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ORIGINAL ARTICLE

# Pattern of Injuries in Deaths by Electrocution: An Autopsy Study

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**Abstract:**

Electrical injuries are complex and associated with high morbidity and mortality. Low voltage injuries cause less severe injuries but are highly fatal whereas high voltage injuries cause more severe skin injuries. In this study we tried to analyse the pattern of injuries from electrocution in relation to the voltage the victim was exposed to. We categorized the exposure according to the voltage and place of exposure into household setup, exposure at construction site and exposure to electric utility poles and exposure to transformers. The maximum number of cases were in the category of electric utility pole exposure. The cases which occurred in a span of about one year were considered and were few in number. The findings that we got in this study were in agreement with some of the previous studies by other observers but due to low sample size further studies would help in reaching more definitive conclusions.

**Keywords:** Electrocution, Voltage, Household, Construction site, Utility pole, Transformer.

## Introduction:

"Electrocution" refers only to a person who is killed as a result of exposure to electricity.[1] Electrical injuries are a complex form of trauma that is often associated with high morbidity and mortality. The majority of deaths occurred in the 21-30 year age group.[4]

The severity of the injuries depends upon the type of current, the voltage, and the resistance. Tissues with the highest resistance tend to suffer the greatest level of damage as a result of an electrical injury. If skin resistance is high, more electrical energy may be dissipated at the skin, resulting in large skin burns but less internal damage. If skin resistance is low, skin burns are less extensive or absent, and more electrical energy is transmitted to internal structures. Thus, the absence of external burns does not predict the absence of electrical injury, and the severity of external burns does not predict the severity of electrical injury. Other determinants of electrical injury throughout the body are the source (i.e., entry point) and ground (i.e., exit point) of the current.[3]

Home accidents were responsible for 56 cases deaths (45.5%).[5] At least half of all electrocutions encountered in an occupational setting occur as a result of contact with power lines, and about a quarter as a result of electrical machines or tools.[6]

Low-frequency alternating current (AC) causes more extensive injury to tissues than does high-frequency AC or direct current (DC).[1] Low-frequency AC can often be more hazardous than high-frequency AC. In general, AC is also approximately three to five times more damaging than DC of equal voltage and current. In addition, DC only causes a single convulsion or contraction, usually propelling the person away from the electrical source. The higher the current and voltage associated with AC or DC, the greater the electrical damage will be. High-voltage current (greater than 500 V to 1000 V) typically will result in deep burns, while low-voltage current (110 V to 120 V) is more likely to result in tetany. Muscle tetany typically occurs in response to electrical stimulation at a frequency of 40 Hz to 110 Hz, a range in which most household currents exist.[6]

The size of burns seen on scene by the medicolegal death investigator can also vary greatly depending on the voltage. If the death involved a low voltage source, there are likely to be a small or multiple small burns where the decedent's body comes in contact with the source. The same would be true for the exit burns. However, with a higher voltage source the external burns could be very severe and cover a large area.[2]

## Materials and methods:

The institutional Review Board (IRB) of St. Paul's hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia, has given ethical clearance for research on the title.

Analytic Prospective cross-sectional study was conducted on 49 electrocution cases which arrived at the mortuary, Forensic medicine dept. in the year 2020, have been selected for this study for studying the pattern of injuries especially in relation to the Voltage the deceased was exposed. Thorough autopsy was done on these cases and Photographs were taken in all cases .

**Inclusion criteria:** All electrocution cases with proper history or with definitive electrical injuries.

**Exclusion criteria:** Cases with doubtful history and doubtful electrical injuries.

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Figure 1. Household electrocution entry.


Figure 2. Household electrocution contact burns.

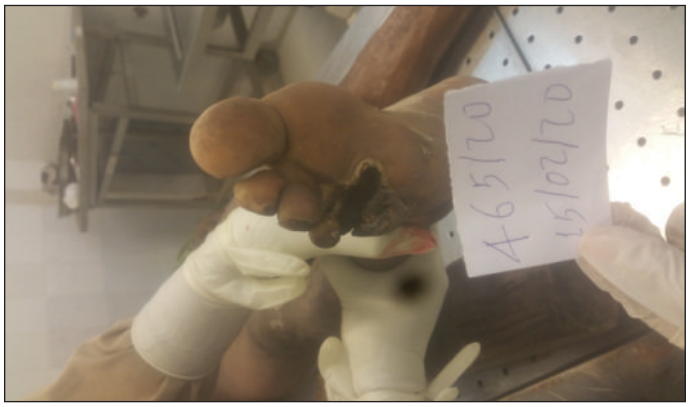


Figure 3. Entry on sole in construction site electrocution.


Figure 4. Electric pole electrocution - arcing.

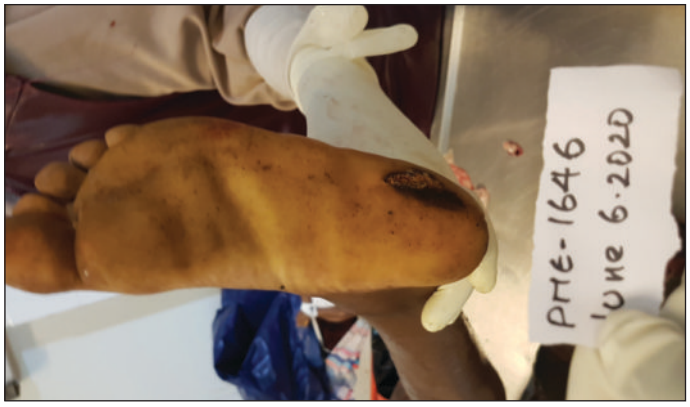


Figure 5. Electric pole electrocution - entry in sole.


Figure 6. Transformer electrocution.

## Results:

Total number of deaths from electrocution which arrived at the mortuary of St. Paul's hospital & Millennium Medical College, Ethiopia in the year 2020 were 49. Out of 49 cases 44 cases i.e. 89.7% were males and 5 were females i.e. 10.2% (Table 1).

Most people out of these 49 cases fell in the 21-30 year age group (48.9%). The maximum number of cases were in the category of electric utility pole exposure. The cases in this study were divided according to the Source of electricity that the person was exposed to. This tries to correlate the Voltage of the source to the severity of injury sustained by the person.

In this study there were 12 cases of electrocution who sustained injury in a household setup i.e. 220V in Ethiopia. The injuries at the site of entry or exit caused by this voltage have been observed to be less severe (involving the superficial layers of skin) and typical (Picture 1), in 10 out of 12 cases (83.3%), than those caused by voltages greater than 380V. In one case out of these 10 cases, one female sustained well-defined widespread contact burns (Picture 2), which were due to fall of the victim on the electric stove on which she was cooking rather than by the primary electric shock.

Out of the 2 electrocuted cases in household setup in which there were apparently more severe or atypical injuries, one case showed electric injury involving the skin of arm which was burnt, black, and hardened. In the other case, there was exit wound, and

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**Table 1. Age group vs gender distribution of deaths from electrocution.**

| Age group in years | Number of deaths | | | | Total | Percentage |
|---|---|---|---|---|---|---|
| | Male | Percentage | Female | Percentage | | |
| 0-10 | 2 | 1 | 1 | 20 | 3 | 6.1 |
| 11-20 | 12 | 27.2 | 1 | 20 | 13 | 26.5 |
| 21-30 | 50.0 | 50.0 | 40 | 40 | 31-40 | 31-40 |
| 31-40 | 5 | 11.3 | 1 | 20 | 6 | 12.2 |
| 41-50 | 1 | 2.2 | 0 | 0 | 1 | 2.0 |
| 51-60 | 4.5 | 4.5 | 0 | 0 | 2 | 4.0 |
| Total | 44 | 89.7 | 5 | 10.2 | 49 | 100 |

**Table 2. Number of cases according to source to which person exposed.**

| Source of electrocution | Number |
|---|---|
| Household | 12 |
| At site of construction | 4 |
| Utility electric pole wire<br>• Intact wire on electric pole<br>• Fallen electric pole wire | <br>15<br>12 |
| Transformer/Factory | 6 |
| Total | 49 |

**Table 3. Findings in electrocution deaths exposed to electric utility pole.**

| Features | Number |
|---|---|
| Entry wound only and less deep injuries | 4 |
| Both Entry and Exit wounds | 4 |
| Entry wound more severe than in household setup cases | 10 |
| Entry wound in sole | 4 |
| Multiple electrical injuries | 3 |
| Arcing | 6 |

was the only case out of the 12 cases with exit wound, involving the sole which was deeper and extended beyond the superficial layers. There were 4 cases of electrocution in which the victims were exposed while they were working at construction sites. Out of these 4 cases, 2 cases were exposed to a voltage greater than 380 V and the other 2 cases exposed to 220V. In those cases exposed to more than 380V, the injuries were more deeper and in both the cases the deep injuries involved the soles. In 1 out of these 2 cases, in which the injury involved the sole, the wound was an entry wound (Picture 3) and there was associated localized burning of skin of foot which is evidence of arcing.

27 cases of electrocution were seen in this study who sustained electric shock from electric utility pole wire, either while the victims were working on the electric pole or they accidentally came in contact with the pole wires while working adjacent to the wires (15 out of 27 cases in both these categories) or they came in contact with fallen electric utility pole wires (12 out of 27) (Table 2).

In 18 out of 27 cases (66.6%) the injuries were found to be more severe deeper injuries, cases associated with arcing (picture 4) that are evident as localized or whole body burns, multiple electrical injuries which are reddish brown, hardened areas of skin] than the injuries seen in household setup. In 4 cases out of the 12 fallen electric utility pole wire exposure, the entry was in the sole (Picture 5). The injury is appreciated as entry wound based upon history and inward indentation or absence of outprojection of skin at the margins in contrast to exit wound which may have outprojecting skin margins. Also, in 11 out of 27 cases (40.7%) it was observed that the injuries involving palms or soles were more severe than the injuries on other parts of the skin.

4 cases in this study were of electrocution in which the victims were exposed to transformers. In 2 out of these 4 cases, the victims touched the transformer with a wet stick. In 1 out of the 2 cases there was evidence of arcing (Picture 6) and in another case the injuries were superficial. In the other 2 of the total 4 cases, the injuries were multiple but were apparently less severe.

Electrical injury may present as Atypical electrical injury in some cases as an abrasion which is reddish brown and hardened.

Victims of electrocution fell from height sustaining fatal head injuries in 6 cases and all of these cases belonged to the category of exposure to a Utility pole. But in all these cases the victims were working at a height and there was no history that they were thrown away to a distance from the site of sustaining electric exposure.

**Discussion:**

In Ethiopia, the voltage in household setup is 220 V. During work of construction the voltage used is 380 – 400 V. The Voltage at electric utility pole is 380 V and the voltage at transformer is 15000V.

This study was mainly focused to see the pattern of electrical injuries particularly in relation to the voltage the victims were exposed to.

The majority of deaths occurred in the 21-30 year age group in a study conducted by Shaha, Joe which is in line with the result in our study (48.9%).

Home accidents were responsible for 56 cases deaths (45.5%) in the study conducted by Tirasci, Goren, Subasi et al. in contrast to our study in which the number of household exposure was 12 out of 49 (24.4%). In the household setup where the voltage was 220V the injuries on the skin were not severe in 83% cases. Whereas those victims exposed to electricity at construction site and those exposed to electric utility pole wires suffered severe injuries (66.6%). This finding is consistent with the study conducted by Zemaitis, Foris, Lopez, et al and the study by Lunn and Runde who concluded in their study that the higher the current and voltage associated with AC or DC, the greater will be the electrical damage. However, in our study we found that Voltage greater than 380V caused deeper burns or injuries than voltage less than 220V. The victims exposed to lesser voltage and sustaining less severe injuries on the skin does not in anyway indicate the potential fatality caused to the person as low voltage is more likely to cause tetany and death of the person and hence more dangerous. Hence, in contrast to the study by Bounds, Khan, Kok it was seen in this study that low voltage injuries cause less tissue damage but the lesser tissue damage does not indicate fatality.

In 40.7% cases it was observed that the injuries involving palms or soles were more severe, as these parts are thicker and offer greater resistance, than the injuries on other parts of the skin. This finding is again consistent with the findings in study by Zemaitis, Foris, Lopez, et al. which says that the tissues with the highest resistance tend to suffer the greatest level of damage as a result of an electrical injury.

The maximum number of cases were in the category of electric utility pole exposure (27 out of 49, i.e. (55.1%). This is in line with the finding in the study conducted by study by Zemaitis, Foris, Lopez, et al.

From our study, we can consider a voltage greater than 350 V as High voltage.

In cases of deaths from electrocution the scene of crime should be visited to understand the circumstances causing the electrical injury to prevent future accidents and also analyse the factors responsible for the production of severe or less severe injuries like presence of water at the site and whether the person was thrown to a distance by the exposure.

A bigger sample size in each category is required for better understanding of the pattern of injuries and for epidemiological purposes.

**Conflict of interest:** The authors declare that there is no conflict of interest.

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