

Original Research Paper

Pattern of Injuries due to Electric Current

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Abstract

A one year study, from October 2007 to September 2008, was under taken in an attempt to study the pattern of electrical injury, the cause of death, manner of death, and diagnosis by histopathological examination. The study was compromised of 62 cases brought with history of electrical shock. Of the total 62 cases, males were 57(91.93%) and females were 5(8.06%) the mean age is 26 .27 year. The peak age of victims are 21-30 years age group 24 cases (38.71%).In the age group of 1n 0-10 years age group victims 3. Most of cases were due to low tension and domestic circuit. The patterns of electrical injuries are noted, such as entry, exit and both entry, exit wounds, flash burns and no electrical signs. The maximum victims showed dermo-epidermal degree of electrical burns .The histopathological examination is an important aid in diagnosis of electrical injuries and recommendations about preventive safety measures to reduce the mortality.

Key Words: Entry Wound, Exit and Pattern, Flash Burns, Electrocution

Introduction:

Electricity is an integral part of modern society, without electricity existence of human life seems difficult, but it has capacity to stand life and destroyed the life up to the death. The most fatalities caused due to electricity are accidental and result from passage of an electric current [both low & high voltage] through the body .Suicides and homicides from electrocution are very rare. They are always affected by alternate current and use of direct current is rare. In developing countries like India, lack of awareness, not operating as per standards and cheap alternates are available at low cost, those are most common causes of electrocution, that leads to penalty of lives, the electrical fatalities are increased.

Most of the times, the Forensic Pathologist is able to diagnose the electrical injuries with pathognomic marks present where as in absence of typical marks, he may face problems. In such conditions circumstantial and laboratory evidence are aids in diagnosis. This study was under taken in an attempt to study, the pattern of electrical injuries, the cause and manner of death. Histopathological examination offers an important aid in diagnosis of electrical injuries.

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Materials and Methods:

In present study a total of 62 Electrical injury cases were admitted in Mamata General Hospital, Khammam for a period of one year from October 2007 to September 2008. In this study the cases were evaluate difference to sex, voltage, contact details, body region distribution. Involved by domestic, industrial, about scene of incident, history given by victims and their relatives, typical and non-specific electrical injuries, flash burns, cause of death ,manner of death, extent of injuries, and confirmed by histopathological examination were recorded. Detailed postmortem examination was conducted on 5 bodies who succumbed out of the 62 cases. All findings are compiled in especially designed Proforma for study and data was collected and statistically analyzed and compared with previous literature.

Observations:

Out of the total 62 cases, males were 57(91.93%) and females were 5(8.06%). The age wise distribution of cases shows that in 21-30 years age group 24 cases (38.71%), with male preponderance of 22 (33.87%) and females 2(3.23%) followed by 31-40 years age group, only males victims 14 (22.58%). In the age group of 11-20 years only male victims are 13 (20.97%) and in 0-10 years age group female victims 2 (3.23%) and male victim only 1(1.61%). In the age group 51-70 years male victims 2 (3.23%) and female victim 1(1.61%).

The Low tension accidents were 42(67.74%) and high tension 20(32.26%) noted. The epidermal electrical burns are common

34(54.84%) followed by dermo-epidermal 12(19.35%) and deep 3(4.84%). The commonly associated injuries are lacerations followed by fractures and Abrasion next is head injury. Highest number of victims have received treatment within 1 hour 43(69.35%) followed by 1-2 hours 11(17.74%) and more than 2 hours 3(4.84%).

As per hospital stay most victims, were admitted within 3 days 40(64.51%), followed by 3-10 days 16(25.80%), and more than 10 days 1(1.61%). The results reveal that discharges were after treatment 40(64.52%), followed by referred cases 10(16.13%) and left against medical advice are 7(11.29%), lastly deaths were 5 (08.06%). In our study, most of the electrical injury cases were entry wounds 47 (75.80%), followed by exit wound 24(38.71%) and both entry and exit wounds 22 (35.48%), next was flash burns 16(25.80%).

In 13(20.96%) cases no signs of electrocution were observed. In our observation only entry wound were 25(40.32%) and both entry and exit wounds were 22(38.48%) cases. Majority of entry wound were involved in right hand 25(40.32%) followed by left hand 9(11.51%) and head and neck 5 (8.06%), next is thorax 4(6.45%); lastly right feet in 1(1.61%). In 3(4.84%) cases both hands are involved. The most common site of entry wound is hand. (Table No. 41). Only exit wound were 2(3.23%) and both entry and exit wounds 22(38.48%) were observed. Majority of exit wounds are involved in left feet 13 (20.96%), followed by right feet 6(9.68%) and left hand 4(6.45%), lastly left thigh 1(1.61%).

The commonest site of exit wound is feet. Our study shows in 16 (25.80%) cases were flash burns. Majority of flash burns are effected on face and neck 6(9.68%) followed by thorax 3(4.85%) and upper limbs 3(4.84%) next is abdomen 2(3.23%), lastly whole body in 2(3.23%) cases were 95-98% of T.B.S.

Our study revealed that in all death cases, there was internal viscera congestion and in one case diffuse petechial hemorrhage in brain white matter was noted.

Discussion:

The widespread commercial utilization of electrical power has been associated with a rapid increase of both fatal and nonfatal injury. In India, death occurs mostly at voltage between 220-240 volts alternative current however death due to lower voltage had also been reported. [2, 7, 14] The knowledge of incident of electrical injuries and underlying causes is of prime importance, the ultimate goal being their

prevention. In general the injuries caused by electrical force that reach the statistics are those that are fatal or that cause disability for some duration. Accounts of industrial accidents are usually accompanied by an investigation report and this provides useful information. On the other hand accidents occurring within the home are poorly documented or not reported at all. For the year oct-2007-sept-2008, even though they constitute a miniscule percentage 0.811% compared to wide spectrum of causative factors of medico-legal deaths. It is still on higher note and requires rapt attention as it is the field where all most all the fatalities are accidental in nature and mostly due to human error. There are different types of electrical injuries such as entry wound, exit wound, both entry and exit wounds and flash burns and no signs of electrical injuries. Of the total 62 cases, male were 57 and female were 5 including children. The percentage of male victims 57(91.93%) were more compared to female victims 5(8.06%) as mention in other studies. [4, 5, 10, 14, 15] The reason for such a marked male predominance in a variety of studies from different communities probably includes the fact that only males are involved in the electrical works.

The peak incidence was more in the age group of 21-30 years 24(38.71%) then other groups. The reason can be attributed to the fact the age at which one earns for lively hood, whereas at extreme ages the fatality was quite rare. These results are consistent with the work of others in age group 0-11 years (2.38%) and 9%. [7] Least number of cases 2(3.23%) in age group 51-60 and 1(1.61%) in 61-70 years age group. In children electrical accidents are due to playing near power lines, removal of entangled kite from live wires. [1] In extreme ages electrical accidents are quite rare.

Accidental electrocution among these would have occurred because of carelessness, ignorance, haste, malfunction of appliances or equipment such as ineffective insulation, lack of protective earthing, faulty grounding and short circuits. [7]

Out of 62 cases, 59(95.16%) were due to domestic supply of current and 3(4.84%) were industrial supply of current. Cases of electrocution are increasing year after year due to increased utility of electrical appliances without taking proper pre caution in the domestic front. The main factor is being the frequent power cut, low voltage for most of the time, year after year, consistent with others. [6]

Low-voltage victims are 42(62.74%) more than high-voltage victims 20(32.26%). [7] In death cases 5, out of this 4 cases due to high-

voltage and 1 case is low voltage current. [8, 9] The majority of electrical burns are epidermal 34(54.84%) as compared to dermo-epidermal burns (i.e. mixed degree of burns) 12(19.35%) and deep burns 3(4.84%). In 13(20.97%), no sign of electrical injury was found, results are similar with others. [7] In addition to electrical injuries, the common injuries were laceration (5) fracture (5) then abrasion (4), and head injuries (2) are associated with a fall due to the electric shock. [7-10] Majority of victims received treatment within one hour 43(69.35%), then between 1 to 2 hours 11(17.74%); more than 2 hours 3(4.84%) and brought dead 5(8.06%) cases. Similar findings made by. [6]

Majority of victims stayed in hospital less than 3 days 40(64.51%) as compared to 3-10 days 16(25.80%) and more than 10 days 1(1.61%) these findings are inconsistent with others. [15] Most of victims were discharged 40 (64.52%) whereas referred cases were 7(11.29%). These results are inconsistent with other studies. [15, 7] Out of total 62 accidental cases 5 cases were brought dead and all victims are males. In this study no suicidal and homicidal cases were recorded. [7-9]

The analysis of medical literature confirms the rarity of suicide or homicide by electrocution. [11, 13, 16] In this study the majority of the fatalities are the result of accidental contact with electricity normally domestic supply. Under estimation of the danger of live circuits carelessness play a part in work place incidents 30 (48.39%), where as ignorance, faulty domestic appliances, frayed or broken flex of electric cables, improper earthing accounts for many of the 16(25.80%) domestic accidents.

The production of electrical injury depends on voltage, amount of current flow, the area of the contact and duration of contact. [13] An electrical burn occurs only if the temperature of the skin is raised enough for a sufficiently long period to produce damage. On the other hand, a glancing contact or fall against conductor results in break in the circuit; in the cases of high-tension supplies the victim is usually repelled violently. [11, 16] The fatal injuries may be then due to fall. It was noted that contact injuries resulted in 49(79.32%) of cases. In 13 (20.96%) cases no electrical burn mark found. There was can be enough current to make it difficult for a person to remove himself from source of current.

From our study, it was noted that electrical injuries are only entry wound in 25 cases, only exit wound in (3.22%) and both entry and exit wounds in 35.48% cases. Flash burns

were found in 25.80% cases. In 20.98% cases no electric burn was found. These results are consistent with studies by others. [1, 5, 7, 15]

In present study the exit wounds were present in the feet, in majority of cases left foot 19.35% cases followed by right foot 9.67% cases and left leg 3.22% cases lastly left hand 3.22% cases. [7, 15] 16(25.80%) flash burns are seen, majority affected face and neck. In 2 cases (90-98%) T.B.S. area is involved; where as in flash burns T.B.S varied from 20-95%. [5, 7] In addition to electrical injuries, are Lacerations (5), fractures (5) are more common than abrasion (4) and head injuries (4). These are associated with electric shock due to fall from electric pole. These results are similar with others also. [7] 59(95.16%) cases were affected by domestic supply where as industrial 3(4.83%). These results are differing from those observed 67% [6] and 84% [2] and 62% [7] and 88%. [15] Low-voltage cases were 42(67.74%) more as compared to high-voltage 20(32.25%). [2-15] An arc produces considerably more burn than a contact that readily transmits the current and the greater the resistance offered by the individual tissue, the greater is the damage. [13] 57 victims were alive, whereas 5 persons dead on the spot.

It is well known that the electric current is particularly more dangerous when it use one of the circuits involving the heart muscle and in this study hands were involved in 37 cases. Electrocution deaths are uncommon and are usually due to ventricular fibrillation from a direct effect on the heart or respiratory paralysis from a direct effect on respiratory muscles, or in cardio-respiratory arrest following damage to autonomic centers within the brainstem. [1-15] Deaths may also be caused by burns and secondary trauma or subsequent multi organ failure. [9, 12] The effects of electricity depend on the voltage, type of current (direct or alternating) the area and duration of contact, skin resistance and path of current flow through tissues and organs [9] and the region of the body in contact with an electrical conductor. [15] Most electrocution is accidental and no suicides and homicides are seen in our study.

These studies are similar to other studies. [3, 5, 9, 10, 15] In 13 cases no electric burn was found. In some cases the victims in contact with water and iron box, three way plug, switch board. Unlike dry skin, wet skin does not offer resistance to the passage of electric current these producing no visible electric burn mark at the site of contact. [11, 13, 15] These findings are similar with others 6.97% and 6% [6] and 7%. [15] Three persons was found to have

consumed alcohol it is well known that consumption of alcohol and consequent intoxication had adverse effects, in form of motor incoordination, increased reaction time, and improper judgment. [13] Among 62 cases, 5 died, and postmortem examination was conducted. In all cases internal organs showed congestion and in one case had diffuse petechial hemorrhage in the brain. Similar studies are conducted by others 74% [10] and 72%. [5] The pathognomonic features of electrocution are the electric marks and joule burn when low or medium voltage current is involved. [11, 13, 15] Electrical marks are not always obvious especially are the hands of manual workers. Among 5 death cases, entry wound in 4 cases, exit wound in 2 cases and flash burn 2 cases noted. These findings are similar in studies conducted by others. [1, 5, 7, 15]

Proof of an electric mark is obtained by histopathological examination. In this context, we had found that histopathological examination could be an important aid in study, where the findings were suggestive of electrical injuries. Of these changes, the most common findings were nucleus streaming, dermo-epidermal junction separation and coagulation necrosis. Electrical injuries frequently represent high temperature burns and this produces characteristic finding of severe thermal denaturation of collagen causing it to stain blue with hematoxylin. The epidermis is often separated and elevated with micro blisters within the squamous epithelium as well as in the horny layer. Nuclei of epidermal cell at the site of an electrical burn frequently show stretching of and narrowing of the contour to produce a palisade type of appearance. This change is often referred as streaming of the nuclei. These findings are similar to studies carried by others. [7, 11, 13] From the present study we conclude that histopathological examination offers an important aid in diagnosis of electrical injuries.

Though fatalities caused by electricity are preventable, still deaths due to electrocution are on the rise. This study revealed that the commonest site of entry wound is palmar and crease fold of hands. The inference is that commonest site of exit wound is feet. This concludes that flash burns mostly affect face and neck. In 13 cases electrical burn marks were not observed, it suggests that the electrical marks not present in all cases. This concludes that the pattern of electrical injuries such as entry wound alone; exit alone, both and flash burns and no external typical signs. All cases were in accidental nature no suicidal and

homicidal cases were observed. This concludes that the manner of electrocution is accidental in nature. From the study conducted it is evident and important that electrocution deaths be through documented and investigated for safety prevention and compensatory reasons.

Summary:

Accidental electrical accidents are more common in both sexes in the age group of 21-30 years. Only 3 children sustained electrical injuries in our study. Electrical injuries are more common in male, rural population, laborers, in day time and at work place is commonest place for accidental. Domestic, low-voltage accidents were more common, and unskilled personnel affected more. Most of the accidents occurred during monsoon and maximum victims are treated within 1 hour. Among 62 cases, 49 cases had contact electrical injuries and in 13 cases no signs of electrical burn marks found, whereas in 16 cases flash burns are observed. Out of 25 cases only entry wound, in 2 cases only exit wound and both entry and exit wounds in 22 cases were observed. 47 entry wounds with both entry and exit wounds noted. Commonest site of entry wound is hand. Of 24 exit wounds with both entry and exit wounds were recorded. Commonest site of exit wound was feet. Of 16 cases of flash burns, majority were affected on face and neck. In 2 cases flash burns extended to 90-98% of TBS. Associated injuries are seen in 16 cases only, majority are lacerations and fractures. Of 5 cases succumbed death, out of 62 cases, postmortem examination was conducted. In all cases internal viscera showed congestion and in one case diffuse brain petechial hemorrhage was observed. High voltage current is the most common factor for fatal injuries.

Recommendations:

The following precautionary measures against electrocution are suggested: Proper precautions should always be taken while handling any electrical fittings or gadgets, water heaters, electric blankets. Constant vigilance in the observance of safety precautions and their extension as may be required is needed to maintain the high degree of safety and maintain standards in industry and the home. Education of the public especially in children in respect of potential dangers is a worthwhile investment. To limit the risk of fire and electrocution to the minimum in the house, the house holders should not only have the wiring of the house approved by the electricity board but also may connection be made only by a professional of repute.

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Table1: Pattern of Electrocution

| Pattern | Cases | % |
|---------------------------|-------|-------|
| Entry wound | 47 | 75.80 |
| Exit wound | 24 | 38.71 |
| Entry Wound alone | 25 | 40.32 |
| Exit Wound alone | 2 | 3.22 |
| Both entry & exit | 22 | 35.48 |
| Flash burns | 16 | 25.80 |
| No signs of electrocution | 13 | 20.96 |
| Total | 62 | 100 |

Table 2: Pattern of Entry Wound

| Pattern | Cases | % |
|---------------|-------|-------|
| Head and neck | 6 | 37.50 |
| Thorax | 3 | 18.76 |
| Abdomen | 2 | 12.50 |
| Upper limbs | 3 | 18.75 |
| Whole body | 2 | 12.50 |
| Total | 16 | 100 |

Table 3: Pattern of Exit Wound

| Pattern | Cases | % |
|------------|-------|-------|
| Left foot | 13 | 54.16 |
| Right foot | 6 | 25.00 |
| Left hand | 4 | 16.67 |
| Left thigh | 1 | 4.16 |
| Total | 24 | 100 |

Table 4: Pattern of Flash Burns

| Pattern | Cases | % |
|---------------|-------|-------|
| Right hand | 25 | 53.19 |
| Left hand | 9 | 19.14 |
| Both hands | 3 | 6.38 |
| Head and neck | 5 | 10.63 |
| Right foot | 1 | 2.12 |
| Total | 47 | 100 |

Figure1: Entry Wound



Figure 2: Exit Wound



Figure3: Flash Burn



Figure 4: Contact Mark

