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Anesthesia Management of Pediatric Burn Patients: A Retrospective Analysis of Patients Treated in a University Hospital

Erol Karaaslan[1], Mehmet Rıdvan Yalın[2], Ahmet Selim Özkan[3], Zekine Begeç[1], Mehmet Demircan[4]

[1]İnönü University Faculty of Medicine, Department of Anesthesiology and Reanimation, Malatya, Türkiye
[2]Mersin University Faculty of Medicine, Department of Anesthesiology and Reanimation, Division of Algology, Mersin, Türkiye
[3]Malatya Turgut Özal University Faculty of Medicine, Department of Anesthesiology and Reanimation, Malatya, Türkiye
[4]İnönü University Faculty of Medicine, Department of Pediatric Surgery, Malatya, Türkiye

ABSTRACT

Introduction: This retrospective study focused on pediatric patients who underwent surgery for burns under anesthesia in our hospital and assessed demographic data, anesthesia management, and risk factors for mortality. The study comprised 278 pediatric patients who were treated in our unit, a major center for burn admissions, between January 2012 and May 2021. All the patients had burns involving more than 10% of the total body surface area.

Methods: Data on the following were collected: patient age, sex, and ethnicity; anesthesia and airway management- and surgery-related procedures; and laboratory test results. The data on the fatal and non-fatal cases and those with/without head and neck burns were compared.

Results: The mean age of the patients was 56.8±42.9 months (range 1-204 months). The number of patients with flame burns was statistically, significantly higher than the number of patients with liquid and electrical burns (54.7%, 37.1%, and 8.3%, respectively) ($p<0.001$). Albumin ($p=0.046$), platelet ($p=0.005$), and calcium ($p=0.001$) values were significantly lower, and blood urea nitrogen ($p=0.024$) and C-reactive protein ($p=0.001$) values were significantly higher in mortality cases than in non-mortality cases. Patients who died were statistically significantly younger ($p=0.023$). For airway management, endotracheal intubation and sugammadex were used significantly more often for head and neck burns than for other types of burns ($p<0.001$).

Conclusion: Appropriate preoperative preparation, including consideration of the anesthetic method and potential complications that may develop during the surgery, is needed in pediatric burn cases. Anesthesia and airway management are important in managing pediatric burn patients.

Keywords: Burn injury, pediatric, mortality, anesthesia, airway device, head-neck burn

Introduction

The skin provides a protective barrier against infections and fluid loss. Burn-induced damage of this barrier increases the risk of infection and fluid regulation disturbances, with the risk increasing with the degree of the burn. Burns can also lead to physiopathological changes in organs and systems (1). Burns can lead to physiopathological changes in organs and systems, depending on the degree of burn. Burn-related changes affecting the cardiovascular system include tachycardia and hypertension. Conditions affecting the pulmonary system include pulmonary hypertension, pulmonary edema, and a decrease in mucociliary activity, which is due to the release of pulmonary system mediators. These changes cause an increase in the incidence of clinical laryngospasms, bronchospasms, and pneumonia (2). In cases of hepatic damage due to burns, elevated liver enzymes and coagulation disorders, such as disseminated intravascular coagulopathy and thrombocytopenia, may develop. Thus, burns are an important cause of mortality and morbidity (3).

Knowledge of burn-related pathophysiological changes is important for the anesthetic management of burn patients. For example, impairment of hepatic and renal clearance due to burns has implications for the pharmacodynamic and pharmacokinetic effects of many pharmacological agents, especially muscle relaxants, which complicates anesthesia management (4). Airway management in children is more difficult than in adults due to their shorter chin, neck, and trachea, in

Address for Correspondence: Assoc. Prof. MD, Erol Karaaslan, İnönü University Faculty of Medicine, Department of Anesthesiology and Reanimation, Malatya, Türkiye
E-mail: erkara44@hotmail.com **ORCID ID:** orcid.org/0000-0002-8534-3680

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addition to the narrowness of the cricoid cartilage and the increased length of the epiglottis. In addition, pathologies, such as burn-induced contractures in the head-neck and chest wall and subglottic stenosis, especially during the recovery period, make mask ventilation and intubation difficult in the pediatric population (5).

Bleeding and fluid loss are the most common complications of burn surgery. Early surgical debridement can reduce blood loss. Fluid replacement is critical for organ perfusion. During anesthesia management, urine output, blood pressure, central venous pressure, and the acid-base balance must be maintained. Blood and fluid replacement are also vital (5).

The purpose of this study was to retrospectively investigate anesthesia management and factors affecting mortality in a pediatric population who underwent burn surgery under anesthesia in our unit between January 2012 and May 2021.

Methods

Study Population

This study included pediatric patients (n=305) who underwent surgery under anesthesia for burns at İnönü University Medical Faculty Hospital (Malatya, Türkiye) between January 2012 and May 2021. Twenty-seven patients with missing hospital records and anesthesia follow-up were not included in the study, as shown in the flow diagram (Figure 1). The final study included 278 pediatric patients with burns involving ≥10% of the total body surface area (TBSA).

Study Protocol

The Non-interventional Clinical Research Ethics Committee of İnönü University approved this study, and the study was prepared in accordance with the Consolidated Standards for Reporting Studies (CONSORT) (6) (approval number: 2022/2818, date: 11.01.2022).

Preoperative Procedures

As premedication, midazolam (dose: 0.5 mg/kg) was administered periorally, as all the patients were older than 1 year and therefore not expected to have a difficult airway. As standard, in all surgical cases, mean arterial pressure (MAP), heart rate (HR), peripheral oxygen saturation (SpO_2), and end-tidal carbon dioxide pressure ($EtCO_2$) monitoring was performed. Electrocardiogram monitoring was performed in all cases, except for patients with severe trunk burns.

Anesthesia Management

An experienced anesthesiologist was in charge of the anesthesia protocol. Propofol (0.5-2 mg/kg), pentothal (5 mg/kg), ketamine (1-2 mg/kg), or ketofol was administered intravenously (IV) for induction of anesthesia after preoxygenation (100% 5 L/minute oxygen for 3 minutes; 1 mg/kg ketamine and propofol mixture, IV). Rocuronium (0.4-0.6 mg/kg) or vecuronium (0.1 mg/kg) was used as a muscle relaxant. Fentanyl (0.5-1 µg/kg) was administered for analgesia during anesthesia induction.

Anesthetic drugs were administered in appropriate doses according to ideal body weight. Ventilation parameters were set to ensure a tidal volume of 6-8 mL/kg and $EtCO_2$ value of 35-45 mmHg. Anesthesia maintenance was provided by inhalation of desflurane or sevoflurane in a 50% oxygen-nitrous oxide mixture. Atropine (0.01-0.20 mg/kg, IV) and neostigmine (0.05 mg/kg, IV) or sugammadex (2-4 mg/kg, IV) were administered to reverse residual muscle relaxation at the end of the surgery.

Patients who opened their eyes in response to a stimulus at the end of the surgery had regular spontaneous breathing, and had SpO_2 of >95% were extubated and taken to the postanesthesia care unit. Patients who were hemodynamically unstable or did not show sufficient respiratory effort after the surgery were intubated and taken to the intensive care unit (ICU).

Outcome Measures

Demographic data on the patients, duration of the anesthesia and surgery, length of stay in the hospital and ICU, cause of burn, burn site, mortality, biochemical data [i.e., glucose, C-reactive protein (CRP), blood urea nitrogen (BUN), albumin, hemoglobin, and platelets], and anesthesia management data were recorded. Anesthesia follow-up data were obtained from the hospital's database. Values for HR, MAP, and SpO_2, along with time intervals T0 (preanesthesia), T1 (5 minutes after intubation), T2 (perioperative 30th minute), and T3 (end of procedure), were recorded. $EtCO_2$ was measured at T1 and T2 time intervals.

Procedural Data

The anesthesia duration was defined as the time from induction to conscious response to verbal commands after the surgical procedure. The time of the surgical procedure was determined as the time from removing the dressing to incision closure. Length of stay was considered as the time elapsed from the patient's admission to the hospital until discharge or death. The ICU duration was determined as the time from admission after anesthesia to the ICU to discharge or death. Hospital mortality was defined as in-hospital death postsurgery.

Postoperative Management

Postoperatively, the patients were observed in the postanesthesia care unit. When a modified Aldrete score of ≥9 was achieved, the patient was transferred to the relevant service (7). For postoperative analgesia, morphine (0.05-0.1 mg/kg, IV), tramadol (0.5-1 mg/kg, IV), or paracetamol (15 mg/kg, IV) was administered in all cases.

Statistical Analysis

Data are displayed as mean, standard deviation, or frequency (percentage). The normality distribution of the data was determined using the Shapiro-Wilk test. Qualitative data, were evaluated by Yates-corrected chi-square test, Pearson's chi-square test, or Fisher's exact test, when appropriate. Pairwise comparisons were analyzed using Pearson's chi-square test with Bonferroni correction. Normally distributed data were compared using an Independent samples t-test. Data where $p<0.05$ were considered statistically significant. IBM SPSS statistics version 25.0 for Windows (New York, USA) was used for statistical analysis. The superscripts a and b indicate the statistical significance of the column proportions at the 0.05 level in the figures.

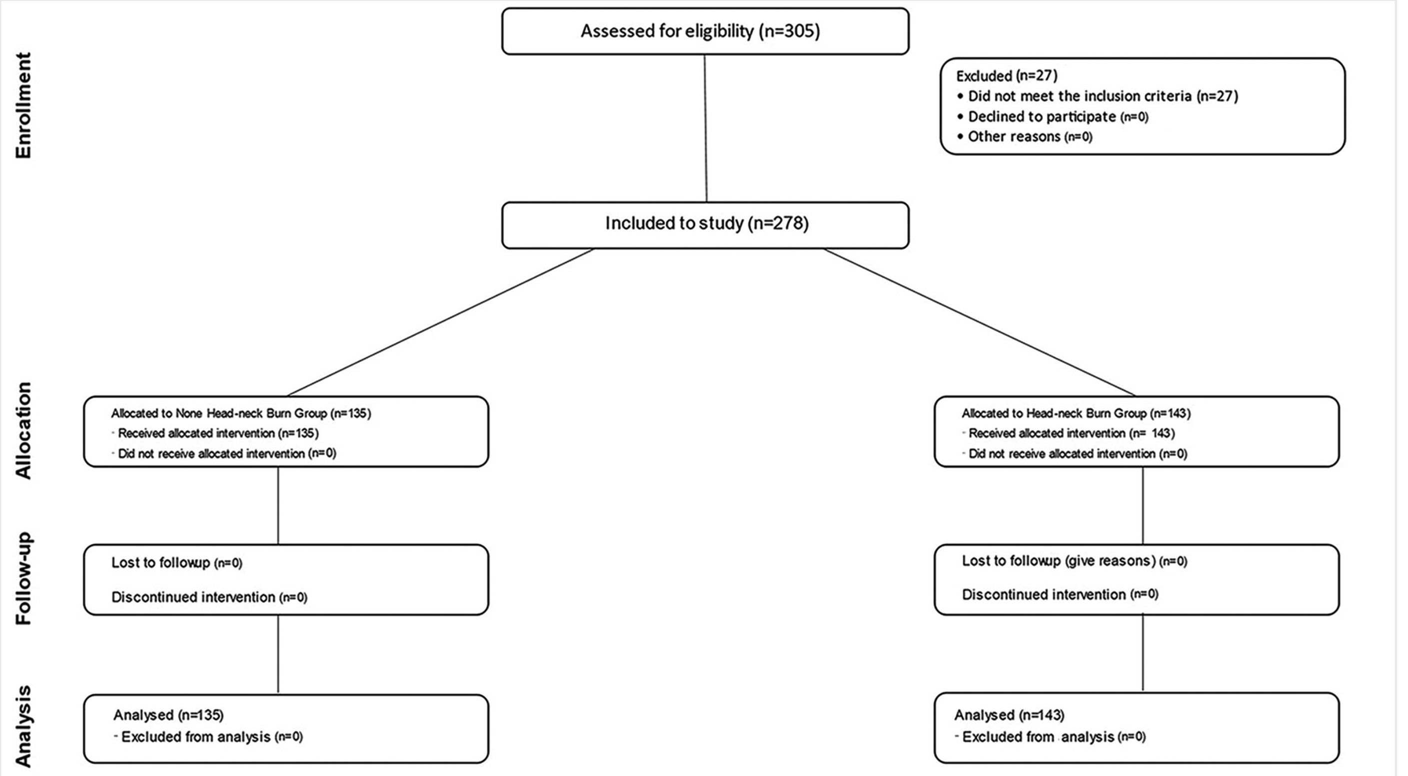

Figure 1. Consort diagram

Results

The mean age of the patients was 56.8±42.9 months (range 1-200). Of the 278 patients, 159 (57.1%) were males, and 119 (42.9%) were females. In total, 133 (47.8%) patients were Turkish citizens, and 145 (52.2%) patients were Syrian nationals.

The number of flame burns was significantly higher than the number of liquid and electrical burns (54.7%, 37.1%, and 8.3%, respectively) ($p<0.001$) (Table 1). The time to hospital discharge (35.2±5.8 days) and ICU stay (35.1±5.8 days) was longer in the flame burn group, with a statistically significant difference ($p<0.001$).

In terms of surgical interventions, the findings were as follows: graft (n=206, 74.1%), debridement (n=60, 21.6%), graft plus amputation (n=5, 1.8%), contracture opening (n=4, 1.4%), flap (n=2, 0.7%), and dressing (n=1, 0.4%). Eleven patients died during the study period (January 2012-May 2021) (mortality rate: 4%). Demographics and procedural-related data are shown in Table 1.

In total, 1.1% of the patients were taken to the operating room while intubated. In 91.5% of cases, general anesthesia was administered. Regional anesthesia or sedoanalgesia was administered in 7.8% and 0.7% of cases, respectively. Oral endotracheal intubation was used in 66.3% of cases, and laryngeal mask airway (LMA) was used in 33.1% of cases. Table 2 provides information on anesthesia management and the mean biochemical values in the laboratory tests.

When we compared the preoperative laboratory values of the mortality and non-mortality cases, the mortality cases were characterized by statistically significantly lower albumin ($p=0.046$), platelet ($p=0.005$), and calcium ($p=0.001$) values and higher BUN ($p=0.024$) and CRP ($p=0.001$) values. The length of hospital stay and ICU stay were shorter among the mortality cases than the non-mortality cases ($p<0.001$). Younger age was significantly associated with mortality ($p=0.023$). Table 3 provides details on the characteristics of the mortality and non-mortality cases.

In terms of the intubation tools used in airway management of the patients with head and neck burns, there was a significant difference in the use of video laryngoscope (VL), LMA, fiberoptic bronchoscope, and direct laryngoscope ($p<0.05$). The results associated with the use of airway devices were not statistically significant (Table 4). The use of endotracheal intubation in the patients with head and neck burns was significantly higher than in those without ($p<0.001$).

The use of rocuronium, a muscle relaxant agent employed in anesthesia induction, was significantly higher in the patients with head and neck burns than in those without head and neck burns ($p<0.001$). The use of sugammadex to reverse the effects of the muscle relaxant was significantly higher in patients with burns of the head and neck than in patients without head and neck burns ($p<0.001$). Head and neck burns were significantly more common among patients of Syrian origin than among those of Turkish origin ($p<0.001$). When the cause of burns was examined, the most common cause was flame burns ($p<0.001$). Characteristics of the face and neck burns are given in Table 5. Figure 2 shows the hemodynamic data of the patients measured at specified times.

Discussion

In this study we evaluated pediatric patients who underwent surgery for burns in our unit, and more than half the patients were foreign nationals. Flame burns were the most frequent, and the most common surgical procedure was the opening of contractures. General anesthesia was applied in the majority of cases. Propofol was preferred as the IV anesthetic agent, and sevoflurane was preferred as the inhalation agent. The use of sugammadex to reverse the effects of muscle relaxants was significantly higher in patients with burns of the head and neck than in patients without these types of burns. The overall mortality rate during the study period was 4%.

Burns are generally more common among boys than girls. In a previous retrospective study, males accounted for 62% of burn cases (8). In another study, 52% of burn cases were male (9). In our study, 57.1% of the burn patients were males, which is consistent with the literature. There is a predominance of face and neck burns, with 58% occurring in males and 42% in females. The preponderance of Syrian burn patients

Table 1. Demographics and procedure data

Gender, n (%)	
Male	159 (57.1)
Female	119 (42.9)
Age (month)	56.8±42.9
ASA score, n (%)	
I	41 (14.7)
II	200 (71.9)
III	36 (12.9)
IV	1 (0.4)
Nationality	
Turkish	133 (47.8)
Syrian	145 (52.2)
Burn cause, n (%)	
Flame	152 (54.7)
Liquid	103 (37.1)
Electric	23 (8.3)
Type of surgery, n (%)	
Debridement	60 (21.6)
Graft	206 (74.1)
Dressing	1 (0.4)
Graft + amputation	5 (1.8)
Contracture	4 (1.4)
Flap	2 (0.7)
Burn percentage, %	40.1±15.9
Duration of surgery, min.	58.7±24.8
Duration of anesthesia, min.	69.7±27.1
Length of hospital stay, day	83.5±48.5
Length of ICU, day	78.7±48.8
Mortality, n (%)	11 (4)

n: Number, %: Percantage, ASA: American Society of Anesthesologists, ICU: Intensive care unit, Min.: Minimum

Table 2. Anesthesia management characteristics and laboratory data

Coming with entubation, n (%)	3 (1.1)
Premedication, n (%)	37 (13.3)
Position, n (%)	
Supine	264 (95)
Prone	12 (4.3)
Lateral	1 (0.4)
Supine + prone	1 (0.4)
Anesthesia management, n (%)	
Sedoanalgesia	2 (0.7)
Regional anesthesia	22 (7.8)
General anesthesia	254 (91.5)
Entubation management, n (%)	
None	2 (0.7)
Oral	184 (66.3)
LMA	92 (33.1)
Exit as intubated, n (%)	2 (0.7)
IV anesthetic used in induction, n (%)	
None	1 (0.4)
Propofol	182 (65.5)
Thiopental	13 (4.7)
Propofol + ketamin	81 (29.1)
Propofol + thiopental	1 (0.4)
Opioid used in induction, n (%)	
Fentanyl	260 (93.5)
Remifentanyl	18 (6.5)
Neuromuscular drug used in induction, n (%)	
None	98 (35.3)
Rocuronium	172 (61.9)
Vecuronium	8 (2.9)
Neuromuscular reversing drug used in induction, n (%)	
None	98 (35.3)
Neostigmine	170 (61.2)
Sugamadex	10 (3.6)
Postoperative analgesic drug, n (%)	
Contramal	23 (8.3)
Morphine	78 (28.1)
Paracetamol	38 (13.7)
Contramal + paracetamol	28 (10.1)
Morphine + paracetamol	111 (40)
Central catheterization, n (%)	15 (5.4)
Blood transfusion, n (%)	70 (25)
CRP (mg/L)	5.2±6.1 (0.2-32)
Glucose (mg/dL)	105.8±25.9 (57-321)
BUN (mg/dL)	9.2±4 (2-29)
Creatinin (mg/dL)	0.4±0.6 (0.23-10.68)
Albumine (g/dL)	2.6±0.7 (0.8-4.6)
Platelet (10^3 cell/mL)	470.1±175.1 (22-1128)
Hemoglobine (g/dL)	10.6±1.7 (6.6-15.9)

n: Patient number, LMA: Laryngeal mask, IV: Intravenous, CRP: C-reactive protein, BUN: Blood urea nitrogen

(52.2%) in our study is likely due to the high number of immigrants in Türkiye and our unit being a major center for burn admissions.

Among burn patients requiring surgery, airway management is one of the main issues complicating anesthesia management, with a high risk of airway edema and respiratory failure, especially in patients with head and neck burns. In these patients, a low-pressure, cuffed endotracheal tube should be used when intubation is indicated to reduce air leakage together with positive pressure ventilator strategies (10). Although the use of a cuffed endotracheal tube in pediatric patients is associated with a risk of tracheal mucosal ischemia and postextubation stridor, this risk can be minimized by using an appropriately sized tube and low cuff pressure (11). In our study, a cuffed endotracheal tube was employed in 68.5% of cases, with an uncuffed endotracheal tube used in the other cases (31.5%). The majority of head and neck burns are caused by flame exposure, which results in inhalation injury.

An airway evaluation should be undertaken before intubation, especially in pediatric patients with head and neck burns because of burn-related edema and exudate on the face. During anesthesia induction, various factors, including facial lesions, nasogastric tubes, and topical antibiotics, complicate mask ventilation. Edema in the glottic and subglottic region due to inhalation burns, and contractures that prevent mandibular and neck mobility makes endotracheal intubation and airway management difficult (12,13). In addition, upper airway obstruction due to edema may cause the airway to collapse during anesthesia induction and make ventilation impossible. For these reasons, alternatives to VL, LMA, and fiberoptic intubation methods should be considered, including awake intubation, for patients with head and neck burns. Surgical release of neck contractures and the possibility of a tracheostomy should also be considered in this population. Waymack et al. (14) reported that a tracheostomy was performed in four neck contracture cases, despite the surgical opening being performed for the contracture. In our study, irrespective of burn type, none of the patients required a tracheostomy for airway management. We attribute this to the use of VL, LMA, and fiberoptic intubation methods in our clinic.

Table 3. Comparison data of cases with and without mortality

	Absent n=267	Present n=11	p-value
Age (month)	55.7±41.9	87.2±58.0	**0.02**3
Length of hospital stay, day	84.9±48.9	48.1±16.0	**0.014**
Length of ICU, day	81.17±48.2	20.36±12.0	**<0.001**
Burn percentage, %	39.21±14.6	63.18±26.6	**<0.001**
Glucose (mg/dL)	105.3±25.8	118.6±24.2	0.096
BUN (mg/dL)	9.1±3.8	11.9± 6.4	**0.02**4
Creatinin (mg/dL)	0.4± 0.6	0.4±0.1	0.839
Albumine (g/dL)	2.68±0.78	2,2±0.79	**0.046**
Platelet (10^3 cell/mL)	476±173.3	325.4±163	**0.005**
Hemoglobine (g/dL)	10.6±1.7	10.5±2.5	0.970
CRP (mg/L)	4.7±5.6	16.8±6.6	**<0.001**
Calsium	9.3±0.8	8.1±0.8	**0.001**

ICU: Intensive care unit, n: Number, %: Percentage, BUN: Blood urea nitrogen, CRP: C-reactive protein

Table 4. Characteristics of devices used in airway management

Head-neck burn			
Airway devices	**None n (%)**	**Present n (%)**	**p-value**
DL	43^a (31.9)	28^a (19.6)	
VL	18^a (13.3)	56^b (39.2)	
LMA	62^a (45.9)	31^b (21.7)	
FB	12^a (8.9)	28^b (19.6)	**<0.001**
Total	135 (100.0)	143 (100.0)	

^{a,b}: Different superscript letters denote significantly different column proportions at the 0.05 level. DL: Direct laryngoscopy, VL: Video laryngoscope, LMA: Laryngeal mask airway, FB: Fiberoptic bronchoscope

Previous studies reported many potential benefits of regional anesthesia in burn cases, especially in the postoperative period, due to its analgesic effects (15,16). In our study, general anesthesia was applied in 91% of cases and regional anesthesia was applied in 7.8% of cases. The burn distribution, with the burns located in many areas rather than in a single one, as well as the patient population (i.e., pediatric) may explain the reduced use of regional versus general anesthesia in our study.

Major burns are a significant cause of mortality in the pediatric population (3). Kraft et al. (17) reported mortality in 120 (13%) of 952 pediatric burn patients. In their study, the mortality rate was 7 (3%) of 260 cases with 40-49% TBSA burns, 12 (7%) of 171 cases with 50-59% TBSA burns, and 19 (22%) of 85 cases with 70-79% TBSA burns. They reported that the incidence of mortality increased as the TBSA burn increased. In our study, the TBSA burn was 40.1±15.9%, and 11 (4%) of the 278 patients died.

The mortality rate for patients with head and neck burns was 5.6% in our study. When we compared the preoperative laboratory values of the mortality and non-mortality cases, the mortality cases were characterized by statistically significantly lower albumin ($p<0.046$), platelet ($p<0.005$), and CRP ($p<0.001$) values, and statistically significantly higher BUN values ($p<0.024$). These results point to a significant relationship between laboratory values and mortality in burn cases. In addition, we found a significant relationship between mortality and burn percentage, time to hospital discharge, length of stay in the ICU, burn site (head and neck), and age. In another study, burn percentage, burn type, and age were risk factors for mortality among pediatric burn cases (18).

During the acute phase of a burn, systemic edema affects hemoconcentration, causing an increase in hematocrit, and blood viscosity. Anemia may occur later due to hemolysis of erythrocytes caused by the burn-induced rise in the temperature, blood loss in the wound area, and dilution due to fluid resuscitation (3). Burns, also lead to changes in hemoglobin, and excision and grafting interventions in burn surgery cause high blood loss, depending on the size of the surgical area (19). Thus, a blood transfusion is frequently necessary in pediatric burn cases (20). Wittenmeier et al. (21) reported that 11 (22.4%) of 138 pediatric burn cases, with a mean age of 21 (9-101) months and TBSA burn of 30%, required a blood transfusion. In a mixed multicenter retrospective study consisting of adult and pediatric burn cases, 75% of patients with TBSA burns of >20% received a blood transfusion (22).

Table 5. Characteristics of head-neck burn

Characteristics	Head-neck burn		p-value
	None (n=135)	Present (n=143)	
ASA score, (I/II/III/IV)	19/99/16/1	22/101/20/0	0.793
Arterial monitoring, n (%)	135 (48.6)	143 (51.4)	0.788
Gender, (M/F), n (%)	76/58 (56.7/43.3)	83/60 (58/42)	0.903
Coming with entubation, n (%)	2 (1.5)	1 (0.7)	0.613
Entubation management, n (%), (none/oral/LMA)	1/73/61 (0.7/54.1/45.2)	1/111/31 (0.7/77.6/21.7)	**<0.001**
IV anesthetic used in induction, n (%) (propofol/thiopental/propofol + ketamin/propofol + thiopental)	1/96/6/32/0 (0.7/71.1/23.7/0)	0/86/7/49/1 (0/60.1/34.3/0.7)	0.141
Neuromuscular drug used in induction, n (%), (none/rocuronium/vecuronium)	64/68/3 (47.4/50.4/2.2)	34/104/5 (23.8/72.7/3.5)	**<0.001**
Opioid used in induction, n (%) (none/fentanyl/remifentanyl)	5/128/2 (3.7/94.8/1.5)	11/132/0 (7.7/92.3/0)	0.099
Mortality, n (%)	3 (2.2)	8 (5.6)	0.219
Position, n (%) (supine/prone/lateral/supine + prone)	123/11/0/1 (91.1/8.1/0/0.7)	141/1/1/0 (98.6/0.7/0.7/0)	**0.002**
Neuromuscular reversing drug used in induction, n (%) (none/neostigmine/sugammdex)	64/69/2 (47.4/51.1/1.5)	34/101/8 (23.8/70.6/5.6)	**<0.001**
Central catheterization, n (%)	5 (3.7)	10 (7)	0.291
Nationality, n (%), (Turkish/Syrian)	86/49 (63.7/36.3)	47/96 (32.9/67.1)	**<0.001**
Burn cause, n (%), (flame/liquid/electric)	48/71/16 (35.6/52.6/11.9)	104/32/7 (72.7/22.4/4.9)	**<0.001**
Presence of difficult airway, n (%)	133/2 (98.5/1.5)	136/7 (95.1/4.9)	0.714
Uncuffed/cuffed ETT, n (%)	32 (43.9)/41 (56.1)	13 (11.8)/98 (88.2)	**<0.001**

ASA: American Society of Anesthesologists, n: Number of patient, M: Male, F: Female, LMA: Laryngeal mask airway, IV: Intravenous, ETT: Endotracheal tube

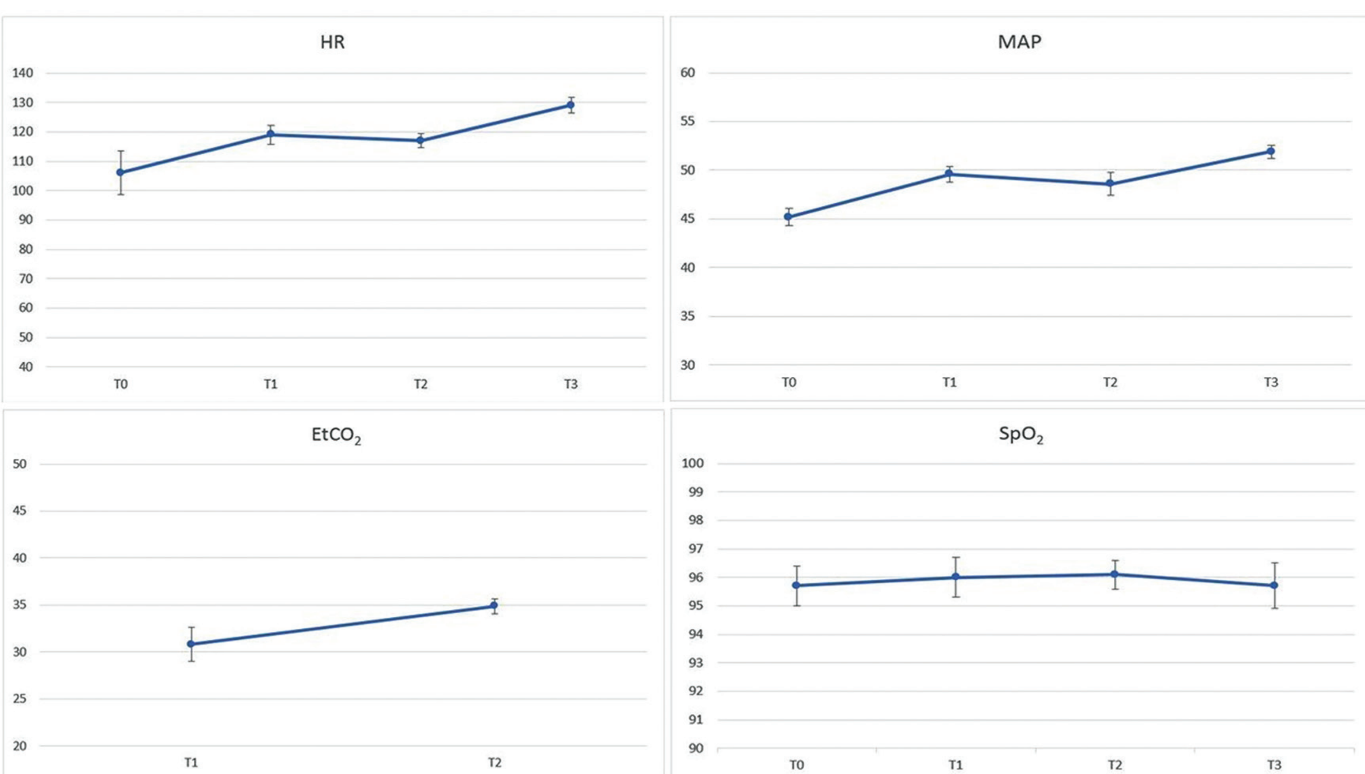

Figure 2. Hemodynamic data of patients (HR, MAP, $EtCO_2$ ve SpO_2)
T0: Before anesthesia, SpO_2: Peripheral oxygen saturation, $EtCO_2$: End-tidal carbon dioxide pressure, MAP: Mean arterial pressure, HR: Heart rate

In our study, 70 (25%) of the 278 patients required a blood transfusion. Differences in the average age of the patients and percentage of TBSA burn may explain the variability in reported blood transfusion rates.

Muscle relaxants are used in burn cases. The muscle relaxant dosage may need to be adjusted due to potential drug resistance. Burn patients may show an excessive hyperkalemic response as a result of hypersensitivity to succinylcholine (23). Therefore, potassium values should be taken into account in the preanesthetic evaluation. In our study, succinylcholine was not used because of the possibility of a hyperkalemic response.

At least 50% of burns in the general population (i.e., children and adults) are located in the head and neck region. Male sex, young age, and flame burns are the primary risk factors for head and neck burns in the general population (24). In our study, the patients were divided into two groups according to the presence or absence of head and neck burns. In line with the literature, 51.4% of our patients had head and neck burns. In our pediatric population, 58% of the patients with head and neck burns were males, and a flame was the cause in 72.7% of cases.

Neostigmine is widely used to reverse neuromuscular blockade in general anesthesia. In a previous study that compared adverse effects of sugammadex and neostigmine, sugammadex was associated with fewer cardiovascular, respiratory, and postoperative side effects (25). In a review of 26 studies on the reversal of neuromuscular blockade using sugammadex or neostigmine, sugammadex reversed neuromuscular blockade faster and was safer than neostigmine (26). In our study, sugammadex was used significantly more frequently in patients with head and neck burns than in patients with other types of burns ($p<0.001$). We attribute the use of sugammadex in these patients to concerns about the risk of cardiac, respiratory, and postoperative side effects. In the present study, the use of rocuronium was significantly higher among patients with head and neck burns than among patients without these types of burns ($p<0.001$). According to previous research, sugammadex rapidly reverses the neuromuscular blockade effects of rocuronium, suggesting that sugammadex may be useful for airway management and reducing postoperative complications (e.g., edema, ventilation and intubation difficulties, limited mouth opening, and restrictions in neck movements due to contracture) (25,26). Endotracheal intubation may be preferable to sugammadex for pediatric burn patients due to safer airway management and other factors (e.g., aspiration, edema, or air leakage) associated with sugammadex that complicate ventilation (27). In this study, the use of oral endotracheal intubation was statistically, significantly higher among patients with head and neck burns than among patients without these types of burns.

Study Limitations

This study has a few limitations. First, the small number of patients is a limitation. Second, the study included only pediatric patients. A further study should investigate whether similar results would be found in an adult population. In addition, this was a single-center study. A multicenter study would have shed light on the outcome of anesthetic management and surgical methods in a range of settings. Finally, this was a retrospective study. A prospective study would have required more specific information regarding the exact variables or data needed for analysis.

Conclusion

There is a significant relationship between mortality and the burn percentage, length of hospital stay, length of stay in the ICU, burn site (face and neck), and younger age. We conclude that the use of VL, LMA, and fiberoptic intubation methods, especially in airway management of head and neck burns, may reduce the need for a tracheostomy in pediatric burn patients. Appropriate preoperative preparation is needed in pediatric burn cases, with such preparation including consideration of anesthetic management methods and potential surgery-related complications.

Ethics

Ethics Committee Approval: The Non-interventional Clinical Research Ethics Committee of İnönü University approved this study (approval number: 2022/2818, date: 11.01.2022).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions: Surgical and Medical Practices - M.D.; Concept - E.K., A.S.Ö.; Design - E.K., M.R.Y., A.S.Ö.; Data Collection or Processing - M.R.Y.; Analysis or Interpretation - E.K., A.S.Ö., Z.B.; Literature Search - E.K., M.R.Y., A.S.Ö., Z.B.; Writing - E.K., A.S.Ö.

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