ELECTRICAL BURN INJURY: A COMPARISON OF OUTCOMES OF HIGH VOLTAGE VERSUS LOW VOLTAGE INJURY IN AN INDIAN SCENARIO

Srivastava S.,1 Kumari H.,2 Singh A.,2 Kumari Rai R.2*

1 Department of Plastic Surgery, Sawai Man Singh Medical College and Hospital, Rajasthan, India
2 University of Health Sciences, Jaipur, India

SUMMARY. Electrical burn injury (EBI) is a mutilating form of injury. The objective of this study was to evaluate the various aspects of EBI and analyse the differences between high voltage injury (HVI) and low voltage injury (LVI). A retrospective study was conducted by reviewing the medical records of all burn admissions from June 2016 to May 2017. A total of 1572 patients were admitted, of which 385 (24.49%) had suffered an electrical injury. 104 (27.01%) patients sustained LVI and 281 (72.98%) HVI. One hundred patients from both groups were randomly selected using the chit method, in order to analyse their differences. In our study, the mean age was 35.23±19.96 in the HVI group and 24.15±14.39 years in the LVI group. Most of the injuries were work related. Events during the early phase of admission included a rise in serum creatine phosphokinases, myoglobinuria, renal failure, abnormal cardiac events and other concomitant injuries in the HVI group (p<0.001). Unfavourable outcomes in the form of amputations, prolonged hospital stay and high mortality rate were observed in the HVI group (8.5%) (p<0.027). However, LVI cannot be overlooked as number of reconstructive surgeries and mean number of operations showed no significant difference between both groups. HVI has a disastrous impact on burn survivors but LVI cannot be underestimated. We advocate a low threshold for managing associated injuries, education on safety principles, for men at work especially, and infrastructure improvement by the state to bring changes to the present scenario.

Keywords: electrical burn, high voltage injury, low voltage injury, prevention

RÉSUMÉ. Les brûlures électrothermiques (BET) sont des blessures particulièrement mutilantes. Le but de cette étude rétrospective, conduite à partir des dossiers des patients hospitalisés entre juin 2016 et mai 2017 est d’analyser les BET et de comparer celles par bas voltage (BBV) à celles par haut voltage (BHV). Parmi les 1 572 patients, 385 (24,69%) avaient une BET dont 104 (27,01%) BBV et 281 (72,98%) BHV. Nous avons tiré au sort 100 dossiers de chaque groupe. L’âge du groupe BHV est de 32,23 +/- 19,96 ans, celui de BBV de 24,15 +/- 14,39 ans. La plupart des accidents ont lieu au travail. Le groupe BHV est plus à risque de complications initiales (rhabdomyolyse avec élévation des CPK, myoglobinurie, insuffisance rénale, complications cardiaques) et a plus fréquemment des lésions associées (p<0,001). La mortalité (8,5%) est plus élevée dans le groupe BHV, ainsi que le nombre d’amputations ainsi que la durée de séjour. Toutefois, il ne faut pas minimiser la gravité des BBV car le nombre d’intervention, initiales et de reconstruction, est superposable à celui observé dans les BHV. La prise en charge doit être spécialisée même en cas de BBV et la prévention (mesures de sécurité en particulier au travail, amélioration des infrastructures) doit être améliorée.

Mots-clés : brûlure électrothermique, haut voltage, bas voltage, prévention

Introduction

Electrical burn injury (EBI) still constitutes a major proportion of total burn admissions in India, and can be associated with significant morbidity and mortality. Most of these injuries in children tend to occur in the home, while most adults sustain them during workplace accidents. The spectrum of presentation is varied, ranging from minor to life threatening events, causing multisystem complications. Improvement in infrastructure by the state can reform the situation. Socioeconomic development worldwide has caused a reduction in the number of electrical burn patients; however, India has not witnessed this. This study is an attempt to elucidate the differences between high voltage (>1000kv) and low voltage (<1000kv) injuries, and identify prevention measures.

Materials and methods

A retrospective study was conducted by reviewing the medical records of all burn admissions to the Burns Unit of the Department of Burns and Plastic Surgery in SMS Hospital, Jaipur, from June 2016 to May 2017. The objective was to assess the proportion of electrical burns among the total number of admissions and to evaluate 100 cases from both groups in order to identify the significant differences between high voltage and low voltage injuries.
voltage injuries. The cases were randomly selected by the chit method. The SMS hospital in Jaipur is a tertiary care referral centre, one of the largest in the state of Rajasthan and North India. Data were collected by the principal investigator, by a self-answered questionnaire and the burn proforma. In cases where the patient was not able to narrate the history, close relatives were contacted. Burn size was calculated by the Lund and Browder chart. The patients were divided into HVI and LVI groups to analyse the differences between the two types of injury.

The sample size was 100 cases after rounding off in each group (high voltage and low voltage) at 95% confidence interval and 80% power to verify the expected proportion of surgical interventions, 54% in the low voltage group compared to 79.6% in the high voltage group. So for this study: Sample Size for Proportions - Alpha: 0.050, Expected p for Sample 1: 0.540, Expected p for Sample 2: 0.796, Power: 0.800.

Sample size for each sample: with continuity correction - 60, without continuity correction - 52.

The qualitative data were expressed in proportion and percentages and the quantitative data expressed as mean and standard deviation. The difference in proportion was analysed by Chi-square test and the difference in means by student t-test and ANOVA. Statistical analyses were done using SPSS software for Windows Version 23.0 (Armonk, NY). A p-value of <0.05 was considered to be significant.

Results

Demographics
A total of 1572 patients were admitted to the burns unit during this period, of which 385 (24.49%) had suffered an electrical injury. 104 (27.01%) patients sustained low voltage injuries while 281 (72.98%) patients had high voltage injury. From the hundred cases in each group, the following results were obtained. The mean age of the study population was 35.23±19.96 in the high voltage group and 24.15±14.39 years in the low voltage group. Men were more commonly affected in the high voltage group, and women in the low voltage group (p <0.001). However, no significant association was observed regarding whether they belonged to rural or urban population bases.

Mode of injury
Most of the injuries in the high voltage group were occupational, while the low voltage injuries were mainly sustained while using household appliances.

Associated injuries
The HVI group had a greater number of associated injuries, as shown in Table I. Fifty patients in the HVI group had bone injuries, compared to twenty patients in the LVI group, and were fixed by open reduction and internal fixation by the Orthopaedics Department. Thirteen patients in the HVI group had spinal cord injury, which was managed conservatively with physiotherapy. Sixty-six HVI patients had closed head injury, of which eight patients were drained for extradural hematoma by neurosurgeons. Sixteen head injury patients belonged to the LVI and were managed conservatively. Twenty-two HVI patients had chest injuries and rib fractures, for which intercostal drainage tube was inserted and managed. Only one patient in the low voltage group had chest injury, and was managed conservatively. Four HVI patients sustained intestinal injuries and were managed by urgent laparotomy. Two patients in the HVI group had loss of vision and were referred to the ophthalmologists for management. These findings are shown in Table I.

Table 1 - Associated injuries in HVI and LVI patients

<table>
<thead>
<tr>
<th>Associated injuries</th>
<th>HVI</th>
<th>LVI</th>
<th>TOTAL</th>
<th>P VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone injury</td>
<td>50</td>
<td>20</td>
<td>70</td>
<td>&lt;0.001S</td>
</tr>
<tr>
<td>Spine injury</td>
<td>13</td>
<td>0</td>
<td>13</td>
<td>&lt;0.001S</td>
</tr>
<tr>
<td>Chest injury</td>
<td>22</td>
<td>1</td>
<td>23</td>
<td>&lt;0.001S</td>
</tr>
<tr>
<td>Intestinal injury</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>0.13NS</td>
</tr>
<tr>
<td>Head injury</td>
<td>66</td>
<td>16</td>
<td>82</td>
<td>&lt;0.003S</td>
</tr>
<tr>
<td>Seizure</td>
<td>0</td>
<td>6</td>
<td>6</td>
<td>0.038S</td>
</tr>
<tr>
<td>Vision loss</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0.47NS</td>
</tr>
</tbody>
</table>

The high voltage group had a significantly larger cutaneous burn size. The mean burn size was significantly greater in the high voltage group - 24.08±8.69 - compared to 18.69±8.0.01 in the LVI group.

Resuscitation phase
More events occurred in the HVI group during the first 24 hrs of injury (escharotomy + fasciotomy): 80% compared to 61% in the LVI group (P<0.001). Elevated serum creatine phosphokinases (71% vs. 20%), myoglobinuria (74% vs. 35%) and renal failure (40% vs. 19%) were greater in the HVI group compared to the LVI group (P<0.001). The number of abnormal cardiac events in the form of sinus tachycardia, ectopic beats and rhythm disturbances were significantly higher in the HVI group. These observations are shown in Fig. 1 (events during the first 24 hours).

Complications
Complications in the form of amputations were significantly higher in the HVI than in the LVI group (52% vs. 26%). The most common site of amputation was the upper limb in the high voltage group. Acute respiratory distress syndrome, acute renal failure requiring dialysis, infection and ventilator support were seen significantly more in the high voltage group, as shown in Fig. 2 (complications and cause of death). Length of hospital stay was longer for the HVI patients (P<0.01).
Mortality rate was high in the HVI group (p<0.027) and was attributed to respiratory failure, multi-organ dysfunction, disseminated intravascular coagulation and renal failure.

Reconstructive procedures
Reconstructive procedures performed were early excision and skin grafting, and distant flaps such as groin and abdomen flaps. Microvascular free flaps were done in ten cases of high voltage injury. Ear reconstruction, rhinoplasty, scalp reconstruction and tendon reconstruction were done mainly in HVI cases. Details are given in Table II. The mean number of operations was greater in the HVI group, however it was not statistically significant.

Table II - Reconstructive surgeries in HVI and LVI

<table>
<thead>
<tr>
<th>Surgery</th>
<th>LVI</th>
<th>HVI</th>
<th>No. of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early excision + split thickness skin graft</td>
<td>50</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>Groin flap for hand defects</td>
<td>25</td>
<td>35</td>
<td>60</td>
</tr>
<tr>
<td>Abdominal flap for upper limb defects</td>
<td>18</td>
<td>27</td>
<td>45</td>
</tr>
<tr>
<td>Free flap</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Contracture release</td>
<td>25</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Tendon reconstruction</td>
<td>16</td>
<td>34</td>
<td>50</td>
</tr>
<tr>
<td>Ear reconstruction</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Rhinoplasty</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Scalp reconstruction</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Discussion
Burns are the fourth most important type of trauma worldwide following traffic accidents, fall and interpersonal violence. Injuries from electricity are mostly occupational and accidental. They have devastating sequelae in electrical burn survivors.

In our study, EBI constitutes approximately 24.49% of total burn admissions, which is a considerable proportion when compared to developed parts of the world (0.04-5%). Hospital data, however, do not represent the exact burden of injury. Low socioeconomic status is a compounding factor in its causation.

It is not an astonishing fact that electrical burn remains a considerable cause of morbidity in the developing parts of the world. High voltage injury causes thermal damage to the tissues and subsequent coagulative necrosis, as has been shown in many studies, subsequently leading to amputation. Demographic data show that a higher number of electrical injuries were occupational. The adult male population mostly sustained electrical burns at work, while most children suffered injuries at home from low voltage appliances. Males predominated the study population, which is quite similar to that observed in other studies. Cutaneous burn size was observed to be smaller compared to other types of burn injuries.

The impact of HVI was profound due to increased incidence of associated injuries, which further complicated its management. An increased rate of orthopaedic injuries, head injuries and other organ injuries due to fall associated with HVI were observed, and necessitated prompt diagnosis and management.

The magnitude of insult inflicted by the HVI was tremendous in view of the increased incidence of muscle necrosis, myoglobinuria, raised creatine phosphokinase levels and renal failure. These factors resulted in a greater number of fasciotomies, escharotomies and amputations.

Prolonged hospitalization and an increased number of surgical procedures were observed in the HVI group. Reconstructive procedures improved the quality of lives. However, the number of surgical procedures performed was not significant between the two groups, emphasizing the fact that LVI cannot be overlooked.

Electrical injuries are the fourth most common cause of traumatic work-related death. Mortality rates were high among the high voltage group (1-17%). We noted an overall mortality rate of 8.5%. However, this data does not include the sudden deaths, which occurred in both groups, of patients who did not reach the hospital.

It is of utmost importance that patients are referred to the plastic surgeon as early as possible, and that the plastic surgeon is involved at each step of the treatment ladder for a better overall outcome.

This study has its limitations in view of its retrospective nature and its population base. There is a lack of a national burn registry system in India, and hospital data represent only a minor fraction of total injuries. Serious HVI patients reach the tertiary care centre from the periphery, while LVI patients do not report to it, leading to overrepresentation of data. The economic costs of these injuries must be profound, but this is beyond the scope of this study and difficult to calculate.

“An ounce of prevention is worth a pound of cure”, said Benjamin Franklin, and this best defines the problem. The Indian Electricity Act 2003 should be adhered to while laying down power lines. Education about safety measures should be imparted, especially at work. Prevention of low voltage injuries is impacted by the use of a protective circuit that interrupts the electrical current in 1/40th of a second if an alteration in circuit occurs, both in homes and in the workplace. It is our duty to also educate parents in order to prevent children suffering such insults from household appliances.

Conclusion
The impact of HVI is catastrophic, but LVI cannot be underestimated. Public awareness and infrastructure improvement by the state can act together to reduce the burden of disease. A National Burn Registry System is required to assess the magnitude of the problem, as hospital records represent just the tip of the iceberg.
BIBLIOGRAPHY


Ethics approval and consent to participate. The study was approved by the institutional ethics committee for reviewing the medical records.

Availability of data and materials. Data may be available from the corresponding author on request.

Competing interests. The authors declare that they have no competing interests.