Original Research Article

Role of Early Fasciotomy and Skin Cover in the Management of Acute Electrical Burns of the Upper Limbs - A Prospective Case Series

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Abstract

Background: Electrical burn injuries are still amongst the highest accident-related morbidities.
Aim: To assess the demographic profile as well as to study outcomes of early fasciotomy in salvage acute electrical burns involving upper limbs.
Materials and Methods: The present study was a prospective case series study conducted in Department of Plastic and Reconstructive Surgery at Gandhi Medical College and Hospital, Secunderabad, from January 2020 to January 2022. Total 20 study subjects were evaluated. Electrical burn injury was assessed at the time of admission. Data was analyzed by using coGuide software, V.1.01.
Results: In the study population, 55% belonged to age group of 30 years. Male predominance with 75% compared to female. Accidents 40% were major cause of injury. In majority, 65% of the cases fasciotomies were done within 48 hrs of electrical burn injuries.
Conclusion: The results of the study concluded that younger generation is more prone to electrical burn injuries and males were majorly affected. Unsafe work areas and accidents are main reasons for injuries. High voltage affected the study population compared to low voltage. Amputations were required in fingers and below elbow. Early fasciotomy, repeated debridement's, definitive skin cover (SSG/flap) have helped in reducing the morbidity and improving the quality of life of the patient.

Key words

Electrical burns, Early fasciotomy, Secunderabad, Upper extremity.

Introduction

Electrical burns and burn-related mortality are increasing due to the use of electricity in all areas of life and technology. The mechanism of injury is complex, being a result of the combination of diverse thermal and non-thermal processes. Electrical contact burns, when compared to flash burns, are more dangerous as they cause deeper wounds that result in increased morbidity and mortality. Electrical burns can be classified as high voltage (>1000V) or low voltage (<1000V). There have been reports of a higher incidence of high-voltage electrical burns in developing countries. An increase in industrialization and population density makes people more prone to electrical injury [1–4]. Statistical data shows that cases of electrical burns constitute approximately 0.04–5% of admissions to burn units in developed countries and up to 27% in developing countries [5].

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, 6]. Electrical injuries occur due to the 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 [7, 8].Within 48 hours of injury, a compartment syndrome may develop in an involved extremity secondary to progressive myonecrosis as well as to fluid resuscitation. If not addressed promptly, increased interstitial pressure results in decreased perfusion of otherwise uninjured tissues, resulting in irreversible damage necessitating amputation [9]. Both morbidity and mortality in electrical injuries are relatively high and have physical and psychological short-term and long-term sequelae. [10, 11] Most electrical injuries are preventable, provided there are appropriate safety precautions. Almost all electrical injuries are accidental and often preventable. The presence of extensive burns and tissue necrosis, associated traumatic wounds, myocardial injuries, and arrhythmias, neurological injury, secondary organ failures will determine the subsequent outcome and long-term prognosis [5, 12].

Early fasciotomy is defined as a fasciotomy performed during a patient's first trip to the operating room. [13, 14]. Rates of 10 to 50 percent of early fasciotomies performed within 24 hours for compartment release have been reported, and these have reduced the rates of limb amputations [15, 16].However, early fasciotomy is not without complications. It may result in disfiguring scars, contractures, nerve damage, and significantly lengthening the course of treatment [17]. Despite early fasciotomy as a limb-saving measure, there are still cases of limb amputation being reported [9, 14]. Hence the current study was conducted to assess the demographic profile as well as to study outcomes of early fasciotomy in salvage acute electrical burns involving upper limbs.

Materials and methods

The present study was a prospective case series study conducted in the Department of Plastic and Reconstructive Surgery at Gandhi Medical College and Jospital, Secunderabad, from January 2020 to January 2022. A total of 20 study subjects were evaluated for the present research. The study population included participants with electrical burns involving the upper limb but not exceeding 30% of total body surface area (TBSA). The exclusion criteria for the study were lightning injuries and electrical burns, which involved more than 30% TBSA.

Electrical burn injury was assessed at the time of admission. The extent of the injury was marked in the case sheet. Photographs were taken for

record purposes. Over the days, the progression of the injury was observed and recorded.

Immediate complications were ruled out or addressed, and resuscitation of the patient was started after determining the percentage of TBSA involved (calculated using the Lund and Browder chart). Adequate resuscitation was confirmed by maintaining adequate urine output. Ringer was administered 7 ml/kg body weight of electrical burns initially adjusted to maintain 1-1.5 ml/kg/hr urine output. Blood transfusions were given in cases of anemia due to red cell destruction. Upper limbs were observed for any signs of increased compartment pressure, such as disproportionate pain, more pain on passive stretch, hard, shiny skin over a swollen limb, and absence of pulse or sensory deficit.

Fasciotomy was performed in circumferential deep burns to prevent an increase in intra-compartmental pressure. The skin cover is achieved by means of a split-thickness skin graft if the wound bed is healthy or granulating without exposing vital structures. Exposed vessels, nerves, tendons, and bone is covered with distant flaps. Groin flaps, hypogastric flaps, and abdominal flaps, either superiorly based or inferiorly based, are commonly used distant flaps. Amputation of the gangrenous part is done in established cases to reduce myoglobin load, prevent infective complications, and reduce the risk of secondary hemorrhages. Written informed consent was obtained from the study participants before enrolling them in the study, and ethical clearance was obtained from the institutional ethical committee.

Statistical methods:

Descriptive analysis: Descriptive analysis was carried out by mean and standard deviation for quantitative variables and frequency and proportion for categorical variables. Data was also represented using appropriate diagrams like bar diagrams and pie diagrams.

Data were analyzed by using coGuide software, V.1.01 [18].

Results

A total of 20 participants were included in the final analysis.

Involvement of the upper limb electrical burns was seen more in adult and adolescent age groups (21-40 years). Males were the victim in majority of cases 15 (75%). History of accidental contact of the high-tension live wires was seen in eight (40%) cases. There were 35% of un-trained causal laborers who sustained electrical burns because of not adhering the safety measures during work. Majority of 75% had high voltage (>1000 V) electrical burns. Out of 20 electrical burn injuries, 17 (85%) were electrical contact burns and 15% were flash or flame type of burns. Out of 20 total cases in my study, fasciotomies were done in 15 (75%) cases. In majority 65% of the cases fasciotomies were done within 48 hrs of electrical burn injuries (**Table - 1**).

Table - 1: Descriptive analysis of Baseline Parameters in the study population (N=20).

Baseline Parameters	**Summary**
Age	
Up to 30 years	11 (55%)
>30 years	9 (45%)
Gender	
Male	15(75.00%)
Female	5(25.00%)
Etiology	
Accidental	8(40.00%)
Unsafe work area	7(35.00%)
Play	3(15.00%)
Alcohol influence	2(10.00%)
Voltage	
High Voltage > 1000 V	15(75.00%)
Low Voltage < 1000 V	5(25.00%)
Type of Injury	
Electrical contact burns	17(85.00%)
Flame or flash burns	3(15.00%)
Timing and Areas of Fasciotomy	
Fasciotomies	15 (75%)
Fasciotomies done (48 hrs)	13 (65%)

Split thickness skin grafts were needed in 25% patients. Serial excisions and serial debridements

were needed in nine cases out of 20 cases. Progressive nature of injury was observed in electrical burn cases which required repeated debridement's in 46% of cases. Delay has been done in all the 10 (50%) flap cases at 3 weeks and after another week division & inset has been Tendon and nerve reconstructions were not done in any of our cases. They were contemplated on follow up after the flap had settled well. In our series, patients are yet to report for the tendon and nerve procedures and functional restoration. In one case we have done re-do flap cover due to wound dehiscence and flap necrosis. Prosthesis has been given to all the five patients who had amputation surgery and physiotherapy has been advised to all the 20 patients to reduce morbidity. Normal functional restoration is yet to be given in the present study. 5 patients had to undergo amputation surgeries. Out of 20 patients, 95% were in regular follow up with us and physiotherapy department except one patient who expired due to cardiac arrest (**Table - 2**).

Table - 2: Descriptive analysis of Timing and Areas of Fasciotomy in the study population.

Timing and Areas of Fasciotomy	PBD 1	PBD 2	PBD 3	Total
Forearm alone	1 (25%)	2 (50%)	1 (25%)	4
Forearm & wrist	1 (50%)	1 (50%)		2
Hand alone		3 (75%)	1 (25%)	4
Forearm, wrist & hand	2 (50%)	2 (50%)		4

***PBD- Post Burn Day**

Table - 3: Descriptive analysis of Amputations in the study population (N=20).

Post electrical days	Disarticulation of fingers	Below elbow amputation	Above elbow amputation	Disarticulation of shoulder
5 Days		1 (33.33%)		
7 Days	2 (66.66%)	1 (33.33%)	1 (100%)	1 (100%)
1-2 weeks	1 (33.33%)	1 (33.33%)		
Total	**3**	**3**	**1**	**1**

Table - 4: Descriptive analysis of Flap Cover in the study population (N=10).
Total number of flap cases done was 10 cases.

Flap Type	<7 Days	1-2 Weeks	2-3 Weeks
Groin flap	2 (66.66%)	1 (33.33%)	
Para Umbilical flap	1 (33.33%)	2 (66.66%)	
Superiorly based abdominal flap	1 (50%)	1 (50%)	
Inferiorly based abdominal flap		1 (100%)	
Superiorly and Inferiorly based abdominal flap			1 (100%)

Amputations / disarticulations, if required were done between day five and before 2 weeks. They ranged from disarticulation of fingers to even shoulder disarticulation (**Table - 3**). Descriptive analysis of Flap Cover in the study population was as per **Table – 4**. Size and dimensions of defects was as per **Table – 5**.

Discussion

The present research focused on electrical burns and their threat as a public health issue as they lead to prolonged hospital admission and multiple surgeries to achieve complete wound healing. In the present study population, while evaluating the demographic data, we found that the majority population affected was the younger generation, and participants of more than 30 years of age were negligible. In the present

study, when genders were compared, there was male predominance observed. Gandhi G et al. found that 65% of patients below 30 years of age and a mean age of 31.83 years, and (91.3%) of patients were males [19]. Study conducted in Albania showed similar findings as the mean age of patients 31 (± 8.3) years old with a predominance of males (94%) [20]. In a study by Ghavami, et al., 97.8% of the affected victims were males, and 59.4% were in the age group between 21-40 years [21]. The current research findings and previous literature shows clear relations between age and gender. Here we can see that due to increased industrialization and exposure to electrical applications.

Table - 5: Size and dimensions of defects.

Flap Type	Site	Defect Size	Dimensions
Groin flap	One First web space defect Two wrist defects	7X5 cm 5X7 cm 8X7 cm	8X6 cm 6X8 cm 9X8 cm
Para Umbilical flap	One Extensor aspect of the forearm defect Two Flexor aspect of forearm defects	9X8 cm 7X5 cm 10X8 cm	10X9 cm 8X6 cm 11X9 cm
Superiorly based abdominal flap	one palmar aspect defect one volar aspect of the wrist and distal forearm defect	7X5 cm 5X3 cm 5X4 cm	8X6 cm 6X4 cm 6X5 cm
Inferiorly based abdominal flap	one Dorsum of the hand defect	7X6 cm	8X7 cm
Superiorly and Inferiorly based abdominal flap	One circumferential defect of distal forearm	14X7 cm	20X8 cm

Another noticeable finding from the present research was the cause of burn injury. We noticed that accidents were a major cause of burn injuries, followed by unsafe occupational areas; a study by Segu SS et al. found forty-six percent of patients sustained injuries at the work site [22]. Similar study in Albania found that, in total, 35% of accidents occurred at night shifts [20]. These observations recommend there is a need for safer workplaces and properly insulated electrical appliances.

In the present study, high voltage > 1000 V was a major cause of injury. Previous literature presented similar findings where it was found that in 38.3% of high-voltage injuries (HVI), a total of 82 patients (50.6%) were observed with HVI in studies by Shih JG et al. and Gille J, et al. [5, 23]. Similarly, a study by Başaran et al. found that 92% were burned with high-voltage electricity [1]. These findings clearly suggest danger signs of HVI, but we also should not underestimate low voltage injury (LVI). Electrical contact burns were presented predominantly by study subjects. Our results were similar to a 5-year review as it presented with 69.01% of patients with direct contact injuries [22].

When we analyzed timings and fasciotomy areas, we found that majority underwent fasciotomy, and few underwent fasciotomy within 48 hrs, while forearm alone, hands alone, and forearm wrist and hand were majorly affected areas. Early fasciotomy releases the pressure within a compartment under tension and restores adequate perfusion to viable tissues, which prevents tissue necrosis. In marginally injured tissues seen in the zone of stasis surrounding the necrotic burn zones, early fasciotomy improves tissue perfusion and prevents further necrosis of burn tissue [14]. In a case report, it was found that participants had 3% visible total body surface

area burns involving bilateral wrists circumferentially and bilateral hands [24].

In the present research, disarticulation of fingers and below the elbow amputation was major sites involved in amputation. A study by Zikaj G et al. found that superior extremities were more affected, with the hand (21.2%) and fingers (18.2%) being the main point of contact ($p < 0.01$) [20]. similar to our study, 46.7% of finger amputations were seen in the study by Bartley CN et al. [25]. In a study conducted at a tertiary center, 28 patients underwent below-elbow amputation [2]. Previous literature suggests that high-voltage burns involved more amputations of one upper limb, probably because that upper limb was the most common current entry point [26, 27]. We observed groin flap and para-umbilical flap were majorly used in our study. In a study by Segu SS et al., the most commonly used flaps for upper extremity reconstructions were groin flap (60 patients), random abdominal flap (28 patients), paraumbilical perforator flap (15 patients) [22].

The limitations of this study include its small sample size. We recommend more studies with larger sample sizes, including outcome measures such as other complications and hospital stay durations.

Conclusion

The results of the study conclude that the younger generation is more prone to electrical burn injuries, and males were majorly affected. Unsafe work areas and accidents are the main reasons for injuries. High voltage affected the study population compared to low voltage. Amputations were required in the fingers and below the elbow. Early fasciotomy, repeated debridements, and definitive skin cover (SSG/flap) have helped in reducing morbidity and improving the quality of life of the patient.

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