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CASE REPORT

An unusual electrical burn caused by alkaline batteries

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Electrical burns caused by low-voltage batteries are rarely reported. We recently encountered a male patient who suffered from a superficial second-degree burn over his left elbow and back. The total body surface area of the burn was estimated to be 6%. After interviewing the patient, the cause was suspected to be related to the explosion of a music player on the left-side of his waist, carried on his belt while he was painting a bathroom wall. Elevated creatine kinase levels and hematuria indicated rhabdomyolysis and suggested an electrical burn. Initial treatment was done in the burn intensive care unit with fluid challenge and wound care. The creatine kinase level decreased gradually and the hematuria was gone after 4 days in the intensive care unit. He was then transferred to the general ward for further wound management and discharged from our burn center after a total of 11 days without surgical intervention.

Introduction

Electrical burns can cause different degrees and extents of damage, depending on factors such as voltage, current flow (amperage), type of current (alternating or direct), path of current flow, duration of contact, skin resistance, and individual susceptibility.[1–4] Clinically, electrical injuries could be divided into high-voltage (over 1000 V) and low-voltage (less than 1000 V). High-voltage electrical injuries are characterized by varying degrees of thermal cutaneous damage combined with extensive destruction of the deep layers, which manifest as fat necrosis, rhabdomyolysis, vascular thrombosis, or nerve injury. Low-voltage electrical injuries, on the other hand, usually result in cutaneous burn with or without soft tissue injury.[5] Skin resistance is affected by certain factors such as humidity.[6] It happens more apparently when the skin is soaked with water that contains free ions, such as sweat. In such special

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circumstances, one can suffer from electrical injury at low voltages, resulting in thermoelectrical burn.

In this report, an unusual electrical burn, caused by alkaline batteries, is presented. Possible pathophysiology and mechanisms are also discussed. We believe that this is one of a few cases of electrical injury caused by extremely-low voltage electricity.

Case report

This case report is of a 63-year-old male patient who had no history of major systemic disease. He was painting a bathroom wall on the afternoon of March 18, 2010, while listening to music via earphones from a battery-powered music player. The player was carried on his belt at the left hip. A short circuit induced a small explosion and a great noise was heard over the earphone. The patient lost consciousness immediately and regained it gradually within a few minutes. He complained of tinnitus with ear ache and therefore visited an Ear Nose Throat (ENT) doctor's clinic in the evening. There were no specific findings for the ear; only a mildly injected tympanic membrane was noted. However, a large area of epidermal loss with surrounding burned gangrenous skin was noted over the back and left elbow. He was transferred to our emergency department right away with suspected acute burn injury.

Upon arrival, the patient's consciousness was clear with no neurological deficit. Physical examination showed no other wounds or tenderness except for the superficial second-degree burns over the patient's back and left elbow; the estimated total body surface area (TBSA) was about 6% (Fig. 1). Due to the initial loss of consciousness, cranial computed tomography was done, and no acute hemorrhaging was noted. However, his serial examinations showed mildly hemoconcentrated hemoglobin (Hb) to be 160 g/L. He also had decreased renal functions [blood urine nitrogen: 19.6 mmol/L and creatinine (CRE): 99.1 μmol/L with previous CRE level 53.4 μmol/L in October, 2009, observed during a regular health examination] and markedly elevated creatine kinase (CK) [11485 U/L] and creatine kinase-muscle and brain (CK-MB) [71.5 U/L]. Urine analysis showed gross hematuria with occult blood 3+. Electrocardiography showed normal sinus rhythm with no evidence of cardiac injury or arrhythmia. In summary, the patient was strongly suspected to have electrical burn with rhabdomyolysis and acute renal injury, probably due to dehydration or myoglobinuria. Therefore, he was admitted to our burn intensive care unit for intravenous hydration with lactated Ringer's solution and received sodium bicarbonate for urine alkalization. Urine output reached 85—105 mL/hour with these treatments and gradual improvement was noted in the follow-up blood and urine examination (Table 1), which suggested a reduced risk of acute renal failure. He was transferred to the general ward after 4 days of intensive treatment. His wound was initially managed with silver sulfadiazine (Flamazine®) coverage, which was shifted to op-site occlusive dressing over the back and intra-site® gel [containing 2.3% modified carboxymethylcellulose polymer together with propylene glycol (20%)] over the left elbow for removal of the eschar after transferring to the general ward. His wounds healed gradually and the eschar was successfully removed (Fig. 2). When stable, he was discharged from our burn center after 11 days of hospitalization, without any surgical intervention.

Discussion

Reviewing the patient's whole clinical history and laboratory data, the known fact is that there was a burn injury caused by the explosion as a result of a short circuit in a music player, an elevation of the CK and CRE levels, and

Figure 1 The patient suffered from superficial second-degree electrical burns over the back and left elbow region. Total body surface area was about 6%. These pictures were taken upon the patient's arrival at the emergency department.

Table 1 Serial laboratory data during the intensive care unit stay. The CK level decreased with adequate hydration.

	Blood sampling										Urine analysis	
	WBC	Hb	Hct	BUN	CRE	Na	K	CK	CK-MB	Tn-I	OB	RBC
	$10^9/L$	g/L		mmole/L	μmol/L	mmole/L	mmole/L	U/L	U/L	μg/L		/HPF
Day 1	13.3	160	0.460	9.78	99.14	136	3.6	11485	71.5	<0.012	3+	45-55
Day 2	10.1	136	0.406	8.57	76.26	136	3.0	7745	36.0		+/-	2-5
								4613	25.7			
Day 3						139	3.5	3170	18.8			
Day 4								1024	11.0			

BUN = blood urea nitrogen; CK = creatine kinase; CK-MB = creatine kinase muscle and brain; CRE = creatinine; Hb = hemoglobin; Hct = hematocrit; OB = occult blood; RBC = red blood cell; Tn-I = troponin I; WBC = white blood cell.

hematuria. According to the patterns and the findings of the burn wound, it was more likely to be an electrical burn with the inlet over the elbow and the outlet over the whole back. And the only electrical substance was the two 1.5-volt alkaline batteries. As for the elevated CRE level, the possible reasons include muscle damage-related myoglobinuria and dehydration. It is really difficult to differentiate the actual cause of the patient's elevation of CRE level, and it might also be the combination of both. But in handling both circumstances, adequate hydration is the standard treatment. However, we noticed the patient did not appear to have tachycardia (heart rate: 56 beats/min upon arrival to the emergency department), and therefore the relationship between decreased renal function and fluid loss seemed less likely. In this situation, rhabdomyolysis-related acute renal injury is more favorable. As for the hematuria, the patient complained of no flank pain nor was any contusion evidence noticed during physical examination at arrival, and therefore blunt injury-related hematuria is less likely. Rhabdomyolysis-related renal tubular injury-induced hematuria could reasonably explain the fact. For the elevated CK level, the reason was muscle injury with multiple possible causes. But the patient did not complain of chest pain or any muscle pain, so we could exclude the possibility of myocardial infarction or muscle injury caused by contusion or after heavy compression. Besides, we did not notice any pressure sore or compressive skin change either, so contusive or compressive muscle injury could be excluded. Therefore, the most reasonable cause of CK elevation is electrical injury-related muscle damage. In conclusion, this patient suffered from burn injury combined with superficial cutaneous injury (burn wounds) and deep conduction injury (muscle injury with clinical appearance of elevated CK and rhabdomyolysis-related acute renal damage), which indicated an electrical burn injury.

Electrical burns can be divided into high voltage (>1000 volts) and low-voltage (<1000 volts). However, extremely-low-voltage electrical injury (defined as <10 volts) is largely anecdotal. Moulton et al. reported a burn injury caused by long duration contact with a watch battery.[6] Numerous corrosive esophageal injuries have been noted in young children who swallowed watch batteries. However, these injuries are actually more chemical as they relate to substances leaking from these batteries. One of the few reports concerning true electrical burn caused by low-voltage batteries was written by Nisanci et al., who described a circumferential electrical burn caused by a metallic watchstrap that incidentally touched a car battery.[5] In our case, although there was a short circuit in a music player powered by two 1.5-volt alkaline batteries, there were no metallic objects to facilitate conduction that would cause an electrical burn. Therefore, the actual cause of this electrical burn remains unclear.

According to the patient's history, we noticed that at the time of the explosion he was painting a wall. He could have been perspiring heavily, which would make his clothes a decent conductor. The major components of sweat are

Figure 2 These pictures were taken on the day before discharge from our burn center. There was new epithelium growing over the back and the eschar over the left elbow was successfully removed using intra-site?gel. These wounds were then covered with op-site occlusive dressing and prepared for home care.

water (98–99%) and NaCl (300 mg/100 mL). Other minor components are urea, ammonia, KCl, fatty acids, lactates, amino acids, glucose, histamine, pyruvate, proteins, and proteases. Studies concerning skin resistance and sweat gland activity have shown that as sweat glands activate, skin resistance is lowered in two ways. First, the skin serves as an additional, parallel resistor and second, the moisture affects the resistances of nonglandular tissues, therefore making it easier to conduct electricity.[7–9]

In summary, from the patient's history, burn wound pattern, and laboratory data (elevated CK and CRE levels and hematuria), the cause of the burn was most likely electrical. The only electrical source was the two 1.5-volt alkaline batteries. The inlet for this injury was possibly over the left elbow, as it was nearer to the explosion, while the back was the outlet. This kind of accident would not cause such severe burns under normal circumstances, but this patient was soaked with sweat over the trunk and upper extremities, making electrical conduction much easier.

Conclusion

This case report illustrates that extremely low voltage electrical burns can still occur under special circumstances. As in our case, rhabdomyolysis with myoglobinuria still happened, even though the voltage was as low as 3 volts. We should not neglect such low-voltage electrical burn injury as it can still cause severe damage to a patient.

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