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Original Research Article

Management of Electric Contact Burn Injuries in Tertiary Care Hospital

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Abstract

Background: Electrical contact burns are severe injuries associated with extensive deep tissue destruction, compartment syndrome, limb loss, prolonged hospitalization, and significant functional disability. Early fasciotomy and timely definitive wound coverage may improve limb salvage and functional outcomes.

Aim: To evaluate the efficacy of early fasciotomy in reducing limb morbidity and to analyze definitive wound management strategies, including flap reconstruction, in patients with electrical contact burns.

Methods: A prospective interventional study was conducted in the Department of Plastic and Reconstructive Surgery, Government General Hospital/Kurnool Medical College, Andhra Pradesh, for a period of 2 years. Forty-eight patients aged 16–60 years presenting within 24 hours of electrical contact burns were included. Initial management consisted of Advanced Trauma Life Support (ATLS)-based resuscitation, cardiac evaluation, aggressive fluid therapy, renal monitoring, and timely surgical intervention. Patients with compartment syndrome underwent emergency fasciotomy, while established gangrene was managed with appropriate amputation. Definitive wound coverage included split-thickness skin grafting and flap reconstruction according to wound characteristics.

Results: Electrical burns accounted for 11.34% of all burn admissions. Most patients were males (85.4%), with high-voltage injuries constituting 75% of cases. Eighteen patients underwent early fasciotomy, resulting in successful limb salvage in 12 (66.7%) patients, while the remaining six required only finger disarticulation due to limited distal gangrene. Nine patients presented with established gangrene, of whom four required emergency amputation and five underwent delayed amputation after tissue demarcation. Split-thickness skin grafting was performed in 37.5% of fasciotomy wounds, while flap reconstruction was required in 52.08% of deep contact burns involving exposed vital structures. Flap-related complications were infrequent and manageable.

Conclusion: Early fasciotomy performed within 24 hours significantly improved limb salvage and minimized the extent of amputation in electrical contact burns. Comprehensive wound management using serial debridement, appropriate grafting, and flap reconstruction achieved satisfactory functional outcomes while reducing morbidity and hospital stay. Early recognition of compartment syndrome and individualized reconstructive strategies remain essential for optimizing outcomes in electrical burn injuries.

Keywords: Electrical Contact Burns, Early Fasciotomy, Limb Salvage, Flap Reconstruction, Compartment Syndrome.

Introduction

Electrical injuries are a complex form of trauma that is often associated with high morbidity and mortality.[1] Electricity is now an indispensible part of modern human civilization due to increase in industrialization, electrification, technological advancement and human dependency on gadgets and machines coupled with population density has made people more prone to such injuries. Most of electrical injuries are accidental and preventable. Injuries in electrical burns can occur either due to direct contact or by flash burn or Arcing. Electrical burns can be classified as high voltage (>1000

volts) or low voltage (<1000 volts)[2]. High voltage electrical burns is a frequent cause of amputation which although a lifesaving procedure that decreases the mortality rate by 20% as found in many studies but increases morbidity and disability. Fasciotomy in electrical contact burns is an emergent decompression procedure aims at limb salvage and reducing the amputation rate[3]. Electrical contact burns are more devastating on size to size basis, involving deeper and distant structures of body due to passage of electricity along the tissues especially over joint areas and interossious areas exposing vital structures that necessitate flap cover[4]. This is a prospective study conducted between September 2022 to July 2024with a sample size of 48 in number with patients of electrical contact burns meeting inclusion and exclusion criteria. At presentation all patients were resuscitated following standard ACLS guidelines and ECG was taken. Patients with ECG changes were monitored according to cardiologist advice.

Intravenous fluid resuscitation done to maintain urine output of 1ml/kg/hr. Renal function and electrolytes was monitored regularly and corrected. In patients with signs of compartment syndrome, fasciotomy was done and those with established gangrene, amputation was done at appropriate level. Patients who presented with deep contact burns were serially derided and wounds resurfaced by split thickness skin graft or by flap cover.

Of the 48 patients included in this study who presented within 24 hours of incident, 18 patients had compartment syndrome and underwent fasciotomy of which we could definitely save 12 limbs. Of the remaining 6 cases, the improvement of circulation by early fasciotomy helped in minimizing distal gangrene and required only disarticulation of fingers. 9 patients had presented with established gangrene of which 4 patients underwent emergency amputation in view of myonecrosis and risk of sepsis and 5 patients underwent amputation at appropriate viable level after 1 week.

9 patients with electrical contact burns to scalp were deep burns that were resurfaced by local flap cover. Deep contact burn wounds elsewhere were serially debrided and those with exposed vital structures and over joint areas were covered with flaps and rest of them resurfaced with Split thickness Skin Grafts.

This study aims to analyse the success rate of early fasciotomy in limb salvage and enumerate the management strategies for deep contact burns and early rehabilitation by flap cover for better functional outcome.

Aims and Objective

- To asses the efficacy of early fasciotomy in decreasing the morbidity of limb in electrical contact burns.
- To analyse the definitive wound management measures including flap cover for better functional outcome

Patients and Methods: A Prospective interventional Study was done in burns unit of department of Plastic & Reconstructive surgery, Govt. General hospital/Kurnool medial college, Kurnool, Andhra Pradesh for a period of 2 years with a total sample size of 48.

Inclusion criteria: Patients admitted with electric contact burns between 16-60 years, Presented within 24 hours of electrical contact, and with associated trauma, TBSA upto 50%.

Exclusion criteria: Patients with neurological illness and arterial injury, with chronic illness other than diabetes, with electrical contact burns with intracranial bleed, major abdominal and thoracic injury, and Patients who died within 24 hours or were hospitalized for less than 24 hours.

Methodology

Patients presenting with electric contact burns were initially managed as per basic principles of Advanced Trauma Life Support (ATLS). Once patient is hemodynamically stable detailed history taking, through clinical examination and documentation was done. All patients with electric contact burns were subjected to ECG as part of initial evaluation. Regular cardiac monitoring was done if patient had history of Loss of Consciousness, Abnormal ECG recordings and history of cardiac resuscitation for this incident prior to presentation. These patients were subjected to biochemical cardiac marker testing including Troponin, Creatinine Kinase (CK) and cardiologist intervention accordingly for 24-48 hrs on case to case basis. Rest all patients had repeat ECG after 24 hours and reassessed for cardiac status.

Fluid management was initiated by securing two large bore intra venous cannulas or central vein cannulation. Urinary catherization was done to monitor urine output. Initial fluid requirement in case of electric contact burn was much higher so initial resuscitation was started at 7ml/kg/%burns. Rate of fluid infusion was titrated according to urine output goal of 1ml/kg/hr. Serum potassium levels were monitored every 12th hourly and KCL infusion rate was calculated based on deficit.

Serum creatinine was monitored every 24 hours. Patients with high coloured urine and high serum creatinine with suspicion of Myoglobinuria were resuscitated with intravenous fluids to maintain urine output of minimum 1ml/kg/hr and force dieresis by loop diuretics, alkanization of urine by

sodium bicarbonate 5% continuous infusion, administration of mannitol at 25g every 6 hours and unresponsive cases were started on hemodialysis on advice of nephrologist. Patients at initial presentation who had signs of compartment syndrome on clinical evaluation with history of electrical contact burns of limb, pain out of proportion to injury, pain on passive movements and hard woody like feel of affected limb was considered for fasciotomy. Once edema settled, fasciotomy incision wounds were closed primarily. If delayed for more than 5 days, split thickness skin grafting (SSG) was done, if vital structures at wrist were exposed, flap cover was done, either abdominal or groin flap.

In patients who developed progressive gangrene with no myonecrosis or AKI, amputation or disarticulation was planned in second week at appropriate vial level and stump closure done.

Patients who presented with established gangrene, after initial resuscitation if they had risk of myonecrosis with AKI, were planned for emergency amputation as guillotine method and subsequent revision amputation and stump closure after one week. Negative Pressure Wound Therapy (NPWT) to stimulate formation of granulation tissue was applied after a day of debridement in few cases that did not develop granulation after 2 weeks. Granulating wounds on non-vital areas are resurfaced with split thickness skin graft. Those with significant soft tissue loss, exposed joint areas and vital structures were covered by Flaps.

Results

Incidence of Electrical Burns: Total number of patients treated for burns of all kinds during the same period was 926. Total number of patients treated for electrical contact burns during this period was105.

This represents an incidence of 11.34% electrical related burns. Of these 48 patients were included in the study meeting the inclusion criteria. Of total 48 patients, males were 41 and females were 7. This represented that 85.4% of the patients were male, thus male predominance of occurrence of electric contact burns in this study.

As per standard triage purpose high voltage was taken as more than 1000 Volts and low voltage as less than 1000 Volts. In this study there were 36(75%) high voltage injuries and 12(25%) low voltage injuries.

Table 1: Age Distribution of the Patients

Age	Number	Percentage
16-25	09	18.75
28-35	17	35.42
36-45	14	29.17
46-60	08	16.66
Total	48	

Table 2: Etiology of Electric Injury

Etiology	Number	Percentage (%)
Agriculture	14	29.16%
Occupation	18	37.5%
Domestic	07	14.58%
Roof of House	07	14.58%
Transformer near House	02	4.16%

Table 3: Type of Associated Injuries

Associated Injuries	Number
Head Injury	01
Spine Injury	02
Femur fracture	01
Tibia Fracture	02
Metatarsal Fracture	02

Table 4: Percentage Burns

Etiology	Percentage TBSA Burns
Agriculture	19.06 +/- 12.26
Domestic	31.11 +/- 22.36
Occupation	27.5 +/- 21.36
Roof Top	30.46 +/- 25.21

Table 5: Distribution of Burns

Distribution	Total	Percentage
Scalp	9	18.75%
Right Upper Limb	17	35.41%
Left Upper Limb	11	22.92%
Right Lower Limb	7	14.58%
Left Lower Limb	8	16.67%
Trunk	12	25%

Table 6: Fasciotomies

Fasciotomy	No	Yes
Low Voltage	09	03(16.67%)
High Voltage	21	15(83.33%)

Table 7: Level of Amputation

Amputations	Right side	Left side
Below Elbow	03	01
Above Elbow	01	01
Above Knee	00	01
Shoulder disarticulation	02	00
Fingers	04	03
Toes	03	01

Split thickness skin grafting was done for covering fasciotomy wounds (37.5%) and for coverage of contact burn wounds after granulation of wound (33.3%). Flap cover was done for both deep contact burns with significant soft tissue loss or exposed vital structures (52.08%) and for post Fasciotomy wounds of forearm (25%)

Table 8: Flaps for Scalp Defect

Type of Flap	No. of Flaps
Transposition Flap	5 (55.55%)
Rotation Flap	1 (11.11%)
Bipedicle Flap	3 (33.33%)

Table 9: Flaps for Upper Limb Defects (Flaps for upper limb defects was mainly distal flaps)

Site	Flap	No. of Flaps
Shoulder	Trapezius Myocutaneous Flap	2
Forearm	Superiorly based Abdominal Flap	2
	Inferiorly Based Abdominal Flap	1
	Groin Flap	1
Wrist and Hand	Superiorly based Abdominal Flap	2
	Inferiorly Based Abdominal Flap	1
	Groin Flap	2
Fingers	Abdominal Flap	1
	Louvre Flap	2
	Groin Flap	3

Table 10: Flaps For Lower Limb Defects (Flaps for lower limbs were mainly regional flaps)

Site	Flap	No. of Flaps
Knee	Islanded ALT flap	1 (16.66%)
	Gastronemius Muscle Flap	1 (16.66%)
Leg and Ankle	Reverse Sural Artery Flap	4 (66.68%)

Table 11: Duration of Hospital Stay

Length of stay in days	No. of patents
<10 days	14
10-30 days	23
>30 days	11

Table 12: Incidence of Complications

Complications	No. & Percentage
Marginal Flap necrosis	8 (16.66%)
Total Flap Necrosis	2 (4.16%)
Dehiscence	5 (10.41%)
Hematoma	2 (4.16%)
Graft Loss	4 (8.33%)

Presentation of patient with electrical contact burns

Compartment syndrome fasciotomy done

Figure 1:

Compartment syndrome fasciotomy done

Figure 2:

Patient presented with established Gangrene

Established gangrene of forearm below elbow amputation

Figure 3:

Established gangrene of upper limb shoulder disarticulation

Figure 4:

Scalp defects and flap cover

Figure 5:

Electric contact burns of shoulder

Figure 6:

Left shoulder contact burn trapezius flap cover done post op picture

Figure 7:

Electric contact burns of right hand managed by abdominal flap

Contact burns on dorsum of right hand inferiorly based abdominal flap

Figure 8:

Post fasciotomy wrist defect resurfaced by groin flap

Post fasciotomy defect of wrist graoin flap to resurface defect well settled flap post op

Figure 9:

Contact burns of finger resurfaced by groin flap

Contact burn of ring finger – abdominal flap

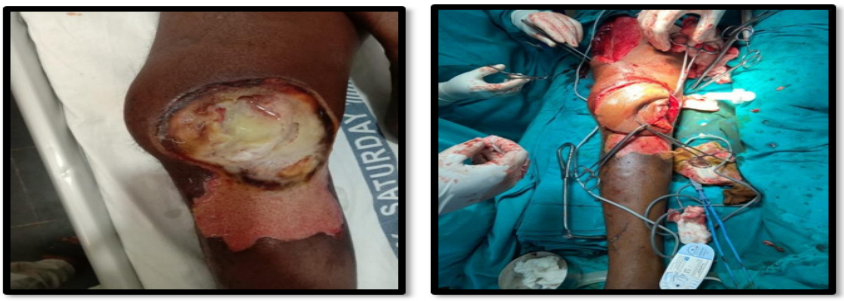
Figure 10:

Figure 11: Contact burn of ring finger – abdominal flap

Multiple finger defects Louvere flap

Figure 12:

Electric burn of right Knee with defect – ALT flap



Contact burn of right knee ALT flap for defect closure

Figure 13:

ALT flap necrosis and gastronemius muscle flap for same defect.

Necrosis of ALT flap Gastronemius muscle flap for same defect

Figure 14:

Figure 15: Defect on ankle and dorsum of foot – RAS flap

Discussion

Incidence of electric burns are increasing in developing countries like India. The proportion of electric burns in this study is 11.34%, which is higher than that reported in western world (4-5%), this increase in incidence is seen in agriculture and profession related injuries due to unsafe practices of handling electricity at agriculture fields and unskilled labour employed at professional level or third party hiring in electric transmission line maintenance and construction labours working at height near high power lines and increased incidence in rural cases of electric burns is due to lack of knowledge about dangers of electric burn injuries and methods of prevention in such injuries.

Males are predominantly affected 85.4%, most of which are agriculture and profession related injuries as men work in high dangerous jobs such as high tension line maintainance , transformations at distribution level and men having increased participation in agricultural activities and modernization of agriculture by use of motor irrigation system have increased the risk in males. Over all males have more contact with electric appliances compared to females thus is the incidence of electric burns. Similar higher incidence of electric burns in males was reported in various other studies like Robson et al[5].

Age group between 26-35 had higher incidence (35.42%), this was related to their profession as power line maintenance, construction worker or at agriculture fields especially motors and transformers for water supply pumps. Teenagers were involved in outdoor activities exposing them to high-tension electrical wires and middle age group was more involved at agricultural activities.

Rooftop electrical injuries especially on rooftop residential buildings were seen in 14.58% cases while accidentally touching high tension wires by a person holding metal objects. This is probably due to increase in electrification at both urban and rural areas, modernization and increased population density. Most of these injuries are due to overhead high tension wires dangerously close to rooftop of residential buildings. Transformers in the vicinity of residential areas constituted 4.16% of total electrical contact burn admission. Proper insulation of overhead wires and safe distance from rooftops in advocated.

High voltage burns constituted 75% of total contact burn admissions, most of these related to professionals (37.5%) followed by agriculture related injuries (29.16%). Low voltage injuries were mainly domestic (14.58%) while attempting to repair electric equipments or lighting equipment.

In this study it was noted that multiple noncontiguous areas were involved in electric burns. The upper limbs were the most commonly involved body part (35.41% and 22.92% - right and left upper limb, respectively) followed by the trunk (25%). The scalp was involved in 18.75% of cases and trunk was involved in 25% cases. In relation to total body surface involved, domestic (31.11 +/- 22.36) and rooftop injuries (30.46 +/-25.21) had higher percentage of total body surface area involved with associated flash burns compared to Agriculture (19.06 +/- 12.26) and occupational (27.5 +/-21.36) which was more of high voltage burns with greater contact injury and deeper burns.

Patients presenting with electric burns had other associated injuries due to having contact at height like in electric pole or construction site, thus presenting with other injuries like head injury with no significant intracranial bleed in 1 case, spine injury with vertebral fracture in 2 cases, lower limb injuries dominate with femur fracture in 1 case, tibia fracture in 2 cases and metatarsal fracture in 2 cases. These fractures were addressed after initial stabilization of patient and along with management of contact burn.

In this study, 18 of the total 48 electric contact burns cases underwent fasciotomy for established or suspected case of compartment syndrome of which 15 cases were for high voltage contact burns and 3 were for low voltage contact burns thus inferring the increase occurrence of compartment syndrome in high voltage (<1000v) electric contact burns. Of total 18 fasciotomies done within 24 hours of electrical contact, 12 patients had no distal ischemic changes ie, limbs were definitely saved.

These fasciotomy wounds were managed by secondary suturing in 4 cases, split thickness skin grafting in 6 cases and groin flap in 1 case and abdominal flap in 1 case. All the remaining 6 cases developed distal finger gangrene, indicating the usefulness of fasciotomy in decreasing the progress of ischemia by early revascularization. The gangrenous fingers in all these cases were disarticulated at appropriate viable level and stumps closed. Fasciotomy wound was grafted in 3 cases and abdominal flap for wound closure in remaining 1 cases and groin flap in 2 cases.

Of the 9 cases presented with established gangrene, 4 patients underwent emergency amputation in view of extensive myonecrosis, risk of AKI and sepsis. There 4 cases included one at shoulder disarticulation, one above elbow, one below elbow and at above knee level. Rest of 5 cases underwent amputation or disarticulation at appropriate viable level after 1 week. Of these one at right shoulder and toes of right leg, one above elbow and fingers of left hand and three cases of below elbow amputations were done electively. The waiting period of one week was chosen for patients with regular monitoring of electrolyte and renal

parameters, adequate resuscitation, antibiotic coverage and in belief that clear line of demarcation between viable and necrotic tissue is not established up until one week in electrical contact burns. Electrical contact burns were found to occur at multiple sites and wound management varied on location, depth of wound and surrounding unburned flap donor site. Contact burn wounds were regularly debrided at 3 day interval and accessed periodically. Healthy and granulating wounds with no exposed vital structures were resurfaced by split thickness skin grafting in second or third week guided by wound characteristics and wound swab culture studied. Unhealthy burn wounds were debrided and Negative Pressure Wound Therapy (NPWT) applied after a day of debridement, this included one case of lower limb fascotomyand wound was resurfaced by SSG.

Deep contact burns with exposed bone, joint, vital structures including vessels, nerves & tendons and with significant soft tissue loss seen at 29 areas, managed by flap cover. 9 patients had scalp defects with loss of pericraneum and exposed skull bone were managed by local flaps including 5 cases by transposition flap, 1 case by rotation flap and 3 cases by bipedicle flap. One of the transposition flap had sutural dehiscence, rest all had uneventful outcome. Of the two cases of shoulder defect resurfaced by trapezius myocutaneous flap, one had marginal flpa necrosis,that was debrided and resurfaced by SSG. Other trapezius flap had suture dehiscence, managed by secondary suturing. 9 cases had forearm and wrist defects. Wounds on volar aspect were found in 5 cases for which superiorly based abdominal flap was done in 4 cases and groin flap in 1 cases.

Of these 4 superiorly based abdominal flaps, marginal necrosis was seen in 1 case and suture dehiscence in 1 case. Groin flap in 1 case had uneventful outcome. Finger defects were seen in 6 cases, of which 2 had multiple fingers involved. 4 cases of single finger involvement were managed by abdominal flap in 1 cases and groin flap in 3 cases. 2 cases of multiple finger involvement were managed by louvre flap. All cases were uneventful.

Defects of lower limb was seen in 3 cases, with knee involvement in 1 case, heel defect in 1 case and dorsum of foot in 1 case. Case of knee defect was initially managed with ALT flap, but this had complete flap necrosis which was later managed by gastrinemius muscle flap and SSG. Of the 1 case of heel defect RSA flap was done, that had marginal necrosis, managed by debridement and pedicle lengthening and secondary suturing. RSA flap for dorsum of foot was uneventful.

Conclusion

Thus electrical contact burns constituted 11.34% of total burn case admission, 85.4% were male. Mostly at occupation or agriculture fields, with major entry site were upper limbs followed by scalp. Most patients had multisite injuries at presentation with risk of compartment syndrome when limbs were contact points for which fasciotomy was done in 18 limbs, 12 of the limb were definitely saved, and remaining 6 had distal gangrene limiting only to fingers clearly highliting the usefulness of early fasciotomy in management of electrical burn induced compartment syndrome.

Electrical contact burns were more devastating on size to size basis, involving deeper and distant structures of body due to passage of electricity along the tissues. Deeper tissues were involved to greater extent due to distant travel of electricity in body tissues form area of contact, greater extent of resistance offered by deeper tissues like bone and tendons causing thermal injury to surrounding tissue thus exhibiting 'Iceberg phenomenon' increasing morbidity and hospital stay. Tissue necrosis and gangrene following electrical contact burns is either immediate at time of contact or progressive with vascular thrombosis and distal ischemia. In cases of established gangrene with significant myonecrosis and risk of AKI and sepsis should be intervened as an emergency basis with amputation by guillotine at appropriate and revision amputations and stump closure planned at later dates depending on general status limb status of the patient.

Whereas those patients with established or progressive gangrene who are hemodynamically stable with no significant renal risk or risk of sepsis can be managed by delayed amputations for demarcation between viable and gangrenous tissue in view of progressive nature of burns. Electrical contact burns mostly presented with multiple deep contact burns of varying degree of thickness necessitating multiple interventions in individuals. Majority were full thickness burns necessitating flap cover. Wounds should be managed by serial debridement, adequate fluid resuscitation, antibiotic coverage, Negative Pressure Wound Therapy followed by split thickness skin grafting or flap cover depending on wound depth, vital structures exposed or availability of tissue for coverage and general condition of patient.

This study concluded that early fasciotomies done in 24 hours reduced the risk of major amputations and many options available for definitive management of deep electrical contact burn wounds by flap cover decreasing morbidity and overall hospital stay.

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