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RESEARCH ARTICLE

Is Blood Transfusion a Trigger for Bloodstream Infections in the Pediatric Burn Intensive Care Unit?

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ABSTRACT

Objectives: This study aims to evaluate potential triggers of bloodstream infections in pediatric patients admitted to burn intensive care units.

Methods: In this retrospective, cross-sectional study, we analyzed data from 70 pediatric patients, aged between 3 and 211 months, who were followed in the Burn Intensive Care Unit of our hospital over a five-year period between 2020 and 2024.

Results: The mean age of the 70 pediatric patients was 79±87 months. The causes of burns were flame in 34%, scalding with hot water in 54%, and electrical burns in 9% of cases. The majority of patients (83%, n=58) had partial-thickness burns. The most commonly affected body region was the trunk (12.96%), followed by the head and neck region (6.21%). Total body surface area (TBSA) burned, length of ICU stay, and number of surgical interventions were higher in the transfused group. The mean pre-transfusion hemoglobin (Hb) level was 8.61 g/dL, which increased to 8.97 g/dL post-transfusion. In total, 29 patients received an average of 6.67 units of erythrocyte suspension (ES) and 4.09 units of fresh frozen plasma (FFP). Blood cultures revealed coagulase-negative *Staphylococci* (CoNS) in five patients and *Acinetobacter baumannii* in another five.

Conclusion: In pediatric patients (aged 0 to 215 months) followed in the Burn Intensive Care Unit, an increase in total body surface area (TBSA) burned is associated with longer ICU stays, a higher number of surgical interventions, increased transfusion of blood components, and a greater incidence of bloodstream infections.

Keywords: Blood transfusion; bloodstream infections; burn intensive care unit; pediatric burns

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Introduction

Burn injuries are among the leading causes of accidental death in the pediatric population. The extent and depth of skin damage resulting from burns are critical determinants of clinical severity. Key factors influencing burn-related tissue injury include the temperature of the burning agent, duration of exposure, skin thickness, and the specific mechanism of injury. While scald injuries are generally superficial, flame and electrical burns tend to cause deeper tissue damage. Although burn injuries may initially appear localized, their physiological effects are systemic.

In the acute phase, significant complications may arise, such as immune system suppression, disruption of the skin barrier that increases susceptibility to infections, respiratory involvement in cases of smoke inhalation, cardiac arrhythmias associated with electrical burns, and potential neurological sequelae due to nerve damage. In the medium and long term, patients may experience

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limb loss, organ dysfunction, joint contractures, aesthetic deformities, and psychological trauma.

Burn injuries are classified based on etiology into scalds, flame burns, electrical burns, contact burns, and chemical burns. Among pediatric patients, scald burns are the most common, followed by flame and electrical burns.

Burn injuries resulting from domestic accidents represent a significant public health concern. The skin serves as the body's first line of defense against microbial invasion. Pediatric burn patients require specialized care due to their unique anatomical and physiological characteristics, which make them more susceptible to complications. Hospitalization rates due to burn injuries vary between countries and are influenced by healthcare reimbursement systems. However, trends in most countries indicate a reduction in the length of hospital stays and an increase in the proportion of patients treated in specialized burn centers.

According to data from the Turkish Statistical Institute (TurkStat), the mortality rate due to external injuries and poisonings in Türkiye increased by 63.53% between 2009 and 2019 compared to previous years. Moreover, TurkStat's 2019 statistics on causes of death reveal that the majority of deaths among children aged 1–17 years (0–215 months) were attributable to external injuries and poisonings.[1]

Children, despite having smaller body sizes, possess a relatively larger body surface area per unit of mass compared to adults. Cardiac function, circulating blood volume, and baseline hemoglobin (Hb) concentrations in pediatric patients are age-dependent, resulting in a higher transfusion volume requirement per kilogram of body weight. An optimal Hb threshold for initiating transfusion in pediatric burn patients has not yet been established. To improve clinical outcomes and patient safety, patient blood management programs have been developed to optimize the use of blood products. Following evidence from prospective clinical trials demonstrating the safety of transfusions at lower hemoglobin thresholds, a restrictive transfusion approach is now advocated in scenarios where the risk of impaired oxygen delivery is increased.[2,3] Recent studies have focused on establishing evidence-based transfusion thresholds for pediatric burn patients who frequently require erythrocyte suspension (ES) transfusions during hospitalization. Considering the immunosuppressive state induced by severe burns and the potential immunomodulatory effects of transfusion, a restrictive transfusion strategy may offer particular benefits in this population. Data from prospective studies in adult burn patients have shown comparable clinical outcomes between restrictive and liberal transfusion strategies.[4–6] Normal hemoglobin (Hb) levels in children vary according to age and differ from adult reference ranges. Newborns typically are born with an Hb concentration of approximately 19 g/dL, which decreases to a nadir of 11.2 g/dL between two and three months of age. Subsequently, levels stabilize around 13 g/dL during later childhood.[7] The increased transfusion rate relative to blood volume in pediatric patients elevates the risk of transfusion-associated metabolic disturbances. These include hyperkalemia, hypomagnesemia, hypothermia, acidosis, and hypocalcemia, which may arise from both transfused erythrocyte suspensions and preservative solutions such as citrate used in blood storage.[8]

Methods

This retrospective cross-sectional study was conducted in the Burn and Wound Intensive Care Unit of Health Sciences University Kartal City Hospital, which consists of six mixed (adult and pediatric) intensive care beds. A total of 70 pediatric patients, aged between 3 and 211 months, who were admitted and treated in the burn center between 2020 and 2024 were included in the study. Patient data were retrospectively obtained through medical records and digital hospital databases.

The variables collected included age, gender, causes of burns, total body surface area (TBSA), burn depths, hemoglobin (Hb) levels at admission to and discharge from the ICU, surgical interventions performed, length of ICU stay (days), mean Hb values before and after transfusion, and microorganisms isolated from blood cultures.

The causes of burns included flame, scalding with boiling water, electrical injury, and exposure to hot oil. The total body surface area (TBSA) affected by burns was recorded based on clinical documentation in patient files. Blood culture samples obtained from treated patients and sent to the medical microbiology laboratory were analyzed using the BacT/ALERT 3D automated blood culture system (BioMérieux, France). Positive cultures were first inoculated onto blood agar, eosin methylene blue (EMB), and chocolate agar media for bacteriological identification and incubated. Colony morphology of the isolated microorganisms was examined by Gram staining, and appropriate biochemical tests (catalase, oxidase, coagulase tests) were performed. Identification and antibiotic susceptibility testing were conducted using the Vitek 2 Compact automated system (BioMérieux, France).

Ethical Approval

Approval was obtained from the Scientific Research Ethics Committee of University of Health Sciences, Kartal Dr. Lütfi Kırdar City Hospital (Approval date: March 26, 2025; Approval number: 2025/010.99/14/18). This study was conducted in accordance with the Declaration of Helsinki.

Table 1. Clinical characteristics of burn patients with and without blood transfusion

Variables	Transfusion group (n=29)		Non-transfusion group (n=41)		Total (n=70)	
	n	%	n	%	n	%
Mean age (months)	98		55		73	
Gender						
Male	23	79.3	25	61.0	48	68.6
Female	6	20.7	16	39.0	22	31.4
Flame burn	15	51.7	9	22.0	24	34.3
Electrical burn	3	10.3	3	7.3	6	8.6
Scald burn (hot water)	11	37.9	27	65.9	38	54.3
Hot oil burn	0	0.0	2	4.9	2	2.9
Inhalation injury	1	3.4	0	0.0	1	1.4
TBSA (%)	32.24		17.66		24.11	
Partial-thickness burn	25	86.2	33	80.5	58	82.9
Partial/Full-thickness burn	0	0.0	5	12.2	5	7.1
Full-thickness burn	4	13.8	3	7.3	7	10.0
Burn ICU length of stay (days)	16.93		4.22		9.49	

Data are presented as mean±standard deviation (SD) or number (percentage). TBSA: Total body surface area; ICU: Intensive care unit.

Statistical Analysis

Data obtained in the study were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro-Wilk test. Variables with a normal distribution were expressed as mean±standard deviation (SD). Independent samples t-test was used to compare continuous variables between two groups. For variables not showing normal distribution, the Mann-Whitney U test was applied. The distribution of categorical variables between groups was analyzed using the chi-square test or Fisher's exact test when the sample size was insufficient. A p-value of<0.05 was considered statistically significant.

Results

Of the 70 patients, 69% (n=48) were male and 31% (n=22) were female. The mean age of the transfused group was 98 months, whereas the control group had a mean age of 55 months. Flame burns were observed in 24 patients (34%), of whom 63% (n=15) were in the transfused group, and this difference was statistically significant (p=0.021). Only one of these children had inhalation injury. Among 38 children (54%) who sustained scald burns from boiling water, 71% (n=27) did not receive transfusion. There was no significant association between transfusion and exposure to boiling water burns (p>0.05). Of the six patients (9%) with electrical burns, half (n=3) received transfusions while the other half did not. Neither of the two patients (3%) exposed to hot oil received transfusions (Table 1). Burn rates in all regions except the right gluteal and genital areas were higher in the transfused group (Table 2). The most affected areas were the anterior trunk (6.76%) and posterior trunk (6.20%), followed by the head (4.48%). Surgical interventions, including grafting, debridement, fasciotomy, and escharotomy, were significantly clustered in the transfused group (p<0.0001, Table 3).

Table 2. Percentage of body surface area affected by burn

Burn areas	Transfusion group (%)	Non-transfusion group (%)	Total (%)
Head	4.96	4.10	4.48
Neck	2.36	0.98	1.73
Anterior trunk	8.09	5.63	6.76
Posterior trunk	6.74	5.58	6.20
Right upper arm	2.50	1.50	2.03
Right forearm	2.00	1.36	1.74
Right hand	2.07	0.95	1.53
Left upper arm	2.68	1.69	2.15
Left forearm	1.78	1.59	1.68
Left hand	1.59	0.84	1.19
Right thigh	4.09	3.58	3.83
Right leg	3.73	2.91	2.91
Right foot	3.21	1.47	2.34
Left thigh	4.71	2.92	3.85
Left leg	3.35	1.44	2.56
Left foot	2.44	0.81	1.73
Right gluteus	1.88	1.90	1.88
Left gluteus	2.33	1.10	1.77
Genital	0.80	1.00	0.83

Table 3. Comparison of various parameters between transfusion and non-transfusion groups

Parameters	Transfusion group	Non-transfusion group	p
Grafting (%)	2.10	0.05	<0.0001
Debridement (%)	2.00	0.10	<0.0001
Fasciotomy (%)	1.00	0.00	<0.0001
Escharotomy (%)	6.12	0.03	<0.0001
Hemoglobin at ICU admission (g/dL)	13.53	12.17	
Hematocrit at ICU admission (%)	40.14	45.14	
Platelet count at ICU admission (×10^3/µL)	400.6	323.2	
WBC count at ICU admission (×10^3/µL)	21.81	15.43	
Hemoglobin at ICU discharge (g/dL)	9.27	10.69	
Hematocrit at ICU discharge (%)	27.61	48.04	
Platelet count at ICU discharge (×10^3/µL)	368.9	356.4	
WBC count at ICU discharge (×10^3/µL)	11.02	12.07	
Pre-transfusion hemoglobin (g/dL)	8.61	–	
Post-transfusion hemoglobin (g/dL)	8.97	–	

ICU: Intensive care unit; WBC: White blood cell.

The mean hemoglobin (Hb) level upon ICU admission in the transfused group was 13.53 g/dL, which decreased to 9.27 g/dL on the day of ICU discharge. In the non-transfused group, the mean Hb level at ICU admission was 12.17 g/dL and 10.69 g/dL on the day of ICU discharge. Among the 29 patients who received transfusions, an average of 6.67 units of erythrocyte suspension (ES) and 4.09 units of fresh frozen plasma (FFP) were administered. The mean Hb level before ES transfusion was 8.61 g/dL, which increased to 8.97 g/dL post-transfusion (Table 3).

No microorganisms were isolated from blood cultures in the non-transfused group. In the transfused group, a total of 11 microorganisms were isolated from eight patients. Among these, five were *Acinetobacter baumannii*, five were coagulase-negative *Staphylococci* (including *Staphylococcus haemolyticus, Staphylococcus epidermidis, Staphylococcus hominis*), and one was *Pseudomonas aeruginosa*.

Discussion

Burns affecting more than 20% of the total body surface area (TBSA) are classified as severe burns and lead to pathophysiological changes both at the burn site and in distant tissues due to a cytokine storm.[9,10] In our study, a total of 70 pediatric patients were admitted to the burn ICU and monitored over a five-year period. Of these, 29 patients received blood transfusions, while 41 patients comprised the non-transfused control group. Although patient numbers were uneven due to the retrospective nature of the study, the data remain reliable. In both groups, male patients predominated (Table 1). The mean age of patients in the transfused group was higher compared to the control group (98 months vs. 55 months, Table 1).

Children are particularly vulnerable to burn injuries, which constitute the fifth most common cause of non-fatal childhood trauma. Children and women are frequently burned in domestic kitchen accidents involving overturned containers, hot liquids, or stove explosions with open flames. While burn-related mortality rates have declined in high-income countries, they remain approximately seven times higher in low- and middle-income countries.[11] Compared to previous literature, the distribution and prevalence of burn types have changed, which may be attributed to shifts in socioeconomic conditions, heating methods, and improved public education regarding the prevention of childhood burns.

Analysis of burn distribution revealed that 49.1% of burns involved the trunk and extremities, 36% affected the head-face-neck region, 10.3% involved the hands, 3.4% the perineum, and 1.1% affected both the hands and face.[12] In a recent study conducted in Türkiye, one of the few in this field, the mean age of 828 patients was found to be 3.4±4.9 years. Among these, 77.3% sustained scald burns, 9.3% flame burns, and 6.7% electrical burns. The most frequently affected areas were the extremities and trunk (59.1%), head-neck-face (30.5%), hands (19.2%), and perineum (4.7%).[13]

In our study, the most common cause of burns was scalding from boiling water (54%), with children frequently affected while eating or in the kitchen. The second most common cause was exposure to flames (34%). Flame exposure generally resulted from domestic accidents, although some cases occurred during picnics. Among adult burn patients, flame exposure was more often related to occupational hazards, and inhalation burns were more common compared to children. Only one inhalation burn was identified in the pediatric group, which was not severe and did not result in mortality.

When comparing flame burns to scald burns, we found that patients exposed to flames were more likely to require blood transfusions (Table 1). This was attributed to the larger total body surface area (TBSA) affected and the deeper nature of flame burns. Six children sustained electrical burns while playing with electrical outlets at home. Although the burn incidence was low (0.3–0.5%), careful evaluation is necessary as all tissue layers were affected. Half of these cases required blood transfusion. Two patients suffered burns from hot oil in the kitchen; however, due to the low TBSA involved, surgical intervention was not needed, nor was blood transfusion required.

The percentage of total body surface area (TBSA) played a decisive role in the need for surgical intervention and blood transfusion. Approximately 83% of the patients sustained partial-thickness burns (Table 1). Regardless of burn depth, an increase in affected TBSA was associated with a higher likelihood of requiring surgery and transfusion. Since most injuries resulted from domestic accidents, partial/full-thickness burns (7%) and full-thickness burns (10%) were relatively uncommon (Table 1). Patients who received blood transfusions had an average length of stay in the intensive care unit (ICU) of 16.93 days, compared to 4.22 days in the control group (Table 1).

Regarding the burn locations, the anterior and posterior trunk were the most frequently affected areas, with an average involvement of 12.96%. This was followed by the head (4.48%), right lower extremity (9.03%), left lower extremity (8.14%), right upper extremity (5.3%), and left upper extremity (5.02%) (Table 2). The genital region was the least affected, with an average involvement of 0.83%.

Debridement, escharotomy, fasciotomy, and grafting procedures were performed almost exclusively in the transfused group of burn patients, and this association was statistically highly significant ($p<0.0001$, Table 3). Within the transfused group, a significant correlation was observed between patients' hemoglobin (Hb) levels on the first and last days of their intensive care unit (ICU) stay ($p<0.05$). The mean Hb value at admission was 13.53 g/dL, which decreased to 9.27 g/dL on the day of ICU discharge despite transfusion. In the control group, where no transfusions were administered, the decrease in Hb levels was not statistically significant ($p>0.05$). This finding was attributed to the higher TBSA involvement and the more frequent surgical interventions in the study group.

Optimization of transfusion practices requires a comprehensive understanding of burn pathophysiology, the risks and benefits of transfusion, and appropriate clinical indications. The age of the child also plays a significant role in determining transfusion requirements. Pediatric physiology differs from that of adults and must be taken into account prior to the administration of blood and blood products.[8] In a single-center study conducted by García-Diaz et al.,[14] 27.2% of 147 pediatric burn patients required an average of 8 units of blood transfusion.

In the transfused group, an average of 6.67 units of red blood cell suspension were transfused per patient. The same group received an average of 4.09 units of fresh frozen plasma per patient. In our study, the difference between pre- and post-transfusion hemoglobin (Hb) levels was not statistically significant ($p>0.05$, Table 3). The mean Hb level before transfusion was 8.61 g/dL, and after transfusion, it was maintained at 8.97 g/dL, reflecting the implementation of a restrictive transfusion strategy. This restrictive transfusion approach did not have an adverse effect on mortality.

Microbial growth was observed exclusively in the transfused group, which was not incidental. As the TBSA affected by burns in pediatric patients increases, the need for surgical intervention, length of stay in the ICU, and risk of blood transfusion also increase. Longer ICU stays in the study group, associated with higher TBSA (32.24% compared to 17.66% in the control group), further elevate the risk of bloodstream infections. Both burn injury and blood transfusion suppress immunity, facilitating the development of bloodstream infections. In one study, bloodstream infections were identified in 1.9% of patients, with CoNS responsible for 40% of the cases, and a reported mortality rate of 1%.[13]

In a multicenter study evaluating blood transfusions in burn patients conducted by Palmieri et al.,[6] bloodstream infections were observed in 24% of 217 participants. Santarelli and colleagues reported that the most common causative agents of bloodstream infections in the pediatric burn intensive care unit were Gram-positive bacteria such as *Staphylococcus aureus* and CoNS, as well as *Pseudomonas aeruginosa*.[15] Our study supports these findings. Among the 11 isolated microorganisms, five were CoNS, five were *Acinetobacter baumannii*, and one was *Pseudomonas aeruginosa*.

In another national study, the average length of stay in the intensive care unit (ICU) was reported as 14 days, with a mortality rate of 2.08%.[16] Advances in ICU resources and surgical techniques have contributed to reductions in morbidity and mortality; however, they have also led to prolonged ICU stays.

Cohort studies investigating changes in transfusion practices in pediatric burn patients have demonstrated that restrictive transfusion strategies do not adversely affect patient outcomes and may be cost-effective. Nevertheless, current transfusion practices and adherence to existing guidelines in pediatric populations have not been sufficiently studied.[17] We advocate for the implementation of a restrictive transfusion strategy in the pediatric burn ICU.

Conclusion

Children represent a significant proportion of burn injury cases worldwide and often sustain severe injuries requiring critical and surgical interventions. However, critical care capacity in contributing centers is frequently limited, making the improvement of healthcare systems a priority to prevent avoidable mortality and morbidity. Due to age-related physiological differences, variations in body mass proportions, and immature cardiac and immune systems, children have variable and complex transfusion needs following burn injuries. Optimizing the treatment of pediatric burn patients necessitates a thorough understanding of these specific challenges and careful evaluation of the impact of transfusion on patient outcomes.

In pediatric burn intensive care units, the development of bloodstream infections is influenced by older age, increased total body surface area (TBSA), prolonged length of stay in the ICU, and a higher number of surgical interventions. Blood transfusion and bloodstream infections are also integral components of this process.

Disclosures

Ethics Committee Approval: The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Scientific Research Ethics Committee (no: 2025/010.99/14/18, date: 26/03/2025).

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