An Evidence-Based Approach

To Electrical Injuries In Children

Abstract

Electrical injuries, while uncommon, can be associated with significant morbidity and mortality. In children, the injuries tend to occur in the household; in adolescents, they are most often associated with misguided youthful exploration outside the home. Injuries in adults are primarily occupational and due to workplace accidents. Electrical injuries are categorized by their electrical source and can result from low-voltage, high-voltage, lightning strike, or electrical arc exposure. The injury can range from minor to life threatening, and they can cause multisystem complications. High-voltage electrical exposures usually cause severe burns, whereas victims of lightning strikes may have no obvious physical injury but may present in cardiopulmonary arrest. Strategies to prevent electrical injuries have been developed and should be discussed with families and healthcare providers to reduce the incidence of these injuries in children. This review highlights the current literature related to the evaluation and management of children with electrical injuries presenting to the emergency department.
Case Presentations

A 17-year-old male with electrical burns is brought by EMS to your ED. The EMS provider reports that the patient was climbing up a utility pole when he lost his balance. Reportedly, while he was still in contact with the pole, he grabbed onto a live power line and was thrown about 20 feet to the ground. He experienced a loss of consciousness of unknown duration at the scene. Upon your physical exam, the teenager is alert, oriented, and has bilateral third-degree burns to his hands and wrists. What type of electrical exposure is this? What complications are you concerned about this patient developing? What diagnostic studies should you order? Does he require admission to the hospital?

EMS transports a 2-year-old previously healthy boy to your ED after his mother found him chewing on an electrical cord. The physical exam is remarkable for an alert, active, crying child in no acute distress. He has a 2-cm grayish-white lesion with an erythematous border at the right corner of his mouth, and he is drooling. What type of electrical injury is this? What should you do next? Does this child require admission to the hospital? What are the risks associated with this injury, and what are the available treatments?

A 16-year-old female presents to your ED after being struck by lightning while playing soccer during a thunderstorm. She was thrown 10 feet and fell to the ground. Her friend immediately called 911, and when EMS arrived, the patient was noted to be in cardiac arrest in asystole. Paramedics began CPR, without immediate return of spontaneous circulation. She was transported to the nearest hospital, with ongoing compressions and assisted ventilation. In the ED, you intubate her, continue CPR, and administer epinephrine. The patient regains a pulse and converts to normal sinus rhythm. When you examine her, you note a burn on her chest with a feathering pattern. What should you do next in assessing this patient? What complications are associated with lightning injuries? Should this patient be admitted to the hospital?

Introduction

While lightning-related injuries have been described for thousands of years, reports of nonlightning-related electrical injuries date back approximately 300 years.¹ The first reported death from artificial electricity occurred in 1879 and was due to contact with a high-voltage generator.¹ As societies have become more industrialized and more reliant on electricity to power machines, injuries from electricity have become more prevalent.

Pediatric electrical injuries are, primarily, unintentional and preventable. Due to their exploratory nature, young children are most often injured from contact with low-voltage household electrical cords, outlets, and appliances. Teenagers, who often engage in risk-taking behavior or who may encounter electricity in their employment, may have injuries resulting from contact with high-voltage power lines and utility poles.²⁻⁴

There is a wide spectrum of electrical injuries, ranging from minor burns to cardiopulmonary arrest and death.³⁻⁵ Electrical injuries can be classified as low voltage (< 1000 V), high voltage (> 1000 V), lightning strike, and electrical arc injuries.⁶⁻⁷ Most household exposures are low voltage. High-voltage and lightning injuries are both secondary to exposure to > 1000 V; however, the primary difference is the duration of contact and pattern of injuries.³⁻⁶⁻⁸ (See Table 1.)

Electrical arc injuries occur when a patient is in close proximity to an electrical source and the current jumps from the source to the patient in its attempt to follow the path of least resistance. The current does not pass through the patient; rather, the current arc comes into direct contact with the victim’s skin.⁷ An arc forms between the electrical source and an object (e.g., umbrella, metal rod), and it can generate temperatures up to 4000°C. Patients who receive electrical arc injuries can suffer extensive flash-type burns. While arc injuries may be high or low voltage, the majority come from household current and, therefore, are low voltage.⁷

Because of the associated morbidity and mortality in children who suffer electrical injuries, prompt, evidence-based care for these patients is essential. This month’s issue of Pediatric Emergency Medicine Practice will address the management of electrical injuries in the pediatric patient.

Critical Appraisal Of The Literature

An online literature search was performed using the PubMed and Ovid MEDLINE® databases. Multiple search terms were used, including: pediatric electrical injuries, electrical injuries, burns, electrical burns, environmental injuries, lightning injuries, cardiac complications, electrocution, Taser®, oral burns, oral commissure stents, amputation after electrical injury, and rhabdomyolysis. All relevant articles were identified and reviewed, and 64 references are included in this article. Treatment guidelines for electrical burn injuries set forth by the Work Loss Data Institute⁹ were found on the National Guideline Clearing House website (www.guideline.gov), and guidelines from the American Burn Association were also reviewed.¹⁰⁻¹¹ However, these guidelines only focused on adult patients. To date, there are no published guidelines or randomized controlled trials for the management of electrical burns in children, and the available published clinical evidence on pediatric electrical injuries is lacking.
Etiology And Pathophysiology

In the United States, burns are the third leading cause of injury resulting in death in children aged < 18 years. According to D’Souza et al, there are approximately 120,000 children treated in an emergency department (ED) each year for burns and fire-related injuries. Electrical burns, in particular, are not very common and comprise only about 3% of all burns in children.

Overall, electrical injuries are associated with high morbidity and mortality, with a risk of death as high as 40%. A 20-year review of electrical injuries in adults and children in a large burn unit in Texas by Arnoldo et al revealed that the mortality rate varied according to the type of electrical exposure: electrical arc, 1.1%; low voltage, 2.8%; high voltage, 5.3%; and lightning strikes, 17.6%. Arnoldo et al found that arc injuries were the most common type of electrical injury, accounting for 40% of all admissions to the burn unit. The investigators noted that arc injuries had a lower mortality than any other type of electrical injury. The incidence and mortality rates for patients exposed to lightning strikes may be underestimated, as many of these patients do not seek medical care or expire at the scene. Although lightning strikes and high-voltage exposures cause higher morbidity and mortality, low-voltage exposures are more common in children.

The most common causes of death in high-voltage exposures and lightning strikes are cardiac arrest and sepsis. According to a retrospective review by Duclos and Sanderson, about 60% of patients struck by lightning die within 1 hour of injury. This finding was supported in a report published in Morbidity and Mortality Weekly Report on lightning injuries. Most of these patients die secondary to a fatal cardiac arrhythmia at the scene.

In low-voltage exposure, electrolyte imbalance and sepsis are more likely to contribute to a poor outcome. In an attempt to evaluate the clinical features and mortality associated with low-voltage injuries, Gokdemir and colleagues performed a retrospective chart review of 36 children presenting to the ED with low-voltage electrical injuries. In this study, there were 5 patients who died after a low-voltage injury; 3 died secondary to sepsis, and 2 died as a result of severe electrolyte imbalance and acute tubular necrosis. The authors also found that children were less likely to survive if they had an elevated lactate dehydrogenase (LDH) level or a positive blood culture. Although the authors found a statistically significant difference, the pathophysiology of this relationship is not entirely clear. They noted in their discussion that “one of the most significant problems was determining the relation between the sepsis, electrolyte imbalance, and death.”

Electrical injuries may result from: (1) the direct effect of electrical current on organs and

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**Table 1. Characteristics Of Electricity And Injury, By Electrical Exposure**

<table>
<thead>
<tr>
<th>Characteristics of Electricity</th>
<th>Lightning</th>
<th>High Voltage</th>
<th>Low Voltage</th>
<th>Arc Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage (volts)</td>
<td>&gt; 30 x 10^6</td>
<td>&gt; 1000</td>
<td>&lt; 1000</td>
<td>Usually &lt; 1000</td>
</tr>
<tr>
<td>Current (amps)</td>
<td>&gt; 200,000</td>
<td>&lt; 1000</td>
<td>&lt; 240</td>
<td>Usually &lt; 240</td>
</tr>
<tr>
<td>Duration</td>
<td>Instantaneous</td>
<td>Brief</td>
<td>Prolonged</td>
<td>Brief</td>
</tr>
<tr>
<td>Type of current</td>
<td>DC</td>
<td>DC or AC</td>
<td>Usually AC</td>
<td>Usually AC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Characteristics of Injury</th>
<th>Asystole</th>
<th>Ventricular fibrillation</th>
<th>Ventricular fibrillation</th>
<th>Unusual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac complications</td>
<td>Direct CNS injury (eg, injury to respiratory control center)</td>
<td>Tetanic contraction of respiratory muscles</td>
<td>Tetanic contraction of respiratory muscles</td>
<td>Unusual</td>
</tr>
<tr>
<td>Respiratory complications</td>
<td>Blast effect (shock wave)</td>
<td>Uncommon; mechanical trauma; eg, from fall or if victim is thrown due to muscle contraction</td>
<td>Uncommon; mechanical trauma; eg, from fall or if victim is thrown due to muscle contraction</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Muscle contraction</td>
<td>Tetanic</td>
<td>Unusual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burns</td>
<td>Rare; superficial</td>
<td>Common; deep</td>
<td>Usually superficial, if any</td>
<td>Common</td>
</tr>
<tr>
<td>Rhabdomyolysis</td>
<td>Uncommon</td>
<td>Common</td>
<td>Possible</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Blunt injury (cause)</td>
<td>Blast effect (shock wave)</td>
<td>Mechanical trauma; eg, from fall or if victim is thrown due to muscle contraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute mortality</td>
<td>Very high</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Abbreviations: AC, alternating current; CNS, central nervous system; DC, direct current.

tissue; (2) the conversion of electrical energy into thermal energy, resulting in a burn; and (3) blunt trauma (eg, fall or severe muscle contractions). The extent of injury depends on multiple factors, including the following: 

- Strength of the current
- Type of the current (alternating current [AC] vs direct current [DC])
- Pathway of the current
- Voltage
- Resistance of the skin (ie, wet vs dry), mucosa, and internal organs
- Duration of contact

In order to understand how exposure to electricity can cause damage, it is helpful to understand the basic principles. Electricity is the flow of electrons across a potential from high concentration to low concentration. The relationship between the above-mentioned factors is described by Joule’s Law:

\[
Q = I V t
\]

where:
- \(Q\) = Energy/heat generated
- \(I\) = Current
- \(V\) = Voltage
- \(t\) = Time duration

The current (I) represents the number of electrons that flow, over time, through an object. There are 2 different types of circuits: AC and DC. In AC circuits, the direction of the flow of electrons alternates cyclically. Standard household current is AC and is low voltage (110 or 220 volts). Electrocution by AC circuit causes muscle tetany. This type of muscle contraction is especially dangerous because it produces a “locking-on” effect in which the victim physically cannot release himself from the electrical source.\(^2,3,13\) In DC circuits, the direction of the flow of electrons is unidirectional. DC is typically found in batteries, railway tracks, automobiles, and lightning. Electrocution by DC causes a single large muscle contraction, which may cause the patient to be thrown from the source.\(^2,13,15\) Voltage (V) is the electrical potential difference between 2 points.

A useful principle in electricity that demonstrates the relationship between voltage, current, and resistance is Ohm’s law: \(V = IR\).\(^1\) Resistance (R) is defined as the impedance to the flow of the electrons across the electrical potential. Moisture on the skin (ie, sweat or secondary to immersion of the patient in water) decreases the resistance, thereby increasing the patient’s risk of developing deep, penetrating burns. The amount of current that flows through the child’s body is the most important factor in determining the likelihood and extent of injury.\(^3,5\) High-voltage injuries tend to result in high morbidity, which is not surprising since voltage is directly related to current.\(^13\) In general, the longer a body part is in contact with the current, the more damage will be done.

### Differential Diagnosis

The situation in which the patient was found, if known, can aid in the diagnosis of an electrical injury. Healthcare providers must have a high index of suspicion for electrical exposure in any traumatized patient who is found unresponsive near train tracks, downed electrical wires, open areas during a thunderstorm, etc. The emergency clinician should attempt to determine (from the patient, family members, friends, and/or emergency medical services [EMS] providers) whether the patient suffered a low-voltage, high-voltage, lightning strike, or electrical arc injury. This information will aid in prehospital and ED resuscitation, assessment, and treatment for the patient.

Age-specific trends are helpful to consider when assessing and treating a patient who presents to the ED after exposure to electricity.\(^3,20\) For example, a case series by Rabban et al found that children aged < 12 years were more likely to suffer from low-voltage injuries (such as oral contact with electrical cords and hand contact with electrical appliances). In contrast, children aged > 12 years were more likely to suffer from a high-voltage injury such as from grasping a power line, climbing a utility pole, or coming into contact with a third rail of a train track.\(^21\)

When a victim is struck by lightning, the history of the event may not be available, especially if

### Table 2. Injuries Due To Lightning

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct strike</td>
<td>Lightning strikes the patient.</td>
</tr>
<tr>
<td>Contact injury</td>
<td>Lightning strikes object with which the patient is in contact.</td>
</tr>
<tr>
<td>Side flash</td>
<td>Current splashes from an object or another person.</td>
</tr>
<tr>
<td>Ground current</td>
<td>Lightning strikes the ground and current is conducted through the ground and into the victim.</td>
</tr>
<tr>
<td>Upward streamer</td>
<td>Lightning does not strike the ground. Electrical current passes through the patient via a vertical path, due to a difference in charges between the ground and the thundercloud.</td>
</tr>
<tr>
<td>Blast injury</td>
<td>Lightning’s blast effect (thunder) causes ruptured tympanic membrane or blunt trauma as the patient is thrown.</td>
</tr>
</tbody>
</table>

there are no witnesses to the event. Children may be injured by lightning in several different ways. (See Table 2.) Lightning exposure can cause a typical erythematous, fern-like burn pattern known as Lichtenberg figures. (See Figure 1.) This pathognomonic burn pattern results from an inflammatory response to the electrical current spreading across the surface of the skin. The dissipation of the current causes ionization and heat production, which may damage the subcutaneous capillaries and tissue. The condition appears within 1 hour of the lightning strike and usually resolves within 24 to 36 hours. If present, this burn pattern can aid in the diagnosis of a lightning injury. If the patient is found unconscious, the medical provider must consider other causes of loss of consciousness and paralysis resulting from lightning exposure (eg, cardiac arrhythmia, stroke, seizure, closed head injury, and spinal cord trauma).  

**Prehospital Care**

The initial goal for prehospital personnel is to ensure the safety of the location in which the patient is found. They should separate the victim from the current source, ensuring their own safety while doing so. It is imperative to disconnect the current, especially in high-voltage events. A properly trained provider may attempt to disconnect the circuit box or cut any live wires with a wood-handled ax or insulated wire cutters. However, to ensure the safety of general rescue personnel, it is prudent to avoid contact with active electrical sources and to contact the local power company and/or fire department to disconnect the power. First responders should stay away from any power lines found on the ground, as they may be live and capable of causing electrocution, if touched. For this reason, prehospital personnel should park at a safe distance away from any live wires to ensure their own personal safety. In lightning-strike events, theprehospital rescuers must be aware that lightning can strike the same place twice. However, a lightning victim is not “electrified,” and rescuers are not at risk of electrocution by touching the victim.  

Once the patient is cleared away from the electrical current source, the next step is to address airway, breathing, and circulation (ABCs). If necessary, the EMS provider should initiate cardiopulmonary resuscitation (CPR) and mechanical ventilation. Rapid assessment and treatment of any arrhythmias is crucial and can be life saving for the victim. Immobilization of the neck and cervical spine is especially important, since the patient may have fallen or been thrown from the electrical source. Any open wounds should be covered with a sterile dressing to avoid contamination during transport. Rapid transport to a hospital is essential.

**Emergency Department Evaluation**

**History**

The history for a patient who has sustained an electrical injury may not be available, since the victim may be unconscious or in shock. If possible, gather information from any bystanders and EMS providers about the electrical source (eg, low voltage vs high voltage), the duration of contact, and the scene where the event occurred. These clues are helpful in assessing the patient’s risk of developing complications. The child’s risk for injury is categorized according to the voltage of exposure. Voltage is chosen to help classify electrical injuries because it is often the only information known at patient presentation to the ED. This information will help guide the management of the patient in the ED and beyond.

**Physical Examination**

Keep in mind that sequelae can occur from an electrical injury, and target your physical examination toward those specific systems. Victims of a high-voltage electrical exposure or lightning strike are in danger of developing serious complications, such as central or peripheral neurologic damage, car-
Cervical Spine And Neurologic System
Maintain a high index of suspicion for spinal injury in any patient with an electrical injury. If a witness is available, ask whether or not the victim was thrown from or fell from the electrical source and may have suffered secondary blunt injury. Palpate the spine for any signs of spinal injury and perform a thorough neurologic examination. Assess the patient’s neurologic status based on mental status, motor and sensory function, and pupillary examination. A spinal injury may present if the patient experiences an alteration in sensation, decreased or absent motor function, poor rectal tone, loss of bladder or bowel control, or vital sign abnormalities.

Neurologic complications as a result of a lightning strike can be placed into 4 categories. The first category of injury involves transient symptoms that resolve within several days, including headache, loss of consciousness, sensory deficits, and weakness. A rare entity categorized within this group is keraunoparalysis, which affects the lower (and sometimes upper) extremities and is associated with cool, pulseless, mottled, and blue extremities. These patients may also have hypertension. The second category of neurologic complication includes neurologic insults that are permanent or prolonged. These patients may have encephalopathy or myelopathy as a result of central nervous system damage, and they may require long-term rehabilitation. The third category includes delayed neurologic complications (eg, amyotrophic lateral sclerosis, Parkinsonism, and focal dystonia or tics), which may present within days to months of the incident. The fourth category comprises neurologic complications that are not directly related to the lightning strike but are secondary to trauma from a fall or blast effect.

Cardiovascular System
Evaluate the patient for a dysrhythmia, since victims of electrical injury can suffer from almost any type of dysrhythmia (eg, ectopic atrial or ventricular beats, sinus bradycardia, sinus tachycardia, supraventricular tachycardia, first-, second-, and third-degree atrioventricular block, ventricular tachycardia, ventricular fibrillation, and asystole) and they can develop life-threatening myocardial infarction. AC injuries are more likely to produce ventricular fibrillation, while DC often causes asystole. Arrowsmith et al reported that an exposure to an electrical current can cause a cardiovascular insult via 3 mechanisms: (1) disturbance of the cardiac electrical system, (2) thermal injury to the myocardium, and (3) ischemic injury. After auscultating the child’s heart, assess the cardiac rhythm and check whether peripheral perfusion is normal.

Skin
Undress the child and remove the shoes to evaluate the skin completely. Exposure to electricity can result in devastating burns. If burns are present, assess their severity based on the presence of blisters, charring, and size. The location of the burn may affect severity. Burns can be superficial, partial thickness, or full thickness, and they are usually most severe at the site of contact with the electrical source and/or the ground contact site. In a review of 220 individuals fatally injured by electrocution, only 57% of the deaths due to a low-voltage exposure had an obvious burn, compared to 96% of deaths due to a high-voltage exposure. High-voltage exposures tend to cause focused entrance and exit burns.

In lightning exposures, the current can enter and exit anywhere on the body; a common exit point is through the feet, so shoes must be removed when evaluating these patients. With any electrical exposure, there may also be destruction of the underlying bone and muscle along with the cutaneous burns. In young children, evaluate the mouth for a burn at the oral commissure, especially if the child was found chewing on an electrical cord. These burns can lead to delayed hemorrhage and severe cosmetic defects.

Electrical arc injuries occur when the current “jumps” from the source, through the air, to a point on the victim’s skin. It usually does not pass through any internal structures. The electrical arc can emit intense heat and light, which can cause a severe burn. Electrical arc injury should be suspected if the victim was working as an electrician or was holding a metal object close to an electrical source.

Renal System
Rhabdomyolysis and myoglobinuric acute renal failure are known possible life-threatening complica-
tions of high-voltage electrical injuries. Evaluate the patient’s urine for color and volume of urine output. If the urine appears red or brown, this may be a sign of rhabdomyolysis. Decreased urine output may be a sign of acute kidney injury.

**Eyes And Ears**

Inspect the eyes and ears for damage. As part of the initial evaluation, perform a visual acuity and fundoscopic examination. Since the head is a common site of electrical contact in high-voltage exposures, it is important to assess the eyes for cataracts. O’keefe Gatewood and Zane reported that lightning strikes result in ocular damage in more than 50% of victims. The cause of the injury is thought to be secondary to direct thermal and electrical contact or from exposure to the intense light. Cataracts may develop hours, days, or even months after the incident. Similarly, a retrospective review by Saffle et al reported that 6% of victims of high-voltage exposure developed cataracts.

Tympanic membrane rupture is also common among victims of lightning strikes. Tympanic membrane rupture is believed to be due to a shock wave, direct burn, or blunt head injury. A retrospective study by Gluncic et al of 18 patients with ear injuries due to lightning strikes found that 67% had a ruptured tympanic membrane. All patients were noted to have experienced healing of their tympanic membrane, with complete restoration of their hearing. Other studies report an incidence of tympanic membrane rupture as high as 80% in lightning strike victims.

**Musculoskeletal**

Evaluate all patients for fractures or evidence of compartment syndrome (ie, pain with passive extension, pallor, pulselessness, paresthesias, or paralysis). Evaluation may be particularly difficult in the setting of burns, since extensive myonecrosis and vascular damage can occur, especially in high-voltage exposures. These patients may initially present with muscle edema that can progress to compartment syndrome. The electrical current can penetrate deeply and cause deep tissue destruction. In a 30-year review of electrical injuries in children, Rai et al noted many cases where the tissue damage was extensive, requiring debridement, fasciotomy, and, at times, amputation. The extent of injury may be overlooked on initial examination, especially if widespread surface-area burns are not present. According to Tarim and Ezer, the cross-sectional area of the burn may be inversely related to surface tissue injury, meaning that smaller surface area burns potentially penetrate deeper than burns with a larger surface area.

**Diagnostic Studies**

Controversy exists regarding recommended ancillary testing for patients with electrical exposures. The diagnostic evaluation depends on the type of voltage exposure and the extent of injury. Children with minor household electrical exposures (low-voltage) who are asymptomatic may not require laboratory evaluation, cardiac evaluation, or hospitalization. In a retrospective review by Garcia et al, none of the 70 children who experienced minor events had complications, and they could have been managed effectively as outpatients.

**Laboratory Testing**

Victims of high-voltage electrical exposure, lightning strikes, and severe burns should undergo a more extensive diagnostic evaluation, given the various complications that may result. A complete blood count (CBC), electrolyte panel, blood urea nitrogen (BUN), creatinine, coagulation panel, pregnancy test, troponin, creatine phosphokinase (CPK), and urine dipstick/urinalysis (including urine myoglobin) are recommended. In a 20-year review of electrical injuries, Arnoldo et al found that CPK and CK-MB are generally poor indicators of cardiac injury. The practice guidelines for electrical injuries published in 2006 by the American Burn Association support this conclusion, stating that there is limited evidence to support the utility of CK-MB in the diagnosis of cardiac dysfunction after electrical exposure. The diagnostic value of a troponin level in this setting has not been thoroughly studied, and its use cannot be recommended at this time.

Evaluate all victims of a high-voltage exposure for myoglobinuria. Myoglobinuria should be suspected if the urine appears grossly pigmented or if the urinalysis reveals blood on the dipstick in the absence of red blood cells on microscopy.

**Imaging**

If the patient was thrown or fell, consider chest, pelvis, and extremity radiographs. Order a computed tomography (CT) scan of the brain if the child has persistent altered mental status or if there is suspicion of a clinically important head injury. Since transient and permanent cervical spinal injury may be caused by electrical injuries, consider cervical spine immobilization and imaging.

**Electrocardiogram**

Cardiac evaluation with an electrocardiogram (ECG) after every electrical exposure is controversial. The 2006 practice-based guidelines established by the American Burn Association recommend obtaining an ECG for all patients with an electrical exposure upon arrival to the ED, regardless of the type of voltage exposure. In 1995, Garcia et al had performed...
a retrospective study of 78 children with electrical injuries and concluded that obtaining an ECG in asymptomatic children with low-voltage exposures or with only minor burns may be unnecessary. To date, there are no specific guidelines in children. The general consensus is that an ECG early in the evaluation of patients who suffer a high-voltage injury is warranted.

Have a high suspicion for compartment syndrome in any patient with an abnormal physical examination with suggestive findings. If there is any concern, measure compartment pressures, obtain a Technetium-99m pyrophosphate scan, or use a Doppler flow meter to assess the extremity’s perfusion.

### Treatment

#### Airway, Breathing, And Circulation

As with any ill or injured child, the initial step in the management for all types of electrical exposure is to assess and secure the airway. It is imperative to secure the airway early in the ED course if the patient has any orofacial burns, as progressive airway edema may develop. The child may require intubation with mechanical ventilation if severe orofacial burns are present. Be prepared to encounter a difficult airway; have airway adjuncts (eg, laryngeal-mask airway) available and call an anesthesia consult early if there is any concern. When manipulating the airway, keep in mind that there may be cervical spine injuries.

The child may also require mechanical ventilation if the breathing or neurologic function is compromised. Furthermore, if the child’s injuries or burns are extensive, it may be necessary to intubate and mechanically ventilate the child to achieve maximal pain control. Administer fluids early in resuscitation, since these patients are at risk for hemodynamic compromise (especially if they have suffered blunt trauma after a fall or a severe burn). Closely monitor urine output in children with an electrical exposure, as some will develop renal failure.

#### Cervical Spine And Neurologic System

Stabilize the cervical spine upon arrival to the ED if it has not already been done by prehospital personnel. Victims of a lightning strike are at high risk of developing cerebral edema hours to days after the injury. Pay close attention to any deterioration in mental status, and conduct frequent neurovascular checks.

#### Cardiovascular System

Early evaluation of the cardiac status of the child is essential. Once CPR has begun, if the ECG rhythm indicates ventricular fibrillation or pulseless ventricular tachycardia, immediately defibrillate the patient with 2 J/kg (maximum 10 J/kg) follow-

ing the Pediatric Advanced Life Support (PALS) guidelines. The presence of any abnormal electrical rhythm in a child exposed to electricity requires careful evaluation and should be discussed with a pediatric cardiologist.

### Skin

All participants in the resuscitation process should wear masks with face shields, gowns, and gloves in order to ensure the safety of the providers and sterility for the patient. The emergency clinician should attempt to remain sterile when coming into contact with the patient’s cutaneous burns in order to prevent contamination. This essential step should be initiated as soon as the ED is notified of an incoming child with burns.

After evaluating the ABCs, the next most important step is to provide adequate pain control. For more information on pediatric pain control, see the December 2012 issue of Pediatric Emergency Medicine Practice, "Pediatric Pain Management In The Emergency Department."

Gently wash the burned skin and apply a sterile cold saline dressing (for no more than 20 min) in an attempt to stop the destructive process and provide some pain relief. Provide tetanus toxoid if the patient’s immunization status is unknown.

The emergency clinician should assess the percentage of the total body surface area (TBSA) that is burned. There are 3 methods for estimating the size of a burn: (1) the Wallace rule of nines, (2) the Lund-Browder method, and (3) the palmar surface area. In children, the rule of nines is not accurate because a child’s head and neck make up a greater percentage of TBSA than an adult’s. Because of this, the emergency clinician should refer to the Lund-Browder chart for any child with a burn. (See Figure 2.) The palmar surface area method (in which the patient’s palm represents 0.5% to 1% total TBSA) is accurate for very large burns or for small burns, but it is inaccurate for medium-size burns. A study by Nagel and Schunk suggests that using the entire palmar surface area (ie, palm and fingers) yields a more accurate estimate of TBSA than the traditional method of using only the palmar surface area (ie, the palm excluding the fingers). Use the Parkland formula (plus maintenance therapy) to determine intravenous fluid needs over the following 24 hours for any child with partial- or full-thickness burns > 10% TBSA.

The American Burn Association recommends that the following patients be transferred to a burn center:

- Partial-thickness burns > 10% TBSA
- Full-thickness burns
- Inhalational injury
- Electrical injuries (including lightning injury)
• Chemical burns
• Significant burns to face, eyes, genitalia, perineum, or major joints
• Patients with significant associated injuries (e.g., femur fracture, intracranial bleed)
• Children with burns who are located in hospitals without pediatric facilities

While burns and deep tissue injury are at high risk for infection, the current recommendation is to not administer prophylactic antibiotics to every patient and to reserve the use of antibiotics for patients with infected wounds.3,9,44,46

Renal System
Perform a urinalysis on every patient with an electrical injury. If the urinalysis reveals blood without the presence of red blood cells, be concerned for rhabdomyolysis and order a serum CPK level on the patient. One retrospective study by Rosen et al found that the 4 factors most associated with the development of myoglobinuria following electrical injury were: (1) high-voltage exposure, (2) prehospital cardiac arrest, (3) full-thickness burns, and (4) compartment syndrome.34 The investigators in this study developed a clinical prediction tool using these 4 risk factors and found that, if 2 or more risk factors were present, the patient was considered at high risk for developing myoglobinuria. The rule had a sensitivity of 96% and a negative predictive value of 99%. They also concluded that serum CPK levels are generally unnecessary and add little predictive value. While the results from this single study show promise in the management of the electrically injured patient, they need to be validated in other populations, particularly children, before being put into practice.34

If the child develops rhabdomyolysis, ensure adequate fluid hydration with intravenous fluids within 6 hours of the injury.3,47 A systematic review by Scharman and Troutman found a benefit from early initiation of intravenous fluids in patients with rhabdomyolysis, although this evidence is weak.47 The concern is that, without aggressive hydration, these patients may progress to develop acute renal failure.5 The reported management of rhabdomyolysis in the literature varies widely in terms of type and rate of fluids, alkalization of urine, and the use of mannitol.42 There are limited pediatric data on rhabdomyolysis; thus, the reported pediatric management draws from the adult studies.48 There is debate over which type of intravenous fluid is more likely to prevent acute renal failure in patients with rhabdomyolysis. Scharman and Troutman’s systematic review in adult patients found no evidence to support the use of lactated Ringer’s solution, sodium bicarbonate, or any other type of fluid therapy over normal saline alone. The ideal rate of fluid administration for children has not been adequately studied.47

Eyes And Ears
Consult ophthalmology and otolaryngology for all lightning-strike patients because of the known complications resulting from these exposures. Saffle et al performed a retrospective review evaluating the development of cataracts in patients with severe electrical injuries. Of the 113 patients enrolled in the study, 7 patients developed cataracts; 6 of these 7 patients developed bilateral cataracts. All of these patients were initially managed conservatively; however, a large percentage of them (77%) ultimately required surgical repair.35

Any child with hearing loss or bloody drainage from the ear after an electrical exposure requires an urgent otolaryngology evaluation. The otolaryngologist can perform otomicroscopy to evaluate the ossicles for hemorrhage and the tympanic membrane for perforation. The child may require hearing evaluation with an audiogram, aseptic aspiration toilet, and repair of any tympanic membrane ruptures with a gelatin sponge soaked in antibiotics.36
Clinical Pathway For Management Of Electrical Injury In Children

Following electrical exposure:
• Secure scene/call for help
• Clear child away from current

Unstable?
YES
• Pediatric Advanced Life Support
• Advanced Trauma Life Support
(Class II)

NO
Life- or limb-threatening trauma?
YES
Transfer to trauma center
(Class II)

NO
Severe or high-risk burns?
YES
Transfer to burn center
(Class II)

NO
Arc injury?
YES

Symptomatic?

NO
Outpatient management
(Class II)

YES
• CBC
• Chem/BUN/creatinine
• beta hCG
• Troponin/CPK
• Coagulation panel

• Urinalysis
• Urine myoglobin
• LDH
(Class II)

Inpatient management
(Class II)

• Electrocardiogram
(Class II)
• Intravenous fluids
(Class II)

Abbreviations: CBC, complete blood count; BUN, blood urea nitrogen; beta hCG, beta human chorionic gonadotropin; CPK, creatine phosphokinase; ED, emergency department; LDH, lactate dehydrogenase.

Class Of Evidence Definitions

Each action in the clinical pathway section of Pediatric Emergency Medicine Practice receives a score based on the following definitions.

Class I
• Always acceptable, safe
• Definitely useful
• Proven in both efficacy and effectiveness

Level of Evidence:
• One or more large prospective studies are present (with rare exceptions)
• High-quality meta-analyses
• Study results consistently positive and compelling

Class II
• Safe, acceptable
• Probably useful

Level of Evidence:
• Generally higher levels of evidence
• Non-randomized or retrospective studies: historic, cohort, or case control studies
• Less robust randomized controlled trials
• Results consistently positive

Class III
• May be acceptable
• Possibly useful
• Considered optional or alternative treatments

Level of Evidence:
• Generally lower or intermediate levels of evidence
• Case series, animal studies, consensus panels
• Occasionally positive results

Indeterminate
• Continuing area of research
• No recommendations until further research

Level of Evidence:
• Evidence not available
• Higher studies in progress
• Results inconsistent, contradictory
• Results not compelling

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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Musculoskeletal System

Injuries with extensive myonecrosis may require fasciotomy to prevent compartment syndrome and/or amputation. As many as 30% to 40% of victims of high-voltage electrical exposure require amputation. In a retrospective review, Arnoldo et al reported that sepsis secondary to extensive myonecrosis was one of the most common causes of mortality in victims of high-voltage electrical injury. Nonetheless, the benefit of early surgical decompression in reducing amputation rates and mortality is controversial. Traditionally, it was thought that all electrocuted patients with muscle and/or vascular injury should undergo surgical intervention within 24 hours of injury. New data suggest that surgical intervention is not necessary for every patient and that surgeons should take a more selective approach in deciding who should undergo immediate surgical decompression. The American Burn Association’s published guidelines for electrical injuries state that surgical decompression with fasciotomy should be performed only if the patient exhibits “progressive neurologic dysfunction, vascular compromise, increased compartment pressure, or systemic clinical deterioration from suspected ongoing myonecrosis.”

Special Circumstances

Burns Of The Oral Commissure

As mentioned previously, toddlers typically suffer from low-voltage electrical injuries. One particular type of injury specific to these children is a burn at the oral commissure as a result of chewing on an electrical cord. (See Figure 3.) It is essential to recognize that these children may experience life-threatening hemorrhage 2 to 21 days from the time of injury if the eschar overlying the labial artery falls off. This type of burn can also lead to contraction, which limits mouth opening and results in future cosmetic deformities. Patients with minimal burns to the oral commissure usually do not require extensive diagnostic evaluation or admission to the hospital. Basic local wound care and proper dental hygiene are sufficient; however, prompt referral to oral or plastic surgery is warranted if there is any suspicion that the burn extends deeper than the superficial layer. These burns may require stents to minimize scarring.

Electrical Weapons

Law enforcement officials often use electrical weapons (eg, stun guns and Tasers®) to apprehend and control suspects. The devices deliver multiple, rapid, high-voltage, low-amperage, and DC-like electricity to the subject. The current emitted is not 100% DC or AC, although it is most similar to DC electricity.

The amount of energy dispensed will depend on the ratio of voltage to current to the time with which the patient is in contact with the device. A large prospective multicenter observational study by Bozeman et al studied the safety and injury profile of electrical weapons. The authors found that of the 1201 subjects studied, almost all of them (99.7%) had mild or no injuries. Only 3 subjects (0.3%) suffered from severe injuries, which included intracranial injuries and rhabdomyolysis. The general consensus is that electrical weapons cause minimal harm as long as the exposure is brief. Asymptomatic patients do not require extensive diagnostic testing, prolonged ED observation, or admission.

If the Taser® barb is lodged in the patient’s skin, it should be removed and the skin cleansed.

Cutting Edge

In general, the traditional rules for mass triage should not be applied to patients with lightning-strike injuries. It has been proposed that first responders should employ a reversed mass triage protocol if multiple lightning-strike victims are encountered. This is in contrast to usual disaster management protocols for other sources of trauma where those who appear dead are abandoned in the

Figure 3. Oral Commissure Burn

hopes of saving the most lives. Although the most common cause of death in victims of a lightning strike is cardiac arrest, many patients still survive the insult. Unresponsive victims who were struck by lightning and are in full cardiac arrest at the scene should, therefore, receive early and prolonged CPR and assisted ventilation. Furthermore, since cardiac arrest is the most common cause of mortality in these patients, if the patient is not in cardiac arrest at the scene, then they are likely to survive without any immediate intervention.

Prevention is the most effective measure available to reduce injury from electrical exposure. According to a retrospective review of children with electrical injuries by Tomkins and Holland, the most common causes of low-voltage injury were contact with faulty electrical equipment, contact with an electrical wire, and probing an electrical socket. Interventions to prevent these unintentional injuries are simple and include close attention of the child by the caregiver, educational initiatives (eg, teaching parents and children about the dangers of electrical injuries), plastic covers over all outlets accessible to children, electrical safety switches, and repair of exposed wires.

### Disposition

Patients who experience a low-voltage electrical exposure, are asymptomatic upon arrival to the ED, and have a normal physical examination do not require admission to the hospital. Table 3 summarizes the suggested criteria for admission.

<table>
<thead>
<tr>
<th>Table 3. Considerations For Admission</th>
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<tbody>
<tr>
<td>1. High-voltage exposure or lightning strike</td>
</tr>
<tr>
<td>2. Presence of entrance/exit wound</td>
</tr>
<tr>
<td>3. Neurologic instability (altered mental status, loss of consciousness)</td>
</tr>
<tr>
<td>4. Cardiovascular instability (any electrocardiogram abnormality, dysrhythmia, myocardial infarction)</td>
</tr>
<tr>
<td>5. Oral burns (if unable to tolerate oral fluid intake)</td>
</tr>
<tr>
<td>6. Extremity burns/myonecrosis</td>
</tr>
</tbody>
</table>

### Risk Management Pitfalls For Electrical Injuries (Continued on page 13)

1. “I know the child was struck by lightning, but he has no external burns, so I thought he could be discharged.”
   The electrical current can penetrate deeply and cause deep tissue destruction even in the absence of extensive surface-area burns. As noted by a study by Tarim and Ezer, the cross-sectional area of the burn is inversely related to the depth/extent of tissue injury. This is especially true in patients with lightning and high-voltage injuries. You should consider admitting the patient because there may be deep tissue destruction that is not externally visible.

2. “The child suffered full-thickness burns to his chest after contact with a high-voltage power line. I decided to administer prophylactic antibiotics to decrease the risk of infection.”
   The American Burn Association does not support the administration of prophylactic antibiotics to every patient with a burn; the use of antibiotics should be reserved for those who develop infected wounds.

3. “The child had an electrical burn at the oral commissure. She did not require follow-up with any medical provider, because these types of burns heal without any complications.”
   Patients with minimal burns to the oral commissure usually do not require extensive diagnostic evaluation or admission to the hospital; however, patients with moderate to severe burns of the oral commissure should be promptly referred to an oral or plastic surgeon because the burn may extend deeper than the superficial layer. The surgeon may place a stent to minimize future scarring. Patients with burns at the oral commissure secondary to chewing on an electrical cord are at a high risk of delayed bleeding from the labial artery 2 to 21 days after the initial incident. Inform the parents of this potential complication prior to discharge.

4. “Even though the patient was electrocuted after touching the third rail, his initial ECG was normal, so I sent him home.”
   The third rail is the high-voltage electrified rail that provides power to a railway track. All patients with high-voltage injuries should be admitted for cardiac monitoring. Although late dysrhythmias are rare (especially if the initial ECG is normal), high-voltage electrical exposure is an important risk factor for developing a cardiac abnormality.

5. “I think this 6-year-old child with 12% burns can be admitted to my community hospital.”
   According to the American Burn Association, any patient with > 10% surface-area burn should be transferred to a burn facility for consultation by a burn specialist and further monitoring.
Patients who are discharged from the ED should follow up with a primary care provider within 3 to 4 days. All high-voltage and lightning-strike victims should have ophthalmologic and otologic follow-up within 2 to 3 days.\textsuperscript{1,13}

Summary

Electrical injuries are uncommon in the pediatric population, although they can result in serious injury.\textsuperscript{1} The spectrum of electrical injuries is wide, and it varies, depending on the type of exposure. Young children are at higher risk of sustaining low-voltage injuries, whereas older children and adolescents more frequently experience high-voltage injuries. All patients should be rapidly assessed upon arrival to the ED. Particular attention should be given to the cardiovascular status, the skin, the kidneys, and the musculoskeletal and the nervous systems, as these are the most frequently injured areas in children exposed to electricity.\textsuperscript{5,13} In general, patients who fit the following criteria should be admitted for fur-
The 17-year-old boy who presented after climbing up a utility pole was found to have full-thickness burns of both hands and wrists and an exit wound in the foot that was touching the pole. From the history provided by EMS, you concluded that this patient was exposed to high-voltage electricity. After a full assessment, you were concerned about your patient developing serious complications from his injury, such as a cardiac dysrhythmia, rhabdomyolysis, deep-muscle necrosis, and neurologic deterioration. You decided to send off a CBC, electrolyte panel, BUN, creatinine, coagulation panel, serum osmolality, and urinalysis including myoglobin, troponin, and CPK. He had an elevated CPK at 62,000 U/L, which you treated with aggressive intravenous isotonic fluid hydration. His ECG displayed normal sinus rhythm. Since the patient experienced significant head trauma after falling 20 feet, you ordered a head CT scan, which was normal. While in the ED, you noted that the patient had progressively diminished perfusion of his right hand, with marked pallor and coolness. He was immediately taken to the operating room for a right hand/wrist escharotomy and fasciotomy. Because this was a high-voltage exposure and the patient had extensive injuries, he was admitted to the burn intensive care unit where he received cardiac monitoring. On postinjury day 20, the patient again developed right wrist pallor and pulselessness, requiring amputation of the right distal extremity. The exit wound on his left foot healed with basic wound care.

**Case Conclusions**

The 17-year-old boy who presented after climbing up a utility pole was found to have full-thickness burns of both hands and wrists and an exit wound in the foot that was touching the pole. From the history provided by EMS, you concluded that this patient was exposed to high-voltage electricity. After a full assessment, you were concerned about your patient developing serious complications from his injury, such as a cardiac dysrhythmia, rhabdomyolysis, deep-muscle necrosis, and neurologic deterioration. You decided to send off a CBC, electrolyte panel, BUN, creatinine, coagulation panel, serum osmolality, and urinalysis including myoglobin, troponin, and CPK. He had an elevated CPK at 62,000 U/L, which you treated with aggressive intravenous isotonic fluid hydration. His ECG displayed normal sinus rhythm. Since the patient experienced significant head trauma after falling 20 feet, you ordered a head CT scan, which was normal. While in the ED, you noted that the patient had progressively diminished perfusion of his right hand, with marked pallor and coolness. He was immediately taken to the operating room for a right hand/wrist escharotomy and fasciotomy. Because this was a high-voltage exposure and the patient had extensive injuries, he was admitted to the burn intensive care unit where he received cardiac monitoring. On postinjury day 20, the patient again developed right wrist pallor and pulselessness, requiring amputation of the right distal extremity. The exit wound on his left foot healed with basic wound care.

**Time-And Cost-Effective Strategies**

1. Do not give all patients with electrical burns prophylactic antibiotics. This should only be reserved for patients in whom there is clinical suspicion for infection.
2. Do not admit all patients with electrical burns. Admission is reserved for patients with the presence of an entrance and exit wound, neurologic instability, cardiovascular instability, presence of oral burns and the inability to tolerate oral fluids, and all high-voltage electrical or lightning exposures. Asymptomatic patients exposed to low-voltage electricity can be safely discharged.

The 2-year-old boy who was found chewing on an electrical cord suffered a full-thickness burn at the oral commissure. You applied topical antibiotic ointment to his lips and wound, but you did not administer oral antibiotics. Because he was unable to tolerate any oral fluids in the ED, you had him admitted to the burn intensive care unit. He was discharged the following day from the hospital and followed up with oral surgery 4 days later for placement of an oral splint. On postinjury day 12, the child returned to the ED because he was bleeding from the oral commissure, and in the ED, pressure was applied to the site. The patient was hemorrhaging despite manual pressure, so he was taken to the operating room immediately for cauterization and ligation of his labial artery bleed. Several months later, the child had minor reconstructive surgery by a plastic surgeon to minimize the scar formation. In conjunction with other members of your ED staff, you initiated an educational program for parents to teach electrical safety precautions.

The 16-year-old girl who was struck by lightning arrived to the ED unconscious but with a normal sinus rhythm on ECG. You evaluated her ABCs and placed her on continuous ECG monitoring. Her Glasgow Coma Scale score was normal throughout her stay in the ED. You ordered a CT scan of the brain, which revealed cerebral edema and a traumatic subarachnoid hemorrhage. Her burns were noted to be superficial and were treated with routine wound care. Both tympanic membranes were ruptured. There was no ocular damage noted on initial ophthalmologic exam. She was admitted to the intensive care unit for cardiac monitoring as well as neurosurgical evaluation and management. She made a complete initial recovery; however 4 months later, she developed bilateral cataracts.

**References**

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study will be included in bold type following the references, where available. The most informative references cited in this paper, as determined by the author, will be noted by an asterisk (*). The number of the reference.


CME Questions

1. Which of the following statements regarding electrical injuries is TRUE?
   a. The most common cause of death in a patient exposed to a high-voltage source is renal failure.
   b. In an electrical arc injury, no current passes through the patient.
   c. Only patients with high-voltage injury develop arrhythmias.
   d. All electrocuted children with burns should be admitted because of their high risk of infection.

2. The type of electrical injury most associated with mortality is:
   a. Low-voltage injury
   b. High-voltage injury
   c. Lightning strike injury
   d. Electrical arc injury

3. Children with low-voltage injuries are at higher risk of sustaining head trauma than those with high-voltage injuries.
   a. True
   b. False

4. DC is associated with the “locking-on effect.”
   a. True
   b. False

5. A 15-year-old boy is struck by lightning. The EMS provider should not directly touch the patient because doing so may result in electrocution.
   a. True
   b. False
6. A 4-year-old child is found chewing on an electrical wire. Which of the following is a known complication associated with this type of electrical injury?
   a. Sepsis
   b. Delayed bleeding
   c. Arrhythmia
   d. Rhabdomyolysis

7. A 12-year-old boy presents to the ED with an electrical injury after bystanders spotted him falling from a telephone pole. Besides injuries related to his fall, he is at highest risk of developing which of the following complications related to the high-voltage exposure:
   a. Myocarditis
   b. Rhabdomyolysis
   c. Corneal burn
   d. Bleeding

8. All electrical burns should be treated with antibiotics.
   a. True
   b. False

9. All of the following are examples of methods for prevention of low-voltage injury EXCEPT:
   a. Electrical outlet covers
   b. Enhanced caregiver supervision
   c. Exposing the electrical cord
   d. Electrical safety switches

10. Which of the following patients requires admission to the hospital?
    a. A 3-year-old child who was burned chewing on electrical cord and is tolerating oral fluids
    b. A 5-year-old child who placed a pin in an electrical socket
    c. A 12-year-old child who presents with a burn after climbing a power line
    d. A 6-year-old child who suffered a low-voltage injury and has a normal ECG

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Chest Trauma In The Pediatric Emergency Department

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Trauma to the head, chest, and abdomen are a source of significant morbidity and mortality in pediatric patients. Worldwide, it is estimated that nearly one-quarter of deaths from pediatric trauma are attributed to some form of chest trauma. Children have unique anatomical and physiological features that may present diagnostic challenges that the emergency clinician must be aware of when managing chest trauma. Blunt trauma to the pediatric chest can present in a variety of ways, from the subtle and nonspecific to the dramatic and deadly. Early recognition and prompt diagnosis is paramount. This issue of Pediatric Emergency Medicine Practice examines blunt trauma to the pediatric chest as well as its relevant etiologies, associated mortality, diagnostic strategies, and treatment options. Commonly encountered injuries (such as pulmonary contusions, rib fractures, and pneumothoraces) as well as rarely encountered—yet highly lethal—chest wall injuries (such as blunt cardiac injuries, commotio cordis, inflicted chest trauma, and aortic disasters) are reviewed.

Pediatric Nerve Blocks: An Evidence-Based Approach

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Successful pediatric injury management is often dependent upon optimal pain control. Many injuries do not require procedural sedation or systemic analgesia, and nerve blocks have been used by emergency medicine clinicians for several decades when pain is expected during the management of lacerations, fractures, and other procedures. These procedures deliver an anesthetic to the nerve that corresponds to the sensory innervation of the area where the wound or injury is located. Several of these modalities rely on anatomic landmarks, and correct needle placement may be contingent on sensation of paresthesia induced by needle-to-nerve contact, use of nerve stimulation devices, or visual confirmation using ultrasound guidance. In the pediatric setting, these modalities may pose a challenge, and they require adaptations to the approach and technique commonly used in adult patients. Peripheral nerve blocks have a high success rate for effective local anesthesia and have a low rate of complications, making them an attractive option for analgesia in the management of many injuries. This Pediatric Emergency Medicine Practice issue presents an evidence-based review of the advantages and disadvantages of peripheral nerve blocks, reviews commonly used local anesthetics, describes the landmark technique for the most common nerve blocks used in pediatric emergency medicine, and presents literature on ultrasound guided technology.
Pediatric Emergency Medicine Practice has been accepted for indexing on PubMed

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To read a letter from Dr. Adam Vella, Editor-in-Chief, about this exciting achievement, please visit www.ebmedicine.net/MEDLINEPEMP

All of our readers have played an instrumental role in ensuring this publication’s high quality, and we greatly appreciate your support.

—THE EB MEDICINE TEAM

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Target Audience: This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

Goals: Upon completion of this activity, you should be able to: (1) demonstrate medical decision-making based on the strongest clinical evidence; (2) cost-effectively diagnose and treat the most critical ED presentations; and (3) describe the most common medicolegal pitfalls for each topic covered.

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