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ORIGINAL ARTICLE

Prospective Study

Epidemiology of electrical burns and its impact on quality of life - the developing world scenario

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Abstract

BACKGROUND

Electrical burns are devastating injuries and can cause deep burns with significant morbidity and delayed sequelae. Epidemiological data regarding the etiology, socioeconomic differences and geographic variation are necessary to assess the disease burden and plan an effective preventive strategy. These severe injuries often lead to amputations and thus hamper quality of life in the long term

AIM

To identify the population at maximum risk of sustaining electrical burns. We also studied the impact of electrical burns on these patients in terms of quality of life as well as return to work.

METHODS

The study was conducted at a tertiary referral teaching hospital over a period of eighteen months. All patients with a history of sustaining electrical burns and satisfying the inclusion criteria were included in the study. All relevant epidemiological parameters and treatment details were recorded. The patients were subsequently followed up at 3 mo, 6 mo and 9 mo. The standardized Brief Version of the Burn Specific Health Scale (BSHS-B) was adopted to assess quality of life. Statistical analysis was conducted using IBM SPSS statistics (version 22.0). A *P* value of < 0.05 was considered statistically significant.

RESULTS

A total of 103 patients were included in the study. The mean age of the patients was 31.83 years (range 18-75 years). A significant majority (91.3%) of patients were male. The mean total body surface area (TBSA) in these patients was 21.1%. In most of the patients (67%), the injury was occupation-related. High voltage injuries were implicated in 72.8% of patients. Among the 75 high voltage burn patients, 31 (41%) required amputation. The mean number of surgeries the patients underwent in hospital was 2.03 (range 1 to 4). The quality of life

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parameters amongst the patients sustaining high voltage electrical burns were poorer when compared to low voltage injuries at all follow-up intervals across nine domains. In eight of these domains, the difference was statistically significant. Similarly, the scores among the amputees were poorer when compared to non-amputees. The difference was statistically significant in six domains.

CONCLUSION

Electrical burns remain a problem in the developing world. Most injuries are occupation-related. The quality of life in patients with high voltage burns and amputees remains poor. Work resumption was almost impossible for amputees. These patients could not regain pre-injury status. Steps should be taken to create awareness and to implement an effective preventive strategy to safeguard against electrical injuries.

Key Words: Electrical burns; Quality of life; Amputation; Return to work; Occupational therapy; High voltage injuries

Core Tip: Electrical burns remain a problem in the developing world. Most injuries are occupation-related. The quality of life in patients with high voltage burns and amputees remains poor. Work resumption was almost impossible for amputees. These patients could not regain pre-injury status. Steps should be taken to create awareness and implement an effective preventive strategy to safeguard against electrical injuries.

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INTRODUCTION

Electrical appliances are used in domestic as well as industrial settings on a daily basis, and it is difficult to imagine normal life without electricity. Electrical injuries are probably as old as the discovery of electricity itself. The first recorded case of electrical injury was in 1879 in France when a carpenter suffered a low voltage injury (250 V) when operating a generator[1], and today electrical injury is considered the most common cause of occupation-related injury in developing as well as developed nations [2,3].

An electrical injury does not only involve the superficial layers of the skin but can injure the deeper tissue and can cause multiorgan damage and even death[4,5]. Electrical injuries occur due to passage of the electric current through the body and can be challenging to manage due to progressive necrosis as a result of injury to the microvasculature. The injury may lead to limb loss and disfigurement of the victim which will have a lasting impact on the ability of the individual to resume work (Figure 1). Most electrical injuries are preventable provided there are appropriate safety precautions. Epidemiological data regarding the etiology, socioeconomic differences and geographic variation are necessary before an effective prevention strategy can be planned[6,7]. Patients with electrical burns can suffer cognitive disturbances including slower thinking, impaired concentration, language and memory problems, as well as emotional distress[8,9]. Therefore, patients can have long-term residual effects affecting their quality of life. Knowledge of the characteristics of the injury and mechanism by which the injuries are sustained in our area we can help formulate specific preventive strategies. Those people who are at maximum risk of sustaining these injuries can be educated in terms of preventive measures. This will help reduce the morbidity and mortality associated with this injury.

Figure 1 The injury may lead to limb loss and disfigurement of the victim which will have a lasting impact on the ability of the individual to return to work. A: Appearance on day 5 following fasciotomy in a high voltage electrical burns patient showing a gangrenous middle finger and ring finger along with nonviable tendons; B: Following skin necrosis due to electrical burns, debridement and a groin flap were performed; C: Same patient shown in Figure 1A and B using his injured hand to hold a bottle.

MATERIALS AND METHODS

Patient selection

The study was conducted in the Department of Plastic Surgery, Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, India, over a period of eighteen months. This prospective case series consisted of all patients presenting to the Advanced Trauma Centre, PGIMER with electrical burns. Patients who had pre-existing comorbidities, or who were incoherent/intubated were excluded from the study. Patients less than 18 years of age were also excluded as they would not be able to complete the quality of life questionnaire satisfactorily.

Patient evaluation and follow-up

A thorough history and physical examination was undertaken to determine the mechanism of injury, and an evaluation of possible associated life-threatening injuries was carried out. The wounds were evaluated and the need for emergency procedures such as fasciotomy for compartment syndrome were carried out when required.

Immediate complications were ruled out or addressed and resuscitation of the patient was started after determining the percentage of total body surface area (TBSA) involved (calculated using the Lund and Browder chart). Fluid resuscitation was guided by the Parkland formula. Adequate resuscitation was confirmed by maintaining adequate urine output.

An electrocardiogram was performed to rule out arrhythmia and necessary treatment was given if required. Urine myoglobin was determined in all patients with electrical burns. Routine blood investigations including serum electrolytes were evaluated to rule out any anomalies and if necessary corrective treatment was given.

The patient's course was followed in the ward and epidemiological data were collected using a burn proforma and surgical procedures undertaken were recorded. Follow-up was carried out at 3 mo, 6 mo and 9 mo. The standardized and valid Brief Version of the Burn Specific Health Scale (BSHS-B) was adopted to assess health-related quality of life (HRQOL) in patients with extensive severe burns in 40 items among nine domains: heat sensitivity, affect, hand function, treatment regimens, work, sexuality, interpersonal relationships, simple abilities, and body image[10]. The items were scored using a five point Likert scale with 0, extremely; 1, quite a bit; 2, moderately; 3, a little bit; and 4, none (not at all). Higher scores indicated greater HRQOL. Among the specific instruments available for measuring burn patients' quality of life, BSHS-B is the most widely used[11].

Statistical analysis

Discrete categorical data are represented either as a number or a percentage (%); Continuous data are represented as either the mean and standard deviation or the median and interquartile range. The normality of quantitative data was checked using the Kolmogorov-Smirnov tests of normality. For normally distributed data the means of BSHS in 3 types of electrical burns were compared using One-Way ANOVA followed by the post hoc Multiple Comparisons test. For normally distributed data, the Student t-test was applied to compare 2 groups. For comparison of 2 groups of skewed data the Mann-Whitney U-test was used. Proportions were compared using the Chi square or Fisher's exact test, depending on their applicability. For time related variables of skewed data the Wilcoxon Signed rank test was applied; for normally distributed data ANOVA was carried out. Analysis was conducted using IBM SPSS statistics (version 22.0). A P value of < 0.05 was considered statistically significant.

RESULTS

A total of 103 patients who satisfied the inclusion criteria were enrolled in our study.

Patients were aged 18 years to 75 years with a mean age of 31.83 years. 65% of patients were less than 30 years of age with the majority (46.6%) between 21 and 30 years, 91.3% were male and 8.7% were female. Sixty-nine patients (67%) had occupation-related injuries. Seventy-five patients (72.8%) had high voltage electrical burns and only 28 patients (27.2%) had low voltage electrical burns (Table 1). Data regarding the exact mechanism of the burns were collected (Table 2). Thirty-three patients were injured due to contact with a live wire either in the field, roof or the factory. A total of 22 patients had burns related to working with a transformer. Fifteen patients were injured by a home appliance, 8 by farming machinery and 7 youngsters while playing came into contact with a live wire. Six patients were injured at a construction site. Two patients were injured when flying a kite.

Fifty-eight patients (56.3%) had pure contact burns and 30 patients (29.1%) had pure electrical flash burns. Fifteen patients (14.6%) had a mixed injury with a flash as well as a contact burn. The TBSA of the burns ranged from 1% to 90%. The mean area was 22% with a standard deviation of 18.3%. The 25th percentile was 10%, 50th percentile was 18%, and the 75th percentile was 18%.

Of the 103 patients, 40 patients underwent an amputation. A total of 32 patients who suffered a high voltage electrical burn underwent upper limb amputation at different levels. Eight patients with low voltage electrical burns also underwent amputation but this was limited to finger amputation only. Of the 32 patients with high voltage electrical burns who had upper limb amputation, 8 patients had bilateral upper limb amputation at various levels. Seventeen patients also underwent lower limb amputation of which 7 had bilateral lower limb amputation.

Patients with electrical burns are likely to have "progressive necrosis" and hence may need multiple surgeries. The patients usually required two debridements with a debridement in the first 24 h after resuscitation and a relook debridement after another 48 h. In most cases definitive cover was feasible during the second intervention (Figure 2). However, some patients required multiple debridements before the wound was ready for definitive cover. The maximum number of surgeries in a single patient was 4 (Table 3).

Of the total number of patients, 13 (12.6%) succumbed to the injury. The cause of death included acute renal failure, cardiac arrhythmia, and sepsis due to extensive exposed areas.

Of 103 patients, there were 13 deaths and 17 patients were lost to follow-up during the study period. We followed up the remaining 73 patients at 3 mo, 6 mo and 9 mo.

The 40 questions in the BSHS were divided in 9 domains. The quality of life in patients with low voltage electrical burns *vs* those with high voltage electrical burns were recorded.

The mean of scores for all the questions and the standard deviation in the 9 domains at 3 mo, 6 mo and 9 mo are shown in Table 4.

Table 1 Characteristics of electrical burn injuries

Age distribution	Minimum age 18 yr, %	Maximum age 75 yr, %
Sex distribution	Male 94 (91.3)	Female 9 (8.7)
Occupation-related injury	Yes 69 (67)	No 34 (33)
High voltage *vs* low voltage burns	High voltage 75 (72.8)	Low voltage 28 (27.2)

Table 2 Mechanism of sustained injury

Mechanism of injury	Frequency (*n*)	Percent (%)
Construction site	6	5.8
Domestic line repair	2	1.9
Farming machinery	8	7.8
Flying kite	2	1.9
Home appliance	15	14.6
Live wire in field	15	14.6
Live wire in factory	7	6.8
Live wire on roof	11	10.7
Loading in truck	3	2.9
Playing	7	6.8
Transformer	22	21.4
Welding	5	4.9
Total	103	100.0

Table 3 Mean number of surgeries performed with standard deviation and percentiles

Number of surgeries		
Mean number of surgeries (*n*)		2.03
SD		0.842
Minimum number of surgeries (*n*)		1
Maximum number of surgeries (*n*)		4
Percentiles	25	1.00
	50	2.00
	75	3.00

When the *t* test was applied to the data in Table 4, differences in the domains when compared were significant in all except hand function at 3 and 6 mo, treatment regimen at 3 mo, 6 mo and 9 mo, and return to work at 3 mo, 6 mo and 9 mo (Table 5).

We also compared the quality of life amongst the patients who underwent amputation (Figure 3) *vs* those who did not undergo amputation. The mean total scores at 3 mo, 6 mo and 9 mo and the standard deviation are represented in Table 6.

We applied the *t* test to determine if the differences in the scores were significant. Comparisons between amputees and non-amputees showed that the differences in heat sensitivity, treatment regimens and body image were non-significant. All the other parameters were significant at 3 mo, 6 mo and 9 mo (Table 7).

Table 4 Mean scores in patients with high voltage and low voltage burns as per various domains at 3 mo, 6 mo and 9 mo

Domain	Voltage (*n*)	3 mo, mean ± SD	6 mo, mean ± SD	9 mo, mean ± SD
Heat sensitivity	High voltage (49)	12.55 (4.92)	15.14 (4.03)	16.73 (3.41)
	Low voltage (24)	15.71 (4.57)	17.46 (3.01)	18.21 (2.13)
Affect	High voltage (49)	16.12 (7.14)	19.00 (6.59)	20.82 (6.77)
	Low voltage (24)	23.33 (4.07)	25.46 (3.34)	26.5 (2.72)
Hand function	High voltage (49)	11.29 (6.29)	13.88 (6.25)	15.04 (6.09)
	Low voltage (24)	12.08 (5.93)	15.63 (3.94)	17.50 (3.48)
Treatment regimens	High voltage (49)	13.31 (4.35)	14.61 (4.19)	15.9 (4.05)
	Low voltage (24)	14.96 (4.71)	16.38 (3.89)	17.29 (3.22)
Work	High voltage (49)	6.33 (5.83)	7.96 (6.11)	8.73 (6.26)
	Low voltage (24)	8.83 (5.29)	10.50 (5.32)	11.71 (5.47)
Sexuality	High voltage (49)	8.14 (2.89)	9.24 (2.90)	9.63 (2.95)
	Low voltage (24)	10.75 (1.89)	11.21 (1.53)	11.54 (1.10)
Interpersonal relations	High voltage (49)	8.82 (3.97)	10.39 (3.80)	11.69 (3.76)
	Low voltage (24)	13.08 (2.80)	14.58 (2.13)	15.08 (1.67)
Simple abilities	High voltage (49)	6.78 (3.08)	8.85 (2.74)	9.98 (2.68)
	Low voltage (24)	9.0 (2.6)	10.71 (1.4)	11.46 (1.06)
Body image	High voltage (49)	6.39 (3.19)	8.45 (2.93)	10.37 (2.95)
	Low voltage (24)	11.38 (3.28)	13.33 (2.44)	14.50 (1.84)

Table 5 *P* value of the various domains in patients sustaining high voltage *vs* low voltage electrical burns

Domains	3 mo, *t* value (*P* value)	6 mo, *t* value (*P* value)	9 mo, *t* value (*P* value)
Heat sensitivity	- 2.63 (0.010)	-2.49 (0.015)	- 1.93 (0.057)
Affect	- 4.59 (0.000)	- 4.52 (0.000)	-3.95 (0.000)
Hand function	-0.52 (0.606)	-1.25 (0.215)	-1.84 (0.071)
Treatment regimens	-1.48 (0.142)	-1.73 (0.088)	- 1.47 (0.146)
Work	-1.78 (0.080)	-1.74 (0.086)	-1.98 (0.051)
Sexuality	-4.02 (0.000)	-3.11 (0.003)	-3.06 (0.003)
Interpersonal relations	-4.71 (0.000)	-5.03 (0.000)	-4.21 (0.000)
Simple abilities	-3.04 (0.003)	-3.12 (0.003)	-2.60 (0.011)
Body image	-6.22 (0.000)	-7.05 (0.000)	-6.28 (0.000)

DISCUSSION

Electrical burns are devastating injuries and can cause deep burns with significant morbidity, leading to prolonged hospital admission and multiple surgeries to achieve complete wound healing. These injuries are also responsible for amputation of limbs making the patient dependent on caregivers even for basic activities of daily living if multiple limbs are involved. Even after limb salvage surgery, the patient may have to undergo multiple admissions for reconstruction of tendons and nerves in the affected limb before adequate functionality of the limb is achieved. In the present study we attempted to examine the epidemiology of this injury and identify individuals at maximum risk of this injury.

We enrolled patients from 18 years to 75 years of age with 65% of patients below 30 years of age and a mean age of 31.83 years. Buja *et al*[12] in their study included patients with an age distribution of 2 years to 67 years and a mean age of 33.6 years. Ambikavathy Mohan in his study of electrical burns in South India included almost

Table 6 Mean scores in patients undergoing amputation and those not undergoing amputation at 3 mo, 6 mo and 9 mo

Domain	Amputee *vs* non-amputee (*n*)	3 mo, mean ± SD	6 mo, mean ± SD	9 mo, mean ± SD
Heat sensitivity	Amputee (30)	13.64 (4.77)	16.17 (3.41)	17.47 (3.05)
	Non-amputee (43)	13.56 (5.22)	15.72 (4.18)	17.05 (3.18)
Affect	Amputee (30)	14.33 (6.82)	17.80 (6.86)	20.17 (6.91)
	Non-amputee (43)	21.40 (5.84)	23.44 (5.08)	24.44 (5.30)
Hand function	Amputee (30)	7.83 (5.77)	11.13 (6.17)	13.17 (6.62)
	Non-amputee (43)	14.14 (5.00)	16.77 (3.84)	17.72 (3.51)
Treatment regimens	Amputee (30)	14.13 (4.01)	15.43 (3.62)	16.97 (3.43)
	Non-amputee (43)	13.65 (4.86)	15.02 (4.52)	15.93 (4.08)
Work	Amputee (30)	4.47 (4.71)	6.03 (5.38)	7.10 (6.20)
	Non-amputee (43)	9.02 (5.70)	10.72 (5.60)	11.53 (5.46)
Sexuality	Amputee (30)	7.93 (3.40)	9.10 (3.33)	9.53 (3.25)
	Non-amputee (43)	9.74 (2.16)	10.44 (1.99)	10.77 (2.02)
Interpersonal relations	Amputee (30)	8.17 (3.87)	10.43 (4.01)	11.67 (3.73)
	Non-amputee (43)	11.65 (3.72)	12.70 (3.54)	13.60 (3.30)
Simple abilities	Amputee (30)	5.40 (2.88)	7.87 (2.86)	9.27 (3.01)
	Non-amputee (43)	8.98 (2.31)	10.62 (1.41)	11.3 (1.30)
Body image	Amputee (30)	7.03 (3.80)	9.10 (3.52)	11.23 (3.21)
	Non-amputee (43)	8.72 (3.99)	10.72 (3.55)	12.07 (3.31)

Table 7 *P* value of the various domains among amputees and non-amputees

Domains	3 mo, *t* value (*P* value)	6 mo, *t* value (*P* value)	9 mo, *t* value (*P* value)
Heat sensitivity	-0.063 (0.950)	-0.482 (0.631)	-0.564 (0.574)
Affect	4.743 (0.000)	4.040 (0.000)	2.989 (0.004)
Hand function	4.973 (0.000)	4.810 (0.000)	3.814 (0.000)
Treatment regimens	-0.447 (0.656)	-0.413 (0.681)	-1.139 (0.259)
Work	3.601 (0.001)	3.575 (0.001)	3.230 (0.002)
Sexuality	2.781 (0.007)	2.153 (0.035)	2.001 (0.049)
Interpersonal relations	3.872 (0.000)	2.549 (0.013)	2.340 (0.022)
Simple abilities	5.868 (0.000)	5.390 (0.000)	3.952 (0.000)
Body image	1.814 (0.074)	1.927 (0.058)	1.076 (0.286)

50% of patients aged less than 30 years. These were young adults and most of them the sole earners in the family. Sustaining an electrical burn and losing the ability to work is a great loss to the family as well as society in general which has huge economic consequences[13]. In the present study, 91.3% of patients were male and only 8.7% were female. These results may be due to occupational predisposition among the male population. This is consistent with previous data regarding the sex distribution of electrical burns[14,15]. The electrical burns in 67% patients were occupation-related and 33% were due to unrelated causes. Electrical burns are considered the most common job related-injury in both developing as well as developed countries[2,3]. Our findings are consistent with the available literature.

Amongst the 103 patients, 72.8% were injured by a high voltage electric current, whereas 27.2% sustained burns by a low voltage source. High voltage injuries are more distressing causing larger body mass necrosis and have a higher chance of amputation and requiring extensive reconstruction[16]. 41% of patients with high voltage burns underwent amputation. On the other hand, only 8 patients with low

Figure 2 In most cases definitive cover was feasible during the second intervention. A: Electrical contact burns with the entry point at the left parietal region; B: Transposition flap cover after second debridement; C: Same patient shown in Figure 2A and B at 3 mo follow-up.

Figure 3 Bilateral amputee following electrical burns.

voltage burns underwent minor amputation of fingers. Also all 13 deaths during the study period occurred in patients with high voltage electrical burns.

71% of patients had a contact burn component, and 43.7% of patients had a flash burn component. 29.1% of patients had pure flash burns. The contact burn injuries were deeper and required multiple surgeries and flap cover. Flash burns which were limited to the superficial layer of the dermis healed with regular dressings within 2 weeks of the injury. In general, flash burns are superficial and usually do not damage deeper tissues. Surgery is required in these patients and sometimes multiple procedures may be required, but amputations are not usually required[17].

The mean TBSA in these patients was 21.1% with a standard deviation of 18.3%, and the range was from 1% to 90%. In the study by Kym *et al*[18] a mean TBSA of 14% was observed. Agakhani *et al*[19] found that the mean TBSA was 13.5%. The study by Hamid Karimi *et al*[20] in Iran found that the mean TBSA was 13.2%. The reason for the slightly higher mean TBSA in our study can be attributed to inter-observer variation in estimating the burns and to the large number of cases of electrical flash burns with larger TBSA burns.

Forty of the 103 patients (38.8%) underwent amputation. Of the 75 high voltage burn patients, 32 (42%) underwent amputation. Nine patients with low voltage electrical burns (32%) underwent amputation, but these were mainly minor amputations. Agakhani *et al*[19] reported similar results. The study by Kym *et al*[18] in South Korea demonstrated that 625 patients (74.7%) underwent amputation, but most of these were minor. They reported an amputation rate of 15.6% in the low tension group. This high rate of amputation following electrical burns indicates the morbidity associated with these burns and suggests that prevention is better than cure. It also shows the importance of limb salvage by timely fasciotomy and early stable wound coverage after adequate debridement[21].

Thirty-two of our patients had upper limb amputation and 8 of these patients underwent bilateral amputation. Seventeen patients underwent lower limb amputation of which 7 had bilateral lower limb amputation. This is consistent with other studies[22]. In general, upper limbs are affected as they are frequently in contact with the electrical source.

The mean number of surgeries the patients underwent was 2.03 and ranged from 1 to 4. The 25th percentile was 1, 50th percentile was 2 and the 75th percentile was 3. Extensive raw areas following flash burns required 2 surgeries consisting of split thickness skin grafts.

Early adequate debridement is the key to successful reconstructive procedures. The injury is usually most severe in the small muscle branches, where blood flow is slower [22]. Sometimes complete damage is not initially evident. As the smaller vessels become thrombosed tissue damage then becomes evident. This creates the illusion of progressive tissue necrosis. Performing a flap and then having problems of pus discharge from below the flap is distressing both for the patient as well as the surgeon. We therefore found it prudent to occasionally have a second look when we had doubts about the viability of the tissue. This in our view prevented problems with both over debridement as well as under debridement. Frankly necrotic and devitalized tissue was removed in the first surgery and indeterminate tissue was left behind. Then further surgery was performed after 48 to 72 h to provide definitive cover. The only disadvantage of this technique is increasing management by one stage and the patient undergoing anesthesia an additional time and therefore increasing the cost of management. As our hospital is a government hospital the cost factor did not have much bearing, but this approach may increase the cost of management in a private setup. Hence this method was not followed in all patients.

During our study period, a total of 13 deaths (12.6%) were observed. The patients with a higher percentage of flash burns succumbed to sepsis, while acute renal failure and cardiac events were the cause of death amongst patients with contact burns. Mortality is reported to be between 3% and 15% in the U.S.[23]. A possible reason for the number of deaths being higher is that ours is a tertiary referral center with a lot of complex cases being referred to us on a regular basis.

The morbidity associated with burns is huge especially if the patient undergoes major amputation. It may be impossible for patients to return to work[24] and they may also become dependent on caregivers even for activities of daily living. This has an impact on the psychology of the patient.

The patients in our study were followed up at 3 mo, 6 mo and 9 mo to determine their quality of life. We compared quality of life based on the domains in patients with high voltage electrical burns *vs* low voltage electrical burns. In the total heat sensitivity domain the difference in the score was significant at all stages of follow-up. Patients with a flash component and large surface who underwent grafting had more problems regarding heat sensitivity. The difference in the score of the affect of high voltage electrical burns and low voltage electrical burns was significant at all stages. This may be due to the fact that usually high voltage burns are more devastating and have a poor affect as compared to patients with low voltage electrical burns. The hand function scores between the two groups showed that patients with low voltage burns fared better, but the difference was not statistically significant different between the groups at all stages of follow-up.

In general, patients with low voltage electrical burns had more trouble coping with the treatment regimen. This may be due to the fact that a lot of these patients required grafts and thorough post-graft skin care is required. The difference between the low voltage and high voltage groups was not significant, possibly because some patients in the high voltage group required grafts and they too needed to take care of the skin thus confounding the results.

With regard to work, the difference in scores between the low voltage and high voltage groups was significant, and patients sustaining low voltage electrical burns were significantly better at 3 mo, 6 mo and 9 mo. This is because high voltage electrical burns are usually more destructive[16].

Amongst the other domains, sexuality, interpersonal relationship, simple abilities and body image, patients with low voltage electrical burns were significantly better placed than those with high voltage electrical burns. We also compared the quality of life of amputees *vs* non-amputees. The domains of affect, hand function, sexuality, work, interpersonal relationship and simple abilities were significantly different and patients with amputation were significantly poorly placed as compared to non-amputees. The difference between the score for body image was non-significant. The reason for this could be due to amputees not liking their "incomplete" body and non-amputees not being able to accept their bodies with extensive scars.

As 67% of electrical burns are related to occupation we strongly feel that a good education program for the at-risk population would be extremely beneficial.

From the available data it is clear that a prevention strategy should include the following 2 aspects: (1) Strict implementation of existing laws; and (2) An education program aimed at the at-risk population and the general public regarding the devastating outcome of electrical burn injuries and essential safety measures.

Strict implementation of existing laws can be ensured by heavy fines for the contractor or the builder responsible for breaking the law. Sign boards indicating danger depicted pictorially should be used. These sign boards will get the message across even to the uneducated population keeping them away from the areas where accidents are likely to happen. Various education programs regarding the effects of these devastating injuries and safety measures to be undertaken for prevention will go a long way to reduce the incidence of such injuries. Today we live in a world where communication is very easy and has become a powerful tool. There are countless means of mass communication including the internet, social media, television and radio. Only constant reminders will probably finally reduce accidental burn victims in our country[25] and we can use all these media to our advantage to spread the message.

CONCLUSION

In conclusion, electrical burns are still a major problem in India and most injuries are occupation-related. Furthermore, extensive injuries need to be managed in a tertiary care center using a multidisciplinary approach. Quality of life in patients with high voltage electrical burns and amputees is poor. Thus, steps should be taken to create awareness as well as plan and implement a good preventive strategy for electrical burns

ARTICLE HIGHLIGHTS

Research background

We have come a long way since the discovery of electricity and have become totally dependent on it. Yet there are numerous hazards associated with it. The accidental injuries sustained from electricity can potentially cripple individuals making them completely dependent on others for activities of daily living. There are a limited number of studies investigating the causes and characteristics of electrical injuries and the quality of life in these patients following treatment. In-depth evaluation of the circumstances of injuries and overall quality of life in this particular subset of patients has not been thoroughly evaluated.

Research motivation

Knowledge of the characteristics of electrical burn injuries and understanding the circumstances in which these injuries are sustained can help to formulate specific preventive strategies. The subjects who are at maximum risk of sustaining these injuries can be educated on these preventive measures. This will help reduce the morbidity and mortality associated with these devastating injuries.

Research objectives

To study the epidemiology of electrical burns and to define the population which is at maximum risk of sustaining such injuries. The impact of electric burns on these patients and their quality of life along with the potential of returning to previous work were also evaluated.

Research methods

This prospective study was conducted over a period of 18 mo at a tertiary care teaching hospital. All patients presenting to the Trauma Center with a history of sustaining electrical burns and satisfying the inclusion criteria were included in the study. The course of the patient in hospital was followed and epidemiological data were collected using a burn proforma. Follow up was carried out at 3 mo, 6 mo and 9 mo. The standardized and valid Brief Version of the Burn Specific Health Scale (BSHS-B) was adopted to assess health-related quality of life (HRQOL). The normality of quantitative data was assessed by the Kolmogorov-Smirnov test. Normally distributed data were compared using One-Way ANOVA followed by the post hoc Multiple Comparisons test. For time related variables of skewed data the Wilcoxon Signed rank test was applied; for normally distributed data ANOVA was carried out. Analysis was conducted using IBM SPSS statistics (version 22.0). A P value of < 0.05 was considered statistically significant.

Research results

These injuries were more common in males and in the younger population. The majority of injuries were occupation-related and mostly accidental in nature, mainly due to ignorance as well as carelessness on the part of the victims. Hence, many injuries and resultant morbidities could have been prevented by mass education and awareness. A significant number of patients were uneducated. Thus, they had to take menial jobs without being aware of the appropriate safety measures. There was also a lack of awareness amongst their supervisors. Patients had a combination of contact and flash burns. The variety of associated injuries in these patients made a multidisciplinary approach vital for effective management. The patients underwent a variety of surgeries depending on the extent of the initial injury, of which amputation was the most devastating. Limb salvage necessitated multiple complex procedures which required intricate planning and execution. The quality of life among patients sustaining high voltage electrical burns and amputees was poor.

Research conclusions

Electrical burns cause extensive damage requiring multiple surgeries and reconstructive techniques. This makes it a major economic burden for the patient as well as the government. In addition, there are various social and rehabilitative challenges for the patient as well as his or her family. The patients who underwent multiple limb amputations became dependent on caregivers even for basic activities of daily living for the rest of their lives. It is a major challenge for these patients to return to pre-injury status due to the significant stigma of initial injury and persistent tissue damage. This underscores the importance of effective preventive strategies to reduce these injuries.

Research perspectives

Future studies should be carried out to determine the efficacy of various preventive strategies to decrease the frequency of these injuries and to reduce the morbidity and mortality associated with electrical burns.

REFERENCES

1 **Acosta AS**, Azarcon-Lim J, Ramirez AT. Survey of electrical burns in Philippine General Hospital. *Ann N Y Acad Sci* 1999; **888**: 12-18 [PMID: 10842615 DOI: 10.1111/j.1749-6632.1999.tb07938.x]

2 **Mohammadi AA**, Amini M, Mehrabani D, Kiani Z, Seddigh A. A survey on 30 mo electrical burns in Shiraz University of Medical Sciences Burn Hospital. *J International Society for Burn Injuries* 2008; **34**: 111-113

3 **Opara KO**, Chukwuanukwu TO, Ogbonnaya IS, Nwadinigwe CU. Pattern of severe electrical injuries in a Nigerian regional burn centre. *Nigerian J Clinical Practice* 2006; **9**: 124-127

4 **Arnoldo BD**, Purdue GF, Kowalske K, Helm PA, Burris A, Hunt JL. Electrical injuries: a 20-year review. *J Burn Care Rehabilitation* 2004; **25**: 479-484

5 **Hussmann J**, Kucan JO, Russell RC, Bradley T, Zamboni WA. Electrical injuries--morbidity, outcome and treatment rationale. *J International Society for Burn Injuries* 1995; **21**: 530-535

6 **Liao CC**, Rossignol AM. Landmarks in burn prevention. *Burns* 2000; **26**: 422-434 [PMID: 10812263 DOI: 10.1016/s0305-4179]

7 **Linares AZ**, Linares HA. Burn prevention: the need for a comprehensive approach. *Burns* 1990; **16**: 281-285 [PMID: 2257071 DOI: 10.1016/0305-4179]

8 **Cherington M**. Central nervous system complications of lightning and electrical injuries. *Semin Neurol* 1995; **15**: 233-240 [PMID: 8570925 DOI: 10.1055/s-2008-1041028]

9 **Primeau M**, Engelstatter GH, Bares KK. Behavioral consequences of lightning and electrical injury. *Semin Neurol* 1995; **15**: 279-285 [PMID: 8570930 DOI: 10.1055/s-2008-1041033]

10 **Kildal M**, Andersson G, Fugl-Meyer AR, Lannerstam K, Gerdin B. Development of a brief version of the Burn Specific Health Scale (BSHS-B). *J Trauma* 2001; **51**: 740-746 [PMID: 11586169 DOI: 10.1097/00005373-200110000-00020]

11 **Yoder LH**, Nayback AM, Gaylord K. The evolution and utility of the burn specific health scale: A

systematic review. *Burns* 2010; **36**: 1143-1156 [PMID: 20382480 DOI: 10.1016/j.burns.2010.01.004]
12 **Electrical burn injuries**. An eight-year review. In: Buja Z, Arifi H, Hoxha E. Annals of Burns and Fire Disasters, 2010
13 **Gilboa D**, Friedman M, Tsur H. The burn as a continuous traumatic stress: implications for emotional treatment during hospitalization. *J Burn Care Rehabil* 1994; **15**: 86-91; discussion 91
14 **Patil SB**, Khare NA, Jaiswal S. Changing patterns in electrical burn injuries in a developing country: should prevention programs focus on the rural population? *J Burn Care Res* 2010; **31**: 931-934
15 **Ramakrishnan KM**, Ramachandran K, Jayaraman V. Electrical burns treated in an Indian hospital. *Burns* 1991; **17**: 481-483
16 **Chudasama S**, Goverman J, Donaldson JH, van Aalst J, Cairns BA, Hultman CS. Does voltage predict return to work and neuropsychiatric sequelae following electrical burn injury? *Ann Plast Surg* 2010; **64**: 522-525 [PMID: 20395807 DOI: 10.1097/SAP.0b013e3181c1ff31]
17 **Handschin AE**, Vetter S, Jung FJ, Guggenheim M, Kunzi W, Giovanoli P. A case-matched controlled study on high-voltage electrical injuries vs thermal burns. *J Burn Care Res* 2009; **30**: 400-407
18 **D Kym**, DK Seo, GY Hur2, JW Lee. Epidemiology Of Electrical Injury: Differences Between Low- And High-Voltage Electrical Injuries During A 7-Year Study Period In South Korea
19 **Aghakhani K**, Heidari M, Tabatabaee SM, Abdolkarimi L. Effect of current pathway on mortality and morbidity in electrical burn patients. *Burns* 2015; **41**: 172-176
20 **Karimi H**, Momeni M, Vasigh M. Long term outcome and follow up of electrical injury. *J Acute Disease* 2015; 107-111
21 **Maghsoudi H**, Adyani Y, Ahmadian N. Electrical and lightning injuries. *J Burn Care Res* 2007; **28**: 255-261 [PMID: 17351442 DOI: 10.1097/BCR.0B013E318031A11C]
22 **Hunt JL**, McManus WF, Haney WP, Pruitt BA Jr. Vascular lesions in acute electric injuries. *J Trauma* 1974; **14**: 461-473 [PMID: 4152263 DOI: 10.1097/00005373-197406000-00003]
23 **Bingham H**. Electrical burns. *Clin Plast Surg* 1986; **13**: 75-85 [PMID: 3956083]
24 **Wick R**, Gilbert JD, Simpson E, Byard RW. Fatal electrocution in adults--a 30-year study. *Med Sci Law* 2006; **46**: 166-172 [PMID: 16683472 DOI: 10.1258/rsmmsl.46.2.166]
25 **Puri V**. Mass media magic- the power to Empower. *Indian J Burns* 2014; **22**: 1-2

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