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Research Article

Anesthesia in patients with electrical burn: A retrospective study

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ABSTRACT

Aim: We aimed to share our anesthesia experiences with patients hospitalized for electrical burns and underwent surgical intervention under anesthesia in the burn clinic of our hospital.

Method: Data gained from our hospital's patient files and medical information system were retrospectively evaluated. The study included patients diagnosed with electrical burns hospitalized in our burn clinic in 2018-2022.

Results: The study involved files of a total of 694 patients. Fifty (7.2%) patients were treated for electrical burns. The required data from 3 of the patients could not be accessed, therefore the study was completed including 47 patients. We found that 22 patients did not need surgical treatment. Twenty-five were given anesthesia for different surgical procedures: 20 of those received general anesthesia, while five underwent neuraxiel anesthesia/regional anesthesia. There were no anesthesia-related complications in any patients in the perioperative period.

Conclusions: Anesthesia applications should be carefully planned against possible complications in patients with electrical burns.

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1. Introduction

Burns are among the most common traumas worldwide, especially in developing countries, and are a significant cause of morbidity and mortality. According to the World Health Organization (WHO) data, approximately 11 million burn injuries occur annually, 180,000 of which result in death [1]. Burn injuries may occur after contact with flame, hot liquids, chemicals, and electricity. Electrical injuries constitute 5% of the total burn admissions to the hospital and are reported to cause approximately 1000 deaths per year in the United States of America (USA) [2] For electrical burns, these rates are much higher in low-income countries and can account for 30% of hospitalizations [3].

As the electric current passes through the tissues, it impairs the permeability of the cell membrane with a direct effect and causes cell necrosis. As an indirect effect, it damages the tissues it passes through due to the conversion of electrical energy into heat energy [4,5]. The severity of this damage depends on the voltage and duration of the electric current, the path the current travels through the body, and the resistance of the body tissues that the current encounters [6]. Necrosis may later develop in tissues that initially appear normal due to the nature of electrical burns, unlike other burns [7]. Necrosis can result in reduced or complete loss of function in the affected limb. Life-threatening complications such as kidney failure and sepsis may occur [8]. In effort to avoid such complications, close follow up of the patients must be performed and surgical interventions under anesthesia must be scheduled appropriately [9].

Both intensive care follow-up and intraoperative management of burn patients require special attention from the anesthesiologist. Depending on the severity of the burn, a systemic reaction develops in the body in ad-

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dition to the injury in the local burn area. Inflammatory and vasoactive mediators such as histamines, prostaglandins, and cytokines are released—capillary permeability increases. Intravascular fluid loss, decrease in cardiac output, hypovolemia, and hypo-perfusion develop [10,11]. Therefore, the following are critical in the management of burn patients: providing vascular access for appropriate fluid replacement at the appropriate time, providing hemodynamic support, maintaining organ perfusions, treating arrhythmias, controlling temperature regulation, determining difficult airway management and mechanical ventilation strategies when necessary, choosing the appropriate anesthesia method (if general anesthesia is to be applied), paying attention to the drugs to be used in the induction and maintenance of anesthesia, and providing pain control [12].

Our goal is to share the experience we have gained regarding anesthetic management of the patients hospitalized for electrical burns in the burn clinic of our hospital, who underwent surgical interventions under anesthesia.

2. Materials and Methods

This study was carried out retrospectively by evaluating our hospital's patient files and medical information system data. It involved patients hospitalized in our burn clinic with the diagnosis of electrical burns in the years 2018-2022 after receiving the approval of the Samsun University Ethics Committee (SUKAEK 2023/9/6). Patients who died within the first 24 hours and who were admitted to a department or hospital other than the burn clinic due to electrical burns were excluded from the study.

The study form included the following: the patients' age, gender, systemic diseases, American Society of Anesthesiologists physical status classification (ASA), burn percentage, previous surgeries, number of surgeries, anesthesia methods applied, development of Acute respiratory distress syndrome (ARDS), development of secondary infection, whether kidney failure developed, length of hospital stay, type of discharge. Complications and results of anesthesia methods applied in patients were evaluated.

2.1. Statistics

We used the Statistical Package for the Social Science (SPSS) program, version 26 (IBM, Corp. Armonk, NY, USA) for statistical evaluation. Distribution analysis of the data was evaluated using the Kolmogorov-Smirnov test or, for subgroup analyses with a sample size of 30 or less, the Shapiro-Wilk test according to normality tests. Patient data were presented according to normality test results using mean (± standard deviation) or median (interquartile range) for quantitative data and frequency (and percentage) for categorical data. Student T and Mann-Whitney U tests were used for comparisons between quantitative variables. Chi-square ($\chi 2$) and Fisher's exact test were used to compare categorical data. For all tests, a p-value of <0.05 was considered statistically significant.

3. Results

The files of 694 patients were reviewed during the study period. Treatment causes were as follows: electricity in 50 (7.2%) patients, hot water in 340 (49%), milk in 34 (4.9%), flame in 257 (37%), inhalation in two (0.3%), and chemical burns in 11 (1.6%). Data of three patients followed up for electrical burns could not be reached. The study was completed with 47 patients followed up for electrical burns (Fig. 1). Table 1 shows their demographic and clinical characteristics.

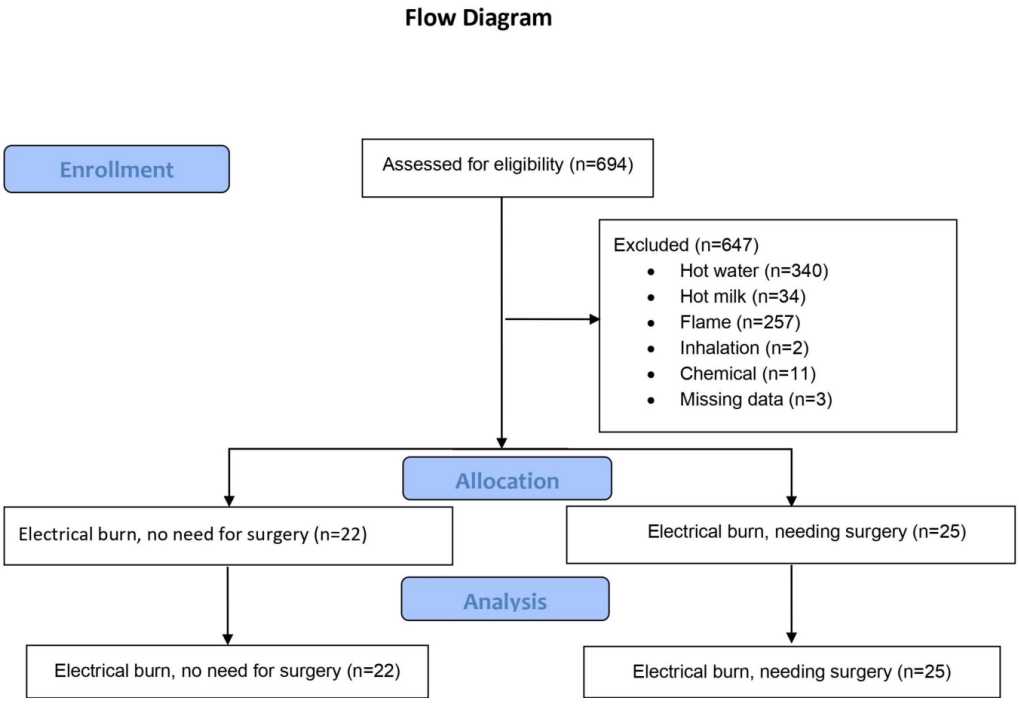

Fig. 1. Flow diagram showing patient selection.

Table 1. Demographic and clinical characteristics of the patients.

Age (years) mean ± SD	40 ± 15
Gender (female/male) n (%)	2 (4.3) / 45 (95.7)
ASA n (%)	
I	8 (17)
II	38 (80.9)
III	-
IV	1 (2.1)
TBSA (degree) median (IQR)	10 (22)
Technique n (%)	
Regional Anesthesia	5(10.6)
General Anesthesia	20(42.5)

ASA: American Society of Anesthesiologists physical status classification. TBSA: Total body surface area.

Of the patients included in the study, 22 (46.8%) did not need surgical treatment and anesthesia. Six patients (12.8%) required surgical treatment and anesthesia for debridement, 11 patients (23.4%) for grafting, one patient (2.1%) for fasciotomy, and seven patients (14.9%) for amputation. We observed that 20 (80%) of the anesthetized patients underwent general anesthesia, and 5 (20%) underwent regional anesthesia. We found that propofol, fentanyl, and rocuronium were used most frequently (75%) for general anesthesia induction, and often (56%) anesthesia was maintained with sevoflurane inhaler anesthesia. Two (8%) patients needed inotropic support during the intraoperative period. Of the 25 patients who underwent surgical treatment, 24 required more than one surgical intervention. No patients had anesthesia-related complications in the perioperative period. The duration of the patient's stay in the hospital was [days; median (IQR)]: 27 (38). Complications that developed during the hospitalization period and the variables affecting the hospital duration are in Tables 2 and 3, respectively.

Table 2. Complications during hospitalization.

ARDS n (%)	2 (4.3)
AKI n (%)	3 (6.4)
Secondary infection n (%)	18 (38.3)
Discharge n (%)	
Healing	30 (63.8)
Disabled	13 (27.7)
Mortality	3 (6.4)
Transfer to another hospital	1 (2.1)

Table 3. Variables of hospital duration.

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Need of anesthesia	< 0.01
ASA	0.371
Age	0.592
TBSA	< 0.01
Times of surgery	< 0.01

4. Conclusions

Electrical burns occur less frequently than scalding or flame burns. The mechanism of tissue damage is usually directly related to cell damage and denaturation caused by electrical forces. These patients deserve special attention because of their high morbidity and mortality rates. They constitute approximately 0.04% to 5% of all applications to burn centers in developed countries and 30% in developing countries [13]. The incidence of electrical burns was reported as 16% in a study conducted in our country, 17% in Kosovo, 18% in China, and 10.8% in Iran [1]. Although the frequency of electrical burns in our study was lower compared to some studies conducted in developing countries, it was generally similar to the literature.

Electrical injuries are more common in men, as men are more exposed to power tools and work in high-risk jobs. Al et al.14 reported that 76.4% of electrical burns occurred in adult men and 23.6% in women. Haberal et al. similarly reported that 82% of electrical burns occurred in adult men and 18% in women. Another study carried out in our center indicated that 89% of the patients were male, and 11% were female [14]. In our study, 95.7% of our patients were men. Various studies have reported the mean age of electrically injured patients differently. The mean age is reported as 2.5 to 71.5 years, depending on the study population [1]. Our study's mean age (mean ± SD) was 40 ± 15 years.

Electrochemical and thermal damage caused by electricity passing through tissues may cause coagulation necrosis, hemolysis, thrombosis, muscle or tendon rupture, and massive tissue edema [15]. Compartment syndrome may develop in the extremities. Compartment syndrome is a condition that requires early diagnosis and emergency fasciotomy. Otherwise, amputation is inevitable. In addition, necrosis tissues should be cleaned with serial debridements, and wounds should be closed in the early period [16]. For this purpose, performing surgical interventions in burn injuries under anesthesia at the appropriate time is critical. Güzel et al. [17] performed 197 surgical procedures on 104 cases and reported that they performed one surgical procedure in 50% of the cases, two in 24%, and three or more in 26% of cases. They performed 94.2% of these procedures under general anesthesia. Michael et al. [18] performed 19 anesthesia-guided surgical procedures on 16 patients, 64.8% of which were general anesthesia and 26.3% were subarachnoid blocks. In our study, 96 surgical interventions were performed on 25 patients under anesthesia. Twenty-four patients had more than one surgical intervention, and 80% of these were performed with

general anesthesia and 20% with central regional anesthesia. We thought the patients underwent such surgical procedures because our clinic was a burn center. General anesthesia was preferred because surgical procedures were mostly planned in multiple regions.

Inflammatory reactions and pathophysiological changes in burn patients may complicate intraoperative anesthesia management. Ensuring airway safety, providing adequate fluid replacement, maintaining hemodynamic stability and organ perfusion, ensuring adequate tissue oxygenation, intervening in arrhythmias, maintaining body temperature, and selecting drugs used in the induction and maintenance of anesthesia require special attention. In our study, intraoperative inotropic support was needed in two patients due to bleeding and hypovolemia during the surgical procedure. None of the patients had anesthesia-related complications in the perioperative period.

Control of burn pain is very important in the recovery of patients with burn injuries. Inadequate pain control causes stress hormones to rise and recovery time to be delayed. It causes long-term physical and psychological problems and prolongs hospital stays [19,20]. It has been determined that nociceptive, neuropathic and inflammatory mechanisms play a role in burn pain, and multimodal analgesia methods are recommended to control this pain. For this purpose, nonsteroidal anti-inflammatory drugs, opioid analgesics, non-opioid analgesics, benzodiazepines, narcoleptics, antidepressants, and anticonvulsants can be used. Neuraxial analgesia and peripheral nerve block methods can be applied [20,21]. Additionally, it has been shown in the literature that virtual reality and hypnosis techniques are effective in reducing the patient's anxiety and the severity of pain [19,22,23]. We provided pain control for our patients with intravenous analgesia. For this we used tramadol, morphine, acetaminophen and nonsteroidal anti-inflammatory drugs. Midazolam, haloperidol, and olanzapine were added to the treatment according to the patient's needs. Patient-controlled analgesia, neuraxial/regional anesthesia methods, and lack of use of non-pharmacological methods are the limitations of our pain protocol in our burn clinic.

In conclusion, electrical burns are injuries that cause significant mortality and morbidity. They can cause clinical pictures ranging from minor skin burns to life-threatening organ damage. Considering the pathophysiological changes that develop due to the damage caused by the electric current while passing through the tissues, the patients should be evaluated meticulously in the perioperative period. General or regional anesthesia methods should be chosen according to the selected surgical procedure. Precautions should be taken against possible complications, and these patients should be followed up closely with a multidisciplinary approach.

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Conflict of Interest
The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this manuscript.

Data Availability
The datasets created and/or analyzed during the current study are not publicly available, but are available from the corresponding author upon reasonable request.

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