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Wound management and outcome of 595 electrical burns in a major burn center

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ABSTRACT

Background: Electrical burns are important causes of trauma worldwide. This study aims to analyze the clinical characteristics, wound management, and outcome of electric burns.

Methods: This retrospective study was performed at the Institute of Burn Research of the Third Military Medical University during 2013-2015. Data including the demographics, injury patterns, wound treatment, and outcomes were collected and analyzed.

Results: A total of 595 electrical burn patients (93.8% males) were included. The average age was 37.3 ± 14.6 y, and most patients (73.5%) were aged 19∼50 years. Most patients (67.2%) were injured in work-related circumstances. The mean total body surface area was 8.8 ± 11.8% and most wounds (63.5%) were full-thickness burns. Operation times of high-voltage burns and current burns were higher than those of low-voltage burns and arc burns, respectively. Of the 375 operated patients, 83.2% ($n = 312$) underwent skin autografting and 49.3% ($n = 185$) required skin flap coverage. Common types of skin flaps were adjacent (50.3%), random (42.2%), and pedicle (35.7%). Amputation was performed in 107 cases (18.0%) and concentrated on the hands (43.9%) and upper limbs (39.3%). The mean length of stay was 42.9 ± 46.3 d and only one death occurred (0.2%). Current burns and higher numbers of operations were major risk factors for amputation and length of stay, respectively.

Conclusions: Electrical burns mainly affected adult males with occupational exposures in China. Skin autografts and various skin flaps were commonly used for electric burn wound management. More standardized and effective strategies of treatment and prevention are still needed to decrease amputation rates.

Introduction

Electrical burn injuries are the fourth leading cause of traumatic work-related death, and lightning injuries are the second leading cause of weather-related death.[1,2] Risk of electric injuries is increased in developing countries because of the widespread use of electricity.[1,3] Although electrical burns are uncommon relative to scald and flame burns, electrical burns had greater severity, higher disability and mortality rate, more complicated management, long-term hospitalization, and more costly expenditures, and therefore were perceived as one of the most devastating injuries.[4-6] The effects of electricity on the body are determined by seven factors: type of current (alternating or direct), amount of current, pathway

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of current, duration of current, area of contact, and resistance of the body and voltage.[1,6] Electrical burns are typically divided into low-voltage burns (<1000 V) and high-voltage burns (>1000 V) according to the electrical voltage, and arc burns and current burns are based on whether electric current flows through the body or not.[6]

Previous studies showed that electrical burns commonly affected young men—the main work-force.[7,8] The high morbidity, mortality, and expenditure place heavy burdens on patients, families, and society.[5,6] However, data on the management and outcome of electrical burns in China are rare.[8-10] This study aims to analyze the clinical characteristics, wound management, and outcome of electrical burn injuries at the Institute of Burn Research, Southwest Hospital of the Third Military Medical University (TMMU), which is also a public hospital that admits about 1800 burn inpatients every year, about 200 patients with >30% total body surface area (TBSA), and about 100 patients combined with inhalation injury.

Materials and methods

Ethical approval and informed consent

This study was approved by the Institutional Review Board of the Southwest Hospital, the TMMU. All human experiments were performed in accordance with the guidelines of the Institutional Review Board of the Southwest Hospital and the 1975 Declaration of Helsinki. Informed consent was obtained from all patients involved in this study.

Data extraction

We reviewed all 643 patients with the main diagnosis containing "electricity" admitted to the Institute of Burn Research, Southwest Hospital, the TMMU, between January 2013 and December 2015. Patients who did not have electrical burn wounds were excluded. The excluded patients were admitted for scar reconstruction ($n = 29$), flame or contact burns by electronic equipment ($n = 9$), injury by electric saw ($n = 1$), and readmissions ($n = 9$). The following data of the 595 electrical burn patients were collected: the clinical characteristics (mainly including demographical data, electricity voltage, burn type, burn depth and area, and injured anatomic locations), the wound management (mainly including operation times and operation names), and the outcome (mainly including amputation, death, length of stay [LOS], and total cost). According to the voltage, electrical burns were categorized as low-voltage burns (<1000 V) and high-voltage burns (>1000 V). According to the existence of contact points, electric burns were divided into electric arc flash burns (without) and electric current contact burns (with). Upper limbs were defined as the region between the wrist joints and the shoulder joints, and the lower limbs were defined as the region between the ankle joints and the inguina.

Statistics

The data were primarily entered and processed using Microsoft Excel 2010 (Microsoft Corporation), and the descriptive statistics (mean and standard deviation) were calculated. The data analysis was performed using the GraphPad Prism 6 (GraphPad Software Inc) and SPSS 13.0 (SPSS Inc) software. Q2 Pearson chi-square test or Fisher's exact test was used to compare the patient numbers in different groups. *T*-tests were used to compare two quantitative variables (e.g., TBSA%, LOS, LOS/TBSA, cost, and cost/TBSA). The multicollinearity among included variables was analyzed using the collinearity diagnostics method before the following regression. Multiple linear regression (stepwise regression method, entry: $P = 0.05$; removal: $P = 0.10$) was used to screen the risk factors for the LOS. Multiple logistic regression (forward LR method, entry: Q3 $P = 0.05$; removal: $P = 0.10$) was used to screen the contributory factors for the amputation. The detail of variable assignments and multicollinearity are shown in Tables S1 and S2. *P* values <0.05 were considered significant.

Results

Demographic characteristics

From January 2013 to December 2015, a total of 4041 burn patients were admitted to our center. Of these, 595 were injured by electricity (14.7%). Figure 1 shows the distribution of patient demographics. The number of electrical burn patients gradually decreased from 2013 to 2015 (Fig. 1A). The incidence of burns peaked in the autumn season (July-September, 32.1%) and bottomed in the spring season (January-March, 16.8%; Fig. 1B). Most patients came from local province (65.4%), followed by Sichuan province (19.5%), Guizhou province (9.6%), and others (5.5%). Most patients (67.2%) were injured in work-related circumstances. Of the 595 patients, 558 were males (93.8%) and 37 were females (6.2%). The average age of the burn patients was 37.3 ± 14.6 y (median: 40), ranging from 1 y to 77 y. The prevalence of electrical burns was highest in 40- and 41-y-olds (Fig. 1C) and in the 41-50 y age group (Fig. 1D). Most patients (73.5%) were aged 19-50 y. The percentage of male patients was lowest in 0-18 y age group (78.0%) and highest in the 41-50 y age group (97.8%; Fig. 1D).

The cause and severity of electrical burns

The number of patients affected by low-voltage electricity (345, 58.0%) was larger than the number of patients suffered by high-voltage electricity (250, 42.0%; Fig. 2A). The incidence of burns caused by arc ($n = 290$, 48.7%) was similar to that of burns caused by current ($n = 305$, 51.3%). However, the percentage of arc burns in low-voltage burns was significantly larger than that in high-voltage burns (60.6% *versus* 32.8%, $\chi^2 = 44.8$, $P < 0.001$). The mean TBSA was 8.8 ± 11.8% (median 5%) with a range of 1%-91%. Most burn patients (78.3%) had a TBSA no >10% and only 1.9% of patients had TBSA >50% (Fig. 2B). Furthermore, high-voltage electrical burns had larger TBSA than low-voltage electrical burns (13.5 ± 16.0% *versus* 5.4 ± 5.4%, $P < 0.01$). Arc burns had a higher TBSA than current burns (11.5 ± 13.6% *versus* 6.3 ± 9.2%, $P < 0.01$; Fig. 2C). Most electrical wounds were full-thickness burns (63.5%), followed by deep partial-thickness burns (34.8%), and superficial partial-thickness burns (1.7%; Fig. 2D). The percentage of