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Electrical Burn Injury: A Five-Year Survey of 682 Patients

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Background: Electrical burn is less prevalent in comparison to other forms of burn injuries, however this type of injury is considered as one of the most devastating due to high morbidity and mortality. Understanding the epidemiologic pattern of electrical burns helps determine the contributing factors leading to this type of injury.

Objectives: Epidemiologic studies on electrical burn are scarce in Iran. This study was conducted to evaluate electrical burn injury at our center.

Materials and Methods: Demographic data, etiology, burn percentage and other measures related to electrical burn injury of 682 electrical burn patients treated from 2007 to 2011 were collected and analyzed.

Results: We assessed 682 electrical burn patients (~10.8% of all burn patients); the mean age was 29.4 years and 97.8% were males. The mean hospital stay was 18.5 days and the mean burn extent was 14.43%. Severe morbidities caused 17 (2.5%) deaths. Amputation was performed in 162 cases. The most common amputation site was the fingers (35%). Most victims were workers and employees and 68.5% of electrical burns occurred at their workplace; 72% of electrical burns were due to high voltage electrical current (more than 1000 V). There was a correlation between voltage and amputation (P = 0.001) and also between voltage and fasciotomy (P = 0.033), but there was no correlation between voltage and mortality (P = 0.131)

Conclusions: Electrical burn injuries are still amongst the highest accident-related morbidities and mortalities. Educating the population about the dangers and hazards associated with improper use of electrical devices and instruments is imperative.

Keywords: Electric Burns; Injury; Morbidity; Complications

1. Background

Although electrical burn is less prevalent in comparison to other forms of burn injuries, this type of injury is considered one of the most devastating injuries due to its high morbidity and mortality. It is also associated with high costs and long-term hospitalization as well as the need for multiple surgical procedures; therefore, specific management consideration are required for this type of injury (1, 2). The burden of electrical burn injury is different among developed and developing countries. According to various reports, it is more prevalent in developing countries and statistics show that its prevalence rate is higher among men (3). This kind of injury most commonly affects the young population and work forces - the main human resources of countries. There are some published articles and reports on electrical burn injury in different parts of Iran, but they were performed on a small scale (4-6). Shahid Motahari Burn Hospital (Tehran, Iran) is one of the largest burn hospitals in Iran and the main center for managing burn patients and it is also the referral center for burn injuries from different parts of the country.

2. Objectives

This study was conducted to evaluate the epidemiology of electrical burn injury and its associated comorbidities in Tehran, to elucidate the burden of this type of injury and other burn related complications for better management, prevention and treatment of patients.

3. Materials and Methods

This descriptive cross sectional retrospective study was conducted on 682 patients with electrical burn from March 2007 to November 2011. Demographic information and the mechanism of injury (high voltage *vs.* low voltage), complications, hospitalization period, surgical interventions and severity of electrical injuries were recorded. Incomplete records and patients who had left the hospital with written consent before the termination of their treatment course were excluded from the study. After hospitalization and initial evaluation of each electrical burn patient, resuscitation was performed using the Parkland formula. Proper resuscitation was evaluated by monitoring urine output. Pain control was achieved by using low-dose opium. Resuscitation and management of life threatening conditions was also performed. After delineation of the gangrenous limb and its limits, amputation was performed using the delayed Guillotine meth-

od. This study was accepted by the ethical committee of Tehran University of Medical Sciences, Tehran, Iran.

All continuous variables were presented as means ± SD, and the frequencies of categorical variables were presented as percentages. Continuous variables were analyzed with the Student *t*-test or one-way analysis of variance when appropriate. Categorical variables were analyzed with the chi-square test. A P value < 0.05 was considered significant.

4. Results

The annual incidence of electrical burn injury showed a relatively constant pattern during this study; the ratio of patients with electrical injuries to other causes of burn injury was relatively constant (Table 1). The most common affected age group was the 21-30 year age group (n = 263, 38.6%), followed by the 31-40 year age group (n = 142, 20.8%) and the 11-20 year age group (n = 122, 17.9%). The frequency of patients in other age groups was lower (Table 2). Electrical burn injury affected males more than females (male/female ratio: 2.9). The mean age of patients with electrical burn injury was similar to other types of burns, but the mean percentage of total body surface area (TBSA) was higher in patients with other types of burn injury (32.54% *vs.* 14.43%). Hospital stay was relatively higher in electrical burned patients in comparison to other groups of burn injury and mortality rate was higher in them as well (Table 3). Patients affected by high voltage electricity outnumbered the low voltage group. The average hospital stay, fasciotomy, amputation and mortality rates were higher in patients with high voltage injury in comparison to low voltage injury. Using the Spearman analysis, there was a positive correlation between voltage and amputation (r = 0.126, P = 0.001) and between voltage and fasciotomy (r = 0.082, P = 0.033), but there was no correlation between mortality and voltage (r = 0.058, P = 0.131) (Table 4). Amputation was performed in 162 cases but amputated sites were more than the number of patients affected (n = 189). The most common site of amputation was the fingers (n = 66, 35%) (Figure 1). Most of these injuries occurred during spring and summer (Table 5). The most common cause of electrical burn injury was electrical contact (n = 431, 61.7%). Construction workers (n = 386, 56.6%) were the most commonly affected. The injuries most commonly occurred in constructing buildings and factories, respectively (Table 6). About 60% of workers and electricians declared that they were not aware of the dangers they may encounter while working with electrical devices. In total, 43% of accidents occurred at night shifts.

Table 1. Frequency of Electrical Burn Injury in Comparison to Other Forms of Burn Injuries [a]

Year	TNPB	TNPE	TNPE to TNPB Ratio, %
2007	1219	128	10.5
2008	1356	146	10.7
2009	1180	119	10.1
2010	1199	138	11.5
2011	1374	151	11
Total	6328	682	10.8

[a] Abbreviations: TNPB, total number of patients admitted with all types of burn injuries; TNPE, total number of patients admitted with electrical burn injury.

Table 2. Age Distribution of the Patients With Electrical Burn Injury

Age Range of Patients, y	No. (%)
0 - 10	60 (8.8)
11 - 20	122 (17.9)
21 - 30	263 (38.6)
31 - 40	142 (20.8)
41 - 50	73 (10.7)
> 50	22 (3.2)

Table 3. Demographic Data of Patients With Electrical Burn Injury in Comparison to Other Forms of Burn Injury [a]

Measurement	Other Types Burn injury	Electrical Burn
Gender, No. (%)		
Male	4702 (74.3)	667 (97.8)
Female	1626 (25.7)	15 (2.2)
Age, y	30.2	29.4
Burn size, TBSA, %	32.54	14.43
Hospital stay duration, mean ± SD, d	14 ± 6	18 ± 3
Mortality, %	17.6	2.5

[a] Abbreviation: TBSA, total body surface area.

Table 4. Hospital Stay, Morbidity and Mortality Rates Regarding Voltage Intensity

Voltage	No. (%)	Hospital Stay, Mean ± SD, d	Fasciotomy, No. (%)	Amputation, No. (%)	Mortality, No. (%)
Low voltage (< 1000 V)	191 (14.4)	16 ± 6	16 (8.4)	29 (15.2)	2 (1)
High voltage (> 1000 v)	491 (86.6)	20 ± 12	71 (14.4)	133 (27.1)	15 (3.1)
Total	682 (100)	18 ± 9	87 (12.76)	162 (23.75)	17 (2.5)

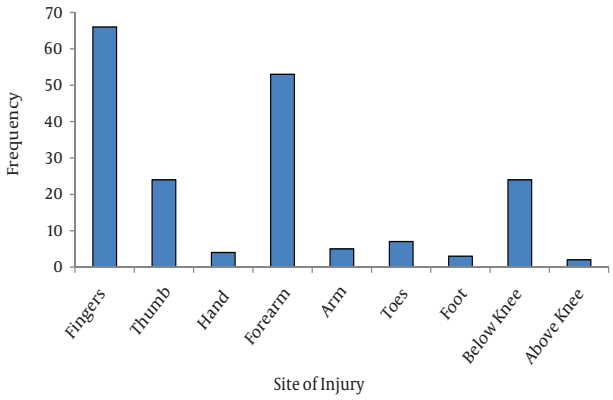

Figure 1. Amputation Rate and Site in Patients With Electrical Burn Injury. Amputation was performed in 162 cases, but in some cases the location of amputation was more than one site.

Table 5. Frequency of Electrical Burn Injury Regarding Different Seasons of the Year

Season	Patients Number	Frequency, %
Spring	208	30.5
Summer	207	30.4
Fall	123	18
Winter	144	21.1
Total	682	100

Table 6. Cause of Injury, Place of Accident and Occupation of Electrical Burned Patients

variables	No. (%)
Cause of injury	
Contact	421 (61.7)
Flash	64 (9.4)
Working with electrical device	197 (28.9)
Occupation	-
Electrician	224 (32.8)
Construction worker	386 (56.6)
Cable stealer	29 (4.3)
Others [a]	43 (6.3)
Place of accident	
House	143 (21)
Building construction	210 (30.8)
Factory	194 (28.4)
Electrical store	74 (10.9)
Electricity mast	61 (8.9)

[a] Others include children and non-professionals accidentally injured by electrical power.

5. Discussion

To our knowledge this study is the largest evaluation of electrical burns in Iran. Electrical burns remain an important issue in developing countries due to its higher prevalence and complications. In the present study, 97.8% of the electrical burn injuries occurred in men. In some studies it is indicated that males are more prone to electrical injuries than females. For example, in a study by Mohammadi et al. in Shiraz, electrical burn injury was more prevalent in males (4). In another study in Turkey, 95% of their patients were also males (7, 8). In a study conducted in Taiwan, 92.5% of patients with electrical burn were males; 60% were injured at work from high voltage (9). This is mainly due to their higher exposure to electrical appliances and devices and their industrial field. Although the frequency of patients with electrical injuries increased during 2009 to 2011, the ratio of electrical burn injury to other forms of burn injury (thermal, chemical, etc.) was constant during this study (about 10-11% annually). The incidence of electrical burn injury in our study was higher in comparison to other studies performed in the USA (4%); but it was lower than some other reports from Turkey (16%), China (18%) and Kosovo (17%) (10-12). In some studies it has been shown that the incidence rate may relate to social or economic factors. For example, in a study conducted in Kosovo it was shown that after the war, frequency of electrical burn patients increased (12). In our study, electrical burn injury mostly affected individuals in their third and fourth decades of life. In a study by Maghsoudi et al. on 2963 burn patients, they detected 88 cases with electrical burn injury in which the most frequent age group was 21-30 years (the third decade) (6). Furthermore, in other studies on electrical burn patients have shown that individuals in their third and fourth decades of life are more prone to electrical burn injuries. This may be due to this fact that these age groups work with electrical devices and instruments (3, 13, 14). Although in a study by Patil et al. electrical burn injury prevalence was higher in the second decade of life which probably was due to increased household injuries after economic surge and increased availability of electricity in houses in their country (3).

Male to female ratio in electrical burn injury is considerably high (M/F = 44:1) in comparison to other types of burn injury (M/F = 2:1). As mentioned before this is due to higher exposure of men to electrical appliances and their work status in industrial fields, factories and buildings which makes them more prone to electrical injuries. The mean age of patients with electrical burns was not significantly different from the mean age of other patients with other types of burn injury. TBSA of patients with electrical burn injury was significantly less than patients with other types of burn injury (14.43% *vs.* 32.54%). In patients with electrical burn injury, usually the extent of burn is not evident superficially. Electrical injuries may affect multiple organs and different

systems of the body. It is not possible to determine the exact extent of tissue damage by investigating the entrance and exit wounds. Site of injury may be far away from its visible pathway through the victim. Moreover cells are injured by thermal mechanism produced by electrical current (15, 16). The mean hospital stay was higher amongst electrical burn patients in comparison to other types of burn injury. This longer hospitalization duration may be due to complications associated with electrical burn injuries and following procedures, which are mandatory in these patients such as skin graft, fasciotomy and amputation. In a study by Tarim et al. they found that the mean hospitalization duration was higher in amputation patients, but we did not find any statistically significant association between amputation and hospital stay or TBSA (17). In the present study, injury with high voltage was seen in 491 cases (72%) and the mortality rate was higher in this group of patients. There was a correlation between amputation and mortality ($P < 0.05$) and also fasciotomy and mortality ($P < 0.05$) and mortality was higher in patients who underwent fasciotomy and amputation. There was also a statistically significant association between voltage and amputation ($P = 0.001$), and voltage and fasciotomy ($P = 0.033$). Amputation and fasciotomy procedures were performed more in patients with high voltage burn injury. Hospital stay was longer in patients with high voltage injury, which was mainly due to performed procedures and their poor general condition and complications. In similar studies, there was an association between high voltage rate and comorbidities and mortality (2, 6, 17). Most amputations were executed on fingers and upper limb. This is similar to the results of studies by Sun, Buja and Tarim (11, 12, 17). This is because most of these accidents occur while work with electrical devices. Therefore, precautions measurements such as wearing protective and insulating gloves and clothes are of great importance. The higher frequency of accidents in spring and summer may indicate this fact that sweating increases in warm and hot seasons of the year, which would decrease the skin resistance and therefore increase the current through the body (18).

The most common cause of electrical burn injury was contact with electrical current which led to severe damage. This can be due to nonstandard wires and devices. Construction workers and electricians were the most common population involved in electrical burn injury. However in a study by Patil et al. most accidents occurred at home, which was proposed to be due to improper use of electrical devices at home (3). Standardization of electrical devices and continuous supervision of workers, proper use the devices, security precautions, using “danger” labels on highly dangerous electrical devices, restriction of access of unskilled individuals to dangerous electrical instruments, setting proper shifts, settlement of continuous educational programs for workers and electrician, informing them about the dangers of improper use of electrical devices and explaining preventive methods to them would be beneficial in reducing this type of injury. As copper is expensive, in developing countries, many teen resort to stealing copper cables. This abnormal and improper behavior leads to detrimental and harmful consequences. Falling down from a high electric posts besides electrical damages may result in multiple trauma, severe injuries and even death. Moreover, ignoring precautions and preventive measures and contact with high voltage cables lead to severe electrical injuries, internal organ damage and death. New rules and regulations should be designed and implemented for prevention of electrical burn injuries. This study evaluated electrical burn patients admitted to hospital, but those who died on way to the hospital were not included. Unfortunately we did not have access to all the information. In addition, follow-up of these patients was not performed to obtain information about the delayed complications and adverse effects of electrical burn injury on the quality of life.

Authors’ Contributions

Study design: Reza Vaghardoost; data analysis and writing: Yaser Ghavami; editing and data collection: Mohammad Reza Mobayen.

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