Perioperative Management of a Case for Elective Surgery After High-voltage Electrical Injury

Rajender Kumar, Ritika Gandhi, Meenaxi Bose

Department of Anesthesia and Intensive Care, Dr. Baba Saheb Ambedkar Medical College and Hospital, New Delhi, India

Abstract

The spectrum of electrical injury ranges from minor skin lesions to severe multiorgan damage, at times associated with occult or delayed complications and even death. High-voltage electrical injury is characterized by skin lesions that are confined in comparison to the profound destruction of deeper tissues involved and masked by the good general condition of the patient. In light of the limited existing literature, we share our experience of managing a patient who survived a high-voltage electrical injury (6000 V) 5 days prior to scheduled laparoscopic interval appendicectomy, and discuss the factors that influence the degree of injury, probable complications, and our perioperative management.

Key words: Electrocution, high-voltage electrical injury, perioperative management

Introduction

High-voltage (>1000 V) electrical injury is infrequent but can lead to potentially devastating multisystem damage and even death. High-voltage electrical injuries are usually reported as occupational accident among adults.[1,2] Electrical injury was responsible for 9059 deaths in 2010 in India, representing 2.5% of all accidental deaths. During same period, the number of nonfatal electrical injuries reported from India was 439, probably indicating that nonfatal cases are underreported.[3] Anesthetic considerations of electric injuries are usually limited to patients requiring fasciotomy, escharotomy, or reconstructive surgeries after burns caused by low-voltage currents. Because of high case fatality, patients of high-voltage injuries are rarely encountered by anesthesiologists. We share our experience with a patient who survived a high-voltage electrical injury (6000 V) 5 days prior to emergency appendicectomy, and discuss the factors that influence the degree of injury, probable complications, and our perioperative management.

Case Report

A 40-year-old male patient was scheduled for elective interval appendicectomy 1 month after the acute appendicitis episode was managed conservatively. He was assessed as American Society of Anesthesiologists (ASA) 1 on preliminary preanesthetic checkup (PAC).

During review PAC conducted 1 day prior to surgery, the patient reported a history of a high-voltage (6000V, direct current) electric injury 5 days earlier, while working as a factory electrician. The reported point of entry was the right middle finger and the shock lasted for 30 s as one of his colleagues switched off the mains supply. During the episode, the patient also reported an “explosion”-like sensation in his right foot, with his socks getting burnt but protective footwear remaining intact. The patient remained conscious throughout the episode and was rushed to a nearby hospital. Related medical records revealed that his vitals were stable, physical examination and electrocardiogram (ECG) were normal immediately *post* injury, and that he was discharged after first-aid, symptomatic treatment with intravenous (i.v.) diclofenac, pantoprazole, and diazepam and 2 h of observation. The patient had been largely asymptomatic thereafter, except for generalized paraesthesia that lasted for 2 days *post* injury. The probable factors that averted a fatal outcome or extensive tissue damage in the patient include short duration of exposure,

Address for correspondence: Dr. Rajender Kumar, A-22, Sai Apartment, Plot No - 47, Sector-13, Rohini, New Delhi - 110 085, India. E-mail: drrbarua@gmail.com

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presence of protective shoes, direct current exposure, and a current path that did not involve the heart.

Examination findings during review PAC were unremarkable, including regular heart rate, palpable peripheral pulses, capillary filling time of <3 s, and breath-holding time of 26 s. The patient had burn marks on his right middle finger tip (entry wound) [Figure 1] and right sole (exit wound) [Figure 2]. While all the fresh routine hematological and biochemical investigations and ECG were found to be normal, additional investigations were ordered to screen for possible tissue damage due to electrical injury. Urinalysis for screening skeletal muscle for skeletal muscle or renal damage, serum cardiac enzymes for myocardial injury, coagulation profile for vascular damage, and liver function tests for hepatocellular damage were all found to be normal. However, considering the possibility of underlying neuromuscular injury that could not be screened for, the patient was taken up for the surgery after obtaining high-risk consent.

Perioperative anesthesia management of the patient was as per standard protocol and included nil by mouth for 6 h prior to surgery, premedication with alprazolam 0.5 mg, noninvasive monitoring of blood pressure, ECG, oxygen saturation and capnometry, securing i.v. access with 18-G cannula, i.v. administration of glycopyrrolate 0.2 mg and midazolam 1 mg, induction with injection fentanyl 2 μg/kg and propofol 2 mg/kg, muscle paralysis with vecuronium 0.1 mg/kg, securing airway with Proseal LMA (Teleflex) size 4 and maintenance of anesthesia with 50% nitrous oxide and 1% isoflurane in oxygen. Additional measures taken were oral administration of pantoprazole 40 mg as part of premedication and perioperative ECG monitoring using additional electrodes for leads II and V.

After the surgical procedure that lasted for approximately 1 h, anesthesia was reversed with i.v. glycopyrrolate 0.4 mg and neostigmine 2.5 mg. Paracetamol 1 g was given as i.v. infusion and ondansetron 6 mg as bolus during the postoperative period. With the entire perioperative period being uneventful, the patient was discharged on the third postoperative day without any complication, with advice to follow-up.

Discussion

Electrical injury is arbitrarily categorized into burns caused by low-voltage sources (<1,000 volts) or high-voltage sources (>1,000 volts), with high-voltage burns being associated with substantially higher morbidity and mortality.[1,4] Factors influencing the severity of electrical injury include the type of current (alternating current exposure to the same voltage tends to be three times more dangerous than direct current), voltage, magnitude of energy delivered, resistance to current flow, pathway of current through the patient, and the area and duration of contact.[1,5,6]

Superficial entry and exit site wounds may reflect only the "tip of the iceberg" and extensive deep destruction of the tissues may exist between these sites in case of high-voltage electrical injuries.[1,2] Electric shock injuries are caused by the direct effects of current on cell membranes and vascular smooth muscle as well as thermal energy causing burns and coagulation necrosis. The higher the resistance of a tissue to the flow of current, the greater is the potential for transformation of electrical energy to thermal energy.[1,2,4]

Much of the damage caused by electrical shock presents immediately after the episode and may include cardiovascular manifestations (conduction defects, arrhythmias, transient ST segment elevation, and rarely myocardial infarction), neurological manifestations (various degrees of confusion, convulsion, transient memory loss), and mechanical injuries (head injury, cervical spine injury, fractures). Damage to other visceral organs (pancreas, liver, intestines, gall bladder, urinary bladder) are rare but have been reported. Lungs are very rarely involved in electrical injuries, perhaps because air is a poor conductor.[1,2,4]

From an anesthesiologist's perspective, it is critical to be aware of and screen for those complications of electrical injuries that are occult or delayed, during preanesthetic evaluation. As there are no guidelines for perioperative anesthetic management of patients with electrical injuries, such patients may be managed on lines similar to that of patients with crush injury, because

Figure 1: Entry wound

Figure 2: Exit wound

of the large amount of tissue damage often present under normal-appearing skin. Specific anesthetic considerations are mentioned below.

Preoperative

The anesthesiologist should review the history of the current injury, including amount and sites of burn, time elapsed since injury, and associated traumatic injuries. A history of recent weight loss may reflect the extent of dehydration due to electrical injury.[4]

As electrical injury can lead to vascular damage, pulses and capillary refill should be assessed and documented in all extremities. Electrical injury may damage vascular media, causing delayed hemorrhage, or vascular intima causing immediate or delayed thrombosis and vascular occlusion.[1] Possible late onset and delayed neurological complications of electrical injuries such as myelopathy and spinal muscular atrophy should also be looked for during physical examination.[7]

All high-voltage injury victims and low-voltage victims with cardiorespiratory complaints should have an ECG and cardiac isoenzyme determination. Although ECG changes and dysrhythmias are common with electrical injuries, anesthesia and surgical procedures performed after the first 48 h of care can be accomplished without cardiac complications. Cardiac enzyme levels should be interpreted with care in the setting of electrical injury, as the peak creatine kinase-MB level is not indicative of myocardial damage in electrical injury because of the large amount of skeletal muscle injury. Other cardiac enzymes (such as troponin) are not well studied in electrical injury but may prove useful in determining suspected myocardial injury. Other recommended investigations include coagulation profile, complete blood count; urinalysis; blood urea nitrogen; and serum levels of electrolytes, myoglobin, creatinine, and pancreatic and hepatic enzymes.[1,6]

Perioperative

It is suggested that formulas for i.v. fluids based on percentage of burned body surface area be relied upon for patients with electrical injuries. This may lead to underestimating the required resuscitation fluid and the patient may progress to myoglobinuria and acute renal failure. Hemodynamic management should involve close monitoring of vital parameters, ensuring 1–2 mL/kg/h urine output (to hasten the excretion of products of muscle breakdown) and use of diuretics and/or mannitol if the need arises.[1,4]

Additional monitoring to be considered in patients with electrical injury include 5-lead ECG, peak airway pressure, inspired oxygen tension monitoring, and a peripheral nerve stimulator.[1,4]

A narcotic-based, balanced anesthetic technique is recommended for stable intraoperative hemodynamics, smooth emergence, and easily titrable levels of postoperative analgesia. No specific anesthetic agent is contraindicated in such patients except succinylcholine, which can trigger a potentially fatal hyperkalemic response. Considering possible underlying damage to skeletal muscles in patients with electrical injuries, nondepolarizing neuromuscular blocking agents should be administered with caution and monitoring of the degree of blockade.[4]

Documentation of injuries is important not only for appropriate perianesthetic management of the patient but also from the medicolegal perspective. Many cases of electrical injuries eventually involve litigation for negligence, product liability, or worker compensation.[1]

Conclusion

In conclusion, there are no specific guidelines for perioperative management of patients of electrical injury, and the principles involve careful screening to avert possible underlying damage to various tissues/organs, and extensive monitoring.

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Conflicts of interest

There are no conflicts of interest.

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