergency Department Treatment of Minor Burns

Analgesics (ibuprofen).

Cleanse burn with soap and saline or water.

Debride blisters.

Tetanus toxoid and tetanus immune globulin as needed.

Dress burn wound with thin layer of antibiotic ointment.

All burn patients must be seen in 24 hours to reassess the injury.

Outpatient Care

Remove dressing once or twice a day and cleanse wound with soap and water.

Reapply antibiotic ointment and redress.

Fine mess gauze or semi-synthetic occlusive dressings for partial-thickness wounds.

ELECTRICAL INJURY

Epidemiology

Electrical injury accounts for approximately 3 percent of burn unit admissions and an estimated 1000 deaths per year in the United States.

The majority of household electrical injuries involve 110-220 volt current..

High voltage injury is arbitrarily defined as greater than 1000 volts.

Although electrical and construction workers are the most commonly injured by high voltage electricity, male children and adolescents are at special risk for this type of burn injury. The majority of high voltage electrical injuries in this age group are secondary to high risk activity that results from contact with power lines (such as tree climbing, utility pole climbing, and trespassing around electrical transformer or train stations.) This type of activity typically occurs after school hours, during the weekend, or on a holiday.

Pathophysiology

Injury associated with electricity is related to the amount of current, type of

current (direct versus alternating), duration of contact, and pathway of current flow through the body and resistance.

Current, or amperage, is related to voltage and resistance according to Ohm's Law (amperage = voltage/resistance.)

Heat generated by electrical current is determined by Joule's Law (heat = amperage^2 X resistance).

Electrical injury can result in cutaneous, neurovascular, musculo-skeletal, cardiac, and multiple internal organ injury. The pathophysiologic mechanism of injury results from the conversion of electrical energy into heat energy.

Different tissues of the body have varying degrees of resistance which affect the direction of current flow and the severity of injury.

Body tissues differ in their resistance to electricity. In decreasing order of resistance: bone; fat; tendon; skin; muscle; blood vessels; and nerves.

Skin resistance is the most important factor impeding current flow.

Alternating current (AC) is more dangerous than similar direct current of the same magnitude. Low voltage household current alternates at 60 cycles/second. This may cause repetitive muscle contraction (tetani), locking the victim to the current source.

Systemic Effects of Electrical Injury

Electrical injury may result in involvement of many organ systems, including: cutaneous; cardiac; necrologic; vascular; pulmonary; renal; gastrointestinal; muscular; skeletal; and ophthalmologic.

Cutaneous

Cutaneous electrical skin wounds have a charred central area, surrounded by a white-gray-yellow middle zone, and a red, swollen, outer region. Wounds may vary greatly in size.

Electrical injury may be deceiving. Although cutaneous wounds may be small, underlying soft tissue and organ damage resulting from internal current flow may be very extensive.

Oral and perioral electrical burns are very common in young children. This may involve the tongue, lips, teeth, or periodontal tissue. Delayed hemorrhage from the labial artery is a major concern.

Cardiac

High voltage electrical injury can cause small myocardial and pericardial

hemorrhages. Coronary arterial thrombosis has also been documented, but myocardial infarct can occur with or without coronary arterial occlusion as a possible result of coronary spasm.

Although low voltage injuries can result in sudden death from asystole or ventricular fibrillation, most electrically associated cardiac complications are from high voltage injuries. Complications affect 16 to 36 percent of those injured and include: transient dysrhythmia; asystole; ventricular fibrillation; ventricular tachycardia; PVCs; bigeminy; supraventricular tachycardia; bundle branch block; sinus tachycardia; sinus bradycardia; myocardial infarct; and myocardial rupture. In addition, abnormal ECG findings associated with electrical injury include prolonged QT interval, axis deviations, and nonspecific ST wave changes.

Neurologic

Nervous tissue is very susceptible to electrical injury. The brain, spinal cord, and peripheral nerves may be involved. There may be acute and delayed complications. Manifestations of neurologic electrical injury include: loss of consciousness; seizure; quadriplegic; aphasia; focal motor deficit; and auditory and visual disturbances.

Pulmonary

Pulmonary arrest may result from paralysis of the respiratory center or from tetanic contraction of the muscles of respiration. Pulmonary edema and contusion are also complications.

Vascular

Vascular involvement may result from direct injury to the vessel, from thrombosis, or from spasm.

Emergency Department Treatment of Major Electrical Injury

ABCs - Primary ATLS Survey

Protection of the airway, 100% oxygen, intubation, ventilation as needed.

Initiation of fluid resuscitation (20cc/kg).

Secondary ATLS Survey (including assessment for blunt trauma).

Assessment of burn injury (depth and size).

Intravenous narcotics for analgesia.

Tetanus toxoid (o.c IM) and tetanus immunogiobulin (250 units).

Labs - Electrolytes, BUN, creatinine, CBC, CPK, ABGs (COHb), CXR.

Nasogastric tube for potential ileus.

Foley catheter to measure urine output.

Central venous pressure monitoring.

Urinary alkalinization for myoglobinuria.

Cardiac monitoring, electrocardiogram.

Fluid resuscitation to maintain perfusion and counteract possible rhabdomyolysis.

Maintain urine output of 1 cc/kg/hr.

Wound care.

Cardiac Assessment

The criteria for cardiac monitoring and hospitalization of children with low voltage electrical injury has been established with large case series studies. Children sustaining household electrical injury without loss of consciousness, tetany, wet skin, or current flow that crossed the heart region do not require cardiac evaluation and monitoring.

The need to monitor victims of high voltage injury, however, has not been clearly established. Most high voltage induced cardiac dysrhythmia and irregularities, however, present early, are transient, and cause little or no long term sequelae.

The MB fraction of creatine kinase, however, can be falsely elevated, owing to the possible induction of MB fraction production by electrically injured skeletal muscle. Therefore, myocardial infarct cannot be diagnosed by elevated CK-MB isoenzymes alone.

Admission Criteria

All high-voltage (>1000 volts) electrical injuries.

Low-voltage (<1000) electrical injury with: current flow through chest, trunk, or head; cardiovascular, neurologic, or gastrointestinal symptoms; suspected neurovascular compromise; suspected involvement of subcutaneous tissues; associated trauma or underlying medical conditions; suspected dysrhythmia.

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