CASE REPORT

Limb amputation secondary to electrical injuries: case series from a five – year review of Lagos University Teaching Hospital

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Abstract

Background: Electric Burn results from the passage of electric current through the body when in contact with the electric arc. Electric injury of a severe nature results in death. Surviving victims may develop short- or long-term effects on various organs, including gangrene and slow necrosis to tissues. We sought to evaluate electrical burn patients who required amputation in Lagos University Teaching Hospital (LUTH).

Materials & Methods: This was a cross-sectional study of patients who suffered electrical burn injuries at the LUTH Accident & Emergency Unit. Those who required amputations were studied as a case series.

Results: The case series involved 6 patients, with 11 limb amputations, consisting of 8 (72.7%) upper limbs and 3 (27.3%) lower limbs. One patient had had bilateral upper and lower limb amputations while 2 others had bilateral upper limb amputations. Five (83.3%) patients were working-class males, with the only female being a child who was involved in a domestic accident. There was one mortality in this case series, resulting from Traumatic Brain Injury and severe infection.

Conclusion: Developing countries are rife with inefficient electrical energy systems, poor safety measures and working ethics. High voltage electric injuries are frequently sustained at the workplace, particularly by adult males who are occupationally exposed to electricity. High voltage electric injury culminates in gangrene formation and limb amputation as treatment.

Keywords: Electric Injury, Semiconscious, Burn, Gangrene, Amputation, Prosthesis.

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Introduction

The discovery of electricity has improved the life of man and rendered him empty without it. Electrical burn results from the passage of electric current through the body when in contact with the electric arc. Electrical burns are rare compared to other types of burns such as scalds, thermal, chemicals etc[3]. Electric current could be grouped into high Voltage (>1000V) and low Voltage (<1000V). Contact with any voltage greater than 70,000V is usually fatal. The mechanism of injuries is from direct flash burns/heat or current conduction through the body and indirect injuries from muscle contraction and falls. The amount of heat generated, and therefore the degree of tissue damage, is equal to $0.24\times(\text{voltage})^2\times\text{resistance}$. The extent of tissue injury is related to the voltage and tissue resistance[5]

Electric fire outbreaks are common in Lagos, Nigeria. Some are either unreported or not well documented. Electric burns following high-voltage electric cables are usually the reason for some patients presenting to tertiary institutions because of the attendant grave consequences[7] It is a common occurrence to see high-tension wires lying on trees, bridges, buildings, and even on the ground in our environment[6] Electric burns constitute 3-5% of burn injuries in developed countries while in Nigeria it is about 2.8-4.6% in the east[3], to 8% in the west. It is common among electricity workers, installation vandals, and occasionally other workers that fall from high-rising buildings and cranes[7]. It is common among young male adults. Eighty-six percent of patients with high-tension electrical injuries require amputation and mortality is 3-15%[8].

We undertook to review all electrical burns patients who required limb amputation in Lagos University Teaching Hospital during the study period and to elucidate the burden and other complications, and to proffer prevention and treatment methods.

Methods

This was a cross-sectional retrospective study of patients who had limb amputation secondary to electrical burn injuries from 2017 to 2022 in LUTH. Data were sourced from the accident and emergency as well as theatre records. All patients with electrical burns who presented to the accident and emergency of the Lagos University Teaching Hospital during the period were recruited while those who had amputations were studied.

All patients that arrived at the accident and emergency were resuscitated following ATLS protocol. Fluid resuscitation was achieved using Ringers lactate and or normal saline. The extent of the surface area burnt was estimated using Wallace's rule of 9 and resuscitation fluid volume was determined using Parkland formula. Packed cell volume was checked and blood was given as

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required as per the hospital protocol. All patients had Electrocardiography monitoring. The adequacy of resuscitation was determined with an indwelling urinary catheter and vital signs checks. Patients who were brought in dead were excluded from the study. Those who required amputation were studied. Ethical approval was sought and obtained from LUTH. Demographic information, mechanism of injury, voltage, severity, surgical interventions, and outcome were retrieved from the patient's records. Eighty-two (82) patients were admitted and treated for electrical burn injuries within the years under review. Twenty-nine (29) (35.4%) of the cases were due to high voltage and 53(64.6%) were due to low voltage. Nineteen (23.2%) had contact burns six (31.6%) of which resulted in gangrene and subsequent limb amputation.

CASE 1

A 23-year-old male accidentally placed his left hand on a high-voltage distribution panel for an unknown period while working as a construction worker. He sustained electrical burn injuries to the left upper limb. The actual mechanism was not known. He was found semiconscious by a coworker. He was unable to recollect the events or the period soon after. He was taken to a private hospital where he had initial resuscitation with intravenous fluid and had his wounds dressed, admitted for six days

On referral to LUTH on the seventh day, examination showed a young man, healthy-looking, not dehydrated but in distress. His left upper limb had a charred appearance from a full-thickness burn from just below the elbow down to the hand. He had a fixed flexion deformity of the wrist, metacarpophalangeal joints, and interphalangeal joints of the left digits. He also had some wounds on his left wrist, forearm, and cubital fossa. The entry site of the electric current was at the left hand and the exit at both feet as indicated by blisters on the dorsum of both feet.

Diagnosis of gangrene of the left hand, wrist, and forearm with no clear demarcation secondary to electrical burns was made.

The patient's hemoglobin was 14.8g/dl. Electrolytes, Urea, and Creatinine were within normal limits. He had above elbow amputation of the left upper limb. The wound on his feet was debrided and dressed. He was discharged from the hospital after 17 days of admission.

CASE 2

A 46-year-old construction worker was traveling on the back of an open truck. He was carrying an aluminum ladder that came in contact with an overhead high-voltage electrical cable (>1000 volts). He suffered electrical burn injuries to both upper and lower limbs. He was thrown onto the floor of the truck. He was taken to a private hospital where he was assessed to have a Glasgow coma scale of 8 at presentation, and his ECG showed sinus rhythm. He had initial resuscitation with intravenous fluid and blood, dressing of the sustained wound, antibiotics, and an attempt at fasciotomy of all his limbs.

On the 5th day of injury, his upper and lower limbs started getting dry, and darker in appearance, with the upper limbs worse than the lower limbs. On the 7th day, he developed an inability to move both wrists and hands and both legs felt stiff. He was referred to LUTH on the 11th day.

Table 1; Summary of cases

S/N	AGE	SEX	PRESENTATION	DURATION OF HOSP STAY	INJURIES	ASSOCIATED INJURIES	TREATMENT	OUTCOME
Case 1	23	M	1 week	17days	Left upper limb gangrene	None	Left upper limb amputation	Discharged home
Case 2	46	M	3weeks	6weeks	Upper and lower limb gangrene	None	All limbs amputated	Prosthetic limbs fitted
Case3	26	M	1day	5weeks	Both upper limb gangrene	Severe brain injury	Bilateral upper limb amputation Craniotomy	Deceased
Case 4	9	F	5 days	3weeks	Right upper limb gangrene	None	Right upper limb amputation	Refashioning done after 2 years.
Case 5	35	M	5 days	3weeks	Both upper limb gangrene	Right femur fracture	Bilateral upper limb amputation External fixation	Discharged in a wheelchair, awaiting a final O.R.I.F of femur fracture
Case 6	30	M	2weeks	3weeks	Left foot gangrene	None	Trans metatarsal amputation	Discharged home

Investigation results are as follows WBC - 8,810 cells/mm³, Neutrophils - 52.1%, Lymphocytes - 33.6%, PCV - 33.8%, Platelets - 250,000

Urea and electrolytes Na - 137.2, K - 3.25, HCO3 – 18, Cl - 105.6, Urea - 3.36, Creatinine - 119.68.

Examination at his presentation in LUTH showed a middle-aged man in very severe distress. Glasgow coma scale of 15, with a charred appearance of both upper limbs below the elbow with full thickness burns of both forearms extending 8cm distal to the right elbow crease and 10cm distal to left elbow crease. All fasciotomy wounds were oozing seropurulent discharge. He was placed on intravenous antibiotics and fluid resuscitation and transfused 4 units of blood.

Nine days post-admission, he had four limb amputations. As shown in Figure 1.

The wounds healed very well. He was subsequently mobilized on a wheelchair, and then four and half months postoperatively, had prosthetic limbs fitted. See Figure 2

Myoelectric prosthesis for the upper limbs and dynamic walking prosthesis for the lower limbs. All are sponsored by his company. He is ambulating fully presently.

CASE 3

A 26-year-old male electrician with an electric company based in Lagos. He placed his left hand on the electric distribution overhead cable during a power outage when suddenly power was restored to the electric line. He was thrown off the pole of about 10 meters. Landed on his back and hit his head on the ground. He was immediately

Fig 1 and 2

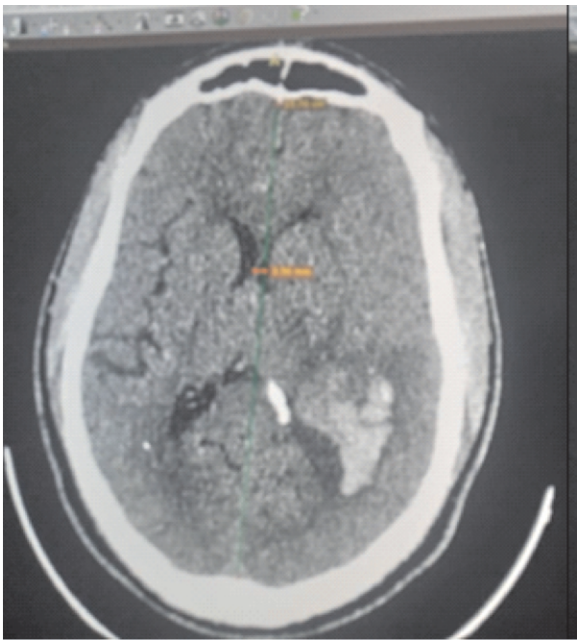

Fig 3

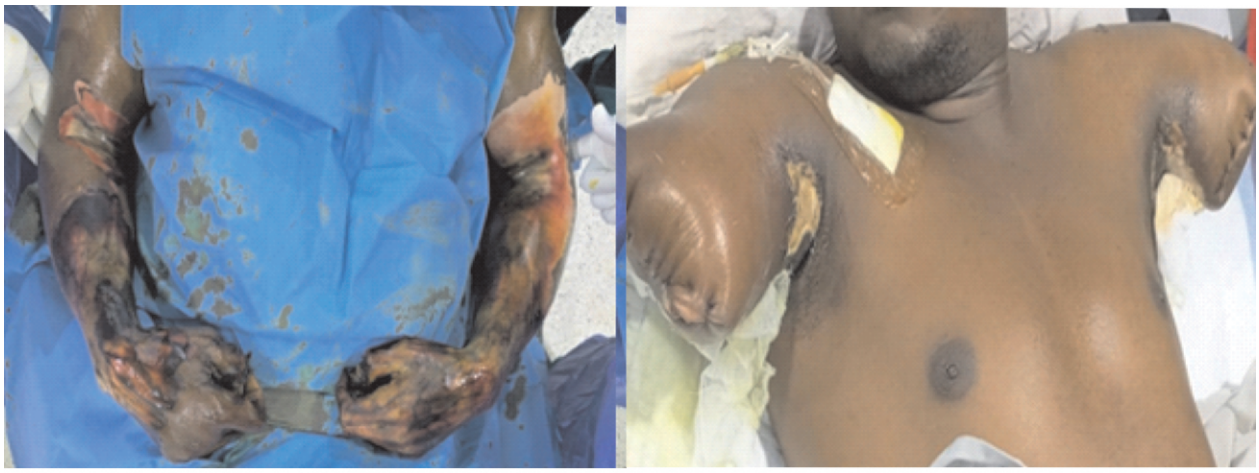

Fig 4 a and b

taken to a private hospital semiconscious. He was resuscitated, his wounds were dressed, admitted for 48 hours, and treated with antibiotics and continuation of the wound dressing.

While on admission in the private hospital, he was noticed to be more confused with GCS deteriorating from 13/15 on admission to 10/15 on the 2nd day of admission when he was referred to LUTH. His left upper limb below elbow got dry and darker in appearance and he was not able to move his wrist and hand. There was also the discharge of some dirty brownish liquid from wounds on the forearm.

On examination in LUTH, a slim-built, malnourished male who was semiconscious, GCS 10/15 having a charred appearance of the upper limb, below the elbow with full thickness burn of the left hand and forearm extending 5cm distal elbow crease was seen. There was a clear-cut dry/wet gangrene of the left forearm and hand. The patient was immediately admitted to the ICU.

Patient Hb=15.3gm/dl
Alkaline phosphatase= 164iu/l
SGOT=306iu/L
SGPT=658um/L
Total bilirubin=1.9
Urobilinogen =increased
Other blood parameters were within normal limits

On the 9th day, the left forearm and hand showed an established line of demarcation. There was gangrene of the metacarpophalangeal joints and interphalangeal joints of the left hand. The fingers were fixed in flexion. There were full-thickness scabs on both upper thighs 4cm x 3cm and blisters on the dorsum of both feet on the anterolateral sides.

He had above elbow amputation and debridement of lower limb wounds. He was then placed on intravenous antibiotics with supportive drugs.

The brain CT scan showed severe intracerebral contusion secondary to intracerebral bleeding. Figure 3

He continued ICU care on intubation. His repeat investigation 2 weeks after admission showed

Hb= 13gm/dl
Alkaline phosphatase=615iu/L
SGPT=361IU/L
SGOT=20u/l
Total bilirubin0.4mg/dl
Total serum protein=5.4g/dl
Albumin=3.7g/dl
Globulin=2.9g/dl

Wound swab MCS showed growth of gentamycin-sensitive staphylococcus and pseudomonas aeruginosa, sensitive to amikacin, and vancomycin. By the 3rd week, the GCS had dropped to 8/15 and he was noticed to require ionotropic support. By 4th week patient had cardiac arrest and was resuscitated, 2nd cardiac arrest 24 hours later was noted and all attempts at resuscitation failed, and was certified dead 29 days post-injury.

Cause of Death – Brain trauma and septicaemia

CASE 4

A 9-year-old girl suffered an electrical injury accidentally while trying to retrieve her book that mistakenly fell close to the distribution panel of their residence early in the morning. Her right hand made contact with the panel for an unknown period. She was thrown off and fell but remained fully conscious, and attracted her relative's attention by her cry for help. She presented to hospital on

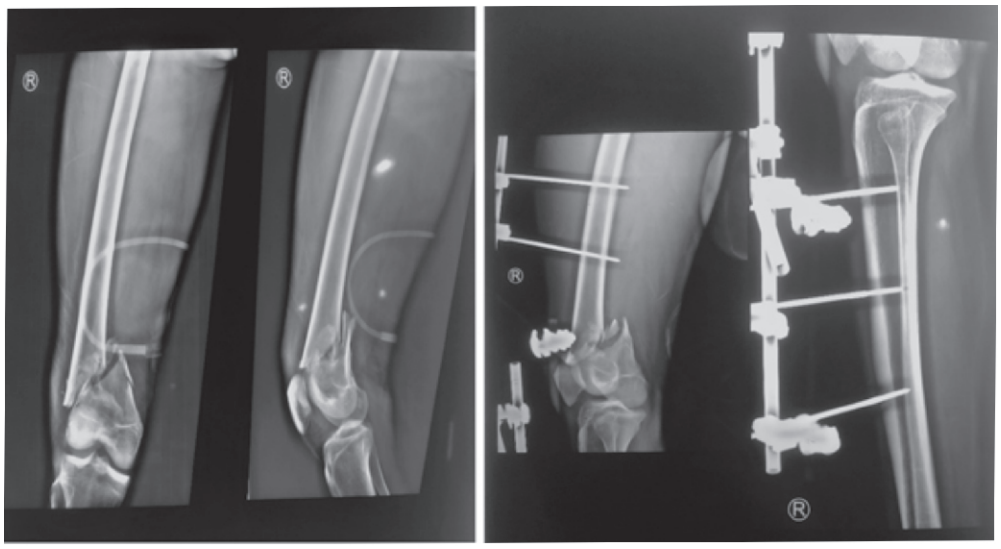

Fig 5 a and b

the third day after injury.

Her right hand, wrist, and forearm had become blackish and there was oozing of blood from her hand. The patient remembered trying to get her book but didn't remember the sequence of events that resulted in the electric injury and the period soon after it. She was taken to a nearby hospital where the wound was dressed and her parents declined admission due to financial considerations. A few days later mother noticed that her right upper limb below the elbow was stiff, she was unable to move the wrist and digits, and the 2nd to 4th digits were dry and darker in appearance.

She felt that her right wrist and hand were bent towards her palm in a very tight fashion.

There were wounds on her thighs, and both feet, which gradually started discharging some brownish liquid. She went back to the hospital where the wounds were dressed and was given some medication.

On the 7th day after the electric injury, finding no relief, the parents asked for a referral to LUTH.

Examination on presentation to LUTH showed a young girl without any systemic abnormality having a charred appearance of right digits and an ischemic contracture of the forearm and hand. There was clear cut dry gangrene of the right digits. The wrist, metacarpophalangeal (MCP) and interphalangeal joints (IP) of the right hand were in a fixed flexion deformity. There were blisters on her right foot including the 4th and 5th toes.

The entry site of the current was her right hand and the exit was her right foot. The wound was about 6.7% of the body's surface area

Patient hemoglobin = 13g/dl
Alk Ph= 122iu
SGOT= 12iu
SGPT= 26iu
Total bilirubin= 0.7mg/dl

Other parameters and E/U/Cr were normal limits. By the 11th day, there was a clear-cut dry gangrene of the right firearm and hand with an established line of demarcation. The patient's right forearm and hand were amputated 3cm above the demarcation and all other wounds were debrided and dressed. She continued on antibiotics and wound care. The amputation stump healed well and the other wounds improved very well.
Repeat liver function test, E/U/Cr and FBC were essentially normal and the patient was discharged home after 21 days on admission.

CASE 5

A 35-year-old male electrician was electrocuted and fell from a 12ft electric pole while doing repairs on some high-tension wires. He sustained electric burns to upper limbs (from hands to mid arm), penetrating abdominal injury to the right flank, head injury with loss of consciousness, and right distal femur fracture.

Initial care following injury was at a private hospital, where he was resuscitated and once he regained consciousness 4hours post-injury, he was referred to LUTH.

He presented to LUTH with stated injuries and dark-colored urine, suggestive of myoglobinuria. He was resuscitated, fracture splinted and investigations ordered.

Gangrene of both upper limbs was noticed 24hours post-injury, gradual in onset from the time of presentation. This is shown in Figure 4a.

Oxygen saturation on all fingers was not recordable, no bleeding following a pinprick test.

Investigations revealed- a deranged kidney function test, neutrophilic leukocytosis, and fractures of the distal femur, and anterior third of the iliac spine all on the right side.
Total number of days spent on first admission- 90 days
Within these days, he had a bilateral above-elbow amputation. See Figure 4b

Fracture immobilization with joint spanning external fixators 36 hours post-injury. Figures 5a and 5b
Hemodialysis (3 sessions) for Acute kidney injury.

Post-surgery he developed scrotal swelling, ulceration of the axillary fold, and partial intestinal obstruction which all resolved with conservative treatment.
2 weeks post-surgery (external fixation) he had open reduction and internal fixation (ORIF) of distal femur fracture following the failure of reduction with an external fixator.
4 weeks later, he had repeat surgery (osteoclasis and repeat ORIF) due to mal-alignment from mechanical implant failure of the supracondylar fracture fragment.
He developed a surgical site infection which was managed with wound dressing and antibiotics.
He was readmitted and had implant removal, debridement, and external fixation.
He was then discharged and is awaiting further O.R.I.F.

CASE 6

A 30-year-old male electrician was referred from a private hospital to LUTH with a complaint of left forefoot gangrene of three weeks duration.
When he was working on a high-tension cable it fell on his left foot causing severe electric burn injuries 3 weeks before presentation.

Following electrocution he fell to the ground. There was no history of loss of consciousness or injuries to other parts of his body except burn on all toes in his left foot.

He was subsequently rushed to a private clinic where

he was admitted for four days. He noticed darkening of all toes of the left foot and was then transferred to a General Hospital where he was managed for a week, but his condition deteriorated further (progressive worsening of gangrene and ulceration over the dorsum of the foot) thus necessitating his referral to LUTH. Darkening of toes was dry initially but developed some minimal discharge between the web spaces and superficial ulcer over the dorsum of the forefoot. See Figures 6a and 6b. The patient has no known medical co-existing morbidity and does not smoke or drink alcohol.

Examination of the musculoskeletal system revealed a charred appearance of the D1-4 dorsal surface extending the junction of the forefoot of the left foot.

Fig 6 a and b

Fig 6 c and d

Ulcer on the midfoot, floor contains thrombosed veins for D1-D2 toes.

The patient was planned and worked up for debridement. In theatre, all necrotic tissue and gangrenous toes were excised and a clean bed was created. The posterior flap developed was used to cover the wound—Figures6c and 6d.

The summary of the cases as in Table 1

Male: Female of 5:1

Discussion

Electrical injuries are very frequent in everyday activities of life all over the world, however injuries resulting in gangrene and amputation are uncommon. Four types of electrical injuries are well documented namely flash, flame, lightning, and true injury. Flash and flame cause superficial burns, lightning leads to immediate death or sometimes charring of the whole body while true injuries make the individual part of the electrical circuit[9]. When a true electrical injury occurs, an entrance and an exit site are usually visible, most times resulting in limb injuries requiring amputation.

Amputation is the removal of a whole or part of a limb or digit by surgically cutting through the bone or joint. Amputation retains its relevance in modern times to save lives by removing dead, useless, or dangerous limbs. Electrical injuries affecting the limbs are significantly associated with an increased risk of amputation with incidence rates as high as 68% [10,11,12]. However, most of these studies were limited by their small sample size. Soto et al described that electrical burns increased the likelihood of amputation by 13.8 times [10.]

As with our series, the majority of these patients are working males, adult to middle-aged[13,14]. This could be explained by the fact that more men had occupational exposure to electricity. In children, most injuries occur in the home environment as the index child case in this series.

The contact point for the current in this series is the hand. The most common contact points for the current in literature are the hands and skull, while the most common ground areas are the heels and foot. The entry point of the flexor surface often produces severe muscle contraction, causing extensive tissue damage as seen in this case series. Most electrical injuries cause damage to muscles, bones, skin, nerves, and vessels resulting in short- and long-term morbidity. There is involuntary muscle contraction of the walls of blood vessels through which the current passed which undergoes necrosis leading to myonecrosis and gangrene. Electric current has the potential to burn tissue beneath the skin and subcutaneous tissues. Occasionally, internal organs are destroyed without any external evidence of such when the body comes in contact with electricity, leading to slow gangrene[12]. A severe electrical injury causes destructive injury with high morbidity, lifelong scars, and even death.

There is a paucity of data on the effect of electrical injury on the musculoskeletal system. From the four reports available, amputation has remained the most predominant if not the only treatment option. Lee et al [9]reports showed gangrene and subsequent amputation in the hand and upper extremity. Upper limbs are more affected than the lower limbs in this series and in the literature. When both upper and lower limbs are affected, the upper limbs are more seriously affected.

In our series of 6 cases, there were 11 limb amputations, consisting of 8 (72.7%) upper limbs and 3 (27.3%) lower limbs. One patient had bilateral upper and lower limb amputations, while another 2 had bilateral upper limb amputations.

Also, 83.3% were working-class males, with the only female being a child who was involved in domestic injury. All the male patients were involved in occupational electric injuries and the child had a domestic injury. This could be explained by the fact that more men had occupational exposure to electricity than children, and women[14, 15].

Their blood parameters were within the normal range except for two patients who had raised liver enzymes, which became normal levels two weeks after injury.

Only one patient (case 3) had neural deficits, from a head injury secondary to an associated fall from a height of over 15 meters. The same case was the only mortality in this case series resulting from traumatic brain injury and severe infection.

Only one patient had full rehabilitation after amputation in this case series. Previous case series demonstrated the potential difficulties in rehabilitating burn-injured patients who had undergone amputation.[15,16]

Conclusion

Developing countries are rife with inefficient electrical energy systems, poor safety measures and working ethics. High voltage electric injuries are frequently sustained at the workplace, particularly by adult males who are occupationally exposed to electricity. High voltage electric injury culminates in gangrene formation and limb amputation as treatment.

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