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An unusual presentation of inhalation injury in a patient with high voltage electrical injury: A case report

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ABSTRACT

BACKGROUND: Electrical injuries comprise a minority of burn center admissions but are associated with significant morbidity and mortality. This is a case of a patient who suffered high-voltage electrical injury who survived despite developing several sequalae, who had an unusual presentation of inhalation injury complicated by the aspiration of metal screws.

CASE PRESENTATION: This is a 20-year-old male who suffered electrical contact injury, and 45.5% total body surface area (TBSA) burns from electrothermal discharge and subsequent ignition of clothing, whose hospital course was complicated by rhabdomyolysis, compartment syndrome, renal failure, and inhalation injury. After cardiac arrest with successful defibrillation and intubation in the field, he was found to have metallic foreign bodies in his airway. Metal screws were retrieved using rigid bronchoscopy and lower extremity escharotomy was performed for compartment syndrome. He was placed on renal replacement therapy for persistent acidosis and severe rhabdomyolysis. On post-burn day (PBD) 3 he developed severe hypoxia and bronchoscopy showed evidence of inhalation injury. This was treated with protocolized nebulizer treatments, prone-positioning, early tracheostomy, and frequent bronchoscopy. Over his hospital course he required lower extremity amputation and numerous excision and grafting procedures. Ultimately, he exhibited renal and respiratory recovery. He was discharged on PBD 75 to a rehabilitation hospital.

CONCLUSIONS: This case highlights that electrical injuries are associated with serious sequelae that can be overt or occult. Clinicians must maintain a high index of suspicion for comorbid conditions with electrically injured patients given variable presentations and the need for prompt, aggressive, and complex management.

1. Introduction

Electrical injury is the fourth most common cause of work-related death in the United States and primarily affects working-aged men. These injuries carry relatively high morbidity and mortality with devastating short and long-term physical and psychological sequalae [1,2]. Initial management of the electrically injured patient should be based on quick assessment and treatment guided by the Advanced Trauma Life Support® and Advanced Burn Life Support® algorithms. Cardiopulmonary arrest requires immediate attention and Cardiopulmonary resuscitation (CPR) in the field is more often successful in this subset, given a higher incidence of shockable rhythms [3]. Electrical injuries affect multiple organ systems and patients can develop serious and insidious sequelae, not always obvious at presentation [2–4]. In accordance with the SCARE criteria for surgical case reports [5], we present the case of a patient presenting to a regional burn center with electrical contact injury and 45.5% TBSA burns from electrothermal discharge with foreign body aspiration, which complicated the diagnosis of inhalation injury. With aggressive early management and specialized burn care, he was discharged home within three months despite multiple complications from his injuries.

2. Case report

An otherwise healthy 20-year-old male working at a construction site was carrying a metal gutter, which contacted a transformer

Abbreviations: TBSA, total body surface area; PBD, post-burn day; CPR, cardiopulmonary resuscitation; GCS, Glasgow Coma Scale; CT, computed tomography; RRT, renal replacement therapy; HV, high-voltage; VNOS, voltage not otherwise specified.

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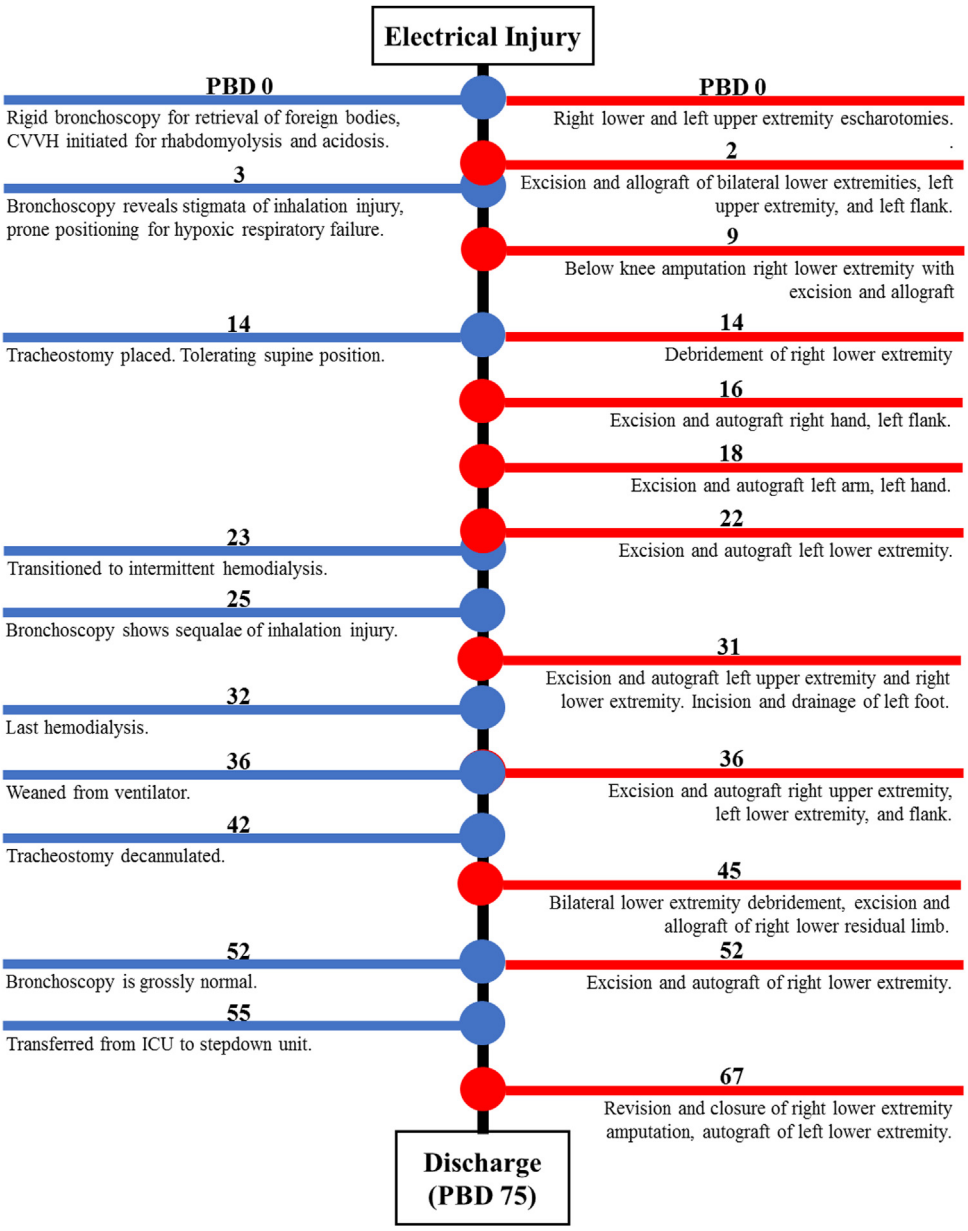

Fig. 1. Timeline of care from admission to discharge. (Abbreviations: PBD, post-burn day; CRRT, Continuous renal replacement therapy).

and overhead wires resulting in both electrical contact injury and flame burns from electrothermal discharge igniting his clothing. He developed pulseless ventricular dysrhythmia and received thirteen minutes of CPR by coworkers and first responders. He was defibrillated with return of spontaneous circulation en route to an outside hospital. He was intubated and transferred to this Burn Center. The care of this patient from admission to discharge is chronicled in Fig. 1*. On arrival, his primary survey was significant for an established airway with an endotracheal tube and adequate oxygenation on mechanical ventilation. He had a heart rate of 108, blood pressure of 153/94, and a GCS of 3T. Total burn area was calculated to be 45.5% TBSA of mixed deep partial- and full-thickness burns to his back, left flank, and bilateral upper and lower extremities. He sustained a full-thickness circumferential burn to the right lower extremity with palpable distal pulses.

Intravenous fluid resuscitation with lactated ringer's (LR) was guided by the consensus formula, which totaled 16.6 L during the first 24 h from burn injury (4 mL/kg/%TBSA). Fresh frozen plasma was used as a colloid adjunct. A Foley catheter placed on admission returned dark urine that was positive for myoglobin (Fig. 2). Laboratory results on arrival were as follows: WBC 28.6 K/μL; Hgb 17.8 g/dL; Hct 52.4%; Platelets 342 K/μL; Potassium 5.3 mmol/L; Calcium 5.9 mmol/L; Bicarbonate 11 mmol/L; Creatinine 0.84 mg/dL; pH 7.09; pCO_2 45 mmHg; pO_2 166 mmHg; Carboxyhemoglobin 0.0%; Base Deficit -16.1 mmol/L. Creatinine Kinase peaked within 24 h at 33,760 units/L.

Whole-body X-ray was significant for metallic foreign bodies in the airway (Fig. 3). Computed tomography (CT) localized the objects to the right bronchus intermedius (Fig. 4A–B). Retrieval attempted with flexible bronchoscopy in the trauma bay was unsuccessful. Persistent acidosis despite resuscitation and diminishing pulses raised suspicion for compartment syndrome of the right lower extremity, prompting emergent operative intervention. A four-compartment fasciotomy revealed dusky bulging muscles responsive to electrocautery stimulation. Subsequently, rigid bronchoscopy was performed with successful retrieval of two metallic screws (Fig. 5). The airway was noted to be erythematous, attributed to repeated instrumentation.

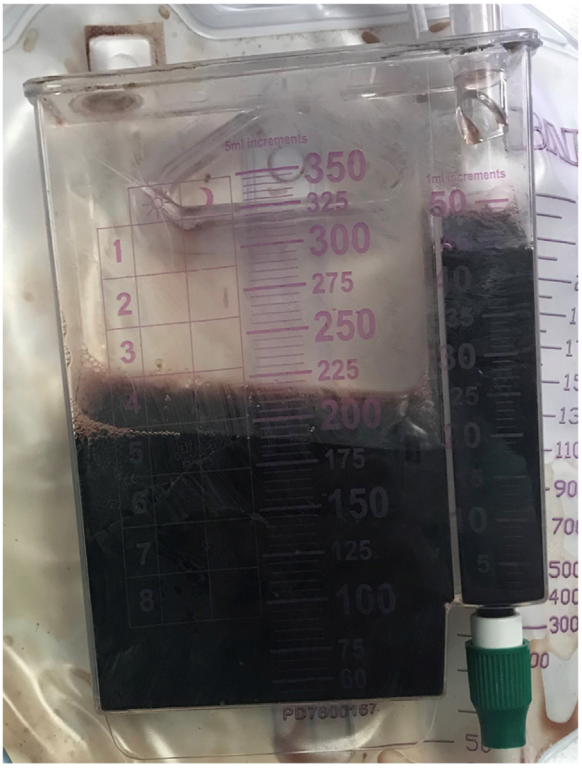

Fig. 2. Appearance of myoglobin positive urine on PBD 0-2.

Continuous RRT was initiated for persistent acidosis and electrolyte derangements secondary to rhabdomyolysis. Burn wound excision began on post-burn day (PBD) 2 and was complete by PBD67. On PBD3 he developed acute hypoxic respiratory failure. Flexible bronchoscopy revealed edematous and erythematous airways, copious secretions, and mucosal sloughing. This inhalation injury was caused by the aspiration of super-heated air and metal screws held in the patient's mouth at the moment of electrothermal discharge, and was not clear during initial management of the foreign bodies. He was diagnosed with grade III inhalation injury, initiated on protocolized nebulized pharmacotherapy (acetylcysteine, albuterol, bicarbonate, heparin) and placed in the prone position. Tracheotomy was performed (PBD14) given prolonged ventilator requirement. He required right lower extremity below knee amputation secondary to non-salvageable myonecrosis. He exhibited renal recovery and his tracheotomy was decannulated prior to discharge. He recovered well and was cleared to return to work just before the one year anniversary of his injury.

3. Discussion

High voltage (HV; >1,000 V) and voltage not otherwise specified (VNOS) electrical injuries are associated with significantly higher rates of morbidity and mortality when compared to low voltage injuries [1]. Pre-hospital cardiac arrest, full thickness burns, and extensive tissue damage can lead to compartment syndrome, rhabdomyolysis, and AKI [6]. HV and VNOS injuries are associated with renal dysfunction in 13.9% and 4.2% of cases respectively [1]. Acute kidney injury requiring RRT is associated with 50% mortality in patients with severe burns [7]. Chung et al. appreciated 30% absolute reduction in mortality in burn patients placed on early RRT for acute indications compared to historical controls that were not [7,8]. Furthermore, 90% of survivors experienced renal recovery [7]. This suggests potential benefits of early RRT in our patient who developed acute renal failure.

Electrothermal discharge produces immense heat in the form of plasma and ozone [4]. Transmission of thermal energy typically injures the upper airway, while irritants injure the lower airways

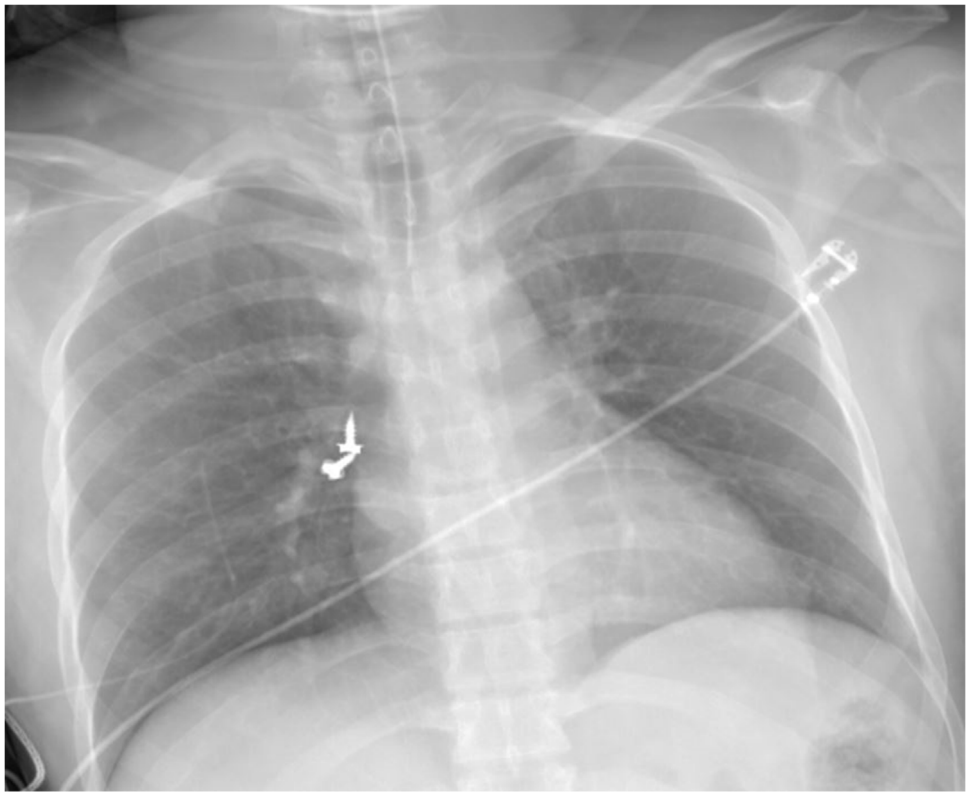

Fig. 3. Admission X-ray significant for metallic foreign bodies in the airway.

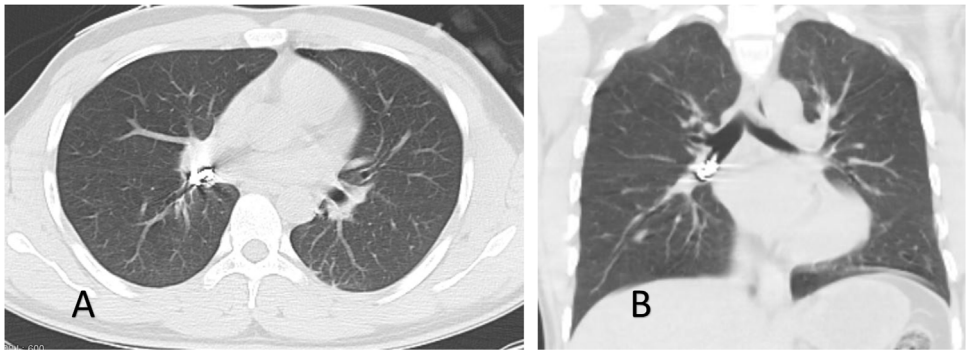

Fig. 4. (A,B): Computed tomography (CT) images localizing foreign bodies to the right bronchus intermedius.

Fig. 5. Screws removed from airway.

and lung parenchyma. Inhalation injury compounds morbidity and increases mortality in burn patients [9]. Physical examination findings such as facial burns, carbonaceous sputum, and singed nasal hairs are unreliable for diagnosis of inhalation injury and are often discordant with findings on bronchoscopy [10]. In our patient, the aspiration of metal screws at the time of injury was both contributory and confounding to the diagnosis of inhalation injury. Absence of carboxyhemoglobinemia or soot in the airway is consistent with inhalation injury secondary to electrothermal arc compounded by foreign body aspiration. Thermal injury and resultant edema to the upper airway was masked by prompt intubation. Lower airway injury characterized by mucosal sloughing, bronchorrhea, and airway casts has a delayed onset that correlates with severity [11]. Our patient's inhalation injury manifested on PBD3. He was successfully treated with lung protective ventilation, prone positioning, regular nebulizer treatments, early tracheotomy, and frequent therapeutic bronchoscopy.

Electrical injuries represent a minority of burn center admissions (0.4–10%) and are associated with significant morbidity and mortality [1,2]. This case highlights that electrical injuries are associated with serious sequelae that can be overt or occult. Clinicians must maintain a high index of suspicion with electrically injured patients given variable presentations and the need for prompt, aggressive, and complex management.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest.

Funding

The authors have no financial disclosures.

Ethical approval

MedStar Health Institutional Review Board has determined that a case report of less than three (3) patients does not meet the DHHS definition of research (45 CFR 46.102(d)(pre-2018)/45 CFR 46.102(l)(1/19/2017)) or the FDA definition of clinical investigation (21 CFR 46.102(c)) and therefore are not subject to IRB review requirements and do not require IRB approval.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contribution

JK collected patient data and consent, drafted the article, and participated in patient care. TT and LJ were directly involved with patient care, and critically revised and contributed important intellectual content to the article. JS was directly involved with patient care, conceptualized the case for potential publication, and was responsible for final revision of the version to be submitted. All authors read and approved the final manuscript.

Registration of research studies

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Guarantor

Jeffrey W. Shupp, MD.

Provenance and peer review

Not comissioned, externally peer-reviewed.

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