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Surgical Perspectives of Electrical Burns

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Abstract

Introduction: Benefits of electricity to mankind are well known because of its easy availability, less pollution, simplicity and no need to store like conventional storage, which makes it more used form of energy in day to day life. Electrical burn injuries represent a special type of lesion; it is one of the most devastating injuries to be seen in emergency departments, leading to functional disability and aesthetic sequelae.

Aim and Objectives: The purpose of this study was to review our experience in treating electrical burns in terms of region of body involved, percentage of burnt area, types of surgical procedures performed, complications and hospital stay in a tertiary care centre.

Material and Methods: The present prospective observational study was carried out at a tertiary care centre from August 2013 to November 2015 in patients with history of electric burns reporting to casualty or admitted in department of general surgery, 70 patients were included in the study. The following variables were studied age, sex, occupation, site of incidence, voltage, clinical presentation, region of body involved, percentage of burnt area, types of surgical procedures performed, complications and hospital stay

Results: Present study showed the incidence of electric burns as 6.18% amongst total burns. Incidence of electric burns was highest in 21–30 years of age and in 31–40 years of age. In present study the incidence of electrical burns is higher in rural population as compared to urban population with percentage of electrical burns as 71.42% in rural population and 28.58% in urban population. The incidence of male was high and measured 87.14% (n= 61).In our study we have found that out of 70 patients, 94.28% injuries were due to direct contact with the electricity In our study we have found that 32.86 % injuries were related to work and 67.14% injuries were not related to work those were accidental and while playing.(Table 1). In present study the incidence of electrical burns was more at workplaces and then at home thus matches with previous studies. In present study we found that 50 (71.43%) patients out of 70 had upper limb involvement, 44 (62.86%) had lower limb involvement. (Table 2) The majority 48.57% of the patients had upto 10% and 25.71% patients had 11–20% burnt surface area. The incidence of myoglobinuria was 8.57%. Amputation (28.4%) was the most common surgery followed debridement by (24.69%). (Table 3)

Conclusion: Electrical injury is very serious type of burn causing considerable health hazard, victims end up with major disabilities, most of the injuries are preventable with proper education and knowledge, efforts for rehabilitation and counseling should be part of treatment protocol.

Keywords: Burns; Electrical; wound; myoglobinuria; Amputation; grafting.

Introduction

Benefits of electricity to mankind are well known because of its easy availability, less pollution, simplicity and no need to store like conventional storage, which makes it more used.

Form of energy in day to day life. On the other hand electricity is having more fatal disadvantage like dependency and electrical burns due to

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improper handling techniques, poor awareness about prevention of injuries associated with it.

Electrical burn injuries represent a special type of lesion; it is one of the most devastating injuries to be seen in emergency departments, leading to functional disability and aesthetic sequelae. The damage due to electrical current is caused by two mechanisms- heating and the passage of electric current itself through tissues. Electric injuries result in extensive deep tissue injury in addition to various systemic complications.

Aim

The purpose of this study was to review our experience in treating electrical burns in terms of region of body involved, percentage of burnt area, types of surgical procedures performed, complications and hospital stay in a tertiary care centre.

Objectives

Primary

1. To study incidence of electrical burns amongst total burns.
2. To study demography of electrical burns.
3. To study the mechanism of electrical injury.
4. To study electrical burns according to region of body involved.
5. To study electrical burns according to percentage of burnt surface area.

Secondary

1. To study electrical burns according to type of surgeries performed.
2. To study the level of amputation in cases of electrical burns.
3. To know the hospital stay duration in electrical burn injuries.
4. To study complications in cases of electric burns.

Material and Methods

The present prospective observational study was carried out at a tertiary care centre from August 2013 to November 2015 in patients with history of electric burns reporting to casualty or admitted in department of general surgery, 70 patients were included in the study. The data was collected by face to face interview or history was obtained from by relatives or by standers in case of unconscious patient and if minor from their parents, with prior informed, written and valid consent in a predesigned proforma. Patients with electrical burns who arrived dead or those with only cardiac complications and those who were not ready to participate in study were excluded from study.

The following variables were studied age, sex, occupation, site of incidence, voltage, clinical presentation, region of body involved, percentage of burnt area, types of surgical procedures performed, complications and hospital stay.

On arrival to the emergency department initial vital assessment was done. Resuscitation began with intravenous fluids according to Parkland formula. In patients with myoglobinuria, osmotic diuresis was induced by infusing adequate amount of Ringer's lactate solution and mannitol 20% (1g/kg), in addition to sodium bicarbonate solution, with the aim of obtaining an alkaline urine output of 1.5 to 2 ml/kg/hr. Routine blood investigations and radiological investigations were done.

The cleaning and dressing of the burn wounds was done with Povidone iodine. Patients were then put on H2 blockers and opioids. Broad spectrum antibiotics were started and after tissue culture were shifted to antibiotics according to report. Required surgical procedures were carried out urgently after being appropriately selected for given patients. Fasciotomy was performed in cases with suspected compartment syndrome, the patients then underwent early debridement of devitalized tissue. When the limbs were completely severed i.e. developed gangrene, amputations were performed as soon as possible to prevent sepsis. Guillotine type of amputations was performed. (Fig 3) When the burn area bed was clean with healthy granulation tissue, split skin grafting was used to cover the burn area, fasciotomy raw area and when expertise was available flap surgery was done. Complications were detected as they occurred and were managed accordingly. Psychiatric counseling was given to overcome stress and depression. Patients were given physiotherapy and were motivated for performing daily routine activities. The patients were followed up until the day of discharge and at 1, 3 and 6 months after discharge.

Observation and Results

Total 555 patients were admitted in burns ward from August 2013 to November 2014 and 578 patients were admitted in burns ward from December 2014 till November 2015, out of which electrical burns cases were 29 and 41 respectively, so the total number of electrical burns admitted from August 2013 till November 2015 was 70 and incidence was 6.18%.

Youngest patient was 1 year old and the eldest patient was 60 years old. Most of the patients were in between 21–30 years of age with mean age of 26.54 years. The male to female ratio was 6.78: 1 showing males are more victims of electrical burns. Electrical burns were seen more in patients belonging to low socioeconomic status. The incidence of electrical burns was more in rural population as compared to urban population, showing need of awareness amongst them. 66 patients had electrical burns due to contact as mechanism of injury. Majority of electrical burns had low voltage 48(68.57%) as nature of injury. (Fig 1)

Table 1: Occupation in cases of electrical burns cases.

Occupation	Number of electrical burns cases	Percentage
Electrician	17	24.28%
Farmer	14	20%
Housewife	3	4.28%
Student	22	31.43%
No occupation	6	8.57%
Construction worker	6	8.57%
Shopkeeper	1	1.43%
Driver	1	1.43%

Occupational related electrical burns were seen in 17 and 6 patients who were electrician and construction worker by occupation. 22 patients were students, 14 were farmer and 6 were non school going children who had accidental electric burns.

Table 2: Region of body involved in electrical burns cases.

Body region involved	Number of electrical burns	Percentage
Upper extremity	50	71.43%
Lower extremity	44	62.86%
Head, neck, face	16	22.86%
Trunk	10	14.29%
Combination of above sites	52	

Extremities were mainly affected, especially the upper extremity followed by lower extremity and head neck face. 52 patients had combination of these sites.

Table 3: Surgical procedures performed in electrical burn patients.

Types of surgery	Number of surgeries	Percentage
Amputation	25	29.07%
Fasciotomy	16	18.61%
Debridement	23	26.74%
Escharotomy	14	16.28%
Flap	1	1.16%
External fixator for fracture femur	1	1.16%
Grafting	6	6.98%
Total	86	100%

Total 44 patients underwent 86 surgical procedures with an average number of 1.95 procedures per patient. Amputation and debridement were the main surgical procedures seen .3 patients underwent bilateral amputations out of which one underwent bilateral forequarter amputation, one underwent bilateral above elbow amputation and one underwent below elbow amputation. 16 patients underwent fasciotomy for compartment syndrome. 23 patients underwent debridement for removing devitalized tissue. Escharotomy was done in 14 patients. Split skin grafting was done in 6 patients after healing to cover the wounds and rotation flap was performed for closure of right below elbow amputation stump. External fixator was applied in one patient who had fracture right mid shaft femur.

Table 4: Level of amputation in cases of electrical burns.

Level of amputation (25 amputations)	Frequency of surgeries
Fore quarter	3
Above elbow	5
Below elbow	6
Finger	6
Below knee	3
Toe	2

The level of amputations observed was below elbow, finger, followed by above elbow in descending order of frequency as upper extremity was mainly involved.

Table 5: Hospital stay in cases of electrical burns.

Hospital stay	Number of electrical burns cases	Percentage
Less than 7 days	34	48.58%
7–29 days	25	35.71%
30 and more than 30 days	11	15.71%

The range of hospital stay was from minimum of 1 day to maximum of 106 days measuring average 15.1 days of hospital stay. 34 patients (48.58%) patients had hospital stay of less than 7 days.

Fig. 1: Low voltage contact electrical burn showing entry wound over palm.

Fig. 2: High voltage electrical burn leading to mummification and auto amputation.

Fig. 3: Postoperative healing wounds after toe amputation surgery in case high voltage electrical burns.

Fig. 4: Postoperative photo of amputation stump covered with myocutaneous flap.

Fig. 5: Contracture formation in case of upper limb electrical burn.

Table 6: Complications associated with electrical burns.

Complications	Number of cases of electrical burns
Septicemia	4
Renal failure	5
Pressure sores	4
Wound infection	26
Gas gangrene	2
Amputation	25
Rhabdomyolysis	6
Neurological sequelae	0
Contracture	2
Death	3

Wound infection was the most common complication seen treated by antibiotics according to sensitivity report, amputation was the commonly performed surgical procedure for gangrenous changes. Septicemia was seen in 4 patients, and was managed by appropriate antibiotics. Acute renal failure was seen in in 5 patients secondary to rhabdomyolysis, none of them required dialysis and were managed by osmotic diuresis. Pressure sore was third common complication followed by contracture. 3 patients died, 2 patients had developed gas gangrene for which timely amputation was done, but they died because of septicemia and one due to septicemia along with acute renal failure.

Table 7: Follow up findings in cases of electrical burns.

Follow up findings	Number of electrical burns cases
Contracture	11
Pressure sores	4
Paraplegia	1

We had followed up patients at 1, 3, and 6 months, 30 patients were lost to follow up (42.86%). Contracture as complication was seen in 11 patients at follow up, 2 had neck contracture and rest 9 had finger contractures. 4 patients developed pressure sores and one of them required debridement. One patient had paraplegia as a result of fracture spine.

Discussion

Final outcome of the data is compared with various previous studies, carried out worldwide till now.

Incidence

Present study showed the incidence of electric burns as 6.18% amongst total burns which correlates with following studies. The increasing incidence of electrical burns is due to the increasing use of electricity in day to day life.

EI-Gallal and Yousef S.M. 1998 found electrical burn patients constituted 7.4% of all burns admissions. Centro Ustioni and Ospedale Di Summa 1998 found that electrical burns account for 3–9% of all patients treated in burns centres.[1]

Age

In present study we found the incidence of electric burns was highest in 21–30 years of age and in 31–40 years of age the number of cases being respectively 25 and 17, showing young persons were mostly affected.

Mohan A et al 2014 had found the incidence of electric burns highest in 21–30 years and in 31–40 years of age.[2] Ehmer Al-Ibran et al 2012 reported that approximately 20% of all electrical injuries occur in children, with a bimodal peak incidence, highest in toddlers and adolescents.[3]

Area

In present study the incidence of electrical burns is higher in rural population as compared to urban population with percentage of electrical burns as 71.42% in rural population and 28.58% in urban population. Thus indicating that higher number of electrical burns cases occurred in rural population may be related to illiteracy and poor handling techniques as well as illegal practice so our results correlate with following study.

Jain S et al 2014 reported that incidence of electric injuries were higher in rural areas with 81.9% as compared to urban with 28.1%.[4]

Gender

In present study we found that incidence of male was high and measured 87.14% (n= 61) and female 12.86% (n=9) with male to female ratio as 6.78:1. Our results match with following studies showing male preponderance.

Haddad S.Y. 2008, in his study found all cases of electrical burns occurred in males.[5] Buja Z et al 2010 found the incidence among males to be 93.95% and in females 6.05%.[6] Olugbenga O and K Innih 2011, found that male population is at more risk to electric burns contributing to 87%.[7]

Socioeconomic status

In present study we have found that out of 70, 50(71.43%) patients were from low socioeconomic class, 15(21.43%) were from middle class and 5(7.14%) were from high socioeconomic strata showing that people from low socioeconomic status were mainly affected. No other study has compared this data.

Mechanism of injury

In our study we have found that out of 70 patients, 94.28% injuries were due to direct contact with the electricity and 2.86% each due to flash and arc. Our study results match with that of Segu S.S. et al 2012[8] but study of Buja Z et al had only two groups one of contact and other of flash and arc, so the difference.[6]

Segu S.S. et al 2014 found that 225 patients of electric burns were because of contact mechanism and 36 patients each due to flash and arc.[8]

Voltage as nature of injury

In our study we have found that 68.57% of electric burns were due to low voltage and 31.43%(n=22) were due to high voltage thus low voltage (Fig.1 injuries outnumbered high voltage (Fig. 2) injuries this was evidently because of domestic accidental injuries except in the study of O. Olugbenga and K. Innih[7] which had been carried out in highly industrialised area so there were more incidences of high voltage electrical burns.

Segu S. S. et al 2014 found that 148 injuries were from high voltage and 24 were from low voltage.[8] Gajbhiye A.S. et al 2013 found 61.37 % electric burns were due to low voltage and 31.63% were due to high voltage.[9]

Cause

Opara K.O. et al 2006 reported 52% of electric burns were work related and 48% were not related to work.[10] Farooq U et al 2008, occupational injuries contribute 37.50% of electrical burns and rest are accidental at home or on streets.[11] Gajbhiye A. S. et al 2013 the majority (93.88 %) were work-related injuries.[9]

In our study we have found that 32.86 % injuries were related to work and 67.14% injuries were not related to work those were accidental and while playing. (Table 1) They were because of touching or grasping of electrically live objects, short-circuiting, inserting fingers into electric sockets and contact with an overhead electric line.

As majority of patients in our study group were between 11–30 years who were students, so data is showing prevalence for accidental injuries as also found by Farooq U et al.[11]

Occupation

We have found that the incidence of electrical burn injuries was more amongst non school going children (6) and young adults (22) who were student by occupation followed by wiremen(17), construction workers (6) , farmers (14), housewife (3) and others (2). (Table 1) In this study we have found more number of patients were students as compared to other studies as most of the population of our study was from age group 11–30 years so results are not matching with following studies.

Jain S et al 2014 most patients were associated with electric department workers 65.3%, household workers 23.5%, and others indirectly associated with electricity jobs were 11.2 %.[4] Sachde. J et al 2008 in their study found 23 patients as young children student by occupation and 28 patients were professional utility workers.[12]

Place of occurrence

Vahdati S.S. et al 2013 found occurrence of electric burns more at workplace followed by home.[13] Jain S et al 2014 most patients were associated with electric department workers 65.3% hence occurring at workplace, household workers 23.5 %, and others indirectly associated with electricity jobs were 11.2%.[4]

In present study the incidence of electrical burns was more at workplaces and then at home thus matches with previous studies.

Region of body involved

In present study we found that 50 (71.43%) patients out of 70 had upper limb involvement, 44 (62.86%) had lower limb involvement and 16 (22.86%) had head neck face involvement and 10 (14.29%) had trunk involvement. (Fig 2) In following study upper extremity involvement was maximum followed by lower extremity as majority of the electrical injuries are due to holding or touching electrical wires.

Buja Z et al 2010 reported 85.7% electric burns were seen in the upper extremities, 7.1% in the lower extremities, 3.6% in the head and neck, and 3.6% in the trunk.[6]

Percentage of total burnt surface area

In present study we found that majority 48.57% of the patients had upto 10% and 25.71% patients had 11–20% burnt surface area according to rule of nine thus correlating with above studies. This shows that although an electrical burn is a devastating entity, percentage of burns is very less in majority of the cases.

Farooq U et al 2008 found majority of electric burns patients (59.37%, n=19) sustained less than 10% burns.[11]

Myoglobinuria

Electrical injures produce muscle damage (myonecrosis) and progressively myoglobinemia and myoglobinuria; if the values of urine myoglobin are found more than 1000 microgram/litre then it is significant.

EI-Gallal and Yousef S.M. 1998 found myoglobinuria in 13(3.34%) patients out of 389 patients.[1]

In present study the incidence of myoglobinuria was 8.57%. The presence of myoglobinuria is an indicator of rhabdomyolysis and thus a warning sign as patient might land up in renal failure if not treated properly.

ECG findings

In present study we found that the most common ECG changes being sinus tachycardia (14.29%) and one patient had tall "t" waves. Patient with tall "t" waves was given insulin drip and medical line of management. Our results correlate with the

study of Subrahmanyam M., as patients with only significant ECG findings who were requiring active medical management were excluded from study and were admitted in medical intensive care unit.

Subrahmanyam M. 2004 found that electrocardiogram records were normal in 22 patients (67%) and showed ST-T changes in 2 patients (6%), tachycardia in 7 patients (21%) and bradycardia in 2 patients (6%).[14]

Associated injuries

In present study we found that 4 patients had head injury, followed by spine injury, femur fracture and rib fracture 1 each.[8]

Subrahmanyam M.2004 found associated injuries were head injury in 7 patients, fracture of long bones in one patient and fracture of vertebrae in 2 patients.[14] Sachde J. et al 2008 in their study found that five patients had head injury, two had spine fracture, two had long bone fractures, 8 had psychiatric complication.[12]

In all above studies head injury was seen as associated injury along with long bone fractures in patients with electrical burns thus correlates with our study, so in cases of suspicion of associated injuries NCCT brain and x ray has to be done.

Surgical management

In our study total 44 patients underwent 86 surgical procedures with an average number of 1.95 procedures per patient. 44 (62.86%) patients required surgical management in form of debridement, fasciotomy, escharotomy or amputation and rest 26 (37.14%) were managed conservatively. Our study results correlate with the following studies.

EI-Gallal and Yousef S.M. 1998 found that 71(19.35%) patients of electrical burns were managed conservatively.[1] Njogu and Paul Mwai 2011 found that majority of the cases of electrical burns required surgical management.[15]

Surgical procedures

In present study amputation (28.4%) was the most common surgery followed debridement by (24.69%), fasciotomy (19.75%) and escharotomy (17.28%). The rate of amputation in our study correlates with the study of Buja Z. et al study.[6] (Table 3)(Fig. 3,Fig. 4)

Amputations followed by debridement was the most performed surgical procedure as patients had developed gangrene, so the results of our study are not correlating with following studies. Patients with electric burns may require repeated debridement for removing the devitalised tissues followed by amputations as seen from following studies. (Fig. 3, Fig. 4).

Sachde J et al 2008 found that 118 patients required amputation, 91 required split skin grafting, 55 required fasciotomy, 5 stump revision and 5 required other surgeries.[12]

Frequency of surgeries

In present study we found that 19 patients were operated one time (43.18%), 16 patients were operated twice (36.36%), 7 patients were operated thrice (15.91%), two patients were operated four times (4.55%) and 26 patients were not operated, managed conservatively thus indicating patients with electric burns require repeated surgical procedures.

Nazerani S. et al 2012 studied 38 patients of electrical burns of upper extremity and found that one surgery is required in 11 patients (36.7%), two surgeries in 8 patients (26.7%), three surgeries in 5 patients (16.7%), four surgeries in 3 patients (10%), five surgeries in 2 patients (6.7%), seven surgeries in 1 patient (3.3%).[16]

Level of amputation

In present study finger amputation and below elbow amputation was performed in 6 patients, two out of six patients required bilateral below elbow amputation so our study correlates with Segu S.S. et al study, overall finger amputations were required most commonly as upper extremities were mainly affected. (Table 4, Fig. 2)

Segu S.S. et al 2014 in their study found that below elbow amputation was most commonly performed surgery, followed by finger/toe amputation the above elbow, below knee and shoulder disarticulation.[8]

Bacteria causing wound infection

In our study staphylococcus aureus was the most common organism causing wound infection in cases of electrical burns, in two cases patients had got gas gangrene thus correlating with following studies.

Subrahmanyam M.2004 the organisms isolated from the wounds of electric burns were Staphylococcus aureus (13), Pseudomonas (2), Klebsiella (2), and Proteus (1). No wound had Clostridial infection. Twenty-one wounds had no organisms grown on culture.[14] Faggiano G. et al 1998 there is a high risk of Staphylococcus aureus and Pseudomonas aeruginosa infection in these patients.[17]

Hospital stay

In present study average duration of hospital stay was 15.1 days. (Table 5) 48.58% patients had hospital stay of less than 7 days, 35.71% patients had hospital stay of 7-29 days and remaining 1.71% patients had hospital stay of 30 and more than 30 days. As majority of the patients in our study were having total burnt surface area less than 10% with low voltage electrical burns cases outnumbering the high voltage so leading to less average hospital stay.

Njogu and Paul Mwai 2011 the mean duration of hospital stay for these patients was 37.8 days. (15) Segu S.S. et al 2014 in their study the range of hospital stay was 7–82 days and mean hospital stay was 24 days.[8]

Complications

In present study wound infection was the most common complication encountered caused by staphylococcus aureus. Amputation was performed in 25 patients for gangrene, majority in the upper extremity .Renal failure was seen in 5 patients secondary to rhabdomyolysis which was managed by osmotic diuresis none of them required dialysis. 4 patients developed septicemia which was managed by appropriate antibiotics but 3 of them died, 2 patients had gas gangrene for which amputation was done. Pressure sores was seen as result of poor mobilisation. 3 deaths were due to septicaemia.

Our study results correlate with study of EI-Gallal and Yousef S.M. and of Sachde J. for wound infection and renal failure. The amputation was seen in consonance with the study of Haddad S.Y. EI-Gallal and Yousef S.M.1998 the most significant complications were septicemia in 48 patients, myoglobinuria in 13, acute renal failure in 8, DIC in 7, multisystem failure in 4, respiratory complications in 3, wound infection in 124, delayed healing in 42, spinal neuropathy in 2, and peripheral main nerve injury in 56.[1]

Follow up

We had followed up patients at 1, 3, and 6 months, 30 patients were lost to follow up (42.86%). Contracture was seen as most common complication in 11 patients (15.71%) due to lack of physiotherapy and 4 patients developed pressure sores due to immobilization and poor care. One patient had spine injury because of which had developed paraplegia and pressure sores. (Fig 5)

Kidd M. et al 2007 in their study mean follow up was 352 days and 12.5 % patients were lost to follow up .Ten patients (8.7%) had developed contracture.[18]

Conclusions

Incidence of electrical burns in our institution was 6.18% amongst the total burns and affected population was between 21–30 years with mean age of 26.54 years.

Male preponderance was seen due to more exposure to electrical appliances and their work status in industrial fields, factories and buildings.

Patients belonging to low socioeconomic status and rural area were more affected may be related to poor literacy, improper handling technique and poor preventive measures.

Low voltage injuries outnumbered the high voltage injuries.

Most of the electric burns were due to contact with power source either accidentally or while working. The main population affected was between 21 to 30 years all being students followed by electrician.

Upper extremities were most commonly involved with total burnt surface area being less than 10%.

44 patients required surgical intervention; amputation was the most commonly performed surgery and that too of upper extremity followed by debridement. Wound infection was the most common complication caused by staphylococcus aureus.

Average hospital stay was 15.1 days. Septicemia was seen in 4 patients and 3 patients died due to it along with acute renal failure. On follow up contracture was the most common complication.

Electrical injury is very serious type of burn causing considerable health hazard, victims end

up with major disabilities, most of the injuries are preventable with proper education and knowledge, efforts for rehabilitation and counseling should be part of treatment protocol.

Our study has found that young males sustained injuries in their successive years so to conclude there is need for adoption of preventive measures, to educate and train our rural people and those working with electricity regarding National electrical safety codes such as

i) to put off energy source/power before repairs.

ii) avoid inadequate wiring, exposed electrical wires, wet conditions and damaged tools/ equipments.

iii) ensure good earthing and insulation techniques.

iv) training in use of personal protective equipments, first aid safety measures, emergency medical services, awareness of fire extinguishers and cardiopulmonary resuscitation.

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