



ORIGINAL RESEARCH PAPER

Forensic Medicine

A PROSPECTIVE STUDY ON PROFILE AND PATTERN OF ELECTRIC INJURIES CASES BROUGHT IN RNT MEDICAL COLLEGE, UDAIPUR

KEY WORDS: electric, season, work place, negligence

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ABSTRACT

It is well known fact that electricity is essential to everyday life, both home and on the job. Perhaps it has become such a familiar part of daily life , most people don't give much thought to it or how much our work depends on a reliable source of electricity. More importantly , people tend to overlook the hazards that electricity poses and fail to treat it with the respect it deserves.

A prospective study on profile of electric injuries cases was conducted at RNT Medical college Udaipur, Rajasthan from July 2019 to November 2020 to know about the incidence and pattern of electric injuries cases , also to study the manner of events, seasonal variation, population at high risk to be victims of electric injury and to provide recommendation for developing useful safety programs to decrease the incidence. Out of the total 100 cases, 86 were male and 14 were female. 83 cases were of 11 year to 50 year age group. 68 cases occurred at work place , out of which 62 were male and 6 were female and 32 cases occurred at home. 40 cases occurred in rainy season and 39 cases occurred in winter season and 21 cases occurred in summer. This study emphasizes on better implementation of electrical injuries control program in communities and increase the awareness of people and also on use of safety equipments and protective measures. As our study suggests that most of the electric injuries cases were preventable.

INTRODUCTION:

Electricity is such an integral part of life, that it's hard to imagine life without it. The uses of electricity put to the service of man have no limitations.¹ Power is the basic need for the economic development of the country. Availability of electricity has been the most powerful aspect of introducing economic development and social change throughout the world. The process of moderation, increase the productivity in industry and agriculture and the improvement in the standard of living basically depend on the adequate supply of electrical energy.²

Electrical injury is a physiological reaction caused by electric current passing through the body.³ The injury depends on the density of the current, tissue resistance and duration of contact.⁴

The annual number of electrical injuries and deaths from electric shock have steadily increased as a result of the widespread use of electricity and the application of electrically powered machinery. Although electricity is a relatively recent invention, humans have always been exposed to the devastating electrical power of lightning and understandably attributed it to supernatural powers.

Electrical injuries are the third most common cause of burns after scald and flame burns. In spite of advances in treatment modalities and the resulting decrease in mortality rates, electrical burns may lead to socioeconomic burden, as well as significant functional and cosmetic problems.⁵

As per the National Crime Records Bureau's Accidental deaths & Suicides in India 2019 report , total accidental deaths due to forces of nature in India in 2019 were 8145 , out of which Lightning's death were 2876 (35.3 percent). Out of 2876 lightning's deaths , 2106 were male and 772 were female. Total accidental deaths due to other causes were 412959 , out of which Electrocutation death were 13432 (3.3 percent). Out of 13432 deaths , 11412 were male and 2020 were female.

Compared to 2018 report , total accidental deaths due to forces of nature in India in 2018 were 6891 , out of which Lightning's death were 2357 (34.2 percent) and total accidental deaths due to other causes were 404933 , out of which Electrocutation death were 12154 (3.0 percent).⁶

MATERIALS AND METHODS

This prospective study on profile of electric injuries cases, during the period of July 2019 to November 2020, was conducted in the Department of Forensic Medicine and Toxicology, RNT Medical College Udaipur. All electric injuries cases admitted in R.N.T. Medical College and MB Government hospital , Udaipur and brought dead to mortuary for postmortem examination on police requisition were included. A total of 100 cases were studied.

Detailed history of cases obtained from the patient's close relatives , friend , patient himself , police and other available persons.

General information : name , age , sex , address , religion , education , socioeconomic status and occupation status etc , date and time of incidence , manner of events , detailed history taken to elicit the circumstances, cause related factors and any motive behind the event. Careful history taken to know whether there was any disease present or not.

Date and time of death, date and time of police information , period of hospitalization , date and time of police inquest and details of autopsy examination recorded.

At the time of post mortem, the gross features of electric burn injury during external and internal examination was noted.

All findings compiled , statistically analysed and compared with previous literature.

Data also collected from hospital records , deceased relatives, and investigating officer.

In this prospective study subjects were included of all age groups , both sex , incidents occurring at home or work places.

EXCLUSION CRITERIA:

It included the cases where electrocution was indirect cause of death. For example a person after getting electrocuted, fallen from height and died due to head injuries. Also all decomposed dead bodies or that having inadequate history also excluded.

RESULTS:

Out of the total 100 cases, 86 percent victims were male and the remaining were female 14 percent. The age of the victims was spread over the range of 1 year to 70 years, though most of them fell in the age group of 11-50 years. Out of the total 83 cases of 11 to 50 years age groups, 75 victims were male and 8 were female. 40 percent of the cases occurred in rainy season (July to Sept), 39 percent of cases occurred in winter season (Oct to March) and 21 percent cases occurred in summer (April to June)

65 Percent of the cases occurred due to human negligence, 16 percent occurred due to faulty equipments and connections and 19 percent cases occurred due to lack of protective measures. Out of the 68 cases occurring at work place, 62 cases were of male and 6 cases were of female. And out of the 32 cases occurring at home, 24 cases were of male and 8 cases were of female. 89 percent of the total cases occurred at dry surroundings and 11 percent of the cases occurred at wet surroundings. All of the 100 percent cases were accidental in nature and no cases found to be suicidal or homicidal in nature. Out of the total cases 13 percent cases occurred in persons, who were professionally trained in electricity handling and 87 percent cases occurred in persons who were not professionally trained. Out of the total cases, 7 percent cases were brought dead in hospital, 92 percent cases were admitted alive and discharged and 1 percent cases died after admission and during the treatment. 57 percent of cases were educated upto 1st to 10th class, 34 percent of cases were uneducated and 9 percent cases were educated upto 11th class and above. Out of the total cases, 36 percent cases occurred due to high voltage, 60 percent cases occurred due to low voltage and 4 percent cases occurred due to lightning.

DISCUSSION:

In our present study, out of the total 100 cases, males were 86 (86 percent) and females were 14 (14%). Similar result found in study of Guntheti B K et al (2012)⁷ in which 62 electric injury cases who were admitted in Mamata General Hospital, Khammam were studied for a period of one year from October 2007 to September 2008. Out of the total 62 cases, males were 91.93% and females were 8.06%.

The age wise distribution of cases shows that in 21- 30 years age group 30 cases (30%), which were only male victims, followed by 31-40 years age group, only male victims 20 (20%). In the age group of 11-20 years, male victims were 13 (13%) and female victims were 8(8%) in 0-10 years age group male victims 3 (3%) and female victim only 2(2%). In the age group 51-60 years male victims were 5 (5%) and female victims were 4(4%). In the studies conducted by Chandru K², Guntheti B K et al⁷, Hyldgaard L et al⁸, Shrigiriwar M et al⁹, Koumbourlis A C et al¹⁰, Tedechi C G et al¹¹ and Wright R K et al¹² similar results were received. The result for such marked male predominance in a variety of studies from different communities probably includes the fact that only males are involved in electrical works.

The peak incidence were more in the age group of 21-30 years that was 30(30%) 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.

Least number of cases 5(5%) in age group 1-10 and 3(3%) in 61-70 years age group. In children electrical accidents are due to playing near power lines, removal of entangled kite from live wires. Similarly in study of Byard W et al¹³ children's were electrocuted accidentally while playing with or near faulty electrical equipment at home or at school, electrical equipment while in the bath, damaged outdoor electrical equipment and due to overhead wires. In study of Tiransci Y et al¹⁴, unique finding was younger age victims of 0 to 10 year age group were 31.7% (39 cases), most electrocution accidents occurred by electric water heaters in bathroom.

In extreme ages electrical accidents are quite rare. Only 3% cases found in 61yr to 70 yr age group and no cases were found of above 70 years. Accidental electrocution among these occurred because of carelessness and malfunction of appliances. Similarly in study of Mellen P F et al¹⁵ as Electrocutation: a review of 155 cases with emphasis on human factors found that in extreme ages electrical accidents are less common and occurred due to carelessness, ignorance, haste, malfunction of appliances or equipment such as ineffective insulation, lack of protective earthing, faulty grounding and short circuits.

Cases of electrocution are increasing year after year due to increased utility of electrical appliances without taking proper precaution 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 data of national crime records bureau, accidental deaths and suicides in india 2019.⁶

In our study low-voltage victims were 60(60%) more than high-voltage victims 36(36%) and 4 (4%) cases were of lightning. As per Guntheti B K et al¹⁸ low tension accidents were 67.74% and high tension accidents were 32.26%, almost similar to our result. Massey B K et al¹⁸ studied retrospective review of records of all the autopsied individual who died from electrocution, 70.1% cases were due to high voltage and 29.9% were due to low voltage.

In our study all 100 cases were accidental in nature, no suicidal or homicidal cases were recorded. Similar results were found in study of Mellen P F et al¹⁵, Karger B et al¹⁷, Knights B et al¹⁸ and Tiransci Y et al¹⁴. In all this mentioned studies all cases of electric injuries were accidental in nature. In contrast in study of Kuitie et al¹⁹ conducted at department of forensic medicine and criminology, Zagreb, Croatia, out of total 89 electrocution cases, 83% cases were accidental, 14% cases were suicides and 3% cases were homicidal in nature.

In our study maximum number of electric injuries cases (40%) occurred in rainy season, where as 39 % cases occurred in winter season and 21 % cases occurred in summer season. In the study conducted by Giri S et al²⁰, out of the total 88 cases rainy season comprised of 38.6% cases, followed by summer season 34.09% and 27.2% cases occurred in winter season. Similarly in study of Kumar S et al²¹ which was done at Dr. S.N. Medical College, Jodhpur on fatal electrocution cases undergoing medical autopsy in the department of forensic medicine, out of the total 100 cases, 44% occurred in summer, 38% in rainy season and 22% cases occurred in winter season.

In our study 89 % cases occurred in dry surrounding and 11 % cases occurred in wet surroundings. In contrast in the study of Khan M K et al²² at AMU, Aligarh out of the total 62 cases, 30.65% cases occurred in hot surroundings and 69.35% cases occurred in wet surroundings. Similarly in study of Gupta B D et al¹ at Jamnagar, Gujrat out of the total 102 cases, in 66.76% cases the surrounding area at the site of incident was found damp or wet, while it was dry in 33.33% cases. These results were different from our study.

Tiransci et al¹⁴ and Dokov W et al²³ reported wet cases of electrocution using bathtubs, heaters and hair dryers. We did not find any such case and there was no such case reported by other workers from India such as study by Rautji R et al²⁷ and study by Shrigiriwar M²⁴. This difference can be explained on the basis of the fact that the prevalence of bathtubs and hair dryers is almost negligible in India. In this study the majority of the fatalities were the result of accidental contact with electricity normally domestic supply. Underestimation of the danger of live circuits, carelessness (negligence) played a part in 65% of electric injury incidents, where as lack of protective measures was a cause in 19% cases and faulty domestic appliances, frayed or broken flex of electric cables,

improper earthing accounts for 16% electric accidents.

In our study electric injuries cases at work place were 68 % and electric injuries cases at home were 32%. Similar to our study Vishwakanth B et al²⁵ prospectively studied electrocution cases at Kampegowda institute of medical sciences, Bangalore for a period of one year from November 2012 to November 2013 and found 66.66% cases at work place and 33.33% cases at home.

Similarly Massey B K et al¹⁸ in his retrospective study found that 63.7% cases occurred at workplace and 36.3% cases occurred at home and outdoor location.

In contrast in the study of Giri S et al²⁰ in which , 22.7% cases occurred at workplace, 47.7 % cases occurred at home and 29.5% cases occurred on places other than work place or home. And as per study of Farooq U et al²⁸ , 40.63% cases occurred at home, 37.50% at workplace and 21.87% cases occurred at places other than work place.

The production of electrical injury depends on voltage, amount of current follow, the area of the contact and duration of contact. 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.

From our study, it was noted that electrical injuries are only entry wound in 39% cases, only exit wound in 5% and both entry and exit wounds in 38% cases. This can be explained by the fact that the point of exit of the current corresponds with the point where the body was earthed, which is a relatively wide area in most cases. Thus the resistance per unit area is small and the heating effects ($GC=C2R/4.187$, where GC is the heat in gram calories per second, C is the current in amperes and R is the resistance in ohms.) is proportionately diminished. So there may or may not be a demonstrable skin lesion. Flash burns were found in 27% cases. In 18% cases no electric burn was found. These results are similar with studies by Shrigiriwar M et al²⁴, Wright R K et al¹², Byard RW et al¹³ and Mellen P F et al.¹⁵

In contrast to this results, Guntheti B K et al⁷ found entry wounds in 75.80% cases, 38.71% cases had exit wounds and in 35.48% cases both entry and exit wounds were present.

Chandru K.² found entry wound in 44% cases, and in 11% cases contact marks with flash burns were present. In 8% cases there was no entry wound or flash burn was present.

Surprisingly in study by Rautji R et al²⁷ done in South Delhi during the period 1996 to 2001, 153 electrocution cases were seen , in which 86.27% cases were present with electric entry wound and 13.73% cases had both entry and exit wound but in their study there was not a single case of electrocution without any mark.

It is well known that the electric current is particularly more dangerous when it uses one of the circuits involving the heart muscle. 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 cardiorespiratory arrest following damage to autonomic centers within the brainstem.^{2,7,8,29}

Deaths may also be caused by burns and secondary trauma or subsequent multi organ failure.^{18,27} 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 organs¹⁸ and the region of the body in contact with an electrical conductor.¹²

In 18% cases no electric burn was found in our study. 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.^{12,29,30}

Among 100 cases, 8 died, and post mortem examination was conducted. In all cases internal organs showed congestion. The pathognomonic features of electrocution are the electric marks and joule burn when low or medium voltage current is involved. These finding were similar in studies conducted by Shrigiriwar M et al²⁴, Polson D J et al²⁸ and Wick R.³⁰

In our study out of the total 100 cases, 7 cases were brought dead in our institution and 1 case died after admission and treatment. 92 cases were admitted alive. Out of the 7 brought dead cases, 6 were male and 1 case was of a female.

In the present study, electrocution deaths accounted for 8 percent of total electric injuries victims, while Rautji R et al²⁷ reported the figure of 1.98 per cent and Tirasci et al¹⁴ reported 3.3%. In terms of deaths due to electrocution per one lakhs population the figure turns out to be 4.4. This is significantly higher when compared to studies done by Dokov et al in Bulgaria²³ and Laupland et al²⁸ in Canada who reported the figures of 0.94 and 0.14 respectively.

Electrical marks are not always obvious especially in the hands of manual workers. Among 8 death cases, entry wound in 7 cases, exit wound in 7 cases and flash burn noted in 4 cases. These findings are similar in studies conducted by Shrigiriwar M et al²⁴, Wright R K et al¹², Byard RW et al¹³ and Mellen P F et al.¹⁵

Majority of victims received treatment within one to two hour 71(71%), then between 2 to 3 hours 17(17%); more than 3 hours ,5 cases (5%) and brought dead 7(7%) cases. These findings was different than study by Martinez J A et al³¹ in which majority of patient received treatment within one hour. Because Udaipur region is a hilly zone, it took some extra time to reach hospital . Being a tertiary hospital , most of the cases (80%) were referred from nearby hospitals.

Majority of victims stayed in hospital less than 3days 66(66%) as compared to 3- 10days 23(23%) and more than 10 days 4(4%) these findings are consistent with study by Guntheti B K et al⁷ in which 64.52% cases were discharged from hospital within 3 days, followed by 3 to 10 days 25.80% cases and 1.61% cases stayed in hospital for more than 10 days.

As per our study , education has a important role in electric injury cases as 34% cases occurred in uneducated victims and 57 % of victims were educated between 1st to 10th class. Only 9% cases occurred in victims who were educated from above 10th class.

In our study 87 % cases were professionally untrained in electricity handling and 13 % cases were trained in professionally trained in electricity handling. And all the 13% cases were male , this again shows male dominance in electric work similar to other studies. . Employees of electrical work were negligent because they were not using the protective measures while working, which were provided them in the form of protective gloves, harness, belts, etc. Similarly in study by Vishwakanth B et al²⁵, 16.66% cases were of electricians.

CONCLUSIONS

All of the cases of death were accidental. It is in similar to other studies as well.^{2,7,27} Males were the predominant victims. In our study 86 % of the cases were of male and 14% were of female. In our study in the rainy season, 40 % cases occurred, 39 % cases occurred in winter season and 21 % cases occurred in summer. Most of the deaths were either instantaneous or immediate. Out of the total 8 death cases in our study, 7 cases were brought dead and 1 case was admitted

alive and was died during treatment. Rate of fatality is significantly higher in India as compared to Bulgaria²³ and Canada²⁸ other parts of world. We did not find any cases of deaths involving bathtubs, heaters and hair dryers. More than 68 percent deaths occurred in work place surroundings and 32 percent cases occurred at domestic surroundings. It signifies that people did not have elementary knowledge of risks of electrocution. Most of the deaths were preventable.

Following suggestions may be helpful in preventing electrical accidents:

Ensure electrical appliances at home and workplaces are in proper working condition with effective non-leaking connections. All electrical wiring should have proper insulation. All electrical installations should be effectively earthed as per standard earthing practice. Houses or extension of houses should not be built underneath, overhead lines or in proximity of the lines. Balconies or windows of house should not be facing bare power lines. Power lines in such cases should be properly insulated. Tying of wire to electric pole for drying cloths should not be allowed. Underground cables within the house should not be laid. Overloading of switches should not be done. Open heating immersion coils should not be used. Electrical equipments and switches should not be used with wet hands. Crisscrossing of television wire with live wire should not be done. Electric employee should be given proper education regarding electrocution. Protective thick rubber gloves should be provided to workers. Harness should be provided to the electrical employee working at height. Helmets should also be provided. All electrical establishments should have Miniature Circuit Breakers (MCB) to limit the load. Installation of Residential Current Circuit Breaker (RCCB) to avoid fatal shocks.

Table 1 Distribution Of Sex

S.NO.	SEX	NO. OF CASES	PERCENTAGE
1	MALE	86	86%
2	FEMALE	14	14%
	TOTAL	100	

Table 2 Distribution Of Age In Electric Injuries Cases

S.NO.	AGE GROUP	NO. OF CASES	PERCENTAGE
1	1 TO 10	5	5%
2	11 TO 20	21	21%
3	21 TO 30	30	30%
4	31 TO 40	20	20%
5	41 TO 50	12	12%
6	51 TO 60	9	9%
7	61 TO 70	3	3%
8	71 TO 80	-	-
9	81 TO 90	-	-
10	91 TO 100	-	-
	TOTAL	100	

Table 3 Seasonal Variation In Electric Injuries Cases

SL. NO.	SEASON	NO OF CASES	PERCENTAGE
1	SUMMER (APR TO JUNE)	21	21%
2	RAINY (JULY TO SEP)	40	40%
3	WINTER (OCT TO MAR)	39	39%
	TOTAL	100	

Table 4 Distribution Table Indicating Cause Of Electric Injuries

SL.NO.	CAUSE OF ELECTRIC INJURIES	NO. OF CASES	PERCENTAGE
1	HUMAN NEGLIGENCE	65	65%
2	FAULTY EQUIPMENTS AND CONNECTIONS	16	16%
3	LACK OF PROTECTIVE MEASURES	19	19%
	TOTAL	100	

Table 5 Sex Distribution Of Electric Injuries Cases In Work Place And Home

SL.NO.	PLACE	FEMALE	MALE
1	WORK PLACE	6	62
2	HOME	8	24
	TOTAL	14	86

Table 6 Pattern Of Electric Injury Cases

SL.NO.	PATTERN	NUMBER	PERCENTAGE
1	ONLY ENTRY WOUND	39	39%
2	ONLY EXIT WOUND	5	5%
3	BOTH ENTRY AND EXIT WOUND	38	38%
4	FLASH BURN	27	27%
5	NO ELECTRIC INJURY MARK	18	18%
	TOTAL	100	

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