ORIGINAL RESEARCH

ADLİ TIP DERGİSİ
TURKISH JOURNAL OF FORENSIC MEDICINE

Received: 05.12.2024
Accepted: 24.04.2025

Evaluation of the Cases of Mortality Related with Electric Current

Elektrik Akımına Bağlı Ölümlü Vakaların Değerlendirilmesi

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Öz

Amaç: Elektrik çarpması, elektrik kaynağı ile temas sonrası kişide yaralanma veya ölüm meydana gelmesi olarak tanımlanmaktadır. Kaza, intihar oranlarının son yıllarda artmasıyla birlikte daha az olarak da cinayet görülmektedir.

Yöntem: Çalışmamızda 2010-2014 yılları arasında elektrik akımı ile ölüm arasında illiyet kurulan 209 olguya ait adli dosya retrospektif olarak irdelenmiştir.

Bulgular: Olgular demografik özellikleri, olayın orijini, aylara göre dağılımları, olay yerleri, otopsi bulguları, hastane yatışı olup olmadığı, kazanın niteliği, olay yeri incelemesi yapılıp yapılmadığı, teknik bilirkişi çağırılıp olay yerinde şüpheli cihazlar hakkında inceleme yapılıp yapılmadığı değerlendirilmiştir.

Sonuç: Tüm adli nitelikteki ölüm olgularında ölüm sebebinin araştırılması olay yerinden başlamaktadır. Elektrik akımına bağlı ölüm olgularında makroskopik ve mikroskobik bir bulgu olmadığı zaman detaylı bir olay yeri incelemesi ile ölüm sebebi ve orijini açıklanabilmektedir.

Anahtar Kelimeler: Otopsi, Yaralanma, Elektirik Akımı, Olay Yeri

Abstract

Objective: Electric shock is defined as occurence of injury or fatality following contact with electric welding.

Methods: In our study, the forensic files of 209 subjects for whom a causal link was found between electric current and mortality between 2010 and 2014 were examined retrospectively.

Results: The subjects were evaluated in terms of demographic properties, the origin of the event, distributions by months, locations of the event, autopsy findings, presence of hospitalization, type of accident, if crime scene investigation was performed or not and if investigation was performed about suspicious devices in the scene of crime by a technical legal expert.

Conclusion: Investigation of the cause of death is initiated in the crime scene in all forensic cases of mortality. In cases of mortality related with electric current, the cause and origin of death can be explained by way of a detailed crime scene investigation when macroscopic and microscopic findings are absent.

Keywords: Electric Injury, Autopsy, Crime Scene, Electric Current

How to Cite: Erdem Z, Üzün İ. Evaluation of the Cases of Mortality Related with Electric Current. J For Med 2025;39(1):63-69. https://doi.org/10.61970/adlitip.1597031

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INTRODUCTION

Electric shock is defined as occurence of injury or fatality following contact with electric welding (1). Many factors including voltage of the current, type of the current, the line through which the current is trasferred and the time period during which the subject is exposed to electric current are important in occurence of injury or mortality (1-3). According to the Ohm rule, voltage is defined as product of current and resistance (V=IxR) (4). Low voltage electric current injuries increase exposure to current by leading to tetanic contractions and the frequency of cardiac injury increases. Although exposure to high voltage electric current lasts for a short time, it may lead to severe tissue destruction and secondary injuries (5,6).

Since the most commonly used voltage range in houses and industry is 110-380 V, mortality is most frequently observed in this range of voltage. Mortality below 110 V is rarely observed (7,8). Macroscopic findings are not always present in cases of exposure to electric current. Lesions may not form when skin resistance is reduced due to wetting during bathing or when the contact area is large. Lesions may also be overlooked if the current passes through the anus, genital region or mouth (especially in children) (2,9).

The most common cause of mortality related to electric current is cardiac arrythmia, with ventricular fibrilation being the most common type. The second most common cause of mortality is respiratory arrest, associated with spasm or paralysis of the intercostal muscles and diaphragm (2).

MATERIAL AND METHOD

The forensic files of 209 subjects for whom an opinion was reported for the definite cause of death by the Council of Forensic Medicine, Forensic Medicine 1st Specialization Board and a causal link was ultimately found between electric current and mortality between 2010 and 2014 were examined retrospectively. The subjects for whose files were examined and for whom a causal link was established by board's decision were evaluated based on demographic characteristics, the origin of the incident, monthly distributions, event locations, autopsy findings, hospitalization status, type of accident, whather a crime scene investigation was conducted, and whather a technical legal expert investigated suspicious devices at the crime scene.

RESULTS

In our study, 180 (86.1%) of the subjects who died in relation with electric current between 2010 and 2014 were male and 29 (13.9%) were female. The age of the subjects ranged from 9 months to 81 years, with a mean age of 28.2±17.01 years.

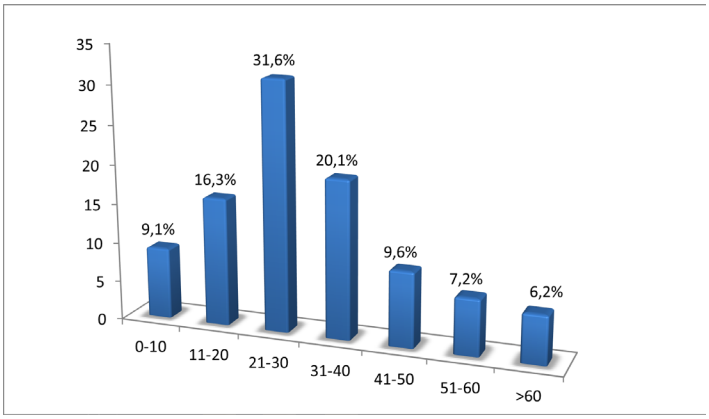

Figure 1. *Distribution of cases according to age range*

When the age distribution of the subjects was examined, 31.6% were found to be in the 21-30 age range. A total of 43 subjects (20.6%) were aged 18 years or younger, of whom 95.3% were male and 4.7% were female (Figure1).

Nearly half of the deaths related to electric current (n= 101, 48.3%) occurred during the summer months.

In contrast, 41 cases (19.6%) occurred in autumn, 39 cases (18.7%) occurred in spring and 28 cases (13.4%) in winter (Figure2).

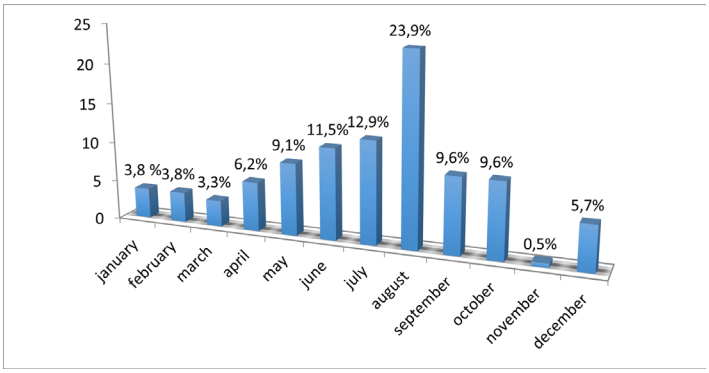

Figure 2. *Distribution of cases by months.*

When the locations where the event occurred were examined, 65 cases (31.3%) occurred in home environments, 68 cases (32.5%) in workplace environments, 33 cases (15.8%) in open areas, 23 cases (11.0%) in environments where electricity and water are coexisted (such as ornamental pools and brooks), and 20 cases (9.6%) at transmission towers or transformers.

In one case, sufficient information about the origin of the incident could not be obtained from the judicial investigation file. Two cases were identified as suicides, while the remaining cases were caused by accidents. Among the accidents 102 cases (48.8%) were occupational, and 50 cases (23.9%) occurred at home. Cases that were neither occupational nor indoor, such as children to exposed to electric current while playing near transmission towers of coming into contact with live wires outdoors, were categorized under the subtitle "other accidents". This group comprised 55 cases (26.3%). Mortality following occupational accidents was found to be statistically significant among men, whereas mortality following home accidents was statistically significant in women ($p<0.01$).

In 121 crime scenes (62.2%) involving deaths caused by electric current, wet or humid conditions that could reduce skin resistance were identified. Thirty-eight (18.2%) crime scenes were found to be dry, while sufficient information could not be obtained for 41 (19.6%) crime scenes. An entrance lesion associated with electric current was absent in 111 (53.1%) cases and present in 75 (35.9%) cases. An atypical entrance lesion was observed in 23 (11%) cases. The absence of entrance lesion was found to be statistically significantly more common in cases where the crime scene was wet or damp.

Exposure to electric current was witnessed in 139 cases (66.5%), while no witness was present in 70 cases (33.5%). Expert examination of suspicious devices revealed that 45% of the devices exhibited electric leakage.

On physical examination, traumatic lesions leading to mortality were observed in 9 cases (4.3%), while artifacts related with resuscitation were identified in 3 (1.4%) cases. Twenty-six subjects (12.4%) who survived the initial accident, either at the crime scene or in the hospital, were hospitalized for varying time periods ranging from 1 day to 8 months. In contrast, 183 subjects (87.6%) were not hospitalized.

Autopsy was not performed in 6.2 % of the cases. In 72 cases (36.73%) no significant autopsy findings were detected. Petechial hemorrhages that we detected by examining autopsy photographs were observed in various areas, including the heart, lungs or beneath the scalp in 96 cases (48.9%). Trauma related signs in addition to electric current were identified as the cause of death in 9 cases (4.5%). Toxicologic analysis of tissues and body fluids revealed 4.26 ng JWH and 1.42 ng of active ingredient of cannabis in one (0.47%) case. Ethanol concentrations ranging between 6mg/dL and 233 mg/dL were detected in 5 (2.3%) cases.

Analysis of the cases in terms of histopathologic examination revealed that tissue samples could not be obtained in 13 cases (6.2%) due to the absence of an autopsy. Despite autopsies being performed, skin samples were not obtained in 94 cases (45%). Among the cases where skin samples were available, 47 cases (22.5%) showed findings compatible with eletric-heat effects, while no electric-heat effects were identified in 51 cases (24.4%) . In 4 cases (1.9%), differentiation between electric-heat effects and traumatic findings, such as abrasions, could not be made.

DISCUSSION

The proportion of electric energy in total energy consumption has been increasing rapidly due to advancements in technology and industry, as well as the convenience provided by an extensive transmission and distribution network that reaches even the smallest settlements (2). With this rise in electric energy usage, the occurrence of injuries related to electric shock has become inevitable. Crime scene investigation, eyewitness reports, technical expert evaluations, and autopsy findings should be assessed comprehensively for a definitive diagnosis.

In our study, a higher rate of male subjects was observed, consistent with findings in the literature (10-11). This higher prevalence among males is likely due to their greater involvement in occupations related to electric energy. The highest number of subjects were in the young adulthood (21-30 years) and middle-age (31-40 years) groups, in alignment with previous studies (12-13). Based on these data, it was concluded that individuals in these age groups, being at the beginning of their productive work life, participated in the workforce at a higher rate, and their relative lack of experience increased the frequency of such cases.

A study by Rautji et al. reported that fatal electric current-related accidents occurred most frequently in the summer, with a rate of 62.7%. Similarly, a study by Tıraşcı et al. involving 123 cases found that accidents most frequently occurred in summer, with a rate of 38.2%. Taylor et al. also reported the highest frequency of such accidents in summer (13-15). In our study, incidents peaked in August (23.9%) and July (12.9%). This rise may be attributed to increased activity in workplaces and social environments, along with a surge in construction projects during the warmer months. Additionally, increased humidity, sweating, and frequent contact with water reduce skin resistance, making the body more vulnerable to electric currents.

In our study, accidental deaths were found at a high rate (98.6%), consistent with other studies (14, 16, 17). Suicide cases were rare, and no homicide cases were observed. Based on our findings, accidental origins should be the primary consideration in cases of mortality related to electric current. However, the possibility of suicide or homicide, though rare, should also be considered.

Work-related accidents accounted for 48.8% of cases, while home accidents comprised 23.9%. Unlike previous literature, our study found a higher rate of work-related accidents (10, 14, 18, 19). It was statistically significant that men were more likely to suffer fatal injuries due to work-related exposure, whereas women were more likely to suffer fatal injuries due to home-related exposure to electric current.

Electric current encounters less resistance when passing through tissues if the skin is wet or damp (5). In our study, the crime scene was reported as wet in 57.9% of cases and damp in 4.3%. No wetness or humidity was reported in 18.2% of cases, and sufficient information on wetness was unavailable for 19.6%. Upon examining autopsy reports and hospital files, an entrance lesion

related to electric current was identified in 35.9% of cases, an atypical entrance lesion in 11%, and no lesion in 53.1%. The rates of crime scene wetness/humidity and entrance lesions observed in our study differed from those reported in previous literature (12, 14, 20, 21), likely due to differences in case selection. The absence of entrance lesions in cases where the crime scene was wet or damp was statistically significant, as was the presence of entrance lesions in cases where no wetness or humidity was reported ($p<0.05$). When electric current enters the body over a large surface area (such as when submerged in water or when the body is wet), skin resistance decreases, allowing more current to pass while also preventing thermal injury by cooling the tissues (21). The high prevalence of wet or humid crime scenes in our study explains the lack of entrance lesions in many cases.

Technical expert reports on suspicious electrical devices were available in 63.2% of cases. Among these, electrical leakage was detected in 45%, no leakage was found in 11.5%, direct contact with the current source was identified in 27.3%, and sufficient information was unavailable in 16.3%. In four cases with incomplete information, records were missing despite the presence of expert reports. In cases of suspected electrocution where autopsy reveals no lesions, crime scene investigations and expert reports on electrical devices are essential for forensic analysis. When mortality is suspected to be related to electric current, obtaining a technical expert report with clear information on electrical leakage is crucial.

At least one eyewitness was present in 66.5% of cases, while 33.5% had no witnesses. From the moment an incident occurs until autopsy results are obtained, witness statements should be integrated into the assessment. These statements significantly contribute to crime scene investigation and help clarify the circumstances of the event.

Traumatic findings were observed at a lower rate in our study compared to previous literature (22-23). Multiple traumatic injuries were detected in 4.8% of cases, and resuscitation-related artifacts were found in 1.9%.

Hospitalization periods ranged from one day to eight months in 12.4% of cases. A significant proportion of subjects died before reaching the hospital or at the crime scene, consistent with the literature (10, 22, 24). In cases where the cause of death was cardiac arrest due to electric current exposure, the response to resuscitation was favorable (12). If resuscitation is delayed following exposure to electric current, mortality rates may increase. Individuals alone at the crime scene may be unable to release the electrical source due to flexor muscle contractions, increasing the amount of current passing through the body and, consequently, the likelihood of death.

Autopsy should be conducted to determine the cause and origin of death in suspected electrocution cases, aiding in labor law and criminal proceedings (12). In our study, autopsy was not performed in 6.2% of cases, and no findings were detected in 36% of those that underwent autopsy. Petechial hemorrhages were observed in 48% of cases, appearing in various regions such as the heart, lungs, and subscalp. Internal organ and bone trauma was found in 4.5% of cases. Cases with internal organ findings from hospitalization or pre-existing conditions identified during autopsy were classified under the “Other” subgroup (11.7%).

Previous studies have reported petechial hemorrhages in 74% (Karger et al.) and 48.3% (Shaha et al.) of cases (10, 25). Antemortem and postmortem electric burns cannot be distinguished; the presence of burns only confirms that electric current passed through the

body (26). In contrast to burns, petechial hemorrhages are considered vital signs, as they require a living state for formation. Though a typical indicator, petechial hemorrhages are not a specific sign of electrocution-related death (25). Our study found a high rate of petechial hemorrhages, supporting their significance in forensic assessments.

Blood alcohol levels are relevant in electrocution cases. In our study, ethanol concentrations ranged from 6 mg/dl to 233 mg/dl in five cases, and one case contained cannabis-derived substances.

In suspected electrocution cases, macroscopic and microscopic examinations of suspicious lesions are crucial (4). In our study, 6.2% of cases did not undergo autopsy, and skin samples for histopathologic examination were not taken in 45% due to the absence of suspicious lesions. Findings indicative of electric or thermal effects were observed in 22.5% of cases, while no such findings were detected in 24.4%. Further analysis to distinguish electric burns from other injuries was not conducted.

CONCLUSION

Preventing electrical injuries, a public health concern, requires increased awareness through education and safety precautions in workplaces and homes. Workplace safety training, upgrading outdated wiring, replacing damaged cables, and ensuring proper grounding are key preventive measures. Protecting children from electrical hazards and ensuring employees wear protective gear near electrical sources are essential. Comprehensive forensic investigations incorporating autopsy, crime scene analysis, and expert reports are necessary for accurate determinations in electrocution-related deaths.

Acknowledgement

Conflict of Interest

The authors declare that they have no conflict of interests regarding content of this article.

Financial Support

The Authors report no financial support regarding content of this article.

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