Original Research

High Voltage Electrical Burn Injury of the Upper Extremity: A Prospective Observational Study from Bangladesh

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Abstract

Introduction. Electrical burn injury is one of the most disastrous forms of burn trauma involving the upper extremity. It may lead to devastating complications, including limb loss and even death. This study aimed to characterise the epidemiology of high-voltage electrical burn injury (HVEB), which is critical for developing prevention strategies and evidence-based management guidelines to address this serious public health issue.

Methods. This prospective observational study was conducted at the National Institute of Burn and Plastic Surgery (NIBPS), Dhaka, Bangladesh, between January 1, 2022, and June 30, 2022. Based on specific inclusion and exclusion criteria, a total of 112 patients with high voltage electric burn injury involving upper limb were included in the study from total 521 patients with high-voltage electrical burn injuries attended the emergency within this period. Data were collected through a structured data sheet and analysed.

Results. A significant male predominance was observed (89.3%), and more than 70% of patients were aged 13-40 years. Ninety-three per cent (93%) of patients came from urban areas. Approximately 56% of accidents occurred while working in unsafe environments without safety protocols, and it was alarming that only 7% of workers used proper protective equipment. Women (2.7%) were primarily affected while drying clothes on rooftops or balconies. Bilateral limb involvement was present in 52% of cases. Seven per cent (7%) of patients presented with charred limbs. The right upper limb was the entry point in 67% of cases. Impending compartment

syndrome was evident clinically in 45.5% of patients, necessitating fasciotomy. Finally, 40% of patients underwent limb amputation at different levels within 7-10 post-burn days. **Discussion and Conclusions.** Electrical burn injury remains a major health problem in developing countries. Most injuries are occupation-related and affect young active males. However, electrical burn injuries are largely preventable. Measures should be taken to create awareness among the population to prevent these devastating injuries.

Keyword: Electrical Burn, Upper Extremity, Bangladesh, Amputation

Introduction

High voltage electrical burn (HVEB) injuries represent some of the most severe and life-threatening forms of burn trauma, particularly affecting the upper extremities. These injuries are typically caused by exposure to 1000 volts or higher electrical currents, resulting in extensive tissue destruction along the current path.[1] The damage is often more profound than visible on the skin, involving significant underlying neurovascular and muscular necrosis. This dual mechanism of thermal and electrical injury leads to coagulative necrosis, cell membrane disruption, and subsequent cell death, posing unique clinical management and reconstruction challenges.[2]

Bangladesh, a densely populated country in Southeast Asia, faces a high incidence of electrical burn injuries due to rapid urbanisation and inadequate safety measures in both residential and occupational settings. The lack of awareness and non-compliance with safety protocols significantly exacerbate the risk. The incidence of electrical burns increases during the summer months, when electricity uses surges, reflecting seasonal variation in burn injury patterns.[1]

Statistics indicate that approximately 0.6 million burn injuries occur annually in Bangladesh, with over 2000 resulting in death. Electrical burns account for a significant portion of these injuries, comprising about one-third of total hospital admissions for burns. The upper extremities are most affected, leading to severe consequences such as disfigurement, functional loss, and limb amputations.[3,4] Construction workers and electric power crews are disproportionately affected. The socio-economic impact is profound, requiring prolonged hospital stays, multiple surgeries, and extensive rehabilitation efforts, which burden both the healthcare system and the affected individuals.[3,4]

Despite the prevalence of these injuries, there is a lack of comprehensive epidemiological data and a detailed understanding of clinical outcomes in Bangladesh. This study aims to address these gaps by providing crucial insights into the epidemiology, clinical characteristics, and outcomes of upper-extremity HVEB injuries, thereby informing the development of effective prevention strategies and management protocols.[5]

Methods

This prospective observational study was conducted at the National Institute of Burn and Plastic Surgery (NIBPS) in Dhaka, Bangladesh, over six months from January 1, 2022, to June 30, 2022. The primary aim was to investigate the epidemiology and clinical characteristics of high-voltage electrical burn injuries involving the upper extremities.

Study Population

Patients admitted to the emergency department of NIBPS with high-voltage electrical burn injuries were included based on strict criteria. Inclusion criteria comprised patients with high-voltage electrical burns involving one or both upper limbs who presented directly to the NIBPS emergency department.

We employed specific exclusion criteria to ensure the study focused on salvageable upper extremity injuries rather than massive systemic trauma. Patients with Total Body Surface Area (TBSA) burns exceeding 50% were excluded; this threshold was selected to focus on functional outcomes and limb salvage in survivable

injuries, as massive burns often result in early mortality unrelated to limb viability. Additionally, patients with burns of mixed aetiology (e.g., combined flame and electrical, with the primary mechanism unclear) were excluded. Patients with mental health disorders or intellectual disabilities were also excluded if informed consent could not be reliably obtained from the patient or guardian. While paediatric patients (age: 0-12 years) and adolescents (age: 13-21 years) were included due to the increased prevalence of electrical injuries among them was evident in the hospital data.

Data Collection

Data were collected using a structured questionnaire validated by five burns surgeons for content review and pilot testing. According to their opinion relevant revisions were done in the questionnaire. The forms were completed by plastic surgery residents who were blinded to the study's objectives, using Google Forms with personal information redacted. The corresponding author conducted the final data review. The questionnaire captured demographic details (age, sex, occupation), injury specifics (limb dominance, place, mode of occurrence), safety measures, and clinical details, including TBSA percentage, depth of burn, time to presentation, presence of compartment syndrome, fasciotomy requirements, and amputation status.

Ethical Considerations

Informed written consent was obtained from all adult participants and the parents or guardians of paediatric patients. The study was approved by the Institutional Review Board (IRB) of NIBPS (Memo no: SHNIBPS/ECC/1680).

Statistical Analysis

Data were analysed using descriptive statistics. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. The Chi-square test was used to assess associations between variables, with p-values <0.05 considered significant.

Results

A total of 112 patients with high-voltage electrical burn injuries involving the upper extremities were included in the study among 521 patients presented to the emergency department of NIBPS in between January 2022 to June 2022.

Demographic and Seasonal Characteristics

The study population demonstrated a significant male predominance, with 100 male patients (89.3%) and only 12 female patients (10.7%). Regarding age distribution, the most affected group was young adults aged 22-40 years (n=47; 42%), followed by adolescents aged 13-21 years (n=35; 31%). Paediatric patients (0-12 years) accounted for 17%(n=19) of cases, while older adults were less frequently affected. An apparent seasonal variation was observed, with admission rates peaking in the summer months, which, in Bangladesh starts from end of the March to September with peak in April, May and June. (Table 1). The month May had the highest incidence (50.4%), followed by June (45.8%) and April (38.8%), likely due to increased electricity usage and outdoor activity during the summer period. The summer weather is characterized by extreme heat & high humidity leads to more electrical appliances used for cooling.

Table 1. Data showing seasonal variation of electric burn injuries (January to June 2022).

Month	Total burn admission	HVEB injury	%
January	376	66	17.5%
February	328	56	17%
March	313	96	30.6%
April	229	89	38.8%
May	216	109	50.4%
June	229	105	45.8%
Total	**1691**	**521**	**30.8%**

Legend. HVEB = High Voltage Electrical Burn.

Occupational and Environmental Contexts

The majority of injuries were occupation-related. Construction workers represented the largest group (n=33; 29.46%), followed by students (n=32; 28.57%) and electrical workers (n=17; 15.17%). Consistent with this occupational distribution, the workplace was the most common site of injury (n=65; 58%). Rooftops were the second most common location (n=24; 21%), followed

by residences (13%). Regarding the mode of occurrence, 56.25%(n=63) of injuries occurred at work, often in unsafe environments without safety protocols. Notably, 13.39%(n=15) occurred while activities on rooftops, and smaller percentages were attributed to activities such as rescuing kites or drying clothes. (Table 2)

Table 2. Distribution of the patients according to occupation and place of occurrence(n = 112).

Characteristic	Category	Patients, n,(%)
Occupation	Construction worker	33 (29.46)
	Student (children and adolescents)	32 (28.57)
	Others (service holder, dish TV, broadband cables)	20 (17.85)
	Electrical worker	17 (15.17)
	Housewife	4 (3.57)
	Grill workshop worker	2 (1.79)
	Plumber	2 (1.79)
	AC servicing	1 (0.89)
	Farmer	1 (0.89)
Place of occurrence	Workplace	65 (58.04)
	Rooftop	24 (21.43)
	Residence (other than rooftop)	14 (12.50)
	Outside residence (playground, road)	9 (8.03)
	Total	**112 (100)**

Clinical Characteristics

Bilateral limb involvement was common, observed in 52%(n=58) of cases, while the right upper limb was involved in 27% (n=30) and the left in 21%(n=24). The right upper limb was the entry point for the current in 67% of cases. In terms of burn depth, full-thickness burns were the most prevalent, affecting 62.5%(n=70) of patients. Mixed burns were seen in 24.11% (n=27) while 7.14% (n=8) presented with charred limbs or frank gangrene. (Figure 1) Regarding the extent of injury, nearly half of patients (49.11%) had burns involving less than 5% of the upper limb surface area, with smaller proportions having more extensive involvement. (Table 3).

Clinical Outcomes

Compartment syndrome was a significant complication, clinically evident in 44.64% (n=50) of patients at admission. All patients presenting with compartment syndrome underwent fasciotomy. (Figure 2) Despite these interventions, the rate of amputation was high. Amputation was required in 39.29% (n=44) of patients. Specifically, eight patients with charred limbs underwent immediate amputation, while 36 required amputation following unsuccessful fasciotomy. (Table 4) However, a timely fasciotomy successfully salvaged the limb in 28% of cases. Inferential statistics revealed a significant association between the presence of compartment syndrome and the eventual need for amputation ($\chi^2 = 40.52$, $p < .001$).

Table 3. Distribution of the patients according to mode of occurrence, percentage of burn and depth (n = 112).

Characteristic	Category	Patients, n,(%)
Mode of occurrence	Accident while working	63 (56.25)
	While playing on rooftop	15 (13.40)
	While playing on balcony	4 (3.57)
	Accident at home	5 (4.46)
	While removing clothes on rooftop	3 (2.68)
	Rescuing kites	3 (2.68)
	Others	19 (16.96)
Limb involvement	Right upper limb	30 (26.79)
	Left upper limb	24 (21.43)
	Both upper limbs	58 (51.78)
Depth of burn	Full thickness	70 (62.50)
	Mixed depth	27 (24.11)
	Electric flash burn	7 (6.25)
	Charred limb / gangrene	8 (7.14)
	Total	**112 (100)**

Figure 1. High voltage electric burn injury involving upper limb: **A**: Charred limb left upper limb. **B**: Post electric burn gangrene of right upper limb **C**: HVEB with compartment syndrome **D**: Involvement of whole upper limb **E**: Muscle necrosis in arm **F**: Gangrene of right forearm.

Table 4. Distribution of patients according to clinical outcome (n = 112).

Characteristic	Category	Patients, n,(%)
Percentage of burn involving upper limb	0–5%	55 (49.11)
	5–10%	37 (33.04)
	10–15%	12 (10.71)
	15–18%	8 (7.14)
Compartment syndrome at admission	Developed	50 (44.64)
	Not developed	62 (55.36)
Fasciotomy performed	Yes	50 (44.64)
	No	62 (55.36)
Amputation	Yes	44 (39.29)
	No	68 (60.71)
	Total	**112 (100)**

Discussion

High voltage electrical burn (HVEB) injuries represent some of the most severe forms of trauma. Our study found a significant male predominance (89.3%), consistent with global trends indicating higher male participation in high-risk occupations such as construction and electrical work.[5,6] The age distribution, peaking in young adults (22-40 years), underscores the economic impact of these injuries, as this demographic is the most active in the workforce.[8,9]

We observed a distinct seasonal variation with injuries peaking in May and June. This aligns with the summer months in Bangladesh, when electricity demand surges, increasing the risk of grid overload and accidental contact.[1,5] This suggests that prevention campaigns should be intensified prior to and during the summer season.

Figure 2. A-B: Fasciotomy and above elbow done amputation following high voltage electric burn injury involving upper limb. C-D: Follow up picture following amputation.

Occupational hazards were the primary driver of these injuries, with construction and electrical workers comprising nearly 45% of the cohort. However, the high number of students and adolescents (28.57%) affected is alarming. Many of these injuries occurred on rooftops or balconies, underscoring the risk posed by unregulated construction where high-voltage lines run dangerously close to residential areas.[5,6,9]

Clinically, the correlation between compartment syndrome and amputation was significant. While 44.64% of patients presented with compartment syndrome, early fasciotomy salvaged the limb in a portion of these cases. However, the overall amputation rate remains high at 39.29% mostly due to delayed presentation. These findings are consistent with recent literature; for instance, Goyal et al. (2021) reported similar high morbidity and amputation

rates in high-voltage injuries, emphasising the critical window for surgical decompression.[16] The presence of charred limbs in 7% of our patients indicates the devastating power of high-voltage contact, often rendering reconstruction impossible.

Implications and Recommendations

The high incidence among young males suggests a need for strict workplace safety enforcement and the provision of protective equipment (PPE), which was utilised by only 7% of workers in our study. Based on the correlation between compartment syndrome and amputation, we recommend:

- Early Detection: Routine screening for compartment syndrome in all electrical burn admissions.
- Prompt Intervention: Protocols ensuring immediate fasciotomy for patients with clinical signs of compartment syndrome.
- Education: Public awareness campaigns focusing on the dangers of rooftop activities near power lines.

Limitations

The study's short duration and focus on a single national referral centre may limit the generalizability of the findings. Additionally, a significant limitation is the lack of long-term functional follow-up data, including rehabilitation outcomes, quality-of-life (QoL) assessments, and workforce reintegration. And also, there is the absence of microbiological or vascular imaging data, and the lack of standardized functional outcome measures. Future research should utilise Participatory Action Research (PAR) to develop longitudinal interventions addressing these gaps.

Conclusion

HVEB injuries remain a significant public health challenge in Bangladesh, predominantly affecting young, active males. These injuries are largely preventable through awareness and safety measures. Our findings highlight the critical need for early surgical intervention to prevent amputation. Further research is needed to explore long-term functional outcomes and quality of life in these patients.

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