Evaluation of Healthcare-Associated Infections in Children in a Burn Center

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ABSTRACT

Objective: Infections are major causes of morbidity and mortality in burn patients. The most common infections include wound infection, bloodstream infections, and sepsis. *Pseudomonas aeruginosa* and *Staphylococcus aureus* are the most common organisms. The aim of this study was to determine the epidemiological characteristics of patients, causes of burns, infections, responsible microorganisms, and treatment strategies.

Methods: This was a cross-sectional study. The medical records of burn patients aged between 1 month and 18 years in 2012-2018 were retrospectively reviewed. Age, sex, length of hospital stay, severity of burns, burn type, burn site, burn percentage, applied interventions and treatments, infections, and prognosis were recorded. Infection definitions were determined according to the National Health Service Associated Infections Surveillance Guide. Microorganisms at surgical sites and in blood, urine, and tracheal aspirate samples, and antimicrobial susceptibilities were recorded.

Results: In total, 878 patients were included in the study. The most common etiology was scalding (77.3%), and the most frequently injured anatomical areas were the trunk and extremities (59.1%). The prevalence of total infection was 12.6%. Forty-four of the total infections were sepsis, 23 were wound infections, 19 were urinary tract infections, and 17 were bloodstream infections. *P. aeruginosa* was detected in 5 patients, *Escherichia coli* in 17, *Klebsiella pneumonia* in 3, *S. aureus* in 8, *Enterococcus spp.* in 6, and coagulase-negative staphylococci in 20. Presence of catheter and percentage of burn surface area were significantly higher and the duration of hospitalization was significantly longer in patients with infection.

Conclusion: At pediatric burn centers, the identification of infectious agents, development appropriate antibiotic strategies, avoidance of the use of prophylactic antibiotics, and strict adherence to isolation measures will reduce the risk of infection.

Keywords: Burn, burn center, children, infection

INTRODUCTION

Burns, which usually occur as a result of home accidents, are a major public health problem. The skin is a physical barrier that provides protection against microorganisms, and the degradation of skin integrity due to burns may cause the introduction of microorganisms into the body and the development of invasive infections (1). Furthermore, the necrotic tissues formed after burns provide an appropriate medium for microorganism growth. Although the burned surface is initially mostly sterile, it soon becomes contaminated with microorganisms. In burn cases, the risk of infection increases owing to heat damage, invasive procedures, use of catheters, bacterial colonization of the burn wound, translocation of the gastrointestinal microbiota, and length of hospitalization (2, 3). Infections are an important cause of morbidity and mortality in burn patients. Although the types of infections vary among centers, the most common infections include surgical site infection, bloodstream infection, sepsis, ventilator-associated pneumonia, and urinary tract infections (UTIs). *Pseudomonas aeruginosa* is the most common cause of surgical

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site infection and UTI, and methicillin-resistant *Staphylococcus aureus* is the most common cause of bloodstream infection (3, 4). The aim of this study was to determine the epidemiological characteristics, the causes of burns, the types of infections in patients, the microorganisms involved, the antibiotic susceptibility of the microorganisms, and the treatments applied to pediatric patients who were monitored in the burn center.

METHODS

Karadeniz Technical University (KTU) School of Medicine Farabi Hospital, which has 780 services and 77 intensive care beds, provides services in the Black Sea Region with four intensive care units and eight service-bed burn units. A total of 150–200 children are followed annually in the burn unit. This study is a cross-sectional study involving children between the ages of 1 and 18 years old who were hospitalized in the burn center of KTU Medical Faculty Farabi Hospital between 2012 and 2018. Patient information was retrospectively reviewed from files and computer records. Given that this study was retrospective, no consent was obtained from the patients and their relatives. The following patient data were included in the study, namely, age, gender, length of stay, severity of burn, burn type, burn site, burn percentage, applied interventions, infection, treatment, and prognosis. Burn types were classified as flame burn, hot liquid burn, electric burn, and hot object burn; burn sites were grouped as hand, head–neck–face, perineum, and extremity–trunk burns. The burn percentage was recorded from the patient information notes. The laboratory values of the patients at the time of admission and at the time of infection were recorded. The microorganisms and antimicrobial susceptibilities grown in the surgical field, blood, urine, and tracheal aspirate samples were recorded. Patient infections were classified as surgical site infection, bloodstream infection, sepsis, ventilator-associated pneumonia, and UTI. The infection definitions were determined according to the National Health Service Associated Infections Guidelines (5). The patients were divided into two groups on the basis of the definitions in the guidelines: patients who had infections and patients who had no infections. These two groups were compared in terms of age, gender, burn site, burn type, burn percentage, hospital stay, and mortality. The antibiotics used were recorded. Age, gender, burn percentage, and hospital stay were compared in patients with and without mortality.

Statistical Analysis

Data for statistical calculations in the study were expressed as mean±standard deviation (SD) and percentage (%) in continuous variables and categorical variables, respectively. For the comparison of the quantitative data of the groups, Student's t-test was used for the normal distribution, whereas the Mann–Whitney U test was used for patients who did not have infections. The chi-square test was used to compare the nonmeasured categorical data (qualitative). $p<0.05$ was considered significant.

Ethics committee approval was obtained from the Clinical Research Ethics Committee of KTU Medical Faculty.

RESULTS

A total of 878 children were included in the study. Among these children, 520 (59.2%) and 358 (40.8%) patients were male and female, respectively. The mean age of the patients was 3.4±4.9 years. Among these patients, 679 patients (77.3%) had hot water burns, 82 patients (9.3%) had flame burns, 59 patients (6.7%) had electric burns, 17 patients (1.9%) had hot milk burns, 15 patients (1.7%) had metal burns, 10 patients (1.1%) had hot oil burns, 2 patients (0.2%) had gasoline burn, three patients (0.3%) had lightning burns, 3 patients (0.3%) had chemical burns, and one patient (0.1%) had sunburn. Among these patients, 169 patients (19.2%) had hand burns, 268 patients (30.5%) had head–neck–face burns, 41 patients (4.7%) had perineum burns, and 519 patients (59.1%) had extremity–trunk burns. The median percentage was 10 (minimum: 1; maximum: 90).

The prevalence of total infections was 12.6%. Among these patients, 44 patients (5%) had sepsis, 23 patients (2.6%) had surgical site infections, 19 patients (2.2%) had UTIs, 17 patients (1.9%) had blood circulation infections, and seven patients (0.8%) developed central catheter–associated bloodstream infections. One patient developed ventilator-associated pneumonia. Table 1 shows the infection agents. Two of the 5 *P. aeruginosa* isolates produced in the patients had carbapenem resistance, five of the 17 *Escherichia coli* isolates produced extended spectrum beta lactamase (ESBL), and two of the three *Klebsiella pneumonia* isolates produced ESBL. Methicillin resistance was detected in three of the eight isolates of *S. aureus*, vancomycin-resistant *Enterococcus* spp. was detected in four of the 16 isolates, and methicillin resistance was detected in eight of the 20 isolates producing coagulase-negative staphylococci. In patients with infections, the presence of catheters and the percentage of burns were significantly higher, and the hospitalization time was significantly longer ($p<0.001$). The average percentage of burns in *Candida* spp. patients was 41±20.6, which was significantly higher than patients without *Candida* spp. Table 2 shows the characteristics of patients with and without infections.

Table 1. Infection agents

	Blood	Urine	Surgical Area	Tracheal Aspirate	Catheter
Enterecoccus spp.	3	6	7	-	-
CNS	11	1	8	-	-
Escherichia coli	-	11	6	-	-
Candida spp.	4	10	7	1	4
Pseudomonas spp.	3	1	2	-	-
Acinetobacter spp.	1	2	5	-	-
Klebsiella spp.	1	2	-	-	-
Staphylococcus aureus	2	-	4	1	1
Proteus spp.	-	2	-	-	-
Corynbacterium spp.	-	-	2	-	-
Stenotrophomonas maltophilia	-	-	1	-	-
Serratia marcescens	1	-	-	-	-

CNS: Coagulase-negative Staphylococcus

Table 2. Comparison of patients with and without infections

	With infection n=111	Without infection n=767	
	median±SD	median±SD	p
Age (year)	1.8±1.3	3.4±4.2	0.190
Hospitalization duration (day)	23.3±20.3	6.3±7.7	<0.001
	n	n	
Gender			
Female	47 (42.3%)	311 (40.5%)	0.719
Male	64 (57.7%)	456 (59.5%)	
Burn percentage (%)			
0-29	73 (67.0%)	658 (97.5%)	<0.001
30-59	29 (26.6%)	14 (2.1%)	
60-90	7 (6.4%)	3 (0.4%)	
Burn type			
Hot water (n=679)	80 (72.1%)	599 (78.1%)	0.156
Flame (n=82)	18 (16.2%)	64 (8.3%)	0.008
Electric (n=59)	5 (4.5%)	54 (7.0%)	0.427
Milk (n=17)	7 (6.3%)	10 (1.3%)	0.003
Hot surface (n=15)	0 (0%)	15 (2.0%)	0.239
Oil (n=10)	1 (0.9%)	9 (1.2%)	1.000
Gasoline (n=2)	0 (0%)	2 (0.3%)	1.000
Lightning (n=3)	0 (0%)	3 (0.4%)	1.000
Chemical (n=3)	0 (0%)	3 (0.4%)	1.000
Sun (n=1)	0 (0%)	1 (0.1%)	1.000
Burn site			
Hand (n=169)	16 (14.4%)	153 (19.9%)	0.210
Head–neck (n=268)	35 (31.5%)	233 (30.4%)	0.835
Perineum (n=41)	12 (10.8%)	29 (3.8%)	0.002
Extremity–Trunk (n=519)	95 (85.6%)	424 (53.3%)	<0.001
Catheter presence			
Yes	29 (26.1%)	11 (1.4%)	<0.001
No	82 (73.9%)	756 (98.6%)	
Prognosis			
Discharged (n=869)	110 (99.1%)	759 (99.0%)	1.000
Death (n=9)	1 (0.9%)	8 (1.0%)	

Among the 292 patients (33.3%) to whom empirical antibiotic treatment was started, sulbactam–ampicillin was given to 214 patients (73.3%), cephalosporin was given to 121 patients (41.4%), aminoglycoside was given to 56 patients (19.2%), antipseudomonal betalactam was given to 23 patients (7.9%), carbapenem was given to 27 patients (9.2%), glycopeptide was given to 18 patients (6.2%), and antifungal treatment was given to 13 patients (4.5%). Empirical antibiotic treatment was used in 111 patients (12.6%) with displacement infection and 181 (55.5%) patients without infection. Local antibiotic therapy was not used.

Forty patients (4.6%) were implanted with central venous catheters, and 10 patients (1.14%) were intubated. Surgical treatment was performed in 467 patients. Surgical intervention included grafting in 62 patients, debridement in 391 patients, fasciotomy in nine patients, escharectomy in four patients, and amputation in one patient. Nine (1%) patients died, and 55.5% of the patients with mortality were female, the median age was 2 years (minimum: 0 years; maximum 3 years; p=0.56), the median duration of hospitalization was 5 days (minimum: 2 days; maximum 33 days; p=80), and no statistically significant difference was found with those without mortality. The median percentage of burns was 60 (minimum: 15; maximum: 90) in patients with mortality and was significantly higher than those without mortality (p<0.001). Table 3 shows the characteristics of patients with mortality.

DISCUSSION

Burns in home accidents are among the important causes of morbidity and mortality in childhood. Despite medical and technological advances, burns are still considered a life-threatening and serious problem. In a study conducted in the United States, burns are the third most common cause of child mortality (6). Therefore, it is important to take preventive measures to prevent burns.

Burns mostly occur in preschool children, particularly in children aged zero to four years old. Similar to other studies in the literature, the average age of burn patients in the present study was 3.4 years (±4.9 years) (7, 8). In this age group, considering that the motor skills of children are not fully developed and given that they want to explore their surroundings, burns occur more frequently. Burns due to accidents are more common in boys than girls (8, 9). Similar to other studies, there were more male patients than female patients in the present study.

In a study investigating the causes of burns in children, scald burns (75%) were the most common burn injuries, followed by electrical, contact, and flame burns, respectively (7). In a retrospective study of 175 pediatric patients in our country, burns were observed in 49.1% patients in the extremity–trunk region, 36% in the face–head–neck region, 10.3% in the hands, and 3.4% in the perineum. In a study in which 400 children were reported from China, the most common burning regions were head and neck (53.5%), lower extremity (52.3%), and upper extremity (48%), respectively (10). In the present study, extremity–body and head–neck burns were the most common types of burns. This finding is in accordance with the findings in the literature.

Several studies have evaluated infections in children burn patients in our country. To the best of our knowledge, the current study has the largest series of patients in Turkish literature.

Although the destruction of skin integrity as a result of burns may cause the introduction of microorganisms into the body, the necrotic tissue on the burn surface may cause the development of invasive infections by mediating the growth of mi-

Table 3. Characteristics of patients with mortality

Patient	Gender	Age (n, year)	Hospitalization duration (n, day)	Burn type	Burn percentage (%)	Intervention	Infection status	Use of antibiotics
1	F	3	1.00	Hot milk	70	-	-	-
2	F	3	1.00	Flame	60	D	-	amikacin, ceftriaxone
3	F	0	2.00	Hot water	23	D	KDE	imipenem, amikacin
4	M	1	5.00	Flame	60	D	-	imipenem, ceftriaxone
5	M	5	1.00	Flame	80	D+F+E	-	ceftriaxone
6	M	9	58.00	Flame	90	D+F+E+G	KDE, İYE CAE,VİP	ceftazidime, meropenem, vancomycin, teikoplanin, ceftriaxone, amikacin, liposomal amphotericin b, levofloxacin
7	M	0	1.00	Hot water	15	-	-	ceftriaxone, piperacillin tazobaktam
8	F	4	39.00	Flame	55	D+E	CAE, İYE	piperacillin tazobaktam, vancomycin, cefazolin, micafungin, meropenem, colistin
9	F	0	1.00	Flame	80	-	-	-

D: debridement; F: fasciotomy; E: escharotomy; G: graft; F: female; M: male; BCI: blood circulation infection; UTI: urinary tract infection; SFI: surgical field infection; VAP: ventilator-associated pneumonia

croorganisms (1). Infections are the major causes of morbidity and mortality in burn patients. The risk of infection in these patients is high owing to the etiology of heat damage, invasive procedures applied, catheter presence, burn wound colonization, gastrointestinal microbiota translocation, and hospitalization duration. In a study of 63 burn patients in our country, the size of the burn surface area, presence of urinary and central catheters, transfusion, and long hospital stay were found to be related to health-related infections (12). In a prospective study of 71 burn patients from India, it was found that patients with infections had longer hospitalization, more central venous catheter applications, and higher mortality (13). Furthermore, the risk of sepsis was found to be higher in patients with a large burn surface area ($p<0.05$). In the present study, the risk factors for patients (presence of catheters, percentage of burns, and longer duration of hospitalization) with infections were similar. As the burn surface area increases, the duration of hospitalization is prolonged, and interventional procedures and risk of infection are increased. The most important factors affecting mortality are patient's age, burn surface area, burn depth, and infection development. The mortality rate was found to be 2.8% in a retrospective study of 175 pediatric patients, and a statistically significant relationship was found between burn surface area, burn type, and severity and mortality (8). In the present study, the burn surface area of the patients with mortality was statistically significantly higher.

Although infections vary from center to center, the most common infections include surgical site infections, bloodstream infections, sepsis, ventilator-associated pneumonia, and UTIs. In our study, sepsis and blood circulation infections were the most common infections in the patients. In contrast to studies in the literature, the incidence of ventilator-associated pneumonia was low in the present study. This finding may be due to the fact that patients in this study need less ventilator time than those in other studies and that no inhalation burn was present. Infection factors vary according to the length of hospital stay (11, 13). Although gram-positive microorganisms are effective in the early period, gram-negative microorganisms became dominant in the late period. This finding may be due to the fact that these factors cause infection in patients colonized with health-related factors. In the present study, the most common infectious agents were gram-positive microorganisms. Similar to our study, the rate of gram-positive microorganism was found to be 66.4% in a study involving 206 burned child patients (2). However, in other studies, it has been shown that gram-negative microorganisms, particularly *Pseudomonas* spp. and *Acinetobacter* spp, are isolated more frequently. The other gram-negative factors include *Klebsiella* spp. and *E. coli* (2, 11–13). *Enterococcus* spp. is frequently seen in centers where vancomycin is used in empirical therapy (14). It can be seen that the infection factors vary from center to center. Therefore, each center should evaluate its own surveillance data and then start effective and appropriate empiric antimicrobial therapy. *Candida* spp. was determined as a factor in patients with a wide burn surface (>50% burn surface) and administered with long-term, broad-spectrum, multiple, antibiotic therapy (15). In the present study, *Candida* spp. was observed in 26 patients who had multiple antibiotic treatments and with burn surface areas similar to those in the literature.

In our study, 66% of *P. aeruginosa* isolates were resistant to carbapenems. In many studies conducted in recent years, a carbapenem resistance of up to 95% has been reported (16, 17). Furthermore, ESBL-producing *E. coli* (22.2%) and *K. pneumonia* (12.5%) isolates were identified in a study examining bloodstream infections in children with burns in our country. The reason for the increase of resistant microorganisms is considered to be due to the use of inappropriate, unnecessary, prophylactic, and empirical antibiotic therapies.

Stapylococcus spp. methicillin resistance in the isolates is important because of the small number of antibiotics that can be used, particularly in children. Methicillin-resistant *S. aureus* and coagulase-negative staphylococci are common in burn centers probably because the agents used in prophylactic and empirical treatments are not effective against methicillin-resistant *S. aureus* and coagulase-negative staphylococci. In the present study, methicillin resistance was found in 37.5% and 40% of *S. aureus* isolates and coagulase-negative staphylococci, respectively.

Limitations of the Study

Given the retrospective nature of this study, patient information was obtained from file records. Deficiencies in the information of patients with incomplete notes may affect the results of the study. Furthermore, infection definitions were made according to the information obtained from the records. This situation can create biases in the definitions and may affect the results of the study.

CONCLUSION

In centers where burn patients were monitored, identifying infectious agents, developing correct, and effective antibiotic strategies, avoiding the use of prophylactic antibiotics, maintaining short-term hospital stay, and ensuring strict adherence to the isolation measures will reduce the risk of infection.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Karadeniz Technical University School of Medicine (Approval No: 2018/39 Approval Date: 30.03.2018).

Informed Consent: Informed consent was not taken from patients due to the retrospective nature of the study.

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