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Original Research Article

Epidemiology and outcomes of electric burn injury: a study of 768 patients in a high volume tertiary care centre of North India

Sunil Srivastava, Hiranmayi Kumari*, Abhimanyu Singh, Rohit Kumar Rai

Department of Burns and Plastic Surgery, SMS Medical College, Jaipur, Rajasthan, India

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***Correspondence:**
Dr. Hiranmayi Kumari,
E-mail: jhahiranmayi@gmail.com

ABSTRACT

Background: Electrical burn injuries (EBI) comprise a small proportion of the total burn admissions but they inflict significant morbidity. The objective of this study was to analyse recent epidemiologic data and identify prevention measures.
Methods: A retrospective study was conducted by reviewing the medical records of all burn admissions from April 2016 to March 2018 and data was analysed for demographic characteristics and outcomes and patterns of electric burn injury.
Results: A total of 3136 admissions were made. Male to female ratio was 1.5:1.0. Rural: urban ratio was 2:1. Mode of injury was accidental (79%), suicidal (12%) and homicidal (9%). Flame burn (64.47%) topped the list of etiologic factors. Electric burn represented 24.49% which was quite significant when compared to other parts of the world. 1042 patients expired (33.22%). Out of the total electric burn admissions, 768 (24.49%) patients were of electric injury. 207 (27.01%) patients sustained low voltage (<1000 kv) injuries while 561 (73.04%) patients had high voltage (>1000 kv) injury. Most of the injuries were work related. There was a rise in serum creatine phosphokinases, myoglobinuria, renal failure, abnormal cardiac events and other concomitant injuries in the high voltage group. Reconstructive surgeries performed in both high and low voltage group was high. A total of 71 (9.24%) fasciotomy and 123 (16.01%) amputations were done. The mortality rate was 10.5%.
Conclusions: EBI has a devastating influence on burn survivors. We advocate a low threshold for managing associated injuries, educating safety principles and improving infrastructure by the state to curb this preventable danger.

Keywords: Electric burn, Epidemiology, Morbidity, Mortality, Prevention

INTRODUCTION

Electrical burn injuries (EBI) comprise a small fraction of the total burn admissions but they are potentially a mutilating type.[1] Most of these injuries are preventable. Education programs and safety measures, both by the individual and the state, can bring changes in the present situation. Socioeconomic development worldwide has brought changes in the burn incidences; however, India has not witnessed the same. The electric injuries are divided into low voltage (<1000 kv, LVI) and high voltage (>1000 kv, HVI) injuries. The aim of this study is to highlight the morbidity and mortality associated with electric burn injury in a high volume tertiary care centre of north India and to identify prevention measures.

METHODS

A retrospective descriptive study was conducted by reviewing the medical records of all burn admissions at the Burns Unit of Department of Burns and Plastic

surgery of SMS Hospital, Jaipur, from April 2016 to March 2018. The objective was to analyse the demographic characteristics and outcomes and patterns of electrical injuries. SMS hospital at Jaipur is a tertiary care referral centre, one of the largest in the state of Rajasthan and North India. The burn centre catchment area includes 7.68 crore population of Rajasthan and the surrounding states. Data was collected by the principal investigator vide a self-answered questionnaire and the burn proforma. In cases where the patient was not able to narrate the history, close relatives were contacted for the same. Demographic characteristics of electric burn patients were noted out of the total burn admissions. They were further classified into high voltage (>1000 kv) and low voltage (<1000 kv) injuries. The burn size was calculated by Lund and Browders chart. Fasciotomies and escharotomies were done by clinical evaluation (tense compartments and pain on passive stretch). The patients were treated by fluid resuscitations, continuous cardiac monitoring and muscle enzymes. Mannitol and soda bicarbonate was used for the treatment of myoglobinuria. Cardiac evaluation was done by serial ECG monitoring. Amputations were done after evaluating the exact vascular status by obtaining a CT angiography of the limbs, before subjecting the patient to the emotional trauma of disability.

RESULTS

Demography: A total of 3136 admissions were made. Male to female ratio was 1.5:1.0. Highest number of patients belonged to the 5-40 years age-group (53.38%). Rural: urban ratio was 2:1. Mode of injury was accidental (79%), suicidal (12%) and homicidal (9%). Flame burn (64.47%) topped the list of etiologic factors. Electric burn represented 24.49% which was quite significant when compared to other parts of the world. 1042 patients expired (33.22%), details are mentioned in Table 1.

Table 1: Demographic characteristics.

Total number of admissions	**3136**	
Type of burn	Flame burn	2021 (64.47%)
	Electric burn	768 (24.49%)
	Scald burn	293 (9.34%)
	Chemical burn	54 (1.72%)
Mode of injury	Accidental	79%
	Suicidal	12%
	Homicidal	9%
Male:female	1.5:1	
Mortality	Overall	1042 (33.22)
Rural:urban	2:1	

Out of the total electric burn admissions, 768 (24.49%) patients were of electric injury. 207 (27.01%) patients sustained low voltage injuries while 561 (73.04%) patients had high voltage injury. Analyzing the patients in both the groups, the mean age of the study population was 35.23±19.96 in high voltage group and 24.15±14.39 years in low voltage group. Men were more commonly affected than women in high voltage group while women suffered more in low voltage group. However, no significant association was observed whether they belonged to rural or urban population bases. Patient demographics are mentioned in Table 2.

Table 2: Characteristics of electric burn injury.

	HVI	LVI
Number	561 (73.04%)	207 (27.01%)
Sex ratio (male: female)	110:1	1:4
Mean age in years	35.23±19.96	24.15±14.39
Mean body surface area	24.08±8.69	18.69±8.01
Mean length of hospital stay	14.94±7.29	11.17±5.83
Associated injuries		
Bony injury	80	20
Spine injury	33	0
Chest injury	22	1
Intestinal injury	4	0
Head injury	76	16
Seizure	0	6
Vision loss	3	0

Mode of injury*:* Most of the injuries were work related in high voltage group while low voltage injuries were mainly sustained while using household appliances.

Associated injuries: HVI group witnessed a greater number of concomitant injuries as given in Table 2.

Electric contact and flash burn combination was significantly more (45%) in high voltage group. The cutaneous burn size had a significant association with type of voltage. The mean burn size was significantly more in high voltage group 24.08±8.69 as compared to the other group 18.69±8.0.01.

Resuscitation phase: HVI patients had elevated serum creatine phosphokinases and myoglobinuria on admission. There were increased number of fasciotomies and renal failure in this group. Abnormal cardiac events were observed in the form of sinus tachycardia, ectopic beats and rhythm disturbances. All these findings were significantly observed in the high voltage group.

Reconstructive procedures*:* They were early excision and skin grafting and distant flaps such as groin and abdomen flaps. Microvascular free flaps were done in thirty cases of high voltage injury. Ear reconstruction,

rhinoplasty, scalp reconstruction and tendon reconstruction were done mainly in HVI cases, details are given in Table 3.

The mean no of operation per person was more in high voltage group 2.04±1.124 as compared to low voltage group 1.91±1.023.

***Complications*:** They were observed in the form of amputations and were significantly more in HVI while amputations in the LVI group was limited to digits in most of times. A total of 123 (16.01%) amputations were done, the most common etiology being high voltage injuries. Fasciotomy was done in 71 (9.24%) cases of amputation however; it did not prove to be of significance in averting the consequences in all these cases. The summary was given in Table 4.

Length of hospital stay was longer 14.94±7.29 (mean±standard deviation) in HVI. Mortality rate was 10.5% and was attributed to respiratory failure, multiorgan dysfunction, disseminated intravascular coagulation and renal failure.

Table 3: Reconstructive surgeries in HVI and LVI.

Surgery	LVI	HVI	No. of patients
Early excision+split thickness skin graft	75	225	300
Groin flap for hand defects	25	35	60
Abdominal flap for upper limb defects	18	47	65
Free flap	0	30	30
Contracture release	75	175	250
Tendon reconstruction	16	34	50
Ear reconstruction	0	20	20
Rhinoplasty	2	13	15
Scalp reconstruction	0	50	50

Table 4: Complications of electric burn injury.

Amputations	Type of injury	Fasciotomy		
Fingers	LVI			12
Toes	LVI			22
Upper extremity	LVI (4), HVI (21)	+(18)	Below elbow	25
Upper extremity	HVI (35)	+(20)	Above elbow	35
Lower extremity	HVI (32), LVI (3)	+(21)	Below knee	35
Lower extremity	HVI	+(12)	Above knee	18
Bilateral shoulder disarticulation	HVI	+		4
Bilateral hip disarticulation	HVI	+		6
Mortality	10.5%			

DISCUSSION

Electric burn injury has been a devastating form of injury which has a long psychosocial impact. Injuries from electricity have been reported for more than 300 years and still remain the most mutilating entity since its inception as a commercial commodity.

In our study, EBI constitutes approximately 24.49% of the total burn admissions and are mostly accidental. [2] It forms a considerable fraction when compared to the developed parts of the world (0.04-5%).[3-5] Hospital data however underestimates the issue as all incidences do not report to the tertiary care center. Low socioeconomic status gets compounded by lack of basic safety education into it becoming a major factor.[6,7] Electric burn still remains a considerable cause of morbidity in the developing parts of the world.[8]

The damage to the tissues depends on the voltage of electricity and resistance of specific tissues, the current pathway and duration of contact. The resistance of tissues is least in nerves, blood vessels and highest in bone, tendon and fat. The more the resistance the more is the damage sustained by these tissues. Lee et al proposed the theory of electroporation in which electrical charges too small to produce thermal damage induced protein conformational changes and thus threatened the cellular integrity and function.[9,10]

Alternating current (AC) is three times more dangerous than direct current (DC) for the same voltage exposure. DC current throws the patient off thus limiting the exposure to the source but inflicting traumatic injuries and cardiac rhythm disturbances. AC current can induce continuous muscle contractions and tetany. Thermal damage to the tissues and subsequent coagulative necrosis is caused by high voltage injury as has been shown in many studies.[11]

Demographic data shows that more number of electric injuries occured at work. Adult male population sustained trauma at work or in fields from the uninsulated high voltage wires while most of the pediatric population suffered injuries at home from low voltage appliances.[12]

Males outnumbered the females which is quite similar to that observed in other studies.[13]

Cutaneous burn size was of lesser magnitude compared to the non-electric burn population. Mean burn size was 20.84 as seen in other population.[14] Increased rate of orthopedic injuries, head injuries and other organ injuries due to fall associated with high voltage injuries are observed.[15] The threshold for suspicion of associated injuries in HVI group should be kept low for prompt diagnosis and management.

In our study, high voltage injuries had a greater incidence of muscle necrosis, myoglobinuria, raised creatine phosphokinase levels and renal failure. Hence greater number of fasciotomies, escharotomies and amputations were seen in this group in comparison to low voltage injuries where amputations were limited to digits only, most of the times.[16]

High tension injury produces gradual ischemia due to thrombus formation in the small arterioles thus constricting blood flow in vessels, subsequently resulting in amputation.

Mean length of hospital stay was found to be longer in high voltage group. The mean number of operations required in high voltage group was more, finding in line with other studies.[17]

Electrical injuries are the fourth most common cause of traumatic work related death. The impact of amputation is grievous in the life of electric burn survivor both physically and economically. The psychosocial impact of such events leave a stigma in the patient's life forever. Most of the patients are linemen or workers and are not able to resume their occupation. Rehabilitation of such patients is another issue which is beyond the scope of this study.[18]

Mortality rates have been high among high voltage group (1-17%). We have noted an overall mortality rate of 10.5%. However, this does not include the immediate fatalities that occurred in both the groups that did not reach the hospital.

Reconstructive procedures are required both in HVI and LVI and have improved the quality of lives of these patients by timely intervention. Surgical procedures in the form of distant flaps and free flap surgery are required in huge numbers in the post resuscitation phase. As such, the impact of LVI cannot be overlooked. A plastic surgeon should be involved each step of the treatment ladder for a better overall outcome.[19] Electric burn injuries inflict profound economic costs but is beyond the scope of this study and difficult to calculate.

Limitations of the study were its retrospective nature and its population base. Most of the patients were referred from other peripheral centres which led to over-representation of serious HVI and underestimation of LVI.

"Prevention is better than cure, as said by Benjamin Franklin, best suits the problem. Power lines should be laid in accordance with the Indian electricity act 2003.[20] Public awareness and education about safety measures should be imparted, especially at work.[21-24]

CONCLUSION

Electric burn in our study still comprised a significant proportion of burn injury. The impact of injury in electric burn survivor is profound in view of the increased number of amputations in these patients. Prevention is a cost effective intervention. We advocate a low threshold for managing associated injuries. Educating about safety principles to the parents and adults at workplace and improving infrastructure by the state can bring changes in the present scenario.

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