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Part 10.9: Electric Shock and Lightning Strikes

Electric shock and lightning strike injuries result from the direct effects of current on the heart and brain and on cell membranes and vascular smooth muscle. Additional injuries result from the conversion of electric energy into heat energy as current passes through body tissues.

Background

Electric Shock

Factors that determine the site and severity of electric trauma are the magnitude of energy delivered, voltage, resistance to current flow, type of current, duration of contact with the current source, and current pathway.

High-tension current generally causes the most serious injuries, although fatal electrocutions may occur with household current (eg, 110 V in the United States and Canada and 220 V in Europe, Australia, and Asia).¹ Contact with alternating current at 60 cycles per second (the frequency used in most US household and commercial sources of electricity) may cause tetanic skeletal muscle contractions, preventing self-release from the source of the electricity and thereby leading to prolonged exposure. The repetitive frequency of alternating current also increases the likelihood of current flow through the heart during the relative refractory period (the “vulnerable period”) of the cardiac cycle. This exposure can precipitate ventricular fibrillation (VF), which is analogous to the R-on-T phenomenon.²

Lightning Strike

The mortality rate from lightning injuries is 30%, and up to 70% of survivors sustain significant morbidity.³⁻⁵ The presentation of lightning strike injuries varies widely, even among groups of people struck at the same time.⁶ In some victims symptoms are mild and require little medical attention, whereas fatal injuries occur in others.^{7,8}

The primary cause of death in victims of lightning strike is cardiac arrest, which may be associated with primary VF or asystole.⁷⁻¹⁰ Lightning acts as an instantaneous, massive direct current shock, simultaneously depolarizing the entire myocardium.^{8,11} In many cases intrinsic cardiac automaticity may spontaneously restore organized cardiac activity and a perfusing rhythm. But concomitant respiratory arrest due to thoracic muscle spasm and suppression of the respiratory center may continue after return of spontaneous circulation. Unless ventilation is supported, a secondary hypoxic (asphyxial) cardiac arrest will develop.¹²

Lightning can also have widespread effects on the cardiovascular system, producing extensive catecholamine release or autonomic stimulation. The victim may develop hypertension, tachycardia, nonspecific electrocardiographic changes (including prolongation of the QT interval and transient T-wave inversion), and myocardial necrosis with release of creatine kinase-MB fraction.

Lightning can produce a wide spectrum of peripheral and central neurologic injuries. The current can produce brain hemorrhages, edema, and small-vessel and neuronal injury. Hypoxic encephalopathy can result from cardiac arrest.

Victims are most likely to die of lightning injury if they experience immediate respiratory or cardiac arrest and no treatment is provided. Patients who do not suffer respiratory or cardiac arrest and those who respond to immediate treatment have an excellent chance of recovery. Therefore, when multiple victims are struck simultaneously by lightning, rescuers should give the highest priority to patients in respiratory or cardiac arrest.

Victims with respiratory arrest may require only ventilation and oxygenation to avoid secondary hypoxic cardiac arrest. For victims in cardiac arrest, treatment should be early, aggressive, and persistent. Resuscitative attempts may have higher success rates in lightning victims than in patients with cardiac arrest from other causes, and efforts may be effective even when the interval before the resuscitative attempt is prolonged.¹²

Modifications to Basic Life Support

The rescuer must first be certain that rescue efforts will not put him or her in danger of electric shock. When the scene is safe (the danger of shock has been removed), determine the victim’s cardiorespiratory status. Immediately after electrocution, respiration or circulation or both may fail. Vigorous resuscitative measures are indicated even for those who appear dead on initial evaluation. Because many victims are young, without preexisting cardiopulmonary disease, they have a good chance for survival if immediate support of cardiopulmonary function is provided.

If spontaneous respiration or circulation is absent, initiate immediate BLS, including activation of the emergency medical services (EMS) system, provision of prompt CPR, and use of a defibrillator when available. Immediate provision of ventilation and compressions (if needed) is essential. In addition, use the automated external defibrillator (AED) to identify and treat ventricular tachycardia or VF.

Maintain spinal stabilization during extrication and treatment if there is a likelihood of head or neck trauma.^{13,14} Both lightning and electrical trauma often cause multiple trauma, including injury to the spine¹⁴ and muscular strains, internal injuries from being thrown, and fractures caused by the tetanic response of skeletal muscles.¹⁵ Remove smoldering clothing, shoes, and belts to prevent further thermal damage.

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Modifications to Advanced Cardiovascular Life Support

Rescuers must be sure that the scene is safe. Patients who are unresponsive after an electrical injury may be in either respiratory or cardiac arrest. Thus, airway control, prompt CPR, and attempts at defibrillation (if indicated) are critically important. Treat VF, asystole, and other serious arrhythmias with the ACLS techniques outlined in these guidelines. Quickly start CPR and attempt defibrillation at the scene if needed. Then take steps to manage the airway, including early placement of an advanced airway (eg, endotracheal intubation). Establishing an airway may be difficult for patients with electric burns of the face, mouth, or anterior neck. Extensive soft-tissue swelling may develop rapidly, complicating airway control measures. Thus, early intubation should be performed for patients with evidence of extensive burns even if the patient has begun to breathe spontaneously.

For victims with hypovolemic shock or significant tissue destruction, rapid intravenous fluid administration is indicated to counteract shock and correct ongoing fluid losses due to third spacing. Fluid administration should be adequate to maintain diuresis to facilitate excretion of myoglobin, potassium, and other byproducts of tissue destruction (this is particularly true for patients with electrical injury).¹¹ As significant as the external injuries may appear after electrothermal shock, the underlying tissue damage is far more extensive. Early consultation with or transfer to a physician and a facility (eg, burn center) familiar with treatment of these injuries is recommended. Survivors may have permanent neurologic and cardiac sequelae.

Summary

Although morbidity and mortality from electric shock and lightning strike is high, patients who respond to immediate

treatment have an excellent chance of recovery. Once the scene is safe, rescuers should provide prompt CPR and early defibrillation even when the victim appears dead. Electric shock and lightning injuries can cause ventricular fibrillation or asystole, musculoskeletal injuries, organ damage, and internal and external burns. Early insertion of an advanced airway and volume administration are often required, and early consultation with experts in these injuries is recommended.

References

1. Budnick LD. Bath-tub-related electrocutions in the United States, 1979 to 1982. *JAMA*. 1984;252:918–920.
2. Geddes LA, Bourland JD, Ford G. The mechanism underlying sudden death from electric shock. *Med Instrum*. 1986;20:303–315.
3. Cooper MA. Lightning injuries: prognostic signs for death. *Ann Emerg Med*. 1980;9:134–138.
4. Kleinschmidt-DeMasters BK. Neuropathology of lightning strike injuries. *Semin Neurol*. 1995;15:323–328.
5. Stewart CE. When lightning strikes. *Emerg Med Serv*. 2000;29:57–67; quiz 103.
6. Fahmy FS, Brinsden MD, Smith J, Frame JD. Lightning: the multisystem group injuries. *J Trauma*. 1999;46:937–940.
7. Patten BM. Lightning and electrical injuries. *Neurol Clin*. 1992;10:1047–1058.
8. Browne BJ, Gaasch WR. Electrical injuries and lightning. *Emerg Med Clin North Am*. 1992;10:211–229.
9. Kleiner JP, Wilkin JH. Cardiac effects of lightning strike. *JAMA*. 1978;240:2757–2759.
10. Lichtenberg R, Dries D, Ward K, Marshall W, Scanlon P. Cardiovascular effects of lightning strikes. *J Am Coll Cardiol*. 1993;21:531–536.
11. Cooper MA. Emergent care of lightning and electrical injuries. *Semin Neurol*. 1995;15:268–278.
12. Milzman DP, Moskowitz L, Hardel M. Lightning strikes at a mass gathering. *South Med J*. 1999;92:708–710.
13. Duclos PJ, Sanderson LM. An epidemiological description of lightning-related deaths in the United States. *Int J Epidemiol*. 1990;19:673–679.
14. Epperly TD, Stewart JR. The physical effects of lightning injury. *J Fam Pract*. 1989;29:267–272.
15. Whitcomb D, Martinez JA, Daberkow D. Lightning injuries. *South Med J*. 2002;95:1331–1334.