EM CASES SUMMARY

Episode 125 Electrical Injuries

With Joel Fish and Maria Ivankovic
Prepared by Lorraine Lau, May 2018

As discussed in the Burn and Inhalation Injuries episode, one of the most important principles to remember with any burn or electrical injury patient is that they are a *trauma patient first*. Follow your primary and secondary survey as you normally would for any trauma, and only then attend to the burns and electrical injuries. There is no way to clearly measure the extent of injury and internal damage caused by electrical injuries. This is an "iceberg injury" – what you see may not be what you get. You may find yourself "fighting the invisible enemy". Be vigilant and suspicious of physical findings that don't quite fit the clinical picture.

Risk stratification of electrical injuries

Factors that help predict the extent of the injury include:

- Voltage
- AC or DC
- Duration of contact and
- Degree of wetness/humidity of the environment.

Low voltage (<600V) such as household or office exposures are generally lower risk injuries.

High voltage (>600V) such as industrial setings, subway rails, power lines are generally higher risk injuries.
Alternating Current (AC) causes prolonged contraction and release of muscle preventing full release from electrical source and hence longer duration of contact and more tissue damage compared to d**irect Current (DC).**
Lightning strikes (up to 1 billion V) are DC with very brief contact (milliseconds) with surprisingly high survival rates of 70-90%, but up 80% of survivors sustain long-term morbidity. Patients may initially appear deceased with fixed and dilated pupils (autonomic dysfunction) and cold mottled extremities from vasospasm. Asystole occurs from direct depolarization of the myocardium but typically spontaneous ROSC is achieved. Respiratory arrest from medullary paralysis can take longer to resolve and patients may develop a secondary hypoxic arrest.

Pearl: *Use Reverse Triage in lightning-strike induced mass casualty incident – those who appear dead may be easily resuscitated with good survival rates, so should be attended to first.*

	Low Voltage (<600V)	High Voltage (>600-1000V)	Lightning
Exposure	Household or office	Industrial	Environment
Voltage	Canada: 110-240 volts Europe: up to 400 volts	> 600-1000 volts	Up to 1 billion volts
Contact	Prolonged	Brief	Very brief (ms)
Current	AC	AC or DC	DC
Injuries	Superficial burns, unlikely rhabdomyolysis, cardiac dysrhythmias (VF) rare	Deep burns, tetany, rhabdomyolysis, cardiac dysrhythmias (VF/asystole)	Burns variable, rhabdomyolysis unlikely, cardiac dysrhythmias (asystole), respiratory arrest, autonomic dysfunction

Emergency Sequelae and Complications of Electrical Injuries

Cardiac complications from electrical injuries

Serious cardiac complications from electrical injury relatively uncommon. The overall incidence of cardiac complication is 4 – 17% and most of the dysrhythmias are benign. They tend to occur in the first few hours from the injury. ECG findings include bundle branch blocks, AV blocks, QT prolongation, ST changes and most commonly, atrial fibrillation. These arrhythmias generally resolve without treatment. Ventricular fibrillation is the most common fatal arrhythmia. It will generally occur immediately after the electrical exposure. VF is more common with AC exposures. Asystole is more common with DC exposures.

Indications for troponins
There are rare cases of STEMI reported in the literature associated with normal coronary arteries (likely due to vasopasm). It is thought that direct electrical and thermal injury and possibly thrombogenic effects of electrical injury contribute to coronary ischemia. It is a myth that electrical burns to both hands increase the risk of cardiac complications due to the arc of electricity passing through the heart. The decision to obtain troponins should be based on clinical presentation and pre-existing risk factors and should not be ordered reflexively.

Myth: *Electrical burns to both hands increase the risk of cardiac complications due to the arc of electricity passing through the heart.*

Compartment syndrome secondary to electrical injuries

Both direct and indirect injury of the muscles from electrical exposure significantly increase the risk of compartment syndrome. Regularly assess limbs for significant pain on passive extension of the muscles, rigid compartments to palpation and signs of poor perfusion. There should be a low threshold to contact a surgeon and consider a fasciotomy.

Rhabdomyolysis and AKI in electrical injuries

CK elevation correlates to the extent of muscle injury, but is not directly related to the probability of developing AKI. If the CK is in the thousands, assume rhabdomyolysis.

Urine myoglobin has poor sensitive sensitivity and may be negative in up to half of patients with rhabdomyolysis and may be misleading. Most patients with rhabdomyolysis secondary to electrical injury will have tea-colored urine within hours of presentation making the diagnosis obvious.

The principles of management and actions to be considered for rhabdomyolysis and AKI based on expert opinion in the setting of electrical injuries include:

- **Correction of volume depletion** until the plasma CK level is stable and not increasing
- Prevention of intratubular cast formation by **forced alkaline diuresis**, using sodium bicarbonate (150mEq/L) to a urine pH > 6.5
- Mannitol or furosemide may be considered in the presence of obvious myoglobinuria *after adequate fluid resuscitation*, particularly if urine has not cleared of pigment/myoglobin in a

timely manner (e.g. over 3 hours) with fluid administration to ensure high urine output in the prevention of acute tubular necrosis and renal failure due to myoglobinuria

Pearl: *Hyperkalemia from a combination of muscle damage and AKI is usually not severe and usually corrected by fluid resuscitation alone; shifting of potassium is rarely required.*

Beware! *If given too early, diuretics can also cause direct insult to the kidneys and worsen renal injury. Patient needs to be adequately fluid resuscitated first. The decision to use mannitol or furosemide should be made in consultation with a burn center.*

Electrical Cord Bite Injury

Beware! Injury to the corner of the mouth in children is not uncommon after chewing on an electrical cord such as a smart phone cable. It can cause burns to tongue and palate and delayed massive bleeding from the labial artery with potential airway compromise. Delayed bleeding can present 5 days – 2 weeks when the eschar separates.

Pearl: *Educate the parents that if the child has delayed labial bleeding, use thumb and index finger to grip lip on both sides with gauze or towel and compress the labial artery, and to seek urgent medical care immediately.*

Fluid resuscitation in electrical injuries

Some general principles for fluid resuscitation in electrical injuries include:

- Patients with electrical burns generally require *more* fluid as outlined by the **Modified Brooke/Parkland formula** for thermal burn injured patients, but unfortunately there aren't any clear evidence based guidelines.
- A continuous infusion of IV fluids is preferred over boluses to minimize tissue edema that may worsen tissue damage associated with electrical injuries
- Start with Ringer's Lactate at 300-500 mL/hr and then titrate to a urine output > 100 cc/hr and other signs of adequate organ perfusion

Cardiac monitoring after electrical injuries

In patients with a low voltage exposure in the absence of chest pain or syncope, the literature does not support need for cardiac monitoring (Pawlik et al 2015). While there is some evidence that ECG monitoring is not required for high voltage injuries with a normal ECG our experts recommend 6-8 hours of cardiac monitoring for high voltage injuries.

Disposition for electrical injuries

- Asymptomatic low voltage (<600V) injured patients patients can be discharged home safely after a normal ECG; no period of observation is necessary
- For high voltage injuries, the literature suggests observing the patient for 12 hours (with 6-8 hours of cardiac monitoring) even if they are asymptomatic
- A referral to a burn center is recommended for all high voltage injuries

Even in the patients who appear to have very benign injuries, the discharge instructions are very important as there are *delayed complications* from electrical injuries. Counsel regarding delayed symptoms including psychological / neurological symptoms (difficulty with concentration, sequencing events, and memory issues) and limb ischemia. For electrical cord bite injuries educate the parents that if the

child has delayed labial bleeding, use thumb and index finger to grip lip on both sides with gauze or towel and compress the labial artery, and to return to the ED immediately.

Key Take Home Points for Electrical Injuries

- Think trauma and tox first. Don't get distracted by the burns
- Perform serial examinations of limbs to assess for compartment syndrome and assume rhabdomyolysis if tea colored urine
- Cardiac complications of electrical injuries are rare with VF occurring immediately after high voltage AC exposure; while ECG is recommended for all patients, only patients with risk factors and/or clinical presentation consistent with cardiac ischemia require troponins
- Cardiac monitoring is only required for low voltage injured patients with chest pain or syncope and all high voltage injured patients
- Electrical injured patients generally require more fluid than suggested by The Modified Brooke/Parkland Formula
- Fluid formulas are starting points only, titrate carefully, assessing urine output and signs of end organ perfusion to avoid over and under resuscitation
- Consider alkalinizing the urine and forced diuresis *after* adequate fluid resuscitation for patients with tea colored urine and/or a CK in the thousands
- Asymptomatic low voltage (<600V) injured patients only require an ECG with no further workup or observation if the ECG is normal
- Refer all high voltage (>600V) injured patients to a burn center
- For patients going home with electrical injuries, counsel regarding delayed symptoms including psychological, neurological, limb ischemia and for kids who bite on an electrical cable, delayed bleeding

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