Research Article (Araştırma Makalesi)

Low-and High-Voltage Electrical Burns in Children: Ten Years of Experience

Çocuklarda Düşük ve Yüksek Voltajlı Elektriksel Yanıklar: On Yıllık Deneyim

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Özet

Amaç: Yanık yaralanmaları her yaş için önemli bir halk sağlığı sorunudur. Elektrik yanıkları yüksek mortalite ve morbidite oranına sahip oldukları için diğer nedenlerle oluşan yanıklardan farklı olarak değerlendirilmelidir. Bu çalışmanın amacı çocuklarda yüksek ve düşük voltajlı elektriksel yanıklar ile ilişkili olabilecek faktörleri belirlemektir.

Gereç ve Yöntemler: Elektrik yanığı nedeni ile tedavi gören toplam 72 hastanın kayıtları retrospektif olarak incelendi. Elektriksel yanıklar düşük ve yüksek voltajlı olarak iki gruba ayrıldı. İki grup arasında demografik veriler, klinik seyir, tedavi ve sonuçlar karşılaştırıldı.

Bulgular: Çalışmada hastaların %83.3'ünde düşük voltaj, %17.7'sinde yüksek voltaj elektriksel yanık saptandı. Kırsal kesimde oturanlarda yüksek voltaj yanığı daha fazla saptandı ($p<0.05$) Düşük voltajlı elektriksel yanıklar daha çok ev kazası (%90) sonucu oluşurken yüksek voltajlı yaralanmalar çoğunlukla iş kazası (%100) sonucu oluşmuştu ($p<0.05$). Düşük voltajlı yaralanmalar en sık elektrik prizi ile temas (%91.6), yüksek voltajlı yaralanmalarda trafo ile temas (%83.3)($p<0.05$) sonucu oluşmuştu. Yüksek voltaj yaralanmalarda yanık şiddeti daha derin ve hastanede kalış süresi daha uzundu ($p<0.05$).

Sonuç: Çocuklarda düşük voltajlı elektriksel yanık yaralanması daha sık görülmektedir. Yüksek voltaj yaralanmalarda düşük voltajlı yaralanmalarına oranla cerrahi tedavi gereksinimi, hastanede kalış süresi ve morbidite oranı daha fazladır. Elektriksel yanıkların nedenleri ve koruyucu önlemler ile ilgili eğitimler yapılması, kırsal kesimde alt yapıların düzenlenmesi ile elektriksel yanıklar azaltılabilir.

Anahtar kelimeler: Çocuk, Elektriksel yanık, Yanık

Abstract

Objective: Burn injuries are an important public health problem for all ages. Due to electrical burns high mortality and morbidity rates, they should be evaluated differently from burns from other sources. This study aims to determine factors associated with high-and low-voltage electrical burns in children.

Materials and Methods: The records of 72 patients who were treated for electrical burns were analysed. Electrical burns were divided into two groups: low and high voltage. Demographic data, treatment, outcomes were compared between the two groups.

Results: In this study, low-voltage electrical burns were detected in 83.3% of the patients, and high-voltage electrical burns were detected in 17.7% of the patients. High-voltage burns were more common in rural residents ($p<0.05$). Low-voltage electrical burns mostly occurred as a result of home accidents (90%), while high-voltage injuries were mostly caused by work accidents (100%), ($p<0.05$). The most common cause of low-voltage injuries was contact with an electrical outlet (91.6%), for high-voltage injuries it was contact with a transformer (83.3%) ($p<0.05$). For high-voltage injuries, the severity of the burns was higher, the duration of the hospital stay was longer ($p<0.05$).

Conclusion: Children generally have low-voltage injuries. High-voltage injuries are associated with more surgical treatment and morbidity, longer hospital stays. Electrical burns can be reduced by training on protective measures and proper arrangement of infrastructure in rural areas

Keywords: Burn, Child, Electrical burn

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INTRODUCTION

Burn injuries are an important public health problem for all ages. Electrical Burn Injury (EBIs) constitute 5–7% of all burns (1). Due to their high mortality and morbidity rates, EBIs should be evaluated differently from burns from other sources. With thermal burns, nerve damage, tendon diffusion, or contracture may develop on a small burn surface area that can only be healed by dressing it, and reconstructive surgery may be required (2). Factors such as voltage magnitude, current type, exposure time, individual tissue susceptibility and skin wetness affect the severity of EBIs (3-8). Factors involved in the etiology of EBIs vary according to education level and socioeconomic conditions, cultural factors, industrialization (9,10). While low-voltage EBIs are more common in developed countries, high-voltage EBIs are more common in developing countries (11). Most EBIs occur as a result of preventable home or work accidents (9,12,13). EBIs occur mostly in adults after work accidents, in children after home accidents or while playing at home. (3,14,15) Despite burn intensive care centers, the best way to reduce the frequency of electrical burns and the mortality and morbidity associated with burns is to prevent burns. (3). Studies related to the etiology of EBIs are of vital importance in determining preventive measures. The aim of our study was to evaluate factors that may be associated with high- and low-voltage EBIs in children, and to help determine protective measures.

MATERIALS AND METHODS

In this study, records of paediatric patients admitted to the burn centre of tertiary level training and research hospital between January 2010 and January 2020 were reviewed retrospectively. The study was approved by the Clinical Studies Ethics Committee of Health Sciences University Gazi Yasargil Training and Research Hospital (25.09.2020/No:571). This study was conducted in accordance with the Principles of the Declaration of Helsinki.

Patients treated for EBIs were included in the study. Patients with missing data were excluded from the study.

Age, gender, place of residence, and season of admission to the hospital were recorded. Burn mechanism, burn percentage, burn degree, localisation, examination findings, accompanying injuries, treatments applied, duration of hospital stay, mortality and morbidity rates were evaluated.

The place of residence of the patients was classified as rural or urban. The admission season was categorised as either winter, autumn, spring, or summer. EBIs were divided into two groups: low voltage if they were formed with a voltage less than 1000 V, and high voltage if they were formed with a voltage greater than 1000 V (7,9). Demographic data, clinical course, treatment, and outcomes of the high- and low-voltage electrical burns were compared.

Statistical Analysis

The data in this study were statistically analysed using the SPSS for Windows statistical package. Descriptive statistics for continuous variables and categorical variables are expressed as numbers and percentages, as are mean, standard deviation, and minimum and maximum values. Chi-square tests were used to determine the relationship between groups and categorical variables, and Student-t-tests were used to compare group means of continuous variables. $P<0.05$ was considered statistically significant.

RESULTS

In total, 72 patients were included in the study. Low-voltage EBIs were found in 83.3% of the patients, and high-voltage EBIs in 17.7% of the patients.

In low voltage EBIs, the mean age was 9.1±5.1 years, 30% of the patients were girls and 70% were boys. In high voltage EBIs, the mean age was 12±4.4 years, 16.7% of the patients were girls and 83.3% were boys. There was no difference between rates of low-and high-voltage EBIs in terms of age and gender ($p>0.05$) (**Table 1**).

Overall, 6.7% of patients with low-voltage EBIs resided in rural areas, and 50% of patients with high-voltage EBIs lived in rural areas. High-voltage burns were more common in rural residents ($p<0.05$). While low-voltage EBIs were mostly caused by home accidents (90%), high-voltage injuries were mostly caused by work accidents (100%; $p<0.05$). The most common cause of injury in low-voltage EBI patients was contact with an electrical outlet (91.6%), to a lesser extent, telephone cable (1.7%), electric cable (1.7%), electric stove (1.7%), electric cooker (3.3%) and while in high-voltage EBI patients, it was contact with a transformer (83.3%) and intercity electricity transmission line (16.7%). The burn mechanisms were different between the two groups ($p<0.05$) (**Table 1**).

In 95.8% of the patients participating in the study, the total burned surface area varied between 1–10%. In low-voltage EBIs patients, the total burn surface was 1-10% in 98.3% of patients and 11-20% in 1.7% of patients. The burn area of the total body surface was 1-10% in 83.3% and >30% in 16.7% of the high-voltage EBIs.

Table 1. Sociodemographic data of the patients participating in the study			
Characteristic	**Low voltage injuries (n=60)**	**High voltage injuries (n=12)**	**P Value**
Mean age(year)(min-max)	9.1±5.1(1-17)	12±4.4(4-17)	0.451
Gender n(%)			0.107
Female	18(30)	2(16.7)	
Male	42(70)	10(83.3)	
Residence n(%)			**0.025**
Urban(%)	56(93.3)	6(50)	
Rural n(%)	4(6.7)	6(50)	
Location of injury n(%)			**0.001**
Home	54(90)	0(0)	
Workplace	6(10)	12(100)	
Season n(%)			0.185
Winter	8(13.3)	4(33.3)	
Spring	18(30)	4(33.3)	
Summer	24(40)	3(25)	
Autumn	10(16.7)	1(8.4)	

Burn degree was 78.3% second degree and 21.7% third degree in low voltage EBIs. Of high voltage EBIs, 16.7% had second-degree burns, and 83.3% had third-degree burns. Burn severity of high-voltage EBIs was higher ($p<0.05$) (**Table 2**).

In both high voltage and low voltage groups, upper extremities were the most frequently affected body areas, 93.3% and 58.3% respectively. Low-voltage EBIs were seen more during the summer months, and high-voltage EBIs during the winter and spring months. There was no difference between the two groups in terms of the season in which the burn occurred ($p>0.05$). The mean hospital stay was 15.8±8.1 days for high-voltage EBIs and 4.5±2.2 days for low-voltage EBIs. High-voltage EBI patients had longer hospital stays ($p<0.05$) (**Table** 2).

Transient loss of consciousness (n=4), pulmonary edema (n=1), subarachnoid haemorrhage (n=1), and radius fracture (n=1) due to a fall after the accident were detected in high-voltage EBI patients. There were no concomitant injuries in low-voltage EBI patients.

Of the low-voltage EBI patients, 78.3% were treated with daily dressing. Fasciotomy was performed in 1.7%, partial thickness skin graft was applied to 20% of the patients, and no morbidity was detected in their follow-ups. Fasciotomy was performed in 8.3% of high-voltage EBIs, and split-thickness skin grafts were applied in 75%. (**Table 2**). Contracture was found in the neck region in two patients, and reconstructive surgery was performed. The rate of surgical treatment was higher in high-voltage EBI patients ($p<0.05$).

Amputation was not performed on any of the patients participating in the study, and there was no death.

DISCUSSION

Although EBIs constitute a small percentage of burn cases, they are significant because they can cause lifelong morbidity, especially in children (12). In one study, it was reported that EBIs were most frequently related to domestic accidents and were more common in girls (2). However, in other studies, it has been reported that EBIs are more common in men (1,5,6,9,17-20). Since some patients in our city were admitted to other burn centres, the frequency of electric shock burns in our study (1.5%) was lower than in the literature. Although not to a statistically significant degree, EBIs were more common in males. Electrical burns may have been more common in boys because they may be more interested in electrical devices, because they start working life sooner, or because child workers do not use protective equipment. It has been reported that low-voltage EBIs are more common in young children, and high-voltage EBIs are more common in adolescents (11,21). In our study, no difference was found in terms of age between high-voltage and low-voltage injuries. It may be possible to prevent these injuries by educating families and children and not leaving children alone in places where electrical objects are exposed.

Table 2. Characteristics of low and high voltage injury in children			
Characteristic	**Low voltage injuries (n=60)**	**High voltage injuries (n=12)**	**P value**
Total burn surface area n(%)			0.091
%1-10	59(98.3)	10(83.3)	
%11-20	1(1.7)	0(0)	
% >30	0(0)	2(16.7)	
Burn degree n(%)			**0.005**
Second	47 (78.3)	2(16.7)	
Third	13 (21.7)	10(83.3)	
Site of burn n(%)			0.052
Upper extremity	56 (93.3)	7(58.3)	
Neck	0(0)	2(16.7)	
Lower extremity	4 (6.7)	3(25)	
Mechanism of injury n(%)			**0.004**
Telephone cable	1(1.7)	0(0)	
Electric cable	1(1.7)	0(0)	
Electrical transmission line	0(0)	2(16.7)	
Transformer panel	0(0)	10(83.3)	
Electric stove	1(1.7)	0(0)	
Electric cooker	2(3.3)	0(0)	
Electrical outlet	55(91.6)	0(0)	
Length of stay in the hospital			
days,mean(min-max)	4.5±2.2 (3-10)	15.8±8.1(7-34)	**0.002**
Treatment n(%)			**0.008**
Wound dressing	47(78.3)	0(0)	
Fasciotomy	1 (1.7)	1(8.3)	
Split-thickness skin graft	12(20)	9(75)	
Reconstructive surgery	0(0)	2(16.7)	

EBIs occur in young children due to contact with electrical sockets or electrical cables, and in adolescents due to work accidents (12,21-25). Low voltage injuries are generally seen in children (26). High-voltage injuries are more common in rural areas in developing countries, industrialized countries, where education levels are low and infrastructure is inadequate (1-3,11,14),). The results of our study are compatible with the literature, in that low-voltage burns were more common. Contact with an electrical socket at home is caused by foreign object or finger insertion into the socket. Home accidents cause low-voltage burns because low voltage electricity (220 V) is used in homes. EBIs due to home accidents can be prevented by installing covers on electrical outlets and placing electrical sockets at a height out of the reach of children. In our study, high-voltage burns were more common in rural areas where infrastructure was lacking. High-voltage burns occurred as a result of unintended contact by the children with unknown electrical transmission lines and electrical transformer panels. High-voltage EBIs can be reduced by moving electricity transmission lines underground and moving high-voltage lines and transformer panels outside of residential areas.

In EBIs, there may be accompanying injuries due to the effects of the electric current or falling after the electric shock. Visceral injuries, laceration, haemorrhage, head trauma, and extremity fractures may be seen (1,8,9,26). The results of our study support previously published studies. Cranial, lung, and extremity injuries were detected in high-voltage EBI patients, mostly due to falling during the accident and, to a lesser extent, the effect of the electrical current. It should be kept in mind that organ injuries may occur in addition to burns, especially when high-voltage EBIs cause more severe injury.

EBIs cause more severe burns in children than adults. Electric current causes more tissue damage in children because the skin is thin, there is less subcutaneous adipose tissue, and there is more body surface (1,23). It has been reported that EBIs are most common on the hands and fingers and less common on the head, neck, and lower extremities (1,11,22,27). In our study, EBIs were detected most frequently on the upper extremities. Lower extremity burns were less common and were caused by pressing on exposed electrical wires. A reduction in the number of EBIs can be achieved with infrastructure regulation in rural areas. Upper extremity burns may be more frequent because patients usually come into contact with electrical objects with their hands.

The magnitude of the exposed voltage is one of the factors affecting the severity of the burn. The severity of high-voltage EBIs is higher, the morbidity rate is higher, and more reconstructions are performed as a result of them compared to low-voltage EBIs (11,14,28). It has been reported that more fasciotomies and limb amputations are performed on high-voltage EBI patients and that their hospital stays are longer (1,14). The results of our study are consistent with the literature, as the severity of high-voltage EBIs burns was higher, and the rate of surgical treatment was higher. Parents, teachers, and health workers have a great responsibility to train children in the prevention of electrical burns, which cause permanent disabilities and reduce quality of life in children.

It is thought that the frequency of EBIs may be related to the season. In their study, Duci et al. stated that low-voltage EBIs are mostly seen in the winter months due to the use of alternative energy sources to meet the needs of households, while high-voltage EBIs are generally seen in the summer due to the installation of high-voltage electrical cables by inexperienced personnel (9). In our study, although low-voltage EBIs were more common in summer and high-voltage injuries were more common in winter and spring, it was not to a statistically significant degree.

The limitations of the study were that it was retrospective and was conducted in a single centre.

CONCLUSION

Electrical injuries cause more severe burns in children than adults. In children, low-voltage injuries generally occur as a result of contact with electrical objects, and high-voltage injuries are less common. High-voltage EBIs are associated with more surgical treatment, longer hospital stays, and greater morbidity. EBIs can be reduced by educating children and families through training on EBIs and protective measures in schools and primary healthcare institutions, by preventing children from accessing electrical objects, and by proper arrangement of infrastructure in rural areas.

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