DOI:http://doi.org/10.4038/sljfmsl.v13i1.7872

RESEARCH ARTICLE

# "Pattern of electrocution deaths autopsied in South India" – A 16 year retrospective study

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## ABSTRACT

**Background:** The eastern part of Bangalore is an IT hub. There is a continuous increase in the number of construction sites, work places and residential areas. As a consequence, cases of electric accidents are common and are steadily increasing. Electric injury increases the risk of morbidity and mortality. The purpose of the study is to outline the increased fatality rate due to electrocution and also aims at reducing the severity of electric injury related fatalities by promoting preventive measures.

**Results:** The study showed male preponderance, with increased incidence in age group of 20-30 years. Accidental deaths were common, and the majority of skin samples were taken from suspected site of electric contact and exit showed positive findings for electrocution.

**Conclusion:** The study provides the statistical data on electrocution fatalities in this part of Bangalore for researchers and law enforcement agencies. It also aids in emphasising the usage of protective equipment at the workplace, construction sites and precautionary measures for domestic use of the electricity.

**Keywords:** Electrocution, Histopathology, Electric contact mark, Metallization, Palisading nucleus.

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**ARTICLE HISTORY**
**Received:** 23.07.2021 **Received in revised form:** 22.11.2021
**Accepted:** 21.01.2022 **Available online:** 13.06.2022



## INTRODUCTION

Electrical energy is one of major sources of energy. It is used in industry, construction sites and domestic purpose as well. Even after long use, awareness about how to avoid its detrimental effects is still lacking among the public, resulting in considerable amount of morbidity and mortality. The term "Electrocution" has been coined for skin lesion, organ damage or death caused by the passage of electric current through bodily tissues[1]. Electrical injuries vary from minor physiological shock through minor burns at the point of contact, to extensive burns and fatality from cardiac arrhythmias. In some cases there may be no physical changes visible at autopsy, throwing additional demands on crime scene investigation[2]. Electrocution related fatalities are less common when the voltage is below 100V but more common at 200V and above. Supply for domestic and small-scale industries range from 220V to 240V, careless use of which is capable of resulting in electrocution and fatality. Electric injuries depend on voltage, path of passage of the current, the resistance offered and whether the power is direct or alternating current[3]. Most of the electrocution deaths are preventable. According to NCRB – National Crime Records Bureau 2015, electrocution accounts for 3.0% cases of unnatural accidental deaths in India[4]. The first related electric fatality was in France 1879[5].

### Aims of the Study

1. To determine the pattern of injuries sustained in electrocution deaths.
2. To determine the demographic data of electrocution deaths.

3. To interpret histopathology findings in the electrocution deaths.

## METHODS

This study was done in a tertiary care centre hospital; Department of Forensic Medicine & Toxicology which handles most of the autopsies in eastern part of Bangalore. The study is retrospective and covers a period of sixteen years between 2005 and 2020. A detailed proforma was prepared to summarise information from police requisition forms 146(i) and 146(ii), post-mortem examination reports, autopsy pathologists, histopathology and autopsy photographs. The study analyses the demographic data, pattern of injuries sustained, histopathological findings of the entry and exit points of electric current, and internal organs.

**Inclusion criteria:**
All autopsies with history of electrocution

All autopsies where cause of death was given as electrocution

**Exclusion criteria:**
All other thermal deaths including lightning deaths.

**Statistical analysis:**
Descriptive analysis was used.

## RESULTS

Seventy one cases of death by electrocution were identified. Sixty seven were male. The most common incidence was in the 21-30 year old age group (33 cases), followed by 11-20 year age group (12 cases). Thirty four electrocutions occurred in the work place, 21 outdoors and 16 cases within the home. Upper limbs were involved in 43 cases, lower limbs in 12 cases, trunk in 10 cases, and head in 8 cases, 1 of which included the cornea of eye. Entry marks were seen in 65 cases (multiple entry wounds were present in 6 cases) **(Table 1).** Both entry and exit marks were present in 18 cases. Flame burns were seen in 7 cases. Thirty seven cases were associated with mechanical injuries including abrasions, contusions, lacerations and incised wounds. There were no contact marks in 6 cases.

**Table 1:** Pattern of injuries

| Types of injuries | Number of cases | Percentage |
|---|---|---|
| **Entry Wound** | 65 | 91.5 |
| **Multiple entry wounds** | 06 | 8.45 |
| **Entry and Exit wounds** | 18 | 25.3 |
| **Flame burns** | 07 | 9.8 |
| **Mechanical injuries** | 37 | 52.1 |
| **No injuries** | 06 | 8.45 |

Samples were sent for histopathology in 55 cases. In 16 cases histopathological examination was considered not necessary by the pathologist.

The most common microscopic feature noticed in organs was congestion, which is a nonspecific finding. Myocardial infarction was seen in 03 cases, oedema of brain in 01 case and pneumonia in 01 case. Myocardial infarction and pneumonia were incidental findings in the cases.

Toxicological analysis was done in 04 cases of which 01 showed presence of ethanol.

Incidences were more common in summer, there being 41 cases observed in March to June, followed by 15 cases during each of the periods from July to October and from November to February.

The manner of death in 70 cases was accidental and in 01 case it was homicidal. No case of suicide was observed. The cause of death was given as electrocution in 50 cases followed by electric shock in 12 cases; respiratory failure was given in 03 cases. Cardiac arrest, myocardial infarction, syncope, cardiorespiratory failure, aspiration and injury were stated as the cause of death in 06 cases.

On microscopic examination 35 cases showed nuclear streaming, 21 cases showed dermo-epidermal separation, 10 cases showed coagulative necrosis and 03 showed micro-blisters. (**Fig. 1, 2, 3 & 4**) There was metallisation in 02 cases. Skin samples were normal in 03 cases. Nuclear streaming and dermo-epidermal separation were coexistent in 02 cases.

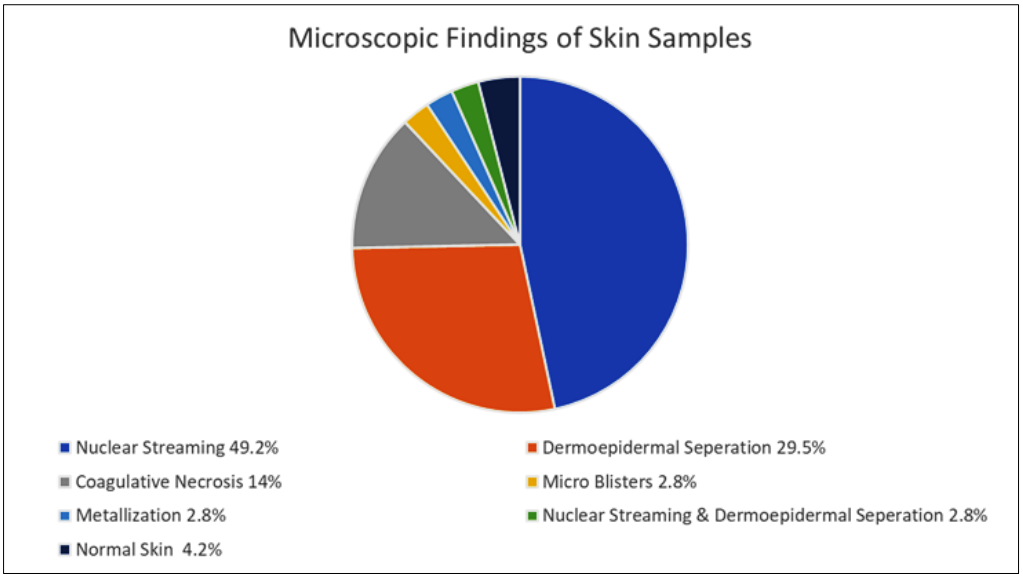


**Figure 1:** Microscopic findings of skin samples

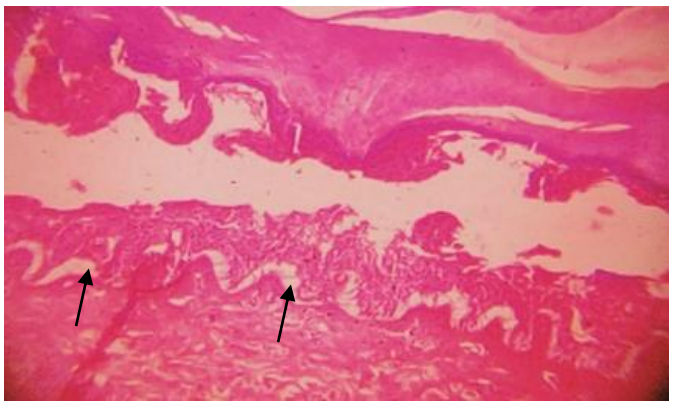

**Figure 2:** Microphotograph of intradermal blister formation (black arrows) (H&E x10)

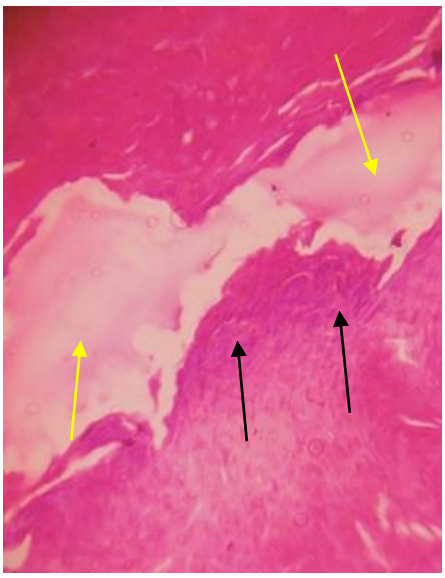

**Figure 3:** Microphotograph of nuclear streaming (black arrows) and coagulative necrosis (yellow arrows) (H&E x10)

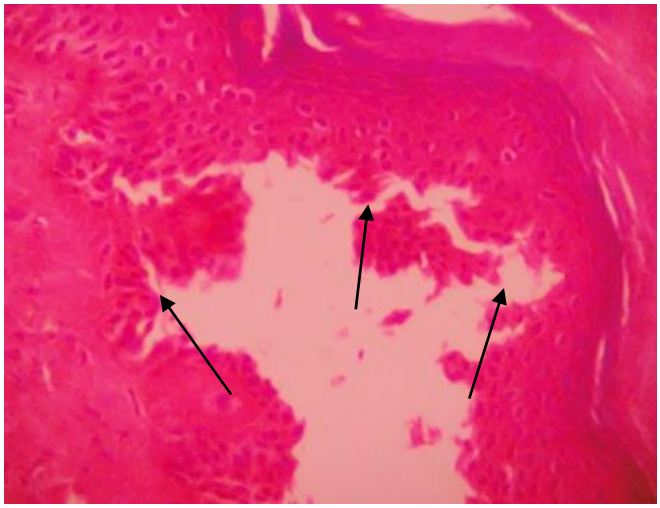

**Figure 4:** Microphotograph of micro blister formation (black arrow) (H&E x10)

## DISCUSSION

The study was done in eastern part of Bangalore for a period of 16 years. Electrocution accounted for about 1.74% of all autopsies done during the study period which corresponded to two studies done in Puducherry, India where it accounted for 1.18% and 0.9% of all autopsies[6,7]. However, it contrasts with a study done in Raichur, Karnataka, India where electrocution contributed to 2.78% of all cases[8].

The current study showed a male preponderance (93.8%) compared to female (6.2%) similar to other studies; maybe because males are involved in more outdoor activities like work in construction sites/factories/other occupations. The 21-30 year age group followed by the 10-20 year age group is commonly affected in the current study which is similar to studies done in Chennai, India and Manipur, India, as it is the productive age group that is more exposed to outdoor activities[9,10]. In the current study youngest case was a 3-year-old girl and oldest was a 75-year-old male.

In the current study, 49% of electrocutions occurred in the workplace, 22% in households and 29% outdoors. This is in contrast to a study done in Aligarh, India and Chennai, India, where electrocution was more common in the domestic situation than workplace and outdoor situations[9,11]. The study is similar to a study done in Raichur, India. The possible reasons as to why the incidences are higher in the workplace in this study is probably due to the fact that this study was done in the eastern part of Bangalore where a larger number of construction sites, industries and IT companies are located and use of electricity is considerably high[8].

In the current study 93% of cases had an entry mark, 25% had an exit mark, 25% had both entry and exit marks and 7% did not have any electric contact mark. The mark may be absent due to brief contact with the live wire or due to collapse of person due to ventricular fibrillation resulting in falling away from the wire. When there is prolonged contact, burns may be produced[12]. The contact mark may be present only in 57-83% of cases as its appearance depends on several factors such as current flow per unit time, voltage, and duration of exposure[2,13].

In the present study the entry mark was predominantly seen in upper extremities followed by lower extremities and trunk. This may be explained by the fact that the upper extremities are the most used part of the body for finer activities. The findings are similar to studies done in Tehran, Zagreb and Northern India where upper extremities were the common site. In Tehran no contact marks were seen in 5.4% of cases. In Zagreb, the skin was normal in 21% of cases. In Northern India contact mark was present only in 61% of cases which contrasts with the current study[14,15,16]. In general, resistance is high in the skin of back and low in forearm, palms, arm and scalp[17].

Knight states that typical features of Electric contact mark may not be present in all cases of electrocution even though the entry mark generally shows the shape and size of conductor. No mark on the skin may be seen if contact point is broad and if there is water which will considerably reduce the resistance[1].

This study showed different types of mechanical injuries like abrasions, contusions and lacerations. In one case, the cause of death was given as due to mechanical injuries sustained due to a fall following electric contact. It is similar to a study done in South Delhi where cause of death was given as polytrauma as a result of fall from height[19]. Gordon had explained that associated injuries from mechanical trauma are due to the deceased being flung violently due to contact with high tension electrical conductor[20].

On considering the manner of death, the current study showed 70 cases as accidental and 01 case as homicidal. No suicidal deaths were identified in this study. In a majority of cases, the manner of death was accidental. In the current study there was one homicidal death where the victim was restrained and later assaulted resulting in loss of consciousness. She was then chairbound and electrocuted using cables entwined around her hand and forefinger. A study done in Gujarat revealed that most of the cases were accidental in nature. However, a study done in Australia revealed that 29% were suicidal deaths. The reason maybe that the study was done in a developing country where other methods are preferred to commit suicide[21,22]. Forty one incidents in the current study were in the summer and 15 cases each in winter and rainy seasons. This is similar to a study done in Coimbatore, where incidences were more during summer probable due to greater use of electric appliances and due to increased sweating, (lowered resistance at point of contact). However, this study contrasts with a study done by Sachin Giri et al from central India where the incidence is greater in the rainy season followed by summer[23,24].

In the current study the cause of death in 50 cases was stated as electrocution. Mode of death was not

indicated in many of the cases. Modes identified were syncope and shock. Syncope was stated due to possible sudden stoppage of circulation, and "shock" here meant electric shock. A study done in Maryland states that deaths due to electrical energy are functional fatalities, which may happen as a result of cardiac arrhythmias / ventricular fibrillations, asphyxia or electrically induced respiratory muscle contractions. In the present study in 03 cases, the death was stated as respiratory failure probably due to involvement of intercostal muscles and diaphragm, as a result of passage of electric current through chest and abdomen. In twelve cases death was concluded as due to electric shock; in one case cause of death was given as due to injury due to a fall from height following electrocution. Cause of death was given as myocardial infarction, Aspiration, syncope, cardiorespiratory failure and cardiac arrest in the remaining 05 cases. Myocardial infarction could be an incidental finding, Aspiration could be a terminal event, and the path of electric current passage through the heart could have caused sudden stoppage of heart resulting in syncope, cardiac arrest and cardiorespiratory failure.

In the current study the cause of death in 50 cases was given as electrocution. Mode of death was not stated in many of the cases. A study done in Maryland states that deaths due to electrical energy are functional fatalities, which may occur as a result of cardiac arrhythmias / ventricular fibrillations, asphyxia or electrically induced respiratory muscle contractions. In the present study in 03 cases, death was given as respiratory failure probably due to involvement of intercostal muscles and diaphragm, as a result of passage of electric current through chest and abdomen. In 12 cases the conclusion was that death was due to electric shock; in one case the cause of death was given as due to injury caused by falling from a height following electrocution. The cause of death was given as myocardial infarction, aspiration, syncope, cardiorespiratory failure and cardiac arrest in the remaining 05 cases.

Damage to biological matter occurs due to the passage of electrons through tissues. Fatality and damage depends on the vital structure through which the electrons had passed. The myocardium is involved when electrons passes from hand and earthed to feet or opposite hand, the most dangerous being contact in the hand with exit through feet. Histopathology of internal organs is a matter of debate because the internal tissues are largely aqueous and contain conductive electrolytes. The organ and visceral damage are mainly functional and involving especially nervous tissue and muscles[18,26].

Congestion and petechial haemorrhages are important features noticed in visceral organs. Focal necrosis, haemorrhages, myocardial infarction and acute contraction bands in myocardium and conduction system are seen. In the current study the heart was normal in 07 cases, 03 cases showed congestion and 03 cases showed features of myocardial infarction. In a study done in Bangalore and by D'Errico S et al, pathological changes that were noticed in myocardium were disarray, haemorrhages, myocellular fragmentation and rupture of myocardial fibres[26,27]. The current study showed 10 cases of congestion of lungs and a case of pneumonia which could be an incidental finding; however the literature shows that damage to lungs is rare. The brain in the current study showed oedema in one case, it was normal in 02 cases and congested in 03 cases; the literature shows cerebral axonal injury is seen in cardiorespiratory arrest which was not noticed in the present study. As a long-term sequel cerebral vein thrombosis were noticed but in current study all the deaths were immediate[28,29].

In the current study the brain was sent in 06 cases for histopathological examination, 02 cases of which had normal gross and microscopy, 03 cases showed congestion and 01 case showed oedema of brain tissue. Gordon had described focal petechial haemorrhages in brain and spinal cord, chromatolysis in nerve cells, dilatation of perivascular space, fragmentation of axon and changes in myelin sheath. These changes could have been missed in current study due less advancement in the detection and due to usage of only Hematoxylin & Eosin staining techniques.[30]

In the current study skin samples of 55 cases were sent for histopathology examination. Routine Hematoxylin and Eosin staining was done. Nuclear streaming was seen in 35 cases, dermo-epidermal separation was noticed in 21 cases, coagulative necrosis in 10 cases, micro-blisters in 03 cases, homogenization and metallic particles were noticed in 02 cases each and samples were normal in 03 cases. The study is similar to a study done in Nagpur. Sachin Giri et al and Deepti Sukheeja et al, noted nuclear streaming, dermo-epidermal separation and coagulative necrosis as important histopathology findings, which helped them in solving cases where clear cause of death was doubtful[24,31,32,33]. Metallization was noticed in 02 cases in current study which was described by Tsokos as evidence of burns due to electrical current, which occur when tissue anions combine with the metal of an electrode to form metallic salts that is seen on surface of skin[2,34].

## CONCLUSION

This study provides the statistics in this part of Bangalore for researchers and law enforcement agencies. Electrocution deaths are rare; however, the morbidity and mortality with electric injury is rising. Arriving at cause of death is difficult by post-mortem examination alone in some cases. It may require methodical examination which includes scene visits and histopathological examination especially where electrical contact marks are not present. The study stresses the use of gross and microscopic findings in arriving at the cause of death. Some internal organ findings are also focused on. The study also concludes that the circumstances are accidental in a majority of cases and commonly occur in the summer. Skin changes consistent with electrocution were noticed in the majority of samples sent for microscopy.

## RECOMMENDATIONS

Use of protective equipment at the workplace, construction sites and precautionary measures for domestic utility of the electric current should be emphasised. Strategies should be implemented by law enforcement agencies at construction sites. Regular field visits and educating the workers at workplace would help in greatly reducing fatalities.

### CONFLICTS OF INTEREST

There are no conflicts of interest.

### ETHICAL ISSUES

None

### AUTHOR CONTRIBUTIONS

**SSS:** conceptualization, formal analysis, resource, writing original draft; **RKG:** writing review and editing

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