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A Clinical Study and Management of Electrical Burns in Upper Limbs

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Abstract

Introduction: Electrical burns constitute the fourth leading cause of work related death. Tissue destruction is extensive often requiring amputation. Upper limb involvement is present in majority of the electrical burn injuries, these injuries can be avoided with proper education, safety regulations, and a safe effective electricity delivery network.

Aims: To study various types of treatment strategies with patients and clinical outcome in terms of functionality.

Materials and Methods: This is a prospective study conducted for a period of 2 years. All the patients with major upper limbs electrical burns were included in the study. 140 patients were admitted with electrical burns out of them 90 had upper limbs involvement. Out of those 140 patients 34 were Pediatric patients with age less than 10 years.

Results: Males (83.3%) mostly presented with burns of upper limbs when compared with females. Farmers and electricians are the most commonest group effected, Most of them being sustaining High-voltage burns. Most common site affected was fore arm followed by hand and arm. Rural to urban ratio was 2:1 and hospital stay of 50 patients (55.5%) was approximately between 0 and 15 days.

Conclusion: Pedicled distant flaps are reliable, durable and easy to perform for the post electrical burn defects of the upper limbs, which gives predictable results.

Keywords: Electrical Burns; amputation; Plastic-reconstructive procedures.

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Introduction

In the modern times with sophisticated life style, population explosion, increased agricultural and industrial activities etc. The use of electricity has increased many times and so, has the incidence of electrical burn injuries. Electrical injuries are the third most common cause of burns after scald and flame burns. Electrical burns constitute the fourth leading cause of work related death.[1] Electrical injuries account for 3–5% of all admissions to major burn centres. According to statistical data, all over the world electrical injuries are second most important cause for admission to a burns unit (US–60%, Asia and Africa – 20%).[2] Approximately 1000 deaths per year are due to electrical injuries in the United States, with a mortality rate of 3–%.[1]

In addition to power company linemen and electricians, construction workers, laborers and crane operators are at special risk. Typical high-tension electrical injuries are generally well-demarcated, full-thickness, and leathery on palpation, Tissue destruction is extensive often requiring amputation. Upper limb involvement is present in majority of the electrical burn injuries. In this study, the profile of electrical burns in upper limbs were assessed including incidence, different sites, extent, degree of burns and various types of treatment strategies.

The spectrum of electrical injuries is complex due to extensive tissue loss and damage to essential structures of the involved areas often requiring extensive plastic-reconstructive procedures. Electrical injuries are unique with very high morbidity, requiring lengthy hospital stay and multiple operations.[2] Timely intervention to save life and limb, followed by efforts to maximize functional and cosmetic outcome are necessary.

Importantly, these injuries can be avoided with proper education, safety regulations, and a safe effective electricity delivery network.

Materials and Methods

This is a prospective study conducted at Osmania General Hospital, Hyderabad from March 2017 to August 2019. All the patients with major upper limbs electrical burns were included in the study. The upper limbs electrical burns resulting requiring multiple surgical procedures like debridement, resurfacing procedures like skin grafting or flap cover were categorized as major upper limb electrical burns. 140 patients were admitted with electrical burns out of them 90 had upper limbs involvement. Out of those 140 patients 34 were Pediatric patients with age less than 10 years and 16 patients sustained electrical burns other than upper limbs hence, not included in my study. On arrival at the emergency department the patients were evaluated for vitals and resuscitated using strict ALTS protocols. An electrocardiogram is performed for all the electrical burn patients and then shifted to The Acute Burn Care Ward, where complete history and clinical examination is carried out. Complete history regarding the occupation, mode of injury, duration of contact, voltage, h/o of fall from height, any associated injuries, comorbidities is recorded. The percentage of burns was calculated by Wallace rule of nine. The fluid replacement was done with normal saline and titrated to maintain the urine output of 0.5 to 1 ml/kg/hr. Myoglobinuria when present was treated with mannitol and sodium bicarbonate. A complete surgical profile (Complete blood picture, blood sugar, bl. urea, s. creatinine, s. electrolytes, screening, protiens and CUE) was done for all the patients. Other investigations like CT brain, arterial blood gas analysis, chest *X*-ray, ultrasound abdomen, MRI spine were done when indicated. Patients with h/o fall from height were examined for any head injury, long bone fractures, blunt trauma abdomen, chest and then treated accordingly by the concerned specialist. Electrical burn wound was managed by serial surgical wound debridements followed by resurfacing of the defects with skin grafting and loco-regional flap covers as indicated. The coverage of the wounds was delayed because of the high chances of progressive necrosis of the injured tissue due to progressive microthrombus formation. Nano crystalline silver with collagen was used for local application over the burned area. Detailed analysis of these 90 cases with major upper limb electrical burns was performed in terms of the following variables as incidence, age, sex, occupation, percentage of burns, percentage of upper limb involvement, sites of Involvement, side of Involvement, procedures done, complications, mortality, hospital stay and rural to urban ratio. After the discharge patients were followed up initially weekly for 15 days followed by once a month there after for one year.

Results

Table 1: Demographic distribution in present study

Age at presentation	Number of patients	Percentages
11–20	27	30%
21–40	47	52.22%
41–60	16	17.77%
Gender distribution		
Male	75	83.33%
Female	15	16.66%
Percentage of burns		
0–20	49	54.44%
21–40	25	27.77%
41–60	10	11.11%
> 60	6	6.66%

- Incidence of Electrical burns admitted in our institute is 8.75% of the total burn admissions of which 5.6% is the incidence of electrical burns sustained in upper limbs.
- Most common age group affected are between 20 and 40 years (52%).
- In this study, Males (83.3%) mostly presented with burns of upper limbs when compared with females.

Table 2: Distribution of study variables in study

Variable	Number of cases	Percentages
Rural	60	66.6%
Urban	30	33.4%
Occupation		
Farmer	30	33.33%
Electrician	25	27.77%
Household	23	25.55%
Construction Laborer	8	8.88%
Painter	3	3.33%
Suicidal	1	1.11%
Type of electrical burns		
High Voltage	68	75.5%
Low Voltage	22	24.5%

Farmers and electricians are the most commonest group effected, Most of them being sustaining High-voltage burns.

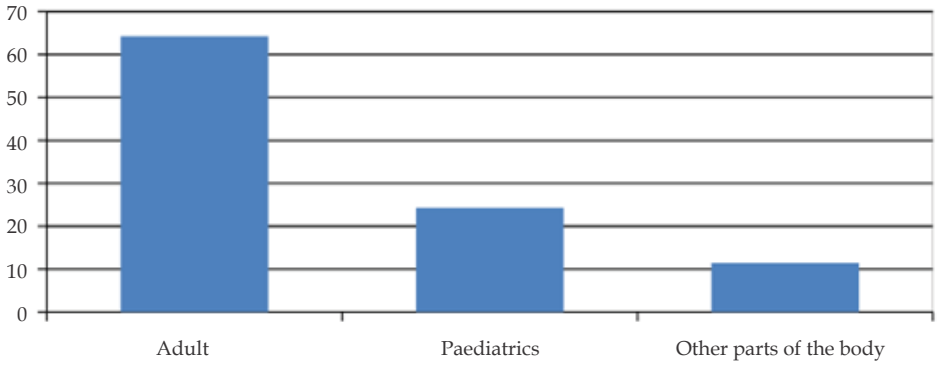

Fig. 1: Percentage of upper limb involvement

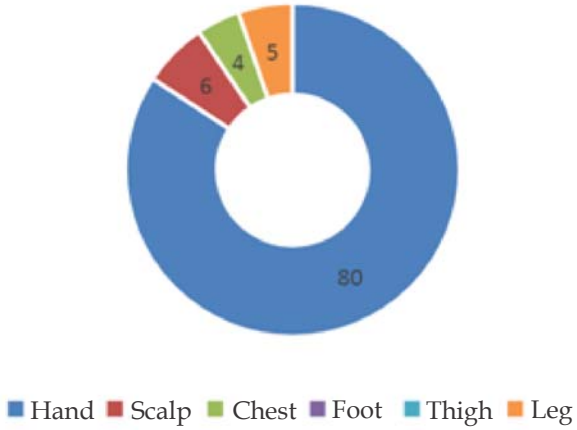

Fig. 2: Point of contact (entry wound and exit wound

Table 3: General variables in study

Variables	Number of subjects	Percentages
Site		
Arm	20	22.22%
Elbow	3	3.33%
Forearm	34	37.77%
Wrist	9	1%
Hand	24	26.66%
Side		
Right	42	46.6%
Left	34	37.7%
Bilateral	14	15.5%
Associated injuries		
Head injury	5	5.55%
Abdominal injury	2	2.22%
Spine injury	2	2.22%
Chest injury	4	4.44%

Most common site affected was fore arm followed by hand and arm. Most effected side was right upper limb followed by left upper limb. In this study, Rural to urban ratio was 2:1

Most of the entry wounds were located in the hand and exit wounds were located in the foot.

Table 4: Procedures done in study

Procedures done	Number of subjects	Percentages
Conservative	11	12.22%
Fasciotomies	20	22.22%
Debridement	18	2%
Shoulder disarticualation	4	4.44%
Above elbow amputation	9	1%
Below elbow amputation	8	8.88%
Disarticulation of fingers	10	11.11%
Groin flap	6	6.66%
Abdominal flap	9	1%
Pia flap	3	3.33%
Lateral thoracic flap	3	3.33%
Cross finger flap	3	3.33%
Thoraco umbilical flap	1	1.11%
Radial artery perforator flap	2	2.22%
Local transposition flap	1	1.11%
SSG	12	13.33%
W flap	1	1.11%

Early fasciotomy, repeated debridements, non-postponement of definitive skin cover (SSG/flap) were observed in this study. In this study, most of the fasciotomies were performed on or before the second postburn day

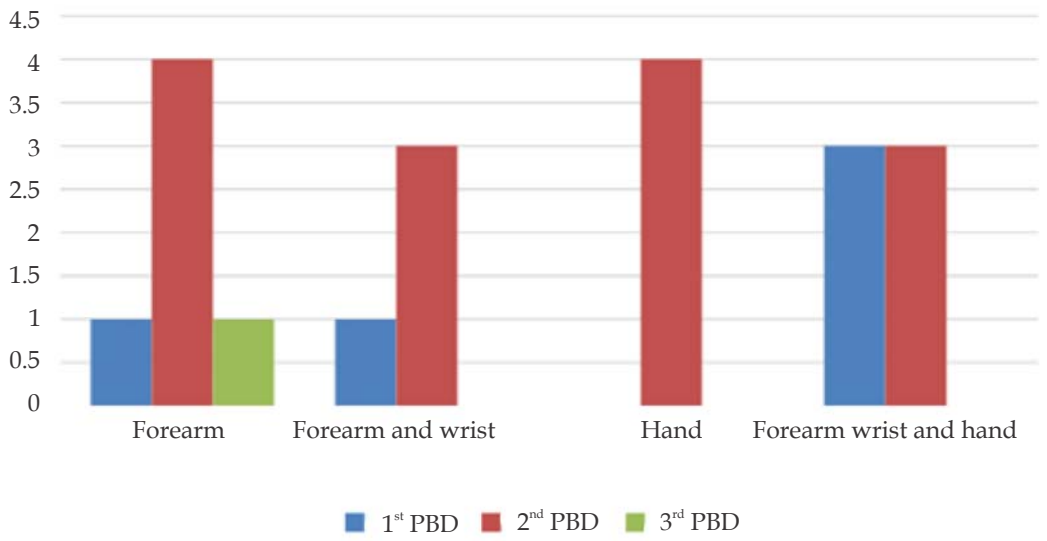

Fig. 3: Timing and area of fasciotomies

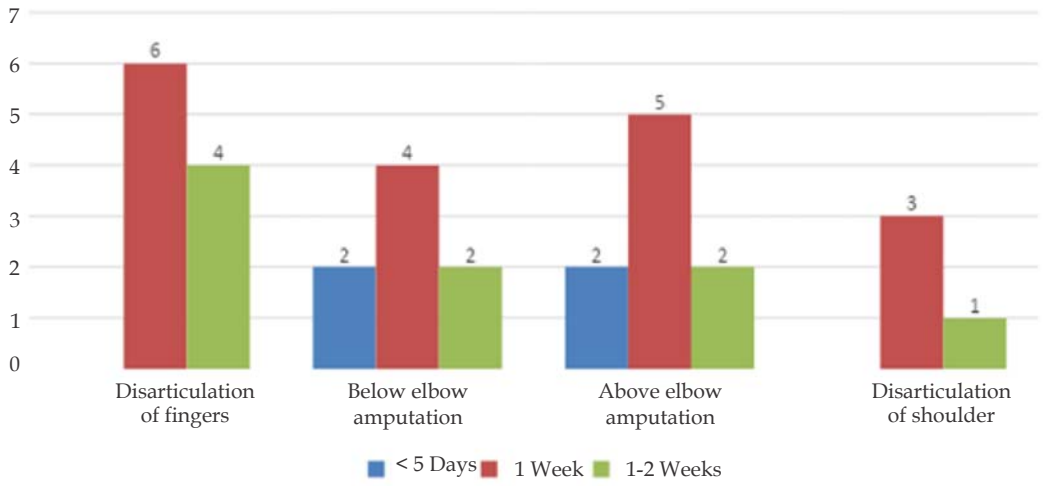

Fig. 4: Timing of amputations

Table 5: Timing of flap covers

Flap type	1 Week	1–2 Weeks	2–3 Weeks
Groin Flap	1	4	1
Abdominal Flap	1	6	2
Pia Flap		2	1
Lateral Thoracic Flap	1	3	
Cross Finger Flap		2	
Thoraco-Umbilical Flap		1	
Radial Artery Perforator Flap		1	1
Transposition Flap		1	
W Flap			1

In this study, the hospital stay of 50 patients (55.5%) was approximately between 0–15 days.

Discussion

Electricity, although an important commodity, has become a significant cause of injury in the society. Electrical burn injuries represent a special type of injury which results in high morbidity with functional and aesthetic sequelae. Both the high and low-voltage electricity can produce muscle damage (myonecrosis) with myoglobinemia and myoglobinuria. High-voltage exhibits a greater current flow and hence causes more severe tissue damage. The strategic management of high-voltage electrical injury can be both challenging and complex. The management of the upper limb electrical burns is more challenging as it involves both functional and aesthetic elements and begins at the moment of the injury and continues through the rehabilitation period. 12 Lead ECG was taken

for all electrical burn cases and signs of myocardial injury or arrhythmia were looked for. Continuous ECG monitoring was done in cases where 12 lead showed some abnormalities. The apparently seen cutaneous injury is the tip of an iceberg. As there will be an extensive destruction of all the underlying structures, fluid requirement is much greater than thermalburns. Limbs were observed for any signs of increased compartment pressure such as disproportionate pain, pain on passive stretch, hard shiny skin over a swollen limb and absence of pulse or sensory deficit. In my study, various pedicled distant flaps including Groin flaps, abdominal flaps, posterior interosseous flap, Lateral thoracic flap, cross finger flaps, thoracoumbilical flaps were used to cover the postelectrical burn defects with exposed vital structures in the upper limbs.[2,3]

A total of 1600 burn patients were admitted between March 2017 and August 2018. Total number of electrical burn patients admitted are 140 during this study period out of which 34 are below the age group of 10.90 Adults sustained electrical burns of upper limbs in this study. The incidence of electrical burns in upper limbs is 5.6% in this study. The most common cause of burns admission was due to thermal burns followed by electrical burns. In a International study conducted by Margarita S Elloso et al. the incidence of electrical burns in upper limbs is 5.8% worldwide.[3] In a study, conducted by Gentian Zikaj et al. the incidence of electrical burns of upper limbs is 5.45% which was studied in 33 patients across 2 years.[4] In our study, the incidence of electrical burns is 5.6%. In a study, conducted by Sunil Srivastava et al. the total number of burns admitted were 2021 out of which electrical burns were 768 across 2 years.[5] The incidence in this study was around 38% which is almost seven times higher than the incidence in our study. In a study, conducted by Ajay Lunawat et al. the incidence of electrical burns in upper limbs was 9.4% which is higher than our study.[6] In a study, conducted by Sachdev et al. the total incidence of electrical burns was 7.2% which was almost similar to the incidence occurred in our study.[7]

Patients in this study were in the age range between 10 and 55 years. Most common age group was between 21 and 40 years comprising of 47 cases which is 52% of the total cases. Next common age group is 10 to 20 years comprising of 27 cases which is 30% of the total cases. In the Kasana et al. study the most common age group was 20–40 yrs constituting about 73.7% of the victims which was higher than our study.[8] In a study, conducted by Ajay Lunawat et al. 71.5% of the patients were in the age group between 21 and 40 years which was higher than our study followed by 23.8% of patients in the age group 0–20 years which was lower than our study.[6]

In our study, Number of males affected were 75 which comprises of 83.3%. 15 were female comprising about 16.7%. Jain et al. study 82% of them were males and in another study by Kasana et al. males constituted about 94 percent.[9,8] Males are more affected because they are the earning group and most of the electrical workers and farmers are males.

In the study, conducted by Gentian Zikaj et al. 94% were males and 6% constituted females which is higher than compare to our study.[4] The percentage of males and females effected from our study were similar to the conducted by Jain et al.[9]

In this study, percentage of upper limb involvement is 64.2%. In a study, conducted by Ashok Suryabhanji Gajbhiye et al. percentage of involvement of upper limbs was 87.2 percent which was quite higher than our study.[10]

Most of the patients belonged to the 0–20 percentage which accounted for 54.4% of the total patients followed by 25 patients who were between 21 and 40% which accounted for 27.7% of total patients. 10 patients were present between 41 and 60% which accounted for 11.1% of total patients. The mean percentage of burns was 23.07%. In a study, conducted by Kasana et al. mean percentage of burns was 16.32 plus or minus 8.13 percentage.[8]

In a study, conducted by D Kym et al. 72.2% of patients were between 0 and 20%, 21.1% were between 20 and 40% and 35.7 percent were between 40 and 60%.[11] In a study, conducted by Gentian Zikaj et al. percentage of total body surface area varied from 3 to 30 percentage.[4]

Farmers, electricians and construction laborers accounted for 68.8% of the total population. 25.5% sustained electrical burns due to house hold activities. In Kasana et al. study the work related injuries were seen in 75.93% of patients.[8] In Jain et al. study the work related injuries were 65.3%.[9]

In our study, 68 patients patients sustained high-voltage burns which was about 75.5% and 22 patients sustained low-voltage burns which was about 24.5%. In a study, conducted by Sunil Srivastava et al. 73.04% patients sustained high-voltage electrical burns followed by 27.01% patients who sustained low-voltage injuries which was almost similar to our study.[5] In a study, conducted by Margarita S Elliso et al. 79 percent were high-voltage electrical burns and 21 percent were low-

voltage electrical burns which was almost similar to our study.[3] In a study, conducted by Gentian Zikaj et al. 81.8% sustained high-voltage burns which was comparatively higher and 18.2% sustained low-voltage burns which was comparatively lower than our study.[4]

In our study, 42 patients sustained burns to right upper limb which was about 46.6 percentage, 34 patients sustained electrical burns to left upper limb which was about 37.7 percentage. 14 patients sustained electrical burns to bilateral upper limbs which accounted for 15.5 percent. In a study, conducted by Kasana et al. 64.2% of patients sustained electrical burns to right upper limbs which was higher than in our study, 35.8 percentage of patients sustained electrical burns to left upper limb which was similar to our study.[8]

In our study, 5 patients sustained head injury, 4 patients sustained chest injury, 2 patients sustained spine injury resulting in quadriplegia, 2 patients sustained abdominal injury causing pancreatic injury and large bowel injury. 13 patients had associated injuries which accounted for 14.4%. In a study, conducted by Karimi H et al. assosciated injuries were seen in 37 patients which accounted for 21.02%, which was higher when compared to our study.[12] In a study, conducted by Alper Kurt MD et al. seven patients presented with associated injuries which was about 7.4%,lower than compared to our study.[13]

Sixty patients from our study belonged to rural area which is approximately 66.6%. 30 patients were from urban area comprising of 33.4%. Higher incidence in rural areas was due to illiteracy and lack of proper staff pertaining to electricity department, lack of proper transmission lines and lack of proper insulating devices. In a study, conducted by Karimi H et al. two thirds of patients were from rural area and one thirds of patients were from urban area.[12] Rural to urban ratio from our study was similar to the study conducted by Karimi H et al.[12]

In our study, most of the entry wounds were from hand about 80 of them and exit wounds were from foot about 81 of them. In a study, conducted by Kasana et al. most of the entry wounds were from the upper extremities and exit wounds were from the lower limbs.[8]

Most frequent point of contact was upper extremities about 63.6% in a study, conducted by Gentian Zikaj et al.[4]

The electrical burn wound management differs from the other types of burns in that there is progressive tissue necrosis secondary to endothelial damage. Hence, serial debridements are required. Available options for wound management encompass total range of plastic reconstructive procedures from skin grafts to loco regional flap covers. In our study, 11 patients had conservative treatment, fasciotomies were done in 20 patients usually on the first or second day, debridements were done in 18 patients, shoulder disarticulation was done in 4 patients, above elbow amputation was done in 9 patients, below elbow amputation was done in 8 patients, disarticulation of fingers in 10 patients, groin flap was done in 6 patients, abdomen flap in 9 patients, posterior interosseous artery flap in 3 patients, lateral thorasic flap in 3 cases, split thickness skin grafting in 12 patients, cross finger flap in 3 patients, thoraco umbilical flap in 1 patient, 'W' flap in 1 patient, transposition flap in 1 patient, radial artery perforator flap was done in 1 patient. Locoregional flaps constituted about 32.2% of all the patients studied, split thickness skin grafting were done in 13.3% of the total patients, amputations were done in 23.3% of the total population, disarticulations were done in 11.1% of the total population, fasciotomies and debridement constituted 42.2% of the total population. Complications like wound dehiscence in 2 cases, infection under flap in 1 case, Partial necrosis in 1 case, Edge necrosis of flap in 2 cases, Graft loss in 2 cases and ligation of radial artery were noted in 1 case.

In a study, conducted by Alper kurt MD et al., 37% of patients underwent surgical wound debridement of which most of them required two or more additional debridements.[13] Reconstruction with skin grafts were performed in 32 patients comprising about 34.4% of the total patients studied, nine patients required the use of various flaps to cover the wounds which comprised about 9% of the total patients studied. Eight patients underwent amputation comprising 8% of the studied patients.

The percentage of locoregional flap cover was significantly higher in our study when compared with study done by Alper kurt MD et al., where as the percentage of skin grafts done in our study were significantly less when compared to study conducted by Alper kurt MD et al. Amputations done were significantly higher in our study when compared to Alper kurt MD et al., which is because of the involvement of high voltage electrical burns in our study.[13]

In a study, conducted by Handschin AE et al. fasciotomies and debridement were done in 47% of the studied population. In our study, 42.2% of patients underwent fasciotomies and debridement

which is almost similar to our study. Amputations were done in 34.6% of patients studied by Handschin AE et al., which was significantly higher when compared to our study (23.3%).[14] In a study, conducted by Zhu Z et al., twenty locoregional flap cover were done which comprised about 19.04%. In our study, 29 locoregional flap covers were done which comprised about 32.2%.[15]

45% of the patients underwent amputations in a study conducted by Wang H et al., which was significantly higher when compared to our study.[16] In a study. conducted by Liu HY et al., 42% of patients underwent amputations which was significantly higher when compared to our study. Thirty-five locoregional flaps were done in a study conducted by Liu HY et al., which was almost similar to our study.[17]

50 patients in our study were treated for less than 15 days whereas 31 patients had a stay ranging from 16 to 30 days and 9 patients stayed in the hospital from 31 to 45 days. Hospital stay in our study ranges from 7 to 44 days. In a study, conducted by Ajay Lunawat et al. hospital stay ranged between 4 and 83 days and according to this study as the percentage of burns increased duration of hospital stay also increased.[6] In a study, conducted by Gentian Zikaj et al. hospital stay for surgically treated patients was 58.1 days plus or minus 24.3 days which was higher than compared to our study.[4] High-voltage burns needed multiple operations, hence lengthening the hospital stay.

Multiple operations were required in 70 of our patients comprising about 55.55 as most of them sustained high-voltage burns. In a study, conducted by Gentian Zikaj et al. number of operations increased in patients who sustained high-voltage burns as multiple operations were required for the same.[4]

Mortality in our study was seen in 11 patients which is about 12.2 percent various reasons being acute renal failure, respiratory failure, septicemia and multi organ dysfunction syndrome. In a study, conducted by Sunil Srivastava et al. mortality rate was 10.5 percentage and was attributed to respiratory failure, septicemia and multi organ failure. The mortality rate in our study was similar when compared with the study done by Sunil Srinivastava et al. and Handschin AE et al.[5,14]

Conclusion

A study of management of acute electrical burns of upper limbs was done in 90 cases in our institution and the following conclusions were drawn as upper limb involvement in electrical burns is more common, Most of the upper limb electrical burns are occupation related. Males are more prone for these type of burns, age group more commonly affected include 20–40 years. Severity and the prognosis depends on the site, extent of the burn and associated injuries, 64.2% of patients sustained electrical burns of upper limbs in our study. Early fasciotomy, repeated debridements, non-postponement of definitive skin cover (SSG/flap) have helped in reducing the morbidity and improving the quality of life of the patient apart from reducing total hospitalstay.

The key of success still remains in meticulous debridement of the non-viable tissues, thereby preparing the bed for early skin cover. Pedicled distant flaps are reliable, durable and easy to perform for the postelectrical burn defects of the upper limbs, which gives predictable results. Preburn conditions such as anemia, greatly influence the final outcome. Early wound debridement and skin cover has helped in reduction in the rate of amputations and faster wound healing. However, reconstruction by flap cover has been delayed in some cases because of the poor general condition of the patients and the presence of extensive injuries over various regions of the body.

"Prevention is better than cure" best suits the problem. Power lines should be laid in accordance with the Indian Electricity Act 2003. Public awareness and education about safety measures should be imparted, especially at work.

Table 6: Comparative analysis with present study

Studies	Total no of patients	Fasciotomies	Amputations	Flap cover	Mortality rate
Liu, H et al.[17]	121	12%	42%	35 predicted flaps	4%
Wang, H et al.[16]	62	32%	45%	29 flaps	7%
Zhu, Z et al.[15]	105	27%	7%	20 flaps	8%
Handschin, AE et al.[15]	61	47%	18%	14 patients	15%
This study	90	42.2%	23.3%	23 patients	12.2%

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