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Characteristics of Injuries Due to Exposure to Electric Current and Their Forensic Medical Consequences: a Three-Year Retrospective Evaluation

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Abstract

Characteristics of injuries due to exposure to electric current and their forensic medical consequences: a three-year retrospective evaluation

Objective: Electrical injuries represent a significant medico-legal problem, as exposure to electric current can lead to a wide spectrum of injuries depending on voltage level and exposure conditions. This study aims to evaluate electrical injuries within a forensic medical framework—specifically in terms of life-threatening condition, amenability to treatment by simple medical intervention, and the presence of fractures and internal organ damage—as well as in relation to associated risk factors.
Methods: A total of 123 cases identified as electrical injuries and reported as forensic cases in a secondary-level state hospital between 2023 and 2025 were analysed with respect to demographic characteristics, timing/location/origin of the injury, voltage type, source of contact, clinical findings, associated trauma, treatment, and medico-legal outcomes.
Results: Of the cases, 70.7% were male, with a mean age of 26.9±16.3 years. Injuries most frequently occurred in individuals aged 19–29 years, on weekdays, and between 08:00 and 16:00 hours, predominantly in domestic and indoor environments. Low-voltage exposure accounted for 87.8% of cases, whereas 12.2% involved high-voltage exposure. All cases were of accidental origin (56.1% occupational accidents; 41.5% domestic accidents). High-voltage exposure was significantly associated with the presence of entry/exit lesions, multitraumatic injuries, fractures, internal organ damage, and medico-legal outcomes including life-threatening condition and non-amenability to treatment by simple medical intervention ($p<0.05–0.001$).
Conclusion: The findings indicate that the voltage level of electrical exposure is a key prognostic and medico-legal determinant in electrical injuries. In low-voltage cases, case-specific evaluation based on clinical findings and standardized documentation are of critical importance
Keywords: Electrical Injuries, Electric Shock, Electrocution, Electrical Burns, Forensic Medicine

Özet

Elektrik akımı maruziyetine bağlı yaralanmaların özellikleri ve adli tıbbi sonuçları: üç yıllık retrospektif değerlendirme

Amaç: Elektrik akımı maruziyetine bağlı yaralanmalar voltaj düzeyi ve maruziyet koşullarına göre geniş bir yelpazede yaralanmalara neden olduğundan önemli bir adli tıbbi problemdir. Bu çalışma elektrik yaralanmalarını adli tıbbi değerlendirme çerçevesinde (yaşamsal tehlike, basit tıbbi müdahale ile giderilebilirlik, kırık/iç organ hasarı) ve risk faktörleri bağlamında incelemeyi amaçlamaktadır.
Yöntem: 2023-2025 yılları arasında ikinci basamak bir devlet hastanesinde adli olgu olarak bildirilen ve elektrik yaralanması saptanan 123 olgu demografi, yaralanma zamanı/yer/orijin, voltaj tipi, temas kaynağı, klinik bulgular, ek travma, tedavi ve adli sonuçlar açısından analiz edilmiştir.
Bulgular: Olguların %70,7'si erkek olup yaş ortalaması 26,9±16,3 yıldır; vakalar en sık 19–29 yaşta, hafta içi ve 08.00–16.00 saatlerinde, ev ve kapalı alanlarda gerçekleşmiştir. Maruziyetin %87,8'i düşük voltaj, %12,2'si yüksek voltajdır ve tüm olgular kaza kökenlidir (iş kazası %56,1; ev kazası %41,5). Yüksek voltaj maruziyeti giriş/çıkış lezyonu oluşumu, multitravmatik yaralanmalar, kırık oluşumu, iç organ hasarı ve adli tıbbi açıdan yaşamsal tehlike ile BTM açısından anlamlı biçimde ilişkilidir ($p<0,05–0,001$).
Sonuç: Bulgular elektrik yaralanmalarında maruz kalınan akımın voltajının belirleyici prognostik ve medikolegal parametre olduğunu düşük voltajlı olgularda ise klinik bulgulara dayalı olgu-özgül değerlendirme ve standart kayıtlamanın kritik önem taşıdığını göstermektedir.
Anahtar Kelimeler: Elektrik Yaralanmaları, Elektrik Çarpması, Elektroküsyon, Elektrik Yanığı, Adli Tıp

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INTRODUCTION

In parallel with industrial and technological advancements, electrical energy has become an indispensable component of modern life. However, the widespread and uncontrolled use of electrical energy has increased in the incidence of electricity-related accidents (1). Electric shock is defined as the passage of electrical current through body tissues through contact with an electrical source completing a circuit or high-voltage arcing, causing injuries ranging from minor to fatal (2). Electrical current can result in fatal injuries through mechanisms such as ventricular fibrillation, tetanic spasm of the respiratory muscles, thermal burns, internal organ damage, and secondary trauma (e.g., falls or being thrown) (3). The characteristics of electrical injuries vary depending on multiple factors, including whether the electrical circuit is completed, the voltage of the current, the type of current (alternating or direct), current intensity (amperage), the pathway of current through the body, duration of exposure, and the electrical resistance of tissues (4).

Electrical injuries continue to represent a prevalent global problem. Higher rates of injury have been reported particularly in developing countries such as Türkiye compared with developed nations, and this situation results in substantial morbidity and mortality (2). In Türkiye, the high frequency of electrical injuries is largely attributable to infrastructural deficiencies, illegal use of electricity, inadequate occupational safety measures, insufficient regulatory oversight, disparities in public education levels, and the improper or unregulated use of electrical systems (1).

In forensic medical practice, cases involving both fatal and non-fatal injuries resulting from electrical exposure constitute a significant proportion of medico-legal evaluations. Studies conducted in Türkiye have demonstrated that the vast majority of electrical injury cases are of accidental origin; however, cases related to suicide and intentional injury, although rare, have also been reported (1,2,5). While electrical injuries are particularly concentrated among young adult males actively engaged in the workforce and within the context of occupational accidents, the proportion of domestic accidents and injuries associated with electrical household appliances is also considerable (6).

The accurate and comprehensive medico-legal evaluation of injuries resulting from electric shock is critical for legal processes. Identification of the entry and exit points of electrical current, determination of the current pathway through the body, and, in fatal cases, clarification of the mechanism of death are essential for establishing liability, particularly in occupational accidents. However, in situations such as low-voltage exposure, contact on wet surfaces, or atypical exposure conditions, the absence of characteristic electrical lesions may create diagnostic challenges. Therefore, the evaluation of electrical injuries necessitates a multidisciplinary approach, requiring close collaboration between clinical disciplines and forensic medicine (7).

This study aims to retrospectively evaluate cases of injuries resulting from electrical exposure among patients presenting to Çankırı State Hospital, with a focus on their general characteristics, injury profiles, and medico-legal outcomes. In addition, it seeks to determine the legal classification of these injuries within the framework of the Turkish Penal Code-such as the presence of life-threatening conditions and whether the injuries are amenable to treatment by simple medical intervention-and to compare these findings with the existing literature. By characterising the epidemiological, clinical, and medico-legal features of electrical injuries within a regional context, the study may contribute to a better understanding of risk patterns and provide data that could support future preventive and occupational safety strategies.

METHOD

A total of 21.751 cases presenting to Çankırı State Hospital between 1 January 2023 and 31 December 2025 and evaluated as forensic cases were reviewed, and 123 cases identified as electrical injuries were included in the study.

For the cases included in the study, general forensic examination reports, patient epicrisis (discharge summary) reports, laboratory test results, operative notes, and radiological images were reviewed. The following variables were analysed: age, sex, occupation, source and type of electrical energy, the day, month, and season of the incident, origin of the event, location where the incident occurred, presence of associated trauma, clinical findings, severity of injury, hospitalisation status and, if applicable, length of hospital stay, history of surgical intervention, and the medico-legal classification of injuries within the scope of the Turkish Penal Code (amenability to treatment by simple medical intervention, presence of bone fractures, life-threatening condition).

Electrical exposure was classified according to voltage level as low voltage (<1000 V) and high voltage (≥1000 V). Voltage classification was determined using available hospital records, emergency department notes, forensic reports, occupational accident records when available, and patient or witness statements documented in the medical files.

Statistical analyses were performed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as frequencies, percentages, means, standard deviations (SD), and minimum (min) and maximum (max) values. Differences between categorical variables were analysed using the Pearson chi-square test and Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

This study was approved by the Ethics Committee of Health Sciences of Çankırı Karatekin University, (Meeting No: 30, Date: March 12, 2026). The research was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

Of the cases included in the study, 70.7% were male (n=87) and 29.3% were female (n=36), yielding a male-to-female ratio of 2.42. The mean age was 26.88±16.25 years, with an age range of 1 to 90 years. The mean age was 22.69±11.74 years for males and 37.0±20.78 years for females. The largest proportion of cases was observed in the 19–29 years age group (n=48; 39%), while 24.4% (n=30) of cases were in the 0–18 years age group and 2.4% (n=3) were aged 70 years or older (Table 1). The distribution of sex across age groups was found to be statistically significant (χ^2=27.357, p<0.001). The sex distribution by age group is presented in Table 2. Accordingly, 90% (n=27) of cases in the 0–18 years age group were male, while 75% of cases in both the 19–29 and 30–39 years age groups were male (n=36 and n=18, respectively). In the 40–49 years age group, 60% of cases were female (n=9), and in both the 50–59 years and ≥70 years age groups, all cases were female (n=3 for each group).

Injuries occurred most frequently during the spring and winter seasons (n=33 for each; 26.8%), on weekdays (n=99; 80.5%), and between 08:00 and 16:00 hours (n=69; 56.1%). The most common setting of electrical exposure was the home environment (n=51; 41.5%), followed by indoor/office environments (n=39; 31.7%) (Table 1).

Table 1. Demographic, Temporal, and Injury-Related Characteristics of the Study Population

		n	%
Age Group (years)	0–18	30	24.4
	19–29	48	39
	30–39	24	19.5
	40–49	15	12.2
	50–59	3	2.4
	60-69	0	0
	≥70	3	2.4
Sex	Male	87	70.7
	Female	36	29.3
Season	Spring	33	26.8
	Summer	27	22
	Autumn	30	24.4
	Winter	33	26.8
Time of Injury	00:00–08:00	18	14.6
	08:00–16:00	69	56.1
	16:00–24:00	36	29.3
Day of Injury	Weekdays	99	80.5
	Weekends	24	19.5
Location	Home	51	41.5
	Construction site	22	17.9
	Factory	4	3.3
	Outdoor area	7	5.7
	Indoor/Office	39	31.7
Voltage Type	Low voltage	108	87.8
	High voltage	15	12.2
Injury Type	Occupational accident	69	56.1
	Domestic accident	51	41.5
	Other accidents	3	2.4
Occupation	General worker	53	43.1
	Electrician	10	8.1
	Other	6	4.9
	Unknown	54	43.9
Causative Electrical Source	Cable	33	26.8
	Work tool	27	22
	Socket	21	17.1
	Electrical appliance	15	12.2
	Wire	10	8.1
	Electrical panel	7	5.7
	Bulb	6	4.9
	Battery	3	2.4
	High-voltage line	1	0.8

Table 2. Distribution of Sex by Age Group

		Gender						χ^2	p
		Male		Female		Total			
		n	%	n	%	n	%		
Age Group (years)	0–18	27	22	3	2.4	<0,001*	24.4	**27.357**	**<0.001***
	19–29	36	29.3	12	9.8	48	39.0		
	30–39	18	14.6	6	4.9	24	19.5		
	40–49	6	4.9	9	7.3	15	12.2		
	50–59	0	0	3	2.4	3	2.4		
	60-69	0	0	0	0	0	0		
	≥70	0	0	3	2.4	3	2.4		
Total		87	70.7	36	29.3	123	100		

It was determined that 87.8% of the cases were exposed to low-voltage current (n=108), whereas 12.2% were exposed to high-voltage current (n=15). Examination of the origin of injuries revealed that 56.1% resulted from occupational accidents (n=69), 41.5% from domestic accidents (n=51), and 2.4% from other types of accidents (n=3) (the "other accidents" group consisted of one agricultural exposure, one outdoor public-area electrical contact, and one generator-related incident.), with all injuries being of accidental origin (Table 1). Among occupational accident cases, 76.8% (n=53) were general labourers, 14.5% (n=10) were electrical workers, and 8.7% (n=6) belonged to other unclassified occupational groups. The distribution of accident types differed significantly by sex (χ^2=6.624, p<0.05). Of the occupational accident cases, 78.3% (n=54) were male and 21.7% (n=15) were female, whereas in domestic accidents, the proportion was 58.8% male (n=30) and 41.2% female (n=21). Accident types also varied significantly according to age (χ^2=35.768, p<0.001), with the distribution presented in Table 3. In the 0–18 years age group, 60% of cases (n=18) were domestic accidents, whereas in the 19–29 years age group, 81.3% of cases (n=39) were occupational accidents. In the 30–39 years age group, occupational and domestic accidents were equally distributed, each accounting for 50% (n=12). In the 40–49 years age group, 60% of cases (n=9) were occupational accidents, while in the 50–59 years and ≥70 years age groups, all cases were classified as domestic accidents (100% for each; n=3).

Table 3. Distribution of Injury Type by Age Group

		Origin of Injury								χ^2	p
		Occupational Accident		Domestic Accident		Other Accidents		Total			
		n	%	n	%	n	%	n	%		
Age Group (years)	0–18	9	7.3	18	14.6	3	2.4	30	24.4	35.768	<0.001*
	19–29	39	31.7	9	7.3	0	0	48	39		
	30–39	12	9.8	12	9.8	0	0	24	19.5		
	40–49	9	7.3	6	4.9	0	0	15	12.2		
	50–59	0	0	3	2.4	0	0	3	2.4		
	60-69	0	0	0	0	0	0	0	0		
	≥70	0	0	3	2.4	0	0	3	2.4		
Total		69	56.1	51	41.5	3	2.4	123	100		

When the distribution of sources causing electrical injuries was examined, the most common mechanism was contact with an electrical cable (n=33; 26.8%). This was followed by contact with work tools (n=27; 22%), electrical sockets (n=21; 17.1%), and household appliances (n=15; 12.2%) (Table 1). A statistically significant association was identified between the source of injury and age group (χ^2=83.473, p<0.001). In the 0–18 years age group, injuries were most frequently associated with electrical sockets (30%; n=9) and household appliances (20%; n=6). In the 19–29 years age group, injuries were most commonly related to electrical cables (37.5%; n=18) and work tools (25%; n=12). In the 30–39 years age group, contact with electrical cables ranked first (37.5%; n=9), whereas in the 40–49 years age group, 60% of injuries were caused by work tools (n=9). All cases in the 50–59 years age group were associated with electrical cables (100%; n=3), while in the ≥70 years age group, all injuries were due to contact with electrical sockets (100%; n=3).

In 86.2% of the cases (n=106), the body region in contact with the electrical current was the upper extremity. Entry lesions were identified in 34.1% of cases (n=42), of which 95.2% (n=40) were localised to the upper extremity. Exit lesions were observed in 19.5% of cases (n=24), with 50% (n=12) localised to the upper extremity and 50% (n=12) to the lower extremity. It was determined that the voltage (V) of the electrical current was a decisive factor in the formation of entry and/or exit lesions (Fisher's Exact Test, p<0.001). Entry and/or exit lesions were detected in 19.4% of cases exposed to low voltage (n=21), whereas such lesions were present in all cases exposed to high voltage (100%; n=15). When the burn severity was evaluated, first-degree burns were identified in 19.5% of cases (n=24), second-degree burns in 7.3% (n=9), and third-degree burns in 7.3% (n=9) (Table 4).

When associated traumatic injuries were evaluated, additional trauma was identified in 17.1% of cases (n=21). Of these, 71.4% (n=15) were due to falls from height, while 28.6% (n=6) resulted from being thrown or propelled. A statistically significant association was found between voltage type and the occurrence of associated trauma (χ^2=22.234; p<0.001). Additional trauma was observed in 11.1% of cases exposed to low voltage (n=12), compared with 60% of those exposed to high voltage (n=9). The Glasgow Coma Scale (GCS) score was 13–15 in 97.6% of cases (n=120), whereas 2.4% of cases (n=3) had a GCS score of 3–8 (Table 4).

Bone fractures were identified in 4.9% of cases (n=6), with 50% (n=3) presenting with a single fracture and 50% (n=3) with multiple fractures. A statistically significant association was found between the occurrence of fractures and the voltage of the electrical current (Fisher's Exact Test, p=0.024). Fractures were detected in 2.8% of cases exposed to low-voltage current (n=3), whereas 20% of cases exposed to high-voltage current (n=3) sustained fractures.

Internal organ injury was identified in 4.9% of cases (n=6). When analysed by subgroups, intracranial, thoracic, cardiac, and abdominal organ injuries were each observed at equal frequencies (n=3; 2.4%). A statistically significant association was found between the occurrence of internal organ injury and the voltage of the electrical current (Fisher's Exact Test, p<0.001). No internal organ injuries were detected in cases exposed to low-voltage current, whereas 40% of cases exposed to high-voltage current (n=6) sustained internal organ injury.

Table 4. Clinical and Injury-Related Characteristics of the Population

		n	%
Body Part in Contact with the Current	Upper extremity	106	86.2
	Head–neck	7	5.7
	Back–trunk	7	5.7
	Lower extremity	3	2.4
Associated Trauma	Fall from height	15	12.2
	Projection / throwing	6	4.9
Glasgow Coma Scale	Severe (3–8)	3	2.4
	Mild (13–15)	120	97.6
Burn Degree	First degree	24	19.5
	Second degree	9	7.3
	Third degree	9	7.3
	No burn	81	65.9
Fracture	Present	6	4.9
	Absent	117	95.1
Number of Fractures	Single	3	2.4
	Multiple	3	2.4
Organ Injury	Present	6	4.9
	Absent	117	95.1
Intracranial Injury		3	2.4
Thoracic Injury		3	2.4
Cardiac Injury		3	2.4
Abdominal Injury		3	2.4
Cut / Laceration	Present	3	2.4
	Absent	120	97.6
Ecchymosis / Abrasion / Hyperemia	Present	84	68.3
	Absent	39	31.7
Muscle Injury	Present	6	4.9
	Absent	117	95.1
Treatment Modality	Outpatient	96	78
	Inpatient	21	17.1
	Intensive care	6	4.9
SMI	Treatable	81	65.9
	Not-Treatable	42	34.1
Life-Threatening Conditions	Present	42	34.1
	Absent	81	65.9

** SMI: simple medical intervention*
** Some patients sustained multiple organ injuries simultaneously; therefore, subcategory totals may exceed the number of individual patients.*

When soft tissue injuries were evaluated, ecchymosis, abrasion, or hyperaemia were identified in 68.3% of cases (n=84), while incisions/lacerations were observed in 2.4% (n=3). Muscle tissue injury was detected in 4.9% of cases (n=6) (Table 4).

When treatment modalities were evaluated, 78% of cases (n=96) were managed on an outpatient basis and discharged on the same day, 17.1% (n=21) were hospitalised in inpatient wards, and 4.9% (n=6) required intensive care unit admission. The mean length of hospital stay was 2.62±1.06 days, ranging from 1 to 5 days. According to survival outcomes, 2.4% of injuries (n=3) resulted in death. All fatal cases were male and resulted from high-voltage electric shock. All deceased were in the 30-39 age group. Three cases were workplace accidents. Two cases involved secondary trauma, including injuries from falls following electric shock. All fatal cases showed extensive burn injuries and multiple organ involvement. All patients required intensive care treatment before death.

When the nature of injuries was evaluated within the framework of the Turkish Penal Code, it was determined that 34.1% of cases (n=42) involved injuries that posed a life-threatening condition, whereas 65.9% (n=81) did not. Similarly, 65.9% of injuries (n=81) were classified as minor and amenable to treatment by simple medical intervention, while 34.1% (n=42) were not amenable to simple medical intervention (Table 4). A statistically significant association was identified between the voltage (V) of the electrical current and the presence of a life-threatening condition (χ^2=32.946, $p<0.001$). A life-threatening condition was observed in 25% of cases exposed to low voltage (n=27), whereas all cases exposed to high voltage (100%; n=15) were associated with life-threatening conditions. Furthermore, a statistically significant relationship was found between voltage (V) and whether the injury was amenable to treatment by simple medical intervention (χ^2=32.946, $p<0.001$). Injuries were classified as amenable to simple medical intervention in 75% of low-voltage cases (n=81), whereas all high-voltage cases were deemed not amenable to such treatment (100%; n=15).

DISCUSSION

The distribution of electrical injuries according to age and sex varies depending on multiple factors, including socioeconomic conditions, work roles, and regional demographic characteristics. Previous studies have consistently shown that young adult males constitute the principal risk group, whereas domestic exposures become relatively more prominent among children, women, and older individuals (2,8,9). Our findings broadly support this pattern. Male predominance was particularly pronounced in younger age groups, while the proportion of female cases increased with advancing age. This distribution likely reflects the greater participation of young and middle-aged men in high-risk occupations such as construction and industrial work, whereas domestic exposure may become relatively more important among women and elderly individuals. The gradual reduction in sex disparity in older age groups may also be associated with decreased occupational exposure after retirement and increased time spent in the home environment.

The temporal distribution of electrical injuries remains heterogeneous across regions and populations (2,3,6,9–13). Many national and international studies report a summer predominance, commonly attributed to reduced skin resistance due to sweating, increased outdoor activity, lighter clothing, and school holidays among children (1,3,9–11). In contrast, electrical injuries in our series clustered predominantly in spring and winter. Given that more than half of the cases were occupational in origin, this finding may suggest that seasonal variation in developing regions is influenced not only by climatic conditions but also by fluctuations in industrial activity, maintenance processes, and production intensity (14). However, because workplace activity levels and regional production cycles were not directly evaluated, this interpretation should be approached cautiously. Rather than establishing a causal relationship, the present findings highlight the possibility that occupational dynamics may partially shape seasonal injury patterns and warrant further investigation.

The concentration of injuries during daytime working hours and on weekdays further reinforces the occupational dimension of electrical trauma. Previous studies have similarly demonstrated that electrical injuries peak during periods of maximal occupational and daily activity (12,15). The predominance of weekday injuries in our study also aligns with reports indicating that workplace-related electrical injury is more common during regular working schedules, whereas weekend cases tend to involve domestic exposure (14,16). Together, these findings emphasise that electrical injury epidemiology cannot be interpreted independently of labour patterns and social routines.

Low-voltage (<1000 V) exposure constituted the majority of injuries in our study. Similar distributions have been reported in emergency department–based and population-based series (17,18), whereas studies from specialised burn centres frequently demonstrate a predominance of high-voltage injuries (19,20). This difference most likely reflects referral bias rather than true epidemiological variation. Burn centres naturally receive a higher proportion of severe and complex cases, while our study included the broader spectrum of forensic electrical injuries, including domestic accidents and relatively minor exposures. The predominance of low-voltage injuries may therefore be related not only to the widespread use of low-voltage systems in households and small-scale workplaces, but also to the inclusion of non-fatal and clinically milder cases that would not typically require referral to tertiary burn centres.

Occupational accidents represented the leading mechanism of injury in our series, followed closely by domestic accidents. The sex- and age-related distribution of these accidents demonstrated a characteristic life-course pattern. Occupational exposure was concentrated among young adult males, whereas domestic injuries were more common in children and older individuals. Previous studies have described a similar transition from domestic exposure in childhood to workplace-related injuries during economically active years, followed by a relative return to domestic risk in older age groups (1,3,6,8,22). This pattern likely reflects changing social roles and environmental exposure over time. Importantly, the findings suggest that preventive strategies should not be designed as a single uniform model; rather, they should be tailored according to age-specific and environment-specific risk profiles.

The sources of electrical injuries also varied substantially across age groups. Electrical cables and occupational tools predominated among working-age adults, whereas household appliances and electrical sockets were more common among children. Similar findings have been reported in both paediatric and adult series (9,21,24). In practical terms, this distribution illustrates how the mechanism of exposure evolves in parallel with daily activity patterns. Childhood injuries largely reflect unsafe domestic environments and insufficient protective measures, whereas adult injuries are more closely linked to occupational exposure and direct interaction with electrical infrastructure. In elderly individuals, the observed shift back toward domestic sources may be associated with reduced mobility, sensory decline, and prolonged time spent at home (24). Collectively, these findings indicate that the epidemiology of electrical injury changes dynamically throughout life rather than remaining constant across age groups.

The anatomical distribution of current entry and exit sites in our study was also consistent with the functional mechanics of electrical exposure. The upper extremities, particularly the hands, were the most common initial contact sites, reflecting the fact that electrical injuries frequently occur during manual handling of cables, tools, or electrical devices (2,12,15,21). Exit lesions, by contrast, were more frequently localised to the lower extremities, supporting the commonly described hand-to-foot current pathway (21,25,26). These findings are clinically relevant because the route of electrical transmission may influence both the extent of tissue damage and the likelihood of internal organ involvement.

One of the most notable findings of the present study was the strong association between voltage level and the presence of characteristic entry and exit lesions. Cutaneous lesions were uncommon in low-voltage exposure but were observed in all high-voltage injuries. This distinction reflects fundamental differences in injury mechanisms. High-voltage currents are more likely to produce deep thermal injury, coagulative necrosis, and extensive tissue destruction, whereas low-voltage exposure may still cause clinically significant systemic effects despite minimal or absent skin findings (27). Accordingly, the absence of characteristic cutaneous lesions should not exclude the possibility of substantial internal injury or serious medico-legal consequences.

Electrical trauma should also be recognised as a complex multisystem injury rather than a purely burn-related phenomenon. In addition to direct electrical effects, secondary blunt trauma caused by falls or forceful projection may substantially contribute to morbidity (6,21,28). Associated trauma was significantly more frequent in high-voltage exposure in our study, supporting the view that increasing voltage not only intensifies thermal damage but also increases the likelihood of severe mechanical injury. This observation has important clinical and forensic implications. Initial assessment should extend beyond the identification of entry and exit wounds and include systematic evaluation for fractures, intracranial injury, thoracoabdominal trauma, and other secondary injuries.

Similarly, fractures and internal organ injuries were strongly associated with high-voltage exposure. Although the overall frequency of these complications remained within the lower range reported in the literature (1,19–22,24), the marked increase observed in high-voltage cases underscores the role of voltage as a major determinant of injury severity. The mechanisms underlying these injuries are likely multifactorial and may include violent tetanic muscle contractions, falls from height, blunt trauma after being thrown, and direct thermal or vascular injury. From a clinical perspective, these findings reinforce the importance of maintaining a low threshold for advanced imaging and multidisciplinary evaluation in high-voltage exposure, even when external lesions appear limited.

The overall clinical course in our series was relatively favourable, with most patients managed on an outpatient basis and a low mortality rate. This pattern is consistent with studies involving general emergency department populations, where low-voltage exposure predominates and severe burns are less common (1,29,30). In contrast, mortality and intensive care requirements are substantially higher in burn-centre cohorts enriched with high-voltage injuries and extensive tissue destruction (19,20,31,32). The relatively low mortality observed in our study should therefore be interpreted within the context of the study population rather than as evidence that electrical injuries are generally benign.

From a medico-legal perspective, one-third of cases were classified as life-threatening and similarly one-third were considered not amenable to treatment by simple medical intervention. Voltage level emerged as the principal factor associated with both classifications. According to the Guideline for the Forensic Medical Evaluation of Injury Offences Defined in the Turkish Penal Code, which is the principal medico-legal reference used in Türkiye for standardising injury assessment in judicial practice, evidence that electrical current has passed through the body or the requirement for cardiopulmonary resuscitation is considered sufficient to establish a life-threatening condition (33). Although this approach standardises forensic assessment, it has also been criticised for potentially overclassifying clinically limited injuries as life-threatening in the absence of systemic involvement (34). This debate highlights an important tension between guideline-based standardisation and clinical individualisation. The lower rates observed in our study compared with some previous reports (1) may partly reflect the retrospective design and the possibility of underdocumentation of transient systemic findings in medical records. Consequently, prospective studies with structured clinical follow-up may provide a more precise understanding of the relationship between electrical exposure, clinical severity, and medico-legal classification

CONCLUSION

The findings of our study demonstrate that electrical injuries are not merely incidental accidents; rather, injury patterns are shaped by a strong causal relationship with the individual's "life cycle" (home environment in childhood, occupational settings in adulthood, and a return to the home environment in older age). Contrary to the prevailing view in the literature, the observed increase in cases during the spring and winter seasons may suggest that industrial workload and working conditions, rather than climatic factors, may play a more decisive role in the occurrence of electrical accidents.

From a clinical perspective, voltage level emerges as the most critical parameter determining injury severity and prognosis. It has been confirmed that high-voltage exposure is not limited to thermal burns but is also associated with a high incidence of concomitant mechanical trauma (such as falls and being thrown), bone fractures, and internal organ injuries. This underscores the necessity of an evaluative approach that extends beyond cutaneous findings to include the assessment of blunt traumatic injuries, particularly in high-voltage cases.

From a medico-legal perspective, the results of this study demonstrate a strong and statistically significant correlation between voltage level and the criteria of "life-threatening condition" and "amenability to simple medical intervention." While the standards for the medico-legal classification of high-voltage injuries are relatively well defined, the legal evaluation of low-voltage and localised injuries requires a case-specific, dynamic assessment process based on clinical and laboratory findings rather than solely on the presence of lesions.

In conclusion, in order to reduce electrical injuries—which are largely preventable—protective strategies should extend beyond occupational training and also include awareness initiatives targeting at-risk groups within domestic environments. Future studies and forensic practice should incorporate voltage level and markers of associated systemic trauma more effectively, integrating them with existing guideline criteria to improve the assessment of injury severity.

Limitations of the Study

This study has several limitations. Due to its retrospective design, there is a risk of incomplete data, information bias, and misclassification. The single-centre setting limits generalisability, particularly for severe cases referred to tertiary centres. Inclusion of only forensic cases may have introduced selection bias. Voltage classification based on records may have limited accuracy of exposure assessment. The absence of standardised follow-up and the relatively small high-voltage sample size may have reduced statistical power. Finally, the lack of long-term follow-up precluded evaluation of late complications.

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Conflict of Interest

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

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Ethical Declaration

Ethical permission was obtained from the Çankırı Karatekin University, Ethics Committee of Health Sciences for this study with date March 12, 2026 and number 30, and Helsinki Declaration rules were followed to conduct this study.

Authorship Contributions

Concept: EGB, Design: EGB, BK, Supervising: EGB, BK, AÖ, Financing and equipment: EGB, BK, AÖ, Data collection and entry: EGB, BK, AÖ, Analysis and interpretation: EGB, BK, AÖ, Literature search: EGB, BK, AÖ Writing: EGB, BK, AÖ, Critical review: EGB, BK, AÖ

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