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# Effect of current pathway on mortality and morbidity in electrical burn patients

*Kamran Aghakhani, Mansoure Heidari*, Seyed Morteza Tabatabaee, Leyla Abdolkarimi*

*Iran University of Medical Sciences, Tehran, Iran*

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ABSTRACT

*Introduction:* Electrical injury is relatively uncommon but it is a devastating form of thermal injury. The aim of this study is to analyze specific aspects of electrical injuries, especially the effect of current pathways on morbidity and mortality.

*Method:* This descriptive-analytical study was performed on patients with electrical burns who were admitted to the Shahid Motahary Burn Center from April 2010 to March 2012. Demographic and clinical data including gender, age, length of hospital stay, total body surface area (TBSA), grading of burn, electrical voltage, inlet electrical mark, outflow electrical mark, current pathway, surgical procedures, and place of electrical burn have been gathered from medical records. The site of inlet and outlet of current on the body is divided into six groups: Rt (right) upper limb, Lt (left) upper limb, Rt lower limb, Lt lower limb, head and neck, and trunk. According to these sites, the current pathway is defined to seven groups. Data were analyzed with SPSS software, version 20.

*Results:* From 287 patients, 283 were men and 4 were women. The mean age was $30 \pm 12$ years (range 1–71) and mean TBSA was $13.56 \pm 12.97\%$ (range 1–100). There were 233 patients (81.2%) with passage of the electrical current through the body and 54 patients (18.8%) with flash burns. A total of 859 surgical procedures were performed on 232 patients. One hundred and eighteen amputations were performed in 83 patients. The most common inlet electrical marks were in Rt upper limb and the most common outlet electrical marks were in Lt lower limbs, and consequently, the most common pathway was upper limb to lower limb.

*Conclusions:* Electrical injuries are mainly occupation-related injuries and in this research majority of injuries occurred outdoor by high voltage cables in young men. Thus the government should consider a distinct strategy for this group. Also it is observed that there were no significant differences in mortality and complications such as amputation between different pathways.



## 1. Introduction

Electrical injury is relatively uncommon than other forms of thermal injuries, but it is potentially devastating with high morbidity [1]. Fewer than 5% of burn centers' admissions are accounted for electrical injuries [2]. Electrical current flows through the tissues which is called electrocution. Electrocution has many manifestations, such as cardiac arrest, skin burn, and deep tissue destruction [3]. Electrical injuries are divided into high voltage ($v > 1000$), low voltage ($v < 1000$), and electrical flash burns. High voltage injuries commonly are

* *Corresponding author*. Tel.: +98 9124033215.
E-mail address: Heidarimansoure83@yahoo.com (M. Heidari).
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work-related. Groups at risk by high voltage include industrial workers and high voltage power linemen. Low voltage injuries usually occur at home or at the work place. In flash burns there is no passage of current through the tissue [4].

The severity of tissue injury is related to several factors, including current, voltage, resistance, duration, and pathway of the electric current [1]. The electricity flows through the tissue and generates heat and cellular depolarization. It often leads to skin burn, deep tissues necrosis leading to fasciotomy, skin grafting, amputation, and other types of surgical procedures.

The actual incidence of electrical injuries is unknown. Mortality is reported between 3% and 15% in the U.S. [5]. The fifth leading cause of occupational death in U.S. is electrocution [6]. In our country despite relative improvements in product safety, electrical injury is still a cause of mortality and considerable complications such as amputation. The reported incidence rates of death and hospitalization are 5.6–10.4% and 30.5% per 100,000 person years in Iran [7] and 19% of the patients needed amputation [8].

The aim of this study is to analyze specific aspects of electrical injury in our country, Iran and to investigate whether the current pathway has effect on mortality and morbidity in electrical burn patients.

## 2. Materials and methods

This retrospective study was performed on patients with electrical burns who were admitted to the Motahary hospital, a referral hospital and burn center in Tehran. Demographic and clinical data were gathered from medical records of the patients admitted to this hospital from April 2010 to March 2012 by a predefined questionnaire. This questionnaire included data about gender, age, length of hospital stay, TBSA, grading of burn, electrical voltage, inlet electrical mark, outlet electrical mark, current pathway, surgical procedures, and place of electrical burn.

Patients were divided into two groups on the basis of type of burning: passage of current and flash burn. In the flash burn group electrical current does not flow through tissues, therefore electrical mark would not be obvious.

Burns have been classified as a four-grading scale: Grade 1: involvement of superficial thickness of skin, Grade 2: destruction of the full thickness of skin, Grade 3: destruction of the skin, subcutaneous tissues, fat, and muscles, and Grade 4: destruction of the skin, subcutaneous tissues, and bone. The electrical voltage was defined as a dichotomous variable. High voltage was considered as above 1000 V and low voltage was considered as below 1000 V. TBSA was calculated with rule of nines in the emergency department by the physician of the emergency department.

Surgical procedures were done in the emergency and surgery department. These procedures include surgical debridement, fasciotomy, escharotomy, skin grafting, skin flap, and amputation. Fasciotomy is used to prevent or treat compartment syndrome in first 24 h of accident. Escharotomy is used to treat full thickness burns to prevent formation of tough, scars and following compartment syndrome. Sometimes surgical debridement of the damaged skin is followed by skin grafting and free flaps. Finally, some patients underwent amputation due to severity of tissue damage. Patients with coexisting trauma or TBSA more than 40% are admitted to intensive care unit.

Site of inlet and outflow electrical marks was documented according to the medical history and examination in patient's medical records. The sites are divided into six groups as follows: right (Rt) upper limb, left (Lt) upper limb, Rt lower limb, Lt lower limb, head and neck, and trunk. According to these groups the current pathway is divided into seven groups as follows: (1) upper limb to upper limb, (2) upper limb to lower limb, (3) head and neck to upper limb, (4) head and neck to lower limb, (5) trunk to upper limb, (6) trunk to lower limb, and (7) lower limb to lower limb.

Data were analyzed with SPSS software, version 20. Descriptive variables were expressed as mean and standard deviation with 95% CI. Independent sample *t*-test and one-way ANOVA were used to compare age, length of hospitalization and TBSA between the electrical pathway groups, place of injury and current or flash burn groups. Chi-square test was used to determine statistical significance between different subgroups of qualitative variables as place of injury, burning stages and different types of surgical procedure. *P*-value $<0.05$ is considered as significant.

## 3. Results

Between April 2010 and March 2012, 287 patients including 283 male (98.6%) and 4 female, with electrical burns, were admitted to the Motahary hospital. The mean age of the patients was $30 \pm 12$ years (range: 1–71 years). The mean length of hospital stay was $17 \pm 16$ days (range: 1–115 days). Seven patients were admitted to intensive care unit and the overall mortality rate was 2.4% (7 out of 287).

There were 203 patients (70.7%) with low voltage current and 84 patients (29.31%) with high voltage current burn. The mortality rate between low voltage patients was 1% (3 out of 203) and this measure was 4% (4 out of 84) in high voltage patients (*P*-value = 0.2). In the low voltage group, 78% of the patients (160 out of 203) underwent surgical procedures while this rate in the high voltage group was 85% (72 out of 84) (*P*-value = 0.19).

The mean percentage of TBSA among the patients was $13.56 \pm 12.97\%$ (range: 1–100%). Patients were divided into four groups according to burning grade. There were 5 cases (1.7%)

**Table 1 – Summary of main characteristics comparing passage of the current group and the flash burn group.**

| Outcome | Passage of current $n = 233$ | Flash burn $n = 54$ | *P* |
|---|---|---|---|
| Surgery procedure, *n* (%) | 189 (65.9%) | 43 (79%) | NS[a] |
| Amputation, *n* (%) | 81 (34.7%) | 2 (3.7%) | $<0.05$ |
| Mortality, *n* (%) | 5 (1.7%) | 2 (0.7%) | NS |
| ICU Add, *n* (%) | 6 (2.6%) | 1 (1.9%) | NS |

[a] Not significant statistically.