

Evaluation of children presenting to the emergency room after electrical injury

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Background/aim: To evaluate children who presented to the Pediatric Emergency Department with electrical injury and to discuss the follow-up of these cases and potential precautions that can be taken.

Materials and methods: A total of 36 patients presented to the Pediatric Emergency Department with electrical injury between May 2010 and May 2013, and these cases were investigated retrospectively. The patients' age and sex, location and form of exposure to electric current, seasonal distribution, length of hospital stay, musculoskeletal and cardiovascular system complications, renal damage, and treatments were recorded.

Results: The majority of the patients were exposed to low-voltage electrical current at home. When the patients were evaluated based on the type of electric current, alanine transaminase, aspartate transaminase, creatine kinase, and creatine kinase-myocardial isoenzyme levels were found to be significantly higher among patients who were exposed to high-voltage electric current. None of the patients died, and the mean length of hospital stay was 2.50 ± 1.06 days.

Conclusion: Electrical injuries can present with a wide variety of problems, ranging from a simple injury to life-threatening severe multiple organ injury. Even simple precautions can prevent possible morbidity and mortality. We think that the public level of knowledge and awareness should be increased.

Key words: Electrical injury, child, pediatric emergency room, precautions

1. Introduction

Patients presenting with electrical injuries (EIs) may have a wide variety of problems, including burns, orthopedic problems, and cardiac problems, and no age group is exempt from the risk of this type of trauma. In the United States, the first known death associated with EIs occurred in 1881; currently, 1000 deaths and approximately 3000 burn cases caused by EIs are reported each year. Children are involved in 20% of these EIs, and occupational accidents account for 50% of these injuries (1).

Electrical injury can be classified according to the voltage as low-voltage (<1000 V), high-voltage (>1000 V), or lightning strike, or as alternating or direct current. In general, exposure to high voltage is associated with higher mortality; however, the severity of the EI varies depending on certain factors such as voltage, type of current, duration, pathway that the current passes through, and body resistance (2-4).

Exposure to high-voltage electrical current in particular can result in death due to cardiac arrhythmias and respiratory muscle paralysis; it may also result in long-term sequelae and morbidities caused by severe burns and multiple system involvement (5). It is therefore crucial that patients be closely monitored throughout their clinical course to recognize and prevent possible complications in a timely manner. Our aim in the present study was to discuss the follow-up of patients who sustained EI and the precautions that can be taken.

2. Materials and methods

We retrospectively reviewed the medical records of the patients who presented to the Pediatrics Emergency Department in our hospital between May 2010 and May 2013 after sustaining an EI. The patients' data were investigated, including age, sex, location and form of exposure to electrical current, seasonal distribution, length

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of hospital stay, musculoskeletal abnormalities monitored during clinical follow-up, and data suggesting renal or cardiac impairment. All of the patients were hospitalized and underwent cardiac monitoring for 24 h and urine output monitoring. Findings of electrocardiography (ECG), serum alanine transaminase (ALT), serum aspartate transaminase (AST), serum creatine kinase (CK), and serum creatine kinase-myocardial isoenzyme (CK-MB) values were recorded. All patients underwent fluid resuscitation, monitoring, burn and wound dressing, and tetanus prophylaxis as indicated.

The data were entered into SPSS 13.0. Demographic data were summarized using descriptive statistics. The correlation between the electrical current types and the length of hospital stay and other parameters were analyzed using Student's t-test. The level of statistical significance was set at $P < 0.05$.

3. Results

Of the 36 patients who were admitted to the Pediatric Emergency Department over a period of 3 years between May 2010 and May 2013, 30 (83.3%) were boys and 6 (16.7%) were girls for a female-to-male ratio of 1:5. The patients most commonly presented in June. The mean age of the patients was 6.6 ± 4.71 (mean \pm standard deviation) years. The youngest was a 9-month-old, and the oldest was a 15-year-old. Of the 36 patients, 22 (61.1%) were of preschool age (0–5 years), 10 (27.8%) were school children (6–12 years), and 4 (11.1%) were adolescents (13–17 years).

Electrical shock occurred at home in 32 cases (91.6%) and in an out-of-home setting in 4 cases (8.4%). All in-house accidents involved exposure to low-voltage electrical current: inserting a conductive object into a power outlet in 9 cases, contact with live electrical cords in 20 cases, biting through an electrical cord in 1 case, and electrical leakage from a heater in 1 case and from a warming pad in 1 case.

All out-of-home electric shocks were caused by contact with downed power lines and involved exposure to high-voltage electrical current. The mean age of these patients was 12.25 ± 1.71 years and all were male.

The entry and exit points were as follows: hand to hand in 30.6%; no entry or exit lesion in 22.2%; hand to foot in 13.8%; and remarkable entry point but no exit lesion in 13.4%. None of the patients suffered from extremity fractures or loss of consciousness.

As shown in Table 1, based on comparison between low- and high-voltage electrical current, patients who sustained high-voltage electrical shock had significantly higher levels of AST, ALT, CK, and CK-MB and longer lengths of hospital stay compared to the patients who were exposed to low-voltage current.

The evaluation of the ECG recordings revealed that 1 patient had isolated sinus tachycardia, 1 patient had sinus tachycardia and right bundle branch block, 2 patients had nonspecific ST changes, and no patients had life-threatening arrhythmia. As shown in Table 2, among the patients who sustained low-voltage electrical current injuries, only 1 had sinus tachycardia, while the other 3 exhibiting ECG changes had sustained high-voltage electrical current injuries.

No patient required surgical management and only burn dressings were applied. None of the patients developed renal failure and none of the patients died. The mean length of hospital stay was 2.50 ± 1.06 days and ranged from 1 to 6 days. Those who sustained high-voltage electric shock had longer lengths of hospital stay.

4. Discussion

Electricity has become an indispensable part of our lives, and no age group is exempt from the risk of EI. EIs occur by the passage of electrical current through living tissues and they affect multiple organ systems. Tissue damage occurs as a result of thermal effect or the direct effects of the current. The severity of the electrical injury varies depending on the current magnitude, body resistance, the path by which the current passes through the body, and the duration of contact with the current source. Electrical injuries are classified as low-voltage (<1000 V), high-voltage (>1000 V), lightning strike, or arch burns (6–8).

Small children often sustain low-voltage electric shock by biting electrical cords, by contact with live electrical cords, or by inserting conductive objects into power

Table 1. Comparison of the patients according to electrical current types.

Findings (mean \pm SD)	Low voltage (n = 32)	High voltage (n = 4)	P-value
Aspartate transaminase, U/L	27.4 \pm 10.1	157 \pm 202	<0.001
Alanine transaminase, U/L	24.1 \pm 11.1	98.5 \pm 83.4	<0.001
Creatine kinase, U/L	118 \pm 43	657 \pm 809	<0.005
Creatine kinase-MB, U/L	4.81 \pm 4.44	134 \pm 171	<0.005
Length of stay, days	2.22 \pm 0.55	4.75 \pm 1.50	<0.005

Table 2. Electrocardiography findings of the patients according to electrical current types.

Findings of electrocardiography	Low voltage (n = 32)	High voltage (n = 4)
Sinus rhythm	31	-
Sinus tachycardia	1	1
Sinus bradycardia	-	-
Right bundle branch block	-	1
ST-T wave abnormalities	-	2

outlets. Sex distribution is equal in this age group. Older children and adolescents sustain out-of-home electric shock by contact with high-voltage transmission lines or industrial electrical currents at the work place, and males predominate in this age group (9–11). Consistent with the literature, low-voltage electric shocks involved preschool and school-age children and high-voltage electric shocks involved adolescents. Electric shock was more common in boys in all age groups, a finding that differs from those in the literature. We think this could be explained by boys being more active in out-of-home activities, engaging more frequently in games such as kite-flying, and showing greater interest in electrical devices than girls.

Rabban et al. reviewed 114 children and adolescent patients and, consistent with our findings, they found that electric shocks were most often caused by contact with live electrical cords. This is why in-house precautions play an important role in preventing electric shocks. Consistent with the literature, the use of outlet plug covers, enacting regulations for the standardization of the manufacturing of electrical cords, generalizing the use of arc-fault circuit breakers that have become mandatory in most countries, and taking precautions against illegal electricity usage are a few measures that could be implemented (7,9). On the other hand, we think that the public level of knowledge and awareness about EIs should be increased via school briefings and the use of mass communication tools.

Cardiac arrhythmias and dysrhythmias secondary to the necrosis of the myocardium, cardiac nodes, electrical conduction pathways, and coronary arteries are reported to be the major cause of death after sustaining EIs. Studies indicate that the higher the voltage is, the more extensive the myocardial damage is (2). Asystole and VF are fatal consequences of an electrical shock, but other ECG changes are also observed, such as sinus tachycardia, nonspecific ST changes, heart blocks, prolonged QT

interval, supraventricular-ventricular arrhythmias, and atrial fibrillation (2,12).

The practice of hospitalizing all victims of electrical shock for 24-h cardiac monitoring is no longer endorsed. Zubair et al. suggest that patients who sustained in-house electric shock can be safely discharged home after 4 h of cardiac monitoring. Similarly, Claudet et al. also reported that there is no clear indication for cardiac monitoring if the ECG on presentation is normal and if risk factors for cardiac arrhythmias (wet skin, tetany, and loss of consciousness) are lacking (10,13). We monitored our patients for 24 h despite normal ECGs at baseline and the absence of loss of consciousness or cardiac arrest. Among the patients who sustained low-voltage electrical current, only 1 had sinus tachycardia, and the other 3 patients with ECG changes had sustained high-voltage electric shock. Based on the current literature and our findings, we suggest that all patients presenting with electric shock should undergo initial ECG testing, and symptomatic patients with cardiac arrest at the scene of the accident who sustained high voltages should be hospitalized and undergo cardiac monitoring.

Similar to the observations in crush syndrome, the levels of some laboratory markers, such as CK, CK-MB, and lactate dehydrogenase, are elevated in EIs because of damage to the deep tissues along the path through which the current passed. Similar studies have demonstrated the utility of elevated laboratory parameters as prognostic markers and as markers of tissue damage (14). In their study, Jurgen et al. reported a correlation between elevated CK levels and extremity amputation and mortality (15). In our study, patients who sustained high-voltage electric shock had significantly higher levels of CK, CK-MB, AST, and ALT compared to patients who were exposed to low-voltage electricity. Thus, symptomatic patients or patients suffering from cardiac arrest, loss of consciousness, or severe burns after sustaining low-voltage electric shock and those patients who sustained high-voltage electric shock should be hospitalized and monitored for 24 h for evidence of multiple system involvement, development of arrhythmias, or other complications.

In conclusion, despite their rare occurrence in childhood, EIs can present with a wide variety of problems, ranging from mild injury to life-threatening severe multiple organ injuries. Preventing such accidents by implementing simple measures and targeted programs to increase public knowledge and awareness would be an easy and rational approach.

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