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Amputations in Burn Patients with a Special Emphasis on Pediatric Patients

ORIGINAL INVESTIGATION

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ABSTRACT

Objective: Digit and extremity amputations are unwanted complications in burn injuries. Although some amputations cause only cosmetic and psychological problems in burn patients, they can lead to serious loss in functionality and impairment in the quality of life. The aim of this study was to investigate the epidemiologic features of amputations among burn patients in the southeastern region of Turkey.

Materials and Methods: We conducted retrospective chart reviews of patients hospitalized in Dicle University Burn Center between January 2011 and January 2016 and evaluated patient demographics.

Results: A total of 3315 (2063 male and 1252 female) patients were treated, and 41 patients (36 males and 5 females) with a mean age of 21.95 years (range: 3-58 years) underwent amputation. The amputation incidence was 1.23% over the 5-year period. In total, 19 of 41 patients were under 16 years, while 16 were male workers. There was a significant male dominance ($p<0.05$), with electrical burns being the most common etiological agent ($p<0.001$). The mean burned total body surface area was 12.4±7.9% (range: 2-60%), and major amputations were significantly higher ($p<0.05$) if the area exceeded 10%.

Conclusion: Electrical burns were the most common etiological factor, and pediatric patients were the most affected group. Educating parents and taking safety measures for protecting children from electrical contact points are as important as educating workers for diminishing the incidence of electrical burn-related amputations.

Keywords: Amputations, electrical burns, pediatric burn

INTRODUCTION

Burn injuries can affect individuals from all socioeconomic groups and result in varying complications depending on different factors. The burn degree with the total body surface area (TBSA) can be the main factor that determines the short- and long-term results of treatment (1). According to theetiological agent, burn injuries are classified as follows: thermal, electrical, chemical, frostbites, and irradiation. Each burn type causes skin burning; however, the extent and severity of tissue damage varies according to the burn agent. Thermal burn injuries usually cause skin and subcutaneous tissue burning; however, high-voltage electrical burns (>1000 V) cause burning of deeper structures such as muscles, nerves, vessels, and even bones (2, 3).

Serious burn injuries can cause mortal complications such as acute renal failure, acute tubular necrosis, acute multi-organ failure, sepsis, or septic shock (4). With recent advances in burn treatments, these complications less frequently cause death, and the burn mortality rate has decreased over the last several decades (1, 4). As can be surmised, with the increase in burn patients' survival rates, the prevention and treatment of late complications and improvement of the quality of life after burn injury has become more important than before (5-7).

Digit and extremity amputations are serious complications of burn injuries and impair thequality of life after burn injury . Amputations might result from the direct burning of tissues or impairment of blood circulation due to compartment syndrome, which is defined as an increased pressure within a body's compartment that contains nerves, muscles, and vessels. In this report, we aimed to investigate the epidemiological features of amputations due to burn injury in Diyarbakır city, which is located in the southeastern region of Turkey.

MATERIALS and METHODS

The medical records of patients treated in Dicle University Burn Center from January 2011 to January 2016 were reviewed, and patients who underwent amputation were identified. Data about the burn agent, TBSA, whether fasciotomy had been performed prior to amputation, interval between the burn injury and amputation, hospitaliza-

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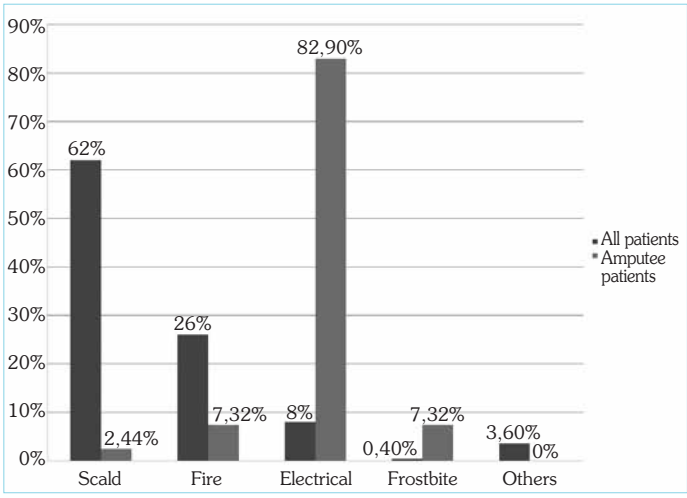

Figure 1. **The ratios of burn types among all burn patients and amputee burn patients**

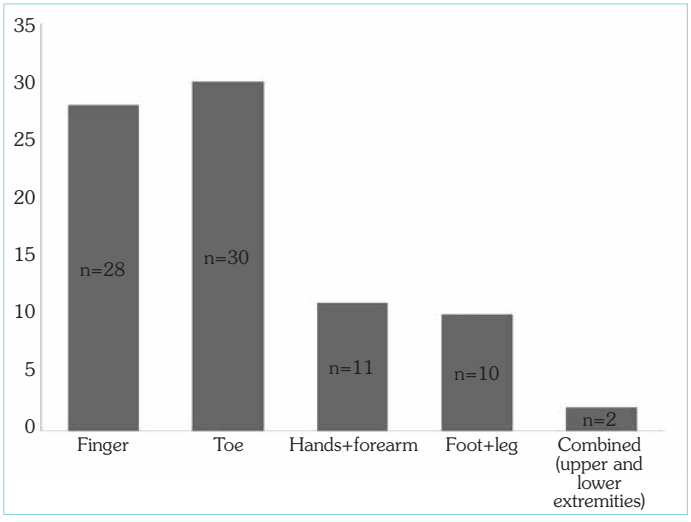

Figure 2. **Amputation level of patients**

tion duration, and total number of operations were collected. Burn injuries were classified as thermal (scalding, fire, and contact), frostbite, and electrical (high voltage, ≥1000 V; low voltage, <1000 V). Amputations were categorized as minor (if only digits were amputated) or major (amputation proximal to the digits), and patients were grouped as minor amputee patients (only minor amputation) or major amputee patients (major amputation with or without minor amputation). We observed that the risk of major amputation increased if the TBSA was greater than 10%; therefore, amputee patients were divided into another two groups: TBSA≤10% and TBSA>10%.

Statistical analysis

The chi-square test was used to determine whether there were differences between categorical variables, that is, between amputation rates and sex, the burn agent, the amputation type, and fasciotomy. The TBSA was calculated as the mean± Standart Derivation (SD) and the Mann-Whitney U test was used for analyzing whether the TBSA was higher in major amputee patients. Analyses were performed using Statistical Package for the Social Sciences software version 15.0 for Windows (SPSS Inc.; Chicago, IL, USA) and $p<0.05$ was considered statistically significant.

Table 1. Demographics of all amputee burn patients

Demographics	Results
Number of patients (n)	41
Mean age, years (range)	21.9 (3-58)
Male-to-female ratio	7.2:1
Mean TBSA (range)	12.4% (2-60%)
Total number of pediatric patients (n, %)	19 (46.34)
Degree of burn injuries	Second degree, 43.9%, Third degree, 56.1%
Compartment syndrome (n, %)	20 (48.78%)
Mean amputation day, (range)	17.34 (1-47)
Mean hospitalization duration days, (range)	43.19 (7-120)
Mean number of operations (range)	3.62 (1-8)
Number of major amputation patients (n, %)	21 (51.2)
Number of minor amputation patients (n, %)	n=20, 48.8%
Total number of amputations	81 (58 digits and 23 extremities)

TBSA: total body surface area

RESULTS

During the 5-year period, 3315 (2063 male and 1252 female) patients were treated in Dicle University Burn Center; 90 patients died (2.71%) and 41 (1.23%) underwent amputation. The burn type ratios were as follows: 62% scalding, 26% fire, and 8% electrical burns (5% high voltage and 3% low voltage) in all burn patiens however, 82.9% electrical burns, 7.3% frostbite and fire, and 2.4% scalding in amputee burn patients (Figure 1). The amputation risk was significantly higher with electrical burns ($p<0.001$).

The demographics of amputee patients are summarized in Table 1. The mean age of amputee burn patients was 21.9 years (range: 3-58 years) with second- (n=18, 43.9%) or third- (n=23, 56.1%) degree burns. Of 41 patients, 19 were under 16 years and 16 were male workers. Pediatric patients and male workers were the most common in the amputation groups.

Fasciotomy was performed 116 time in the 3315 burn patients at a rate of 3.4%, but it reached up to 48.78% in amputee burn patients. Compartment syndrome was significantly higher ($p<0.001$) in amputee burn patients; however, there was no statistical significance ($p=0.272$) between compartment syndrome and the amputation type.

There were 21 patients in the major amputation group and 20 in the minor amputation group. The total number of major amputations was 23 in 21 patients. One patient underwent left below knee amputation with above wrist amputation and the other underwent left shoulder amputation with left below knee amputation. Of the 23 major amputations, 12 were of the upper extremities and 9 were of the lower extremities (Figure 2).

Table 2. Comparison of the major and minor amputee patients

Demographics	Major Amputation (n=21)	Minor Amputation (n=20)	p
Mean age, years	22.3±12.8	21.1±17.1	0.918
Mean TBSA (%)	7.23±6.13	16.85±6.70	<0.001*
Mean amputation day	15.14±12.10	19.65±8.83	0.183
Mean hospitalization duration, days	46.15±15.41	40.38±28.03	0.417
Average number of operations	3.85±1.87	3.4±1.78	0.442
Compartment syndrome	n=8, 38.1%	n=12, 60%	0.161

TBSA: total body surface area *Statistically significant

The total number of digit amputations was 58; 30 were of the toes and 28 were of the fingers. The most commonly amputated finger was the middle finger (n=7); the great toe (n=10) of the foot was the most commonly amputated in the foot. Of 20 minor amputation patients, 13 had multiple digit amputations while the remaining had a single digit amputation. The multiple amputation rate was 65%, and the likelihood of multiple digit amputation was greater than that of single digit amputation in amputee burn patients.

A comparison of the major and minor amputation groups revealed that the mean amputation day after burn injury was longer in minor amputee patients, whereas the mean hospitalization duration was longer and the average number of operations was more in major amputee patients; however, all these differences were not statistically significant (Table 2).

The mean TBSA was 12.4±7.9% (range: 2-60%) in all amputee patients, 7.2±6.1% in the minor amputation group, and 16.8±6.7 in the major amputation group. Whether TBSA was a risk factor for major amputation was evaluated. In the minor amputation group, 5 patients (25%) had a TBSA higher than 10%, but in the major amputation group, 17 patients (81%) had a TBSA higher than 10%. The risk of major amputation was significantly higher with a TBSA higher than 10% (p<0.001).

DISCUSSION

Annually, burns affect millions of people and result in hundreds of thousands of deaths and morbidities worldwide. The total number of patients in a year who received medical treatment due to burn injuries was 486,000 in the U.S.A. with a rate of 0.15% (8). According to 2015 data for the National Burn Repository of the American Burn Association including data including the period between 2005 and 2014, the mortality rate for all cases was 3.2% (9). The World Health Organization (WHO) estimates that that burns cause more than 7.1 million injuries and more than 265,000 deaths worldwide annually, with a mortality rate of 3.73% (10). Burns are more likely to cause much more annual deaths than 265,000 and lead to serious complications because underdeveloped countries don't have reliable medical records as developed countries. All these data clearly show that burns are a common health problem for humans and that the prevention of burn injuries is much more important than treatment.

Mortality rates have declined due to advances in burn treatment over the past several decades; thus, early and late complications of burns have become more important than before (11). The mortality rate was 2.71% for the 5-year period at Dicle University Burn Center, which was lower than the rates estimated by the WHO and in U.S.A. (9, 10). The possible explanation and major factor of the low mortality rate are the epidemiological features of patients who were treated at our burn center because a high proportion of patients suffered from scalding burns (62%) and high-voltage electrical burns accounted for only 3% of all patients.

Although amputation can be a life-saving procedure in serious burn patients, this indication is not easily given by surgeons and is also not well tolerated by patients because amputations cause physiological and psychological sequelae for the rest of the patient's life (12). In cases of amputation of the distal phalanx of the little finger, amputations may cause only esthetic problems; the case of major or thumb amputations, it may lead to serious functionality loss (5, 6). Amputation rates of between 10% and 68% have been reported in the literature by Arnoldo et al. (13). The overall amputation risk ratio of burn patients was reported to be 2% by Gallagher et al. (14) in a time period of 24 years.

Electrical burns are less common than fire and scalding burns; however, they can cause more serious, life-threatening conditions in the acute period and morbidities in the chronic period (4). Electrical or fire burns have been reported as the most common agents of burn-related amputation in different studies (1, 7, 15, 16). Tarim et al. (15) have reported that high-voltage electrical burns cause 75.8% of amputations in burn patients, and Soto et al. (7) have revealed that electrical burns increase the likelihood of amputation by 13.4 times. The result of the presented report was compatible with those in these studies because 82.75% of all amputations were caused by high-voltage electrical burns, whereas it accounted for only 3% of all burn injuries.

Fasciotomy can be a salvage procedure to prevent amputations by decreasing the compartment pressure if extremity circulation is impaired due to post-burn edema. High-voltage electrical burns directly damage muscles, nerves, and blood vessels due to heat, while tissues and bones are resistant to electricity, and fasciotomy cannot improve blood circulation. Of the 3315 burn patients, 116 underwent fasciotomy for the decompression of compartment syndrome. Extremity circulation improved after fasciotomy in 95 of 116 patients but the remaining 21 patients underwent amputations. Fasciotomy was significantly higher (p<0.001) in amputee burn patients than in all burn patients in the presented report. We compared the incidence of compartment syndrome in minor and major amputations. Although the ratio of compartment syndrome was higher in the minor amputation group (60%) than in the major amputation group (38.1%), the difference was not statistically significant (p=0.272). This was an unexpected result because compartment syndrome causes muscle and vessel damage in the forearm or distal leg; therefore, it is expected to be higher in major amputations.

Frostbite burns are very rare, and there are a limited number of cases in the literature. A total of 14 frostbite burns were treated over the 5-year period, and it was the second most common agent with fire resulting in amputations. All frostbite burns were located on the acral regions of extremities, and lower extremity digits were affected twice as often as upper extremity digitd. In two patients, isolated toe amputation was performed, whereas isolated finger amputation was performed in the other patient. In all three patients, multiple digits were amputated, and the average number of amputated digits was five.

The most common amputated digit of the foot was the great toe and that of the hand was the middle finger. The overall toe amputation rate was 33.3% among amputated foot digits and 34.6% in electrical burn patients. The possible explanation of the high frequency of toe amputation in burns (particularly in high-voltage electrical burns) might be related to the foot touching the floor. The surface area of the first metatarsophalangeal joint bears the body weight; it touches the floor, and this feature puts it at a risk of being the exit point of electricity. The middle finger is the longest finger of the hand with a risk of being the first contact point. However, these explanations about the amputation rate of digits are only assumptions and they should be verified in a future prospective cohort study.

There was male dominance among our amputee burn patients ($p<0.001$); 87.8% of amputation patients were males, whereas only 12.2% were females. It has been reported that electrical burns mostly occur among working-age males (1, 2, 6, 7, 15, 16). This conclusion was compatible with our report; however, our study showed that children too are at a risk of amputation due to electrical burns. In the presented report, the most affected group for burn-caused amputation was pediatric patients (n=19, 46.3%), followed by working-age men (n=16, 39%). Majority of amputee pediatric patients were an unexpected result for the authors, and there are no articles about amputations in burn patients including such a large number of pediatric patients.

The main reasons for high-voltage electrical burns in children have been reported to be climbing trees, utility poles, or transformers and contacting overhead wires directly or while flying kites (3-17). Our data showed that the most common reason for high-voltage electrical burns in pediatric patients was climbing utility poles and that the second was overhead wires. In Diyarbakır City, the temperature is very warm, frequently reaching up to 50°C. The local population sleeps on the roof to cool down in the rural regions of the city in summer, so overhead wires are within the reach of children. The presented report showed that pediatric patients are at a risk of electrical burns if they are not educated or protected. Parents should be informed about the dangers of electrical contact points such as pylons, cables, or outlets, particularly in developing or underdeveloped countries.

The mean hospitalization duration and average number of operations were higher in the major amputation group (Table 2). In patients who underwent major amputation, the mean hospitalization duration was an average of six days longer than that in the minor amputation group. Revision of the stump or elevation in the amputation level increased the total number of operations in the major amputation group. Beyond the scope of this report, it can be assumed that the total treatment cost of major amputee patients is definitely higher than that of minor amputee patients.

The percentage of TBSA shows the severity of injury, and the enlargement of TBSA increases the mortality rate in burn patients (18). The results of the presented study show that major amputation was significantly higher if the TBSA was higher than 10%. This outcome might be related only to the severity of burn injury because it is well known that serious high-voltage electrical burns usually cause high TBSAs. The TBSA might not be an independent factor for majority of amputations; however, future prospective controlled studies are required to reveal the relationship between the TBSA and amputation type.

CONCLUSION

The major amputation rate was higher in burn patients who had a TBSA higher than 10% and compartment syndrome was higher in amputee burn patients than in all burn patients. Electrical burns were the major agents for amputation. There were two amputee groups: pediatric patients and male workers. To diminish the amputation incidence due to electrical burns, precautions should be taken at home as well as at work for children and workers, respectively. Educating parents and workers for the purpose of taking safety measures is essential to diminish the incidence of amputation caused by electrical burns.

Ethics Committee Approval: Authors declared that the research was conducted according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in 2013).

Informed Consent: Written informed consent was not received due to the retrospective nature of this study.

Peer-review: Externally peer-reviewed.

Authors' Contributions: Conceived and designed the study: BÖ. Collecting Data: AC. Analyzed the data: BÖ, AC. Wrote the paper: BÖ, AC. Supervision & Critical Reviews: BÖ. All authors have read and approved the final manuscript.

Conflict of Interest: No conflict of interest was declared by the authors.

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