Journal of
Clinical & Medical Surgery

www.jclinmedsurgery.com

ISSN 2833-5465
Open Access
Volume 4

Research Article

The Incidence and Treatment of Electrical Injuries during 20 Years in the Clinic of Burns and Reconstructive Surgery of Kosice-Saca Hospital, Slovakia

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Article Information

Received: Jun 08, 2024

Accepted: Jul 04, 2024

Published: Jul 11, 2024

Archived: www.jclinmedsurgery.com

Abstract

Retrospective analysis of patients with electrical injuries hospitalized during 20 years in the Clinic of Burns and Reconstructive Surgery of Kosice-Saca Hospital, Slovakia. From 4674 patients 147 were admitted with elecrical injury (3,14%). Most of them were men (103/70.1%) followed by children (38/25,85%) and 4 women (6/4,05%). The distribution of low/high tension injury was 98/49. Children younger than 6 years suffered mostly from low, older from high tension injury. The average TBSA was the highest in men (9,15%), followed by women (6,66%) and children (1,06%). Surgical treatment (necrectomy, skin grafting, flap plasty, amputation) was necessary in 66 men (64%), 32 children (84,2%) and in all 6 women. The need of hospital stay the longest in men as compare with children and women 26,04; 19,3 and 11,66 days respectively. During this period only 3 fatal outcomes occured, all in men as results of high voltage injury combined with polytrauma. In two cases cardiac arrest was the immediate cause of death. The results of this study according to causes, complications and treatment modalities are in accordance with most of similar studies carried out in several regions of the world.

Keywords: Electrical injury; Burns; High voltage; Low voltage.

Introduction

Electricity, an essential prerequisite of everyday life can cause serious and mutilating injuries and life threatening situations in case of accidents or misuse. Electrical injuries are divided into two types according to the voltage (despite the fact that the not the voltage but the current is the main factor of the severity of injury). Injuries caused by currents up to 1000V is considered as low-voltage and above 1000V as high-voltage electrotrauma [1]. Another, more practical classification is to „direct electrical injury" which is mostly equivalent to low-voltage injury and „electrical arc injury" caused by very high voltage (in the kV range). Low-voltage injury is caused mostly by alternating current used in households, public places and industry. High-voltage injury occurs usually mostly as occupational accidents. A special but rare forms are the injuries caused by lightning.

Patients with serious electrical injuries are mostly admitted to burn centres but electrical injuries are different from burns caused by fire, hot fluids and contact with hot objects. The main difference is that current entering the body through the skin is affecting deep structures [2-7]. The most awesome consequence of low-voltage injury is cardiac arrest caused by ventricular fibrillation or permanent contraction of the cardiac muscle but other internal organs are often affected, too. Electrical arc injury is also specific because the temperature of the ionized par-

ticles and surrounding gases of the arc can be as high as 4000°C and can immediately carbonize soft tissues and melt bones.

The effects of electricity on the body in general follow the rules of Ohm's law and are determined by several factors:

- Type of current, its intensity and voltage.
- Pathway of current, duration and area of contact.
- Resistance of the skin and the tissues affected.

The effects of low voltage electric currents passing through the body are usually reversible. For a short contact time, a current of 1 mA is the threshold of perception, a current of 10-15 mA causes sustained muscular contraction, and a current of 50-100 mA can result in respiratory paralysis and cardiac arrest. The burns associated with electrical injury depend on energy trasmitted to the skin and the tissues (muscles, nerves) on the pathway of the current according to Joule's law. Life-threatening consequences of low-voltage electric burns can occur without any lesions of the skin at entry and exit points of the current. Absence of local lesions indicates that the surface area of contact was large and/or the resistance of skin was low (wet skin). High-voltage accidents are usually associated with polytrauma [8,9].

The aim of our study was a retrospective analysis of electrical injuries and their treatment admitted and treated at the burns centre of our hospital in years 2004-2023.

Patients and methods

4674 patients from January 1, 2004 to January 1, 2024 were hospitalized in the Clinic of Burns and Reconstructive Surgery of Kosice-Saca Hospital. From these 147 patients were admitted with elecrical injury (3,14%), mostly from eastern regions of our country (population cca 2,5 million). The data of patients were analyzed according to type of injury, sex, age, and according to treatment modalities and prognosis. The data were evaluated by standard statistical methods.

Results

Most of the victims of electrical injury were men with low tension injury, followed by children and only 6 women suffered electrical injury during this period (Table 1). The lowest number was in 2019 (2 admissions) and the highest in 2005 (15 admissions) without any statistically significant trend of change during the evaluated 20 years.

The mechanism of the injury in the group of men was mostly direct contact with the source of current and electric arc injury, and in one case lightning injury. 48 cases of men (46,6%) were work associated. In 16 patients other kind of trauma (vulnera lacerocontusa, fractures of bones, dislaceratio lienis, contusio renis, pneumothorax, commotio cerebri, fissura hepatis, contusio pulmonum). 39 victims from the group of men were unconscious at the time of injury, in 9 of them artificial ventilation was necessary. In the children the electrical injuries were not work associated but 8 of them had associated injuries and 10 of them were unconscious. The distribution according to age and injury type of the children is in Figure 1.

High voltage injury was typical in the age group 7 years and older. The 6 cases of electrical injury of women were not work associated but 2 of them were unconscious. The need of hospital stay was in the group of men in average 26,04 days, in the group of children 193 days, and in women 11,66 days (Table 2).

The mortality of the patients was low and only 3 men died as a consequence of electrical injury. All of them were injured by high voltage and in two patients electrical current damage of the heart was the principal cause of death.

1. 29 years, high voltage injury and fall from 15 m height, conscious. Burns 80% TBSA, polytrauma, rupture of spleen and haemorrhagic shock due to internal bleeding (haemoperitoneum). Despite intensive treatment no recovery of kidney function. Cardiac arrest and exitus lethalis on the 14th day.

2. 36 years, high voltage injury, fall from the pylon, unconscious. Paramedical first aid at the site. Burns 69% TBSA crush syndrome and shock with anuria. ECG and biochemical markers of myocardium damage by electrical current. Cardiac arrest on the 2nd day, exitus lethalis.

3. 19 years, high voltage injury and fall, conscious. Burns 31% TBSA with carbonisation of the left hand and arm (amputation necessary). Tachycardia 136/min, BP 90/60; Biochemical signs of acute myocardial infarction. Anuria. Exitus lethalis due to cardiorespiratory failure on 3rd day / Figure 2.

The basic aim of wound treatment at our clinic is to give time to tissues spontaneous recovery. The treatment (after routine examination and evaluation of the injury) begins with intravenous fluid administration according to Parkland formula with Ringer lactate or updated Brooke Army Hospital formula. In children fluid administration is performed according Galveston Shriners Burns Hospital formula. The rate of fluid administration is tailored to the diuresis controlled every hour but is at least 1 ml/kg.

Non-viable tissues were removed as soon as possible by necrectomy followed by reconstruction of the skin coverage by skin grafting or flap plasties. In most serious cases of mutilating electric injuries we was forced to perform amputation due to gangraenous limbs.

The need of surgical interventions was altogether 174 operations in 104 patients and 43 injuries healed spontaneously. In men 80 of intervention were skin grafting and 25 flap plasties (64 and 20%). In 26 cases (men 20, children 6) amputations were necessary. In the children's group most of them were treated surgically (32 cases, 84,2%) and only 6 of them healed spontaneously. All 6 women were treated surgically (4 skin grafting and 2 flap plasty).

Table 1: Basic parameters of patients with electrical injury during 20 years.

Group	Number	Age Average,Years	Lowvoltage (Direct) injurry	Highvoltage (ARC) injurry
Men	103(70,1%)	44,9	61(59,2%)	42(40,8%)
Children	38(25,85%)	7,3	27(71,05%)	11(28,95%)
Women	6(4,05%)	41,5	All	

Table 2: Characterization of electrical injury.

Group	TBSA, % average, range	Mechanism Direct/ARC	Associated Injuries	Unconsiousness/ Artificial ventilation	Hospital stay days
Men	9,15(1-80)	63/39*	16	39/9	26,04(3-66)
Children	5,80(1-45)	34/4	8	10/0	19,30(2-78)
Women	6,66(1-32)	6/0	0	2/0	11,66(6-16)

*And one lightning injury

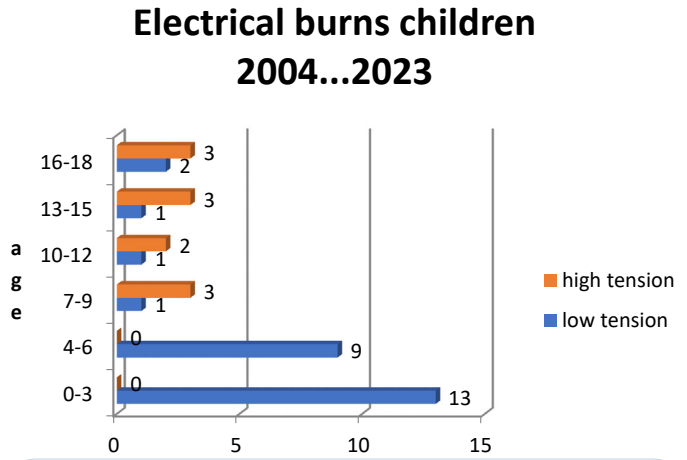

Figure 1: Distribution of electrical burns according to age and tension type in children.

Figure 2: Patient image.

Discussion

In our clinic electrical injury was present in 3,14% of all hospitalized burn patients in the last 20 years. This is in accordance with the data of most other studies from burn centers in different parts of the world [10,11], but in some the incidence was higher (9.1 and 16.4%) [12,13]. However, the true incidence in the general population can be considerably higher because minor accident are not referred to medical institutions and/or are treated in local outpatient clinics. The outcome of high voltage injuries even in profesionals is very dubious and often lead to invalidisation of worker as reported [14]. The danger of electrical injuries as compared to burns of other causes lies in the possibility of hidden damage of internal tissues and organs, especially the heart. This was the case in our case report No 3 but a similar accident with late onset ventricular fibrilation was also presented [15]. The distribution of electrical burn injuries according to its type,, need of surgical treatment is also very similar to our experiences and treatment modalities [16-18].

Electrical burns in children are very rare (38 during 20 years in our study) as compared with other type of general injuries and burns in young people, but they are more dangerous because there are important anatomical, physiological and psychosocial differences between adults and children. Their body proportions are different, they have thinner skin, smaller airways, less blood volume and high levels of distress. Some specific conditions of electrical burn injury in children are described in literature [19-22].The age distribution of electrical burns in children is also very instructive- low voltage injuries prevail in age up to 6 years and in older age high voltage injuries are more common as results of hazardous behavior. As a matter fact this was the case also in our No 3- the injury of the 19 year old boy was not an occupational one. Less soft covering tissue, the lack of supervising adults can lead to mutilating electrical injuries of children, ending with amputation surgery as was described by some authors [23]. Our finding is, that very important is the first examination and management of electrical injury to hand and upper limb, that can save tissues, digits and limbs. This expierence was also reported by other authors [24-26].

Conclusion

The treatment to electrical injury is based on multidisciplinary cooperation to save the patient, allow him recovery with minimum mutilation and maintain the functions [27]. The long time must be given for special rehabilitation and splinting as a prevention of scar and joint contractures. From social point of view is very important the psychological support to patient from the family backgrorund and friends. These factors can help the patient find the way back to life.

Conflict of interest: The authors have no conflict of interest.

Funding: No funding received from any national or international organization.

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