HIGH VOLTAGE ELECTRICAL INJURY: AN 11-YEAR SINGLE CENTER EPIDEMIOLOGICAL STUDY

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SUMMARY. The aim of our study was to retrospectively evaluate the epidemiological characteristics of patients with high voltage electrical injury from 1999 to 2009. The Clinic of Burns and Reconstructive Surgery, Faculty Hospital Brno is located in a region of 2,505,000 inhabitants. In total 13,911 patients (including both children and adults, and outpatients as well as hospitalized patients) were treated at our burn center during the period of study. Of these patients, 1,030 were hospitalized for burns treatment. For the purposes of this study, we have included only patients with high voltage electrical trauma, of which there were 58, 2 of whom were female. Basic epidemiological indicators were gathered on these patients, including age, gender, place of accident, extent of trauma, mortality and whether the injury was occupational or non-occupational. Electrical burns (caused by both low-voltage and high-voltage electric current) made up 1.10% of all burns treated in our burn center and high voltage electrical injuries represented 0.42% of all burn injuries. The average incidence of high voltage electrical trauma was 0.21 cases/100,000 inhabitants. The average age of the patients was 28.59 years. Nine patients died and the mortality was fixed at 15.52%. The average length of hospitalization was 53.43 days. The average extent of burnt area was 35.01% TBSA. In our study, we were able to define the basic epidemiological parameters in 58 patients with high voltage electrical trauma. We also have to highlight the still disappointingly high number of non-occupational electrical injuries affecting those in the lower age groups, especially children. However, preventive programmes for educating specific risk groups have shown positive results.

Keywords: electrotrauma, epidemiology, prevention

Introduction

Electric shock injuries have been around for as long as the discovery of electricity itself. The first documented case was in 1879 when a French carpenter suffered a low voltage injury (250V) while handling a generator.¹ High voltage electrical injuries are fairly infrequent but, with the high mutilating potential and associated frequent need for amputation, these are some of the most challenging injuries, often leading to lifelong stigmatization of the patient.³ Moreover, during treatment of this trauma, many acute and chronic abnormalities that require an interdisciplinary approach can occur.

As regards non-occupational electrical trauma, teenagers are the most affected age group. As regards occupational electrical injury, patients of productive age around 30-40 years are the most affected. Low voltage trauma is more common among the toddler age group, due to their explorative behaviour, while high voltage injury occurs more frequently in adolescents, mainly due to them climbing over trains.³ Both low and high voltage injuries occur in adults and are generally occupational injuries.

The extent of disability depends not only on the size and the nature of the voltage current (DC or AC), but also the length of exposure, location and contact resistance of different tissues. The presence of extensive burns (seen often in high voltage accidents), the extent of muscle and myocardium necrosis, the impact on the central nervous system and subsequent development of multiorgan dysfunction determine morbidity and long-term prognosis of patients.⁴

Electrotrauma is divided between higher and lower voltage injuries, with a borderline of 1000 volts between the two types of injuries.⁴ Low voltage injuries typically cause only local disabilities in the place of contact, while

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high voltage injuries usually induce local disabilities and extensive devastation of deep structures, along with systemic effects.\textsuperscript{5,6,7} The term electrotrauma actually conceals three different mechanisms, that determine the prognosis of the patient: 1) electrotrauma with the passage of electric current 2) electric arc 3) secondary flame burns on ignition of clothing.\textsuperscript{2,8}

In this article, we present the data from years of quality care and treatment of patients with these types of injury at the Clinic of Burns and Reconstructive Surgery, Faculty Hospital Brno.

**Material and methods**

A retrospective single-center study was conducted from January 1 1999 to December 31 2009. During this period, a total of 1,030 patients were hospitalized for burns treatment at the Clinic of Burns and Reconstructive Surgery. The study included only patients with high voltage electrical injuries. For these patients, basic epidemiological indicators such as age, sex, place of accident, extent of disability, mortality and occupational or non-occupational type of accident have been gathered.

Treatment for high-voltage electrotrauma in the Czech Republic is carried out in three burn centers (Prague, Ostrava, Brno). In the period from 1999 to 2009, there were 2,505,000 inhabitants in the region where the Clinic of Burns and Reconstructive Surgery, Faculty Hospital Brno is located. In the Czech Republic, the voltages for transformer stations are 22 kV, 110 kV, 220 kV and 400 kV. In the case of railways, the state is divided south-north (alternating current, 25 kV in the southern part of the Czech Republic or direct current 3000V in the north of the Czech Republic).

**Results**

**Incidence**

In total, 13,911 patients (including children and adults, outpatients and hospitalized patients) were treated at our burn center in Brno from 1999 to 2009. The study included 58 patients (2 of whom were female) treated with high voltage trauma. The largest number of patients with high voltage electrotrauma presented to our clinic in 1999 (10 patients), and the lowest number of patients presented in 2006 and 2008 (2 patients, in both cases). Electrical burns (caused by low voltage and high voltage electric current) represented 1.10% of all burns treated at our burn center. High voltage electrical injuries represented 0.42% of all burn injuries. Given that the total number of patients admitted with severe burns on our BICU in that period was 1,030, the patients with high voltage trauma represented 5.63% of all cases. The average incidence of high voltage electrotrauma for the period was 0.21 cases/100000 inhabitants.

**Mortality**

9 patients died, with a fixed mortality rate of 15.52%. The number of patients and deaths in each year of the period can be seen in Fig. 1 below.

**Sex, age**

There were only 2 women in the group of patients (3.45%). The average age of the patients was 28.59 years. The youngest patient was 9 years old, the oldest 68 years old. The distribution of patients in various age categories is shown in Fig. 2.

**Length of hospital stay, extent of burn wound**

The average length of hospitalization was 53.43 days (SD = 31.73), patients who died were not included in this calculation. The average extent of burnt areas was 35.01% TBSA (total body surface area). The extent of burnt areas in each year of the period is shown in Fig. 3.
Amputations

The high potential for causing devastation to body parts was also confirmed in our study; 30 amputations of the extremities, 20 in upper and 10 in lower limbs, were performed in total.

Occupational or non-occupational type of accident

Electrotrauma represents a frequent type of accident at work. Among our group of patients, 22 injuries (37.93%) were work-related and 36 (62.07%) were incurred during leisure time. Occupational injuries occurred most often at transformer stations and on high voltage towers (Fig. 4). Table 1 shows age differences in relation to patients with either occupational or non-occupational type of injury and place of injury.

Table 1 - Age differences of patients by occupational or non-occupational type of injury and place of injury (AA - average age, SD - standard deviation)

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Total patients</th>
<th>Patients with work accidents</th>
<th>Patients with injuries not related to work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrified Railway</td>
<td>28</td>
<td>5 (AA = 41.23 y (SD = 15.72))</td>
<td>23 (AA = 15.50 y (SD = 4.34))</td>
</tr>
<tr>
<td>High Voltage Transmission Toner (power poles)</td>
<td>14</td>
<td>8 (AA = 31.50 y (SD = 11.22))</td>
<td>6 (AA = 19.83 y (SD = 6.49))</td>
</tr>
<tr>
<td>Substation Transformer Unit</td>
<td>14</td>
<td>9 (AA = 44.11 y (SD = 14.84))</td>
<td>5 (AA = 33.80 y (SD = 16.57))</td>
</tr>
<tr>
<td>Lightning strike</td>
<td>2</td>
<td>0</td>
<td>2 (AA = 41.00 y (SD = 32.53))</td>
</tr>
</tbody>
</table>

2 were the result of criminal acts, and in 11 cases no exact mechanism of accident was established. This can be seen in Fig. 5.

Cause of accident

Of the 58 cases of high voltage electrotrauma, 4 were accidents caused by another person, 40 were accidents caused by the victims themselves, 1 was a suicide attempt, and the rest were classified as criminal acts (Fig. 5).

Discussion

From the total of 13,911 burns patients in the period from January 1 1999 to December 31 2009, we treated 153 patients (1.10%) with electrotrauma and 58 patients (0.42%) with high voltage electrotrauma. This number is very low in comparison to other epidemiological studies, because electrotrauma generally represents 3-7% of all burns. Mortality of patients with high voltage electrotrauma ranges from 0-21.7%. The mortality in our study was 15.52%.

Epidemiological data from an Italian study summariz-
ing a total of 1,991 patients, hospitalized with thermal burns in 2008, show that 4% of these injuries were caused by electricity. The epidemiological study conducted by Maghsoudi et al. focused on the mechanisms, complications, morbidity and mortality of patients with high voltage electrotrauma. Among 5,053 patients hospitalized with acute burns, 202 patients (4%) suffered electrotrauma, and 54% of these were high voltage electrotraumas, including 4% caused by lightning. The overall mortality was 2%. Conversely, in an epidemiological study of 314 adult burns patients in Turkey, Avşaroğullari et al. show a disappointingly high proportion of patients with electrotrauma (11% of all patients and 17% of all hospitalized patients), although in comparison with previous studies there was a decline in incidence. Luz et al. recorded 820 burns patients admitted to hospital over a five-year period. Of these, 86 patients (10.4%) had suffered an electrical injury and 52 patients had suffered high voltage electrotrauma. Overall, mortality in the studied group was 8.1% and the mortality of patients with high voltage electrotrauma was 11.5%.

Arnaldo et al. analyzed the data of 700 patients admitted with electrical injury from 1982 to 2002. Of these, high-voltage electrotrauma was identified in 263 patients. Mortality was highest among patients with injuries caused by lightning (17.6%) and among patients with high voltage electrotrauma in general (5.3%). The incidence of electrotrauma was not the same in all age groups. A number of epidemiological studies aim to define the basic age stratification in relation to the incidence of electrotrauma. Anlatıcı et al. retrospectively evaluated the epidemiological data of 1,083 burns patients and showed that the incidence of electrotrauma in the under 14 years age group was 16.8% and in the over 14 years age group it was 39.7%. Pham et al. focused on the epidemiology of thermal trauma in patients over 55 years and found that electrotrauma in this age group is not very common. This was a multicenter study in which 23,180 patients over the age of 55 years were evaluated. In this age group, electrotrauma represented only 1.6% of all burns, while in patients aged over 75 years it was only 0.3%. In our group of patients, the most commonly afflicted are those aged 16-20 years old. In the age group of those over 55 years old, electrotrauma was recorded in only 6 patients (10.35%).

Electrotrauma is frequently caused by work-related accidents. Handschin et al. show a large number of high voltage electrotrauma in connection with accidents at work (72%). Among our group of patients, a total of 22 accidents (37.93%) occurred in relation to work and 36 (62.07%) occurred during leisure time. The most common places of work for these types of injuries were transformer stations (64.29%) and on high voltage poles (57.14%). Most of the studies that focused on high voltage electrotrauma confirm the high potential of this type of injury to cause mutilation. In various studies, the percentage of amputations ranges from 10% to 68%. In our group of patients, 30 limb amputations (51.7%) were performed. In any case, the optimal surgical approach and the timing of each surgery is always discussed for high voltage electrotrauma.

Most studies dealing with this issue consider the main cause of the increasingly high incidence of this type of trauma to be an insufficient number of preventive activities and programmes. Nonetheless, in general, the incidence of electrotrauma in developed countries is considerably lower than in developing countries, which corresponds exactly with the range of preventive activities. Lower incidence of electric shock injuries could be the result of a significant improvement in preventive activities in terms of education and improved technical standards and security, as well as strict observance of the principles of safety at work.

Even so, some of the lower incidence could also be explained by the increasing centralization of care for patients with electrotrauma, particularly over the last decade, leading some patients, especially those with low-voltage electrotrauma, to escape the records.

However, the low incidence of documented electrotrauma in our study is certainly the result of cooperation between the three burn centers in the Czech Republic regarding preventive activities dedicated to specific risk groups. The results of this study clearly show a high return on invested time and money.

**Conclusion**

In the study we have to point out a still disappointingly high number of non-occupational electrical accidents affecting those in the lower age groups, especially children. Recently, however, thanks to preventive activities and programmes aimed at this age group, we have recorded a dramatic decline in the incidence of high voltage electrotrauma in the Czech Republic. In comparison with the literature, the incidence of electrotrauma in our group was relatively low, but there is always the question of whether some patients are treated outside of the specialized centers. In any case, we continue to focus on preventive activities and improvement of the records of these serious injuries.
et ambulatoires ainsi que les patients hospitalisés) ont été traités dans notre centre pendant la période d'étude. Parmi ces patients, 1,030 ont été hospitalisés pour le traitement des brûlures. Aux fins de cette étude, nous avons inclus seulement les patients avec un traumatisme électrique à haute tension, il y en avait 58, dont 2 étaient des femmes. Des indicateurs épidémiologiques de base ont été recueillies sur ces patients, dont l’âge, le sexe, le lieu de l’accident, l’ampleur du traumatisme, de la mortalité et si la blessure était liée ou non au travail. Les brûlures électriques (causée par une basse tension et le courant électrique à haute tension) représentaient 1,10% de toutes les brûlures traitées dans notre centre, et des blessures électriques à haute tension représenté 0,42% de toutes les brûlures. L’incidence moyenne de traumatisme électrique à haute tension est de 0,21 cas pour 100,000 habitants. L’âge moyen des patients était de 28,59 années. Neuf patients sont décédés et la mortalité a été fixée à 15,52%. La durée moyenne d’hospitalisation était de 53,43 jours. La moyenne surface corporelle brûlée était 35.01% de la SCT. Dans notre étude, nous avons pu définir les paramètres épidémiologiques de base chez 58 patients atteints de traumatismes électrique à haute tension. Nous devons également mettre en évidence le nombre toujours élevé de blessures électriques non-professionnelles affectant ceux dans les groupes d’âge inférieures, surtout les enfants. Toutefois, les programmes de prévention pour sensibiliser les groupes à risque spécifiques ont montré des résultats positifs.

Mots-clés: electrotrauma, épidémiologie, prévention

BIBLIOGRAPHY

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