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Outcomes of Electrical Burns at Chris Hani Baragwanath Burn Centre in South Africa

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Abstract:
Background*: The significant morbidity of electrical burn injuries is well described in the medical literature, especially in the form of major limb amputations. Reported mortality rates are generally described as low, especially in the more recent analyses*
Patients presenting factors, mortality characteristics and morbidity factors (length of stay in hospital and in ICU, procedures performed, organ support factors). These were recorded in an Excel spreadsheet and statistical analysis was done.
Aims*: The study aims was to determine the epidemiology, the morbidity and the mortality of electrical burns in a local South African setting.*
Method*: A retrospective record review was conducted of electrical burn cases at Chris Hani Baragwanath Hospital Adult Burns Unit in the last 15 years, from January 1995 to April 2010.*
Results*: There were 101 patients with electrical burns in the period studied, comprising 7% of total burns admissions. 91% were males. The mean age was 30, 0 and the mean length of stay was 31, 0 days. Mechanism was divided as follows: 37% suspected or documented cable theft, 4% lightning, 10% domestic or informal occupational accidents, and the remainder unspecified. Mean body surface area burn was 19, 9%. 13 patients died during their hospital admission (12, 9%). 19 patients required ICU (29, 7%) and stayed between 2 to 31 days there. Major amputation rate was 16, 9%. 8 fasciotomies, 71 sloughectomies/debridements and 38 skin grafts were performed.*
Conclusion*: A very large proportion of electrical burns in South Africa are probably due to cable-theft related injuries. Mortality from electrical injuries is significantly higher than international data and morbidity remains significant. This may be due to constraints in ICU resources. This may also be due to severity of injuries. Prevention strategies should be refined and implemented to reduce the burden of disease.*

I. Introduction

Electrical burn injuries from electric shock or uncontrolled short circuit are associated with significantly morbidity and mortality. For patients of similar age and surface burn area, electrical burn injuries are more severe than to thermal burn injuries [1]. The outcomes from electrical burn injuries range from loss of limbs to death resulting from multiple-organ failure or sudden cardiac arrest. Moreover, despite adequate management and sophisticated operative techniques evidence in patients with electrical burn injuries have markedly reduced functional outcomes [2, 3].

Mortality rates from electrical burns of 0.59% and 2.3% have been reported from China and India respectively, with earlier studies reporting higher mortality rates [1, 5]. An exception is a 21.7% mortality rate from 68 cases from a Philippine burn unit [6]. Other studies report mortality between 0 to 3.4 % [7] and these include two developing world figures from China [8] and India [9]. Furthermore, for injuries from lightning a significant association between mortality has been found in clinical (mortality rate of 17, 6% in 17 lightning admissions) [7] and forensic data (32, 3% of 291 cases were lightning fatalities) [10]. South African forensic data report a high number of fatalities - up to 100 cases per year (death rates varying from 1, 5 to 8, 8 per million per year) [11].

Electrical injuries are classified into low- and high-voltage injuries of less than and greater than 1000 volts, respectively. High-voltage injuries are sub-classified into electrical arc, contact or lightning injuries. Most high-voltage electrical burn injuries are reported in the literature as occupational injuries. In contrast in South Africa, a major contributor of high-voltage electrical burn injuries, and consequent deaths resulting from the attempted theft of high-voltage steel or copper cables from the electrical utility and telecommunications industries. Such theft has been publicized recently times by these industries in an attempt to curb these substantial financial industry losses. *Eskom*, the state-owned power-supply company, ran a publicity campaign which branded the thieves as *Izinyoka*(Zulu/Xhosa word meaning snake).

Despite this publicity, little published clinical data, exists for South Africa on the prevalence and consequences of electrical burn injuries. In the Gauteng Province in children (under 15 years of age) reported electrocution death rates of 0.3 females, and 1.2 males per 100 000 persons in 2007 [12]. In 2009 a forensic audit by Blumenthal [14] in only 4 years in a single province, Gauteng in South Africa, reported 126 electrocution deaths, the highest number of electrical burn-related fatalities recorded for either developed and developing countries [14]. The study was unable to determine the exact circumstances of injury. The same study, in contrast to international data, found most high-voltage deaths occurred at night or in the early hours of the morning, supporting an association with illegal activity including cable theft.

This disparity of findings from South Africa was further highlighted when comparing studies from the United States and elsewhere. In 2003, a study from Alabama (USA) reported 8 theft-related deaths over 20 years and concluded that this was a rare cause [15]. An Italian study [16] showed a correlation between the rising copper prices in recent years and the number of cable-theft injuries. Even so, a total of only 48 patients (8.5% of their total burn admissions) were treated for electrical injuries over a 15 year period. Other associations in the literature between copper theft and electrical injury have been discussed only in case reports [17, 18]. Furthermore, a forensic audit from Bulgaria showed that of the 291 high-voltage deaths over 41 years, only 10% were related to theft. This study also reported a seasonal variability and concluded that 32% of deaths during this period were possibly lightning-related [10].

It follows that, extrapolating data from international studies for prevalence and causes of electrical burn injury in South Africa, would lead to inaccurate assumptions. Therefore, the current study is the first from South Africa to report on the prevalence and outcomes of electrical burns patients in a region most affected by cable-theft.

Study Objectives

The main objective of this study is to establish the epidemiology, morbidity and mortality rates of patients with cable-theft electrical burn injuries admitted to a major tertiary care hospital in Soweto, in the Gauteng Province of South Africa.

II. Methodology

Study Setting. The population data studied, comprised of all patients admitted to the Adult Burns Unit, the only burn centre in Public sector in Johannesburg, South Africa between January 1995 and April 2010 with a diagnosis of electrical burn injury.

Study Design. This was a retrospective study to determine the epidemiology, morbidity and mortality of the admitted electrical burns cases.

Study Population. Patients admitted to the Burns Unit have a minimum age limit of 11 years and all electrical burns cases admitted during the 15 year study period were included in this study. A review of patients' records over a 15 year period was deemed considered to be comparable to international publications on this subject.

Study Variables. The variables that were assessed were:

- Circumstance of injury
- Age
- Gender
- Body surface area
- Length of stay in hospital
- ICU days
- Ventilator days
- Dialysis days
- Inotrope days
- Number and types of surgical procedures
- Number of blood products used
- Mortality

Data Capturing And Analysis. Data was recorded in Excel (Microsoft) with analysis and comparisons between groups made using SAS Version 9.1. Patient numbers, gender and variables (age, demographics, extent of burns, etc.), mean (±standard deviation) or median were reported.

Ethical Considerations. Permission was obtained from hospital authorities and ethical clearance was obtained from the Human Research Ethics Committee of the University of Witwatersrand in Johannesburg (South

Africa). No direct contact was made with the patients, as this was a retrospective records review study and all data was kept anonymous.

III. Results

Patient Demographics. A total of 101 patients were found to have electrical burns in the 15-year period of the study and comprised 7% of the total burns admissions for this period. Hospital records were incomplete for 37 of these cases (36.6%), however, it was still possible to collect demographic information, body surface area, and length of hospital stay as well as mortality data for these incomplete case records.

Most patients were male (89.1%), resulting in a male to female ratio of 9:1.1. The mean age was 30 ±12 years [range: 11 to 67 years] (Figure 1).

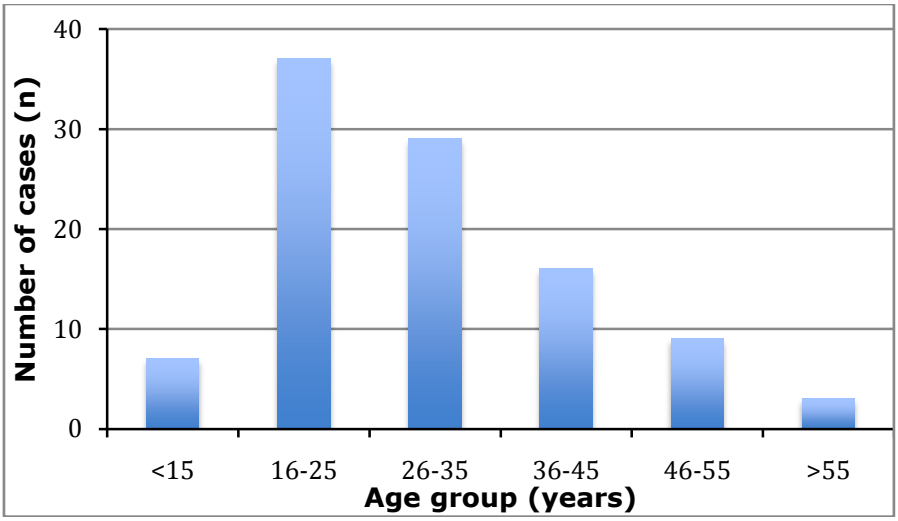

Figure 1: Bar graph of the number of electrical burn injury cases per age group.

Percentage Body Surface Area Burnt. The extent of burn per mean body surface area (BSA) was found to be 19.9 ±16.6% (Figure 2.). The range was 1% to 80%, the median was 15% BSA.

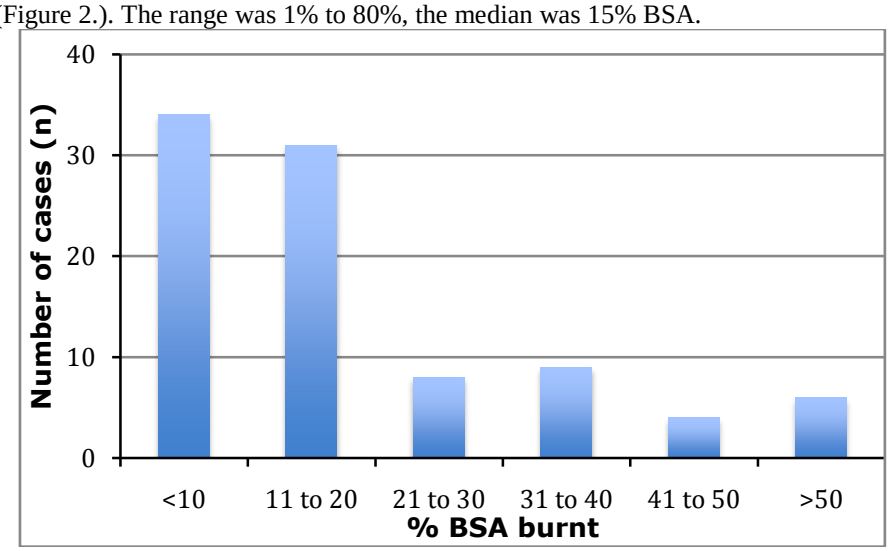

Figure 2: The severity of burn injuries expressed as the number of cases per percentage of body surface area burnt.

Circumstances Of Injury.The circumstances of injury were categorized into 6 groups, including the 37 cases whose hospital records were incomplete (see Figure 3.). Of the total number of electrical burn cases, 10% of injuries were documented as being sustained in domestic accidents and a further 4% through lightning accidents. In only 5% of cases was cable theft specifically documented in the patient records, while in 32% of cases, cable theft was recorded as 'suspected'. In 13% of electrical burn cases, the exact circumstance of injury was not specified in any of the patient records.

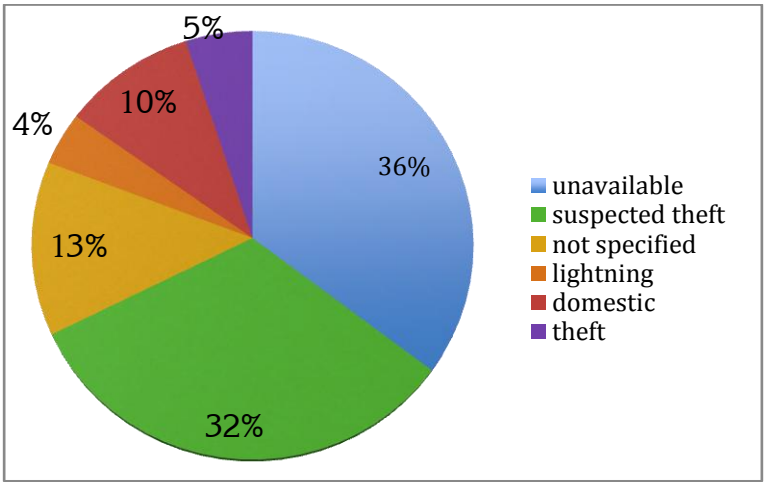

Figure 3: Pie chart of the relative proportions of injury circumstances

Length of Hospital Stay. The mean length of hospital stay was 31 ±35.4 days, range 1 to 266 days; median 17 days. (Figure 4).

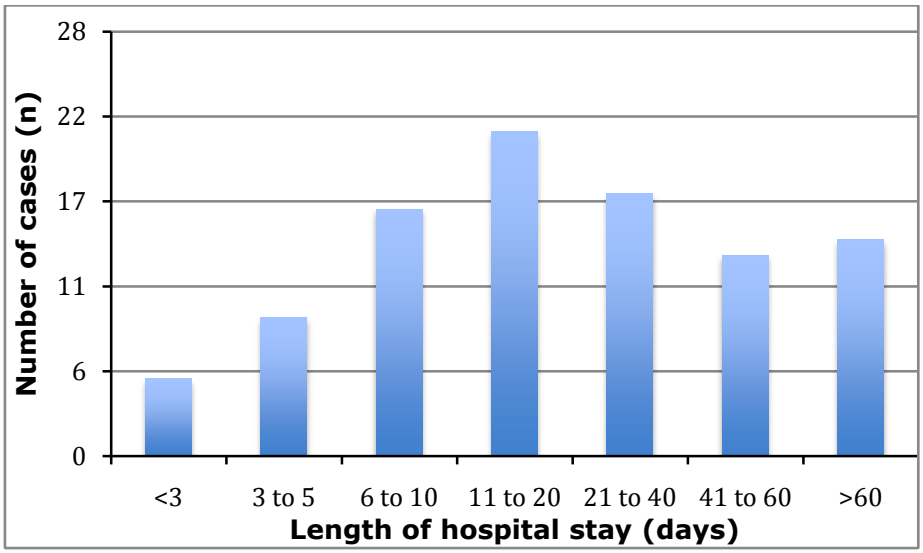

Figure 4: Number of electrical burn injury cases in relation to the number of days hospitalised.

Mortality. In this study of 101 patients, there were 13 mortalities (12.9%) with a mean age of 30.1 ±10.6 years [range: 13 to 48 years]. All mortality cases were male.

Figure 5 shows the number of total electrical burn cases per year studied and the number of mortalities in each of those years. There was no clear overall trend between the total number of electrical burn cases and the number of mortalities per year, but it is evident that over the last five years (2005 to 2010) the number of cases had increased significantly. Of importance is that the year 2010 was in fact merely a four-month period, lending weight to this apparent trend.

Of the total of 13 mortality cases, 4 were due to suspected cable theft, three were unspecified, another five case records were unavailable and one mortality was due to domestic injury (Table 2). This table highlighted the significant proportion (30.8%) of suspected cable-theft cases in the mortality group.

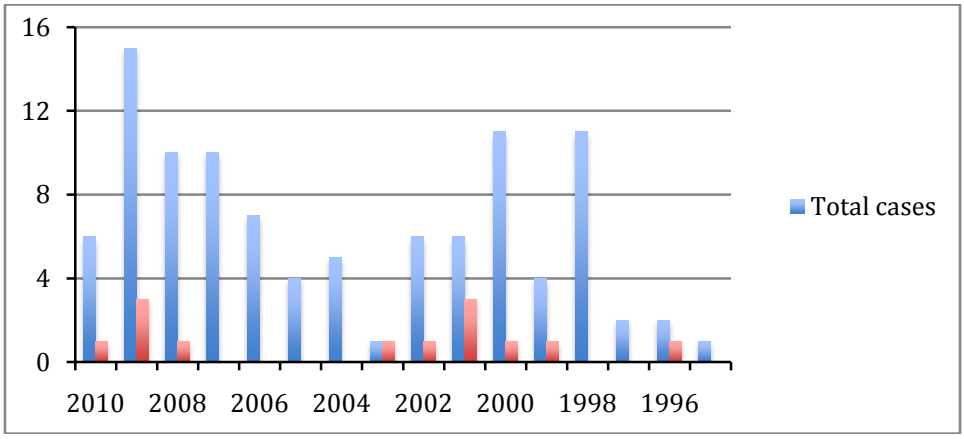

Figure 5: Numbers of electrical burn cases and deaths recorded per each year of this study.

Electrical burn patients who did not survive had a mean of 43.2 ±20.6% BSA burnt [range: 10% to 80%]. Five mortality cases (38.5%) had more than 50% BSA burns. Another six cases (46.2%) had 19% to 25% BSA burns and the remaining two cases had 10% and 15% BSA burns respectively. The 15% BSA burns case had serial amputations of the upper limbs but died of multi-organ failure.

The length of hospital stay of the mortality subgroup was 10.8 ±7.6 days [range: 3 to 32]. In this group the duration of ICU admission was 12.5 ±7.9 days. Each mortality case received an average of 4.1 units of blood, 7.4 days of invasive ventilation, 9.1 days of dialysis and 3.5 days of inotropic support.

Table 2: Circumstance of electrical burn injury resulting in mortality (n=13).

Circumstance of injury	Mortalities (n)
Suspected cable-theft	4
Not specified in files	3
Unavailable records	5
Domestic accidents	1

All of the eight mortality cases with full hospital records died of multi-organ failure and sepsis related to their extensive wounds and tissue damage.

Major Amputations And Other Operative Procedures. A total of ten major amputations were performed in nine out of the 64 cases with complete hospital records (16.9%). Of the patients who underwent major amputation, all but three were cases of suspected cable theft while two of the amputees were mortalities.All of the ten major amputations were upper limb amputations. Six were above-elbow and the remaining four were below-elbow amputations. One case had a finger amputation and two cases underwent tracheostomies.
One hundred and seventeen patients underwent sloughectomy, skin grafts and fasciotomy. (Table 3).

Table 3. Operative procedures performed on patients with electrical burns. Total number of operative procedures n = 117.

	Total number	Average per patient	Range per patient
Sloughectomy	71	1.2	0 to 6
Skin graft	38	0.7	0 to 3
Fasciotomy	8	0.1	0 to 2

Table 4. Length of ICU stay and organ support in 64 patients with electrical burns.

	Total patients (n, % total)	Total number of days	Average days/patient	Range

ICU admission	19 (29.7%)	157	8.3	0 to 31
Ventilation	9 (14.0%)	65	7.2	0 to 10
Dialysis	13 (20.3%)	82	6.3	0 to 16
Inotropes	7 (10.9%)	31	4.4	0 to 11

ICU stay and organ support. Nineteen patients were admitted to ICU with half requiring ventilation, dialysis and/or inotropes (Table 4). The mean peak serum creatinine of these ICU patients was 126.3 ±96.7 mmol/l (range: 45 to 743 mmol/l). Furthermore, a total of 89 units of blood were used in these 64 cases. The average blood units used per patient was 1.4 (range: 0 to 14).

IV. Discussion

The demographic data shows that electrical burns is an injury prevalent in the young male as 65% of patients admitted with these injuries at the burn unit were males between the ages of 16 and 35 years. Our findings are supported by international data which showed that electrical burns patients have a higher morbidity and mortality compared to thermal burns of the same percentage of patient SA. In this study, 65% of admissions of electrical burn injuries had less than 10% BSA burns because one of criteria of admission to our burn centre is electrical burns regardless of size of injury.

Mortality. The mortality rate in this study was very high (12.9%). Of the larger patient number studies (n > 100) published, the mortality rate was the highest, far surpassing the more recent data [2, 4, 7, 8, and 9]. One possible reason for the high mortality rate is the potential delays in patient care in the pre-hospital setting. This is due to the large distances and long transfer times inherent at our hospital, which serves a very large population from a large area. However, this cannot be confirmed by the data as Hospital Burn Centre records had little or no pre-hospital information.

Of the 13 deaths, five (38.5%) had BSA greater than 50%. Other studies [9] have reported 12 out of 15 deaths with similar extensive burns. Whereas Arnoldo et al. [7] reported that half of the deaths were from cardiac arrests in the pre-hospital setting, our present study showed all (100%) mortalities were caused primarily by extensive tissue damage from the electrical injuries.

In our study group there were no deaths from lightning albeit lightning comprised a small group of four patients. In contrast, in the large study by Arnoldo et al [7] lightning was the largest subgroup of the electrical burn injuries, contributing to a mortality of 17.7%.

The ICU admission rate was 29.7% and patients spent a mean of 8.2 days in this unit. However, due to limited resources at our hospital not all patients who required intensive care were admitted to the ICU. This could explain the marked difference in the admission rate compared to the (60.5%) of the study of Arnoldo*et al.* from the US [7]. The limited resources may also contribute to the higher mortality rate in our hospital. Furthermore, fewer of the patients in the Arnoldo et al study [7] who were admitted to the ICU were ventilated compared to the present study (18.6% *vs.* 47.4%). This suggests that more of the patients at our hospital are admitted to the ICU for ventilator support rather than for monitoring purposes.

Cable-theft. In contrast to the available international data, there were no work-related injuries in this study. A possible explanation for this difference is that in South Africa, the formal occupational injuries were routinely managed by the private health-care sector. However, electrical burns account for a significant portion of the CHBH burns unit admissions (7%) and a significant portion (36.6%) of suspected and documented cable-theft electrical injuries are treated in this centre. Although this is not conclusive evidence to support the prevalence of cable-theft injuries, this study does, however, suggest that cable theft injury is common in the South African setting. This is in agreement with data from Blumenthal's [14] study as well as with media and industry reports. Furthermore, Curinga et al, link this type of injury to rising copper prices [16]. At the time when the study was conducted worldwide copper prices were at an all-time high [19]. It is evident that over the last 5 years the number of electrical burns cases has increased significantly, lending more weight to this argument. Indeed, 30.8% of the deaths reported at our hospital in South Africa were suspected to be due to cable-theft, confirming that this is not a trivial injury.

V. Conclusions

This study showsa preponderance of young adult males who sustained electrical injuries requiring hospital admission. The mechanism of electrical injury was markedly different to the findings in several studies from other countries as there were no formal occupational electrical injuries included. A significant proportion of electrical burns seem to be due to cable-theft related injuries. A portion of cable-theft injuries leads to serious

clinical outcomes.Electrical injuries carried significantmorbidity as evidenced by the significant numberof major amputations and other surgical procedures performed**.** The significant numberof admissions to the ICU, frequent need for critical careandsignificant need for ventilatory support, haemodialysis resulting in prolonged hospital stay**.** There was a high mortality rate (12.9%) in patients with electrical burns in South Africa.

Preventative strategies need to be put in place to decrease the amount of electrical injuries. These include public awareness campaigns on the dangers of electrical injuries, measures to decrease the trade of stolen copper cables as well as broader socio-economic development to decrease the incentives promoting cable-theft.

Conflict of interest statement

These authors have no conflicts of interest to declare

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