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Characteristics of burn injury and factors in relation to infection among pediatric patients

Abstract

Burn injury is one of the most common and devastating forms of trauma and a major health problem of pediatric morbidity and mortality worldwide. The risk of infection in pediatric burns is well-known. An observational checklist was used by the researcher to assess the patients' characteristics and factors related to burn injury and infection from 1037 pediatric patients. The observational data collection showed that 56.5% of patients were males. The highest risk groups for burn injury are preschool stages. The most frequent places for burns were home 97.5%. The mechanism of burn includes scalds 72.5%, flame 22.8%, contact 2.1%, electrical 1.8%, chemical 0.8% and friction 0.2%. The prevalence of infection was 23.4%. Patients from flame burns more likely get infections 39.1% (p=0.001). Other factors associated with infection such as degree of burns, extent of body burn surface and length of hospital stay. Regarding etiology of scald burn injury, hot water is a predominant cause of burn injury 78.99%. There was a significant relation between Total Body Surface Area (TBSA) and mortality p<0.001. Patients with >40% of TBSA has a high proportion rate for death 55.7%. The majority of died patients caused by flame 65.6% and statistically highly significant P<0.001. Infection and inhalation injury are the main factors related to death 37.7% vs. 58.0%. From 748 positive samples, the most common found organism was Methicillin-Resistant Staphylococcus aureus (MRSA) 34.2%, followed by Pseudomonas aerogenosa and Acienetobacter baumannii 16.7%, 16.4% respectively. Patients with greater mean TBSA and prolonged hospital stay more likely to get Gram-negative bacterial and fungal infections and highly statistically significant p<0.001. Many other studies are need to determine the epidemiology and factors related to microbiological infection among pediatric burn patients.

Keywords: pediatric, burn patient, nosocomial infection, tbsa & mrsa

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Kamal Jalal Rashid, Muhammed Babakir-Mina, Dana Abdilmagid Abdilkarim
Technical College of Health, Sulaimani Polytechnic University, Sulaimani, Kurdistan Region, Iraq

Correspondence: Muhammed Babakir-Mina, Technical College of Health, Sulaimani Polytechnic University, Sulaimani, Kurdistan Region, Iraq. Tel +964(0)7710213991, Email m.babakir@yahoo.com

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Introduction

Burn is described as one of the leading causes of injury throughout the world, and is one of the most frequent causes of hospitalization. Burn is a major cause of morbidity and mortality, and it is the fourth most common type of trauma worldwide.[1,2] Burn is a major issue on public health in terms of infection control and cost of treatment in both developing and developed countries, and burn in pediatric range from minor to severe injuries[3] Injuries in pediatrics are predictable, avoidable and preventable.[4,5] Burns from hot drinks, food, steam, or other hot liquids are common causes of burn injuries to young children compared to other burn injuries.[2]

Burn patients are at high risk for infection as a result of the nature of the burn injury itself, the immunocompromizing effects of burns, prolonged hospital stays, and intensive diagnostic and therapeutic procedures. Sepsis of burn wounds is a serious problem leading to death and is one of the most important factors determining the prognosis of burn disease.[6–8] Burn wound infection is directly correlated to the extent of burn. It is related to impaired resistance from disruption of skin's mechanical integrity and generalized immune suppression. Non burned wound infection such as Pneumonia and Urinary Tract Infection (UTI) have become a more prominent cause of significant morbidity and mortality following the decline in invasive wound infection.[9]

The risk of burn injuries in children is higher when compared with adults. Burns in pediatric age group are generally accidentally occurring. Many of these injuries occur in the home where young children spend most of their time. There are many reasons for burn in children such as less perception of dangerous situation, recklessness and less ability to react properly in dangerous situation.[10]

Local effects are usually ranging from partial or full thickness skin burn to the destruction underling subcutaneous tissue and bone. While systemic effects cause cell death and it is conducted into surrounding tissue due to increasing capillary permeability and loss of fluid from the intravascular space and potentially fatal systemic inflammatory response syndrome can be delayed for several hours after burn.[11]

According to National Healthcare Safety Network (NHSN), nosocomial infections (NI) are localized or systemic conditions caused by adverse reaction to the presence of infectious agent or its toxins. Nosocomial infections are those infections that develop during hospitalization and are neither present nor incubated at the time of patient's admission. It represents a major problem in health care facilities, resulting in prolonged hospital stays, substantial morbidity and mortality, and excessive costs. The typical incubation period for bacterial hospital-acquired infections (HAIs) is usually≥48 hours after admission.[12,13]

Large open wound areas that containing necrotic tissue make burned patients more susceptible to infection. Burn patients are also need to stay in high-risk intensive care units for prolonged periods of time.[14] The degree or amount of contamination is proportional to the size of the open wound.[15]

Source of organisms are found in the patient's own endogenous, from exogenous in the environment, and from healthcare personal or parents. The most common type of Nosocomial infections in burned children's is bloodstream infections, pneumonia, UTI, skin and surgical site infections. Organisms such as gram-negative bacteria, gram-positive bacteria, viral and yeast/fungal are the main causes of burn nosocomial infections.[16,17]

Burn centers and burn hospitals should routinely determine and observe the specific pattern of burn microbial infection, time-related changes in the predominant microbial flora of the burn patient, the antimicrobial susceptibility profiles of microorganisms implicated in burn wound infections in a given time period, and trends in the nosocomial spread of these agents.[18,19]

Methods

Study design and setting

The study was conducted at Sulaimani Burn and Plastic Surgery Hospital, Kurdistan Region, Iraq. The data collection was collected from the previous medical records of 1307 pediatric burn patients less than 15 years of age who had sustained burn injury and admitted to hospital for receiving medical care to describe the magnitude, clinical presentation and outcome of pediatric burn injuries and infection from January 2010 – December 2015. Data generated from this work were tabulated into Microsoft excel sheets and uploaded to SPSS (Statistical Package for Social Sciences) version 22.0 software. Percentage / correlating was used for measure and analysis Chi-square (χ^2) test was used to test for significance of associations between the predictor and outcome variables in the categorical variables to find an outcome related to health issues. T-test used for comparison two means. Statistical comparison of microbial isolates and their resistance pattern was done. P-value of <0.05 was considered as statistically significant cutoff. In this study the ethical interfere with the legality which applied on patients and their parents who are admitted.

Sample collection

Clinical samples were collected through surface swabs, tissue, blood, and urine. Multiple samples from several areas of the burn were collected in order to obtain the most accurate assessment. To study burn wound colonization and infection, swabs were taken from open burn wounds preferably from upper and lower extremities avoiding oral, genital, scalp, anterior and posterior trunk, buttock, and anal regions. Burn wound swabs were taken initially on admission (patients with 48hours, 5day, second week, third week and fourth week of stay were included in the study). They were taken before dressing changes and before administration of antibiotics wherever possible. Wound swabs were also taken whenever there were clinical signs of grafted skin infections. Urine cultures were performed once per week for those with indwelling urinary catheters and on request for those with signs and symptoms of UTI. Culture and antibiotic sensitivity test undertaken at the center microbiological laboratory department inside the hospital.[18]

Microbiological investigation

The swabs were dipped in Stuarts transport medium, and then inoculated on selective and differential medium (Manitol salt agar), enrich medium (blood agar). The isolates were identified using conventional identification techniques after incubation for 18-48 hours at 37°C [20]. Positive cultures were sub cultured on blood agar and MacConkey agar, as per routine bacteriological guidelines. API (Analytical Profile Index) 20E system was used to identify the isolated gram-negative bacteria. While gram stains, catalase test, hemolysis on blood agar, coagulase and other tests were used to identify gram-positive bacteria submitted to identification tests. Also latex agglutination test were used as a confirmation stages of investigation. (BioMerieux SA,Lyon, France).[21]

Small filter paper disks (6 mm) impregnated with a standard amount of antimicrobials were placed onto an agar plate to which bacteria have been swabbed by a bacterial suspension using distilled water comparable to 0.5 McFarland turbidity standard. After 15 minutes of inoculation, the antimicrobial containing discs are applied to the agar with sterile forceps pressed firmly to ensure contact with the agar and then the plates of Muller Hinton Agar were incubated overnight, and the zone of inhibition of bacterial growth was measured for Gram-positive and Gram-negative bacteria. Then the result will be calculated as describe elsewhere.[22]

Results

Demographic characteristics of patients

A total of 1307 pediatric burn patients were studied, of which 741 (56.5%) patients were males and 566 (43.5%) were females. Children in kindergarten stage (2-6 years of age) makes the highest proportion of the patients 547 (41.9%). According to the place of injury, most frequent burns occurred at home 1274 (97.5%) followed by work 21 (1.6%), picnic 7 (0.5%) and then other locations 5 (0.4%). In addition the majority of burn injury occurred in Spring 362 (27.7%) and 352 (26.9%) in winter, but the frequency of burn injury decreased in Summer 298 (22.8%) in and 295 (22.6%) in autumn (Table1).

Table 1 Demographic characteristic of patients. (Total No.=1307)

Demographic characteristic	No. (%)	Statistical test analysis
Sex		
Male	741 (56.5)	χ2=0.52, 1df, p=0.4
Female	566 (43.5)	
Age group		
<2	453 (34.7)	
6-Feb	547 (41.9)	χ2=16.2, 2df, p=0.001
>6	307 (23.5)	
Place of burn injury		
Home	1274 (97.5)	
Work	21 (1.6)	χ2=3.38, 3df, p=0.3
Picnic	7 (0.5)	
Other locations	5 (0.4)	
Seasonal of injury		
Winter	352 (26.9)	
Spring	362 (27.7)	
Summer	295 (22.8)	χ2=0.39, 3df, p=0.9
Autumn	298 (22.6)	
Total	**1307 (100)**	

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Mechanism and place of burn injury

The study showed that scald burns were more common in pre-school children (421 out of 947, 44.5%) followed by flame (110 out of 296, 36.9%), while majority of flame burns occurred in school children; more than 6 years of age (156 out of 298, 52.3%) and statistically significant p<0.001. (Table 2) The study showed that scald burns was the most frequent causes of burn injury, 947 (72.5%) followed by flame, contact, electrical, chemical, and friction 298 (22.8%), 27 (2.1%), 23(1.8%), 10 (0.8%), and 2 (0.2%), respectively. There were significant differences of infection in terms of mechanism of burn injury; flame burns more likely to be infected followed by Electrical and scald (39.1%, 31.9%, 20.3%, respectively) p=0.001 (Table 3). Regarding etiology of scald burn injury, among 947 cases, the majority of cases were burned by hot water 78.99% followed by soup 6.86% and few cases caused by hot sugar 0.08% (Table 3).

Table 2 Comparison of the mechanism of burn in the different age group

Mechanism of burn	Age group No. (%) / years		
	< 2	2 – 6	> 6
Scald	406 (42.9)	421 (44.5)	120 (12.6)
Flame	32 (10.8)	110 (36.9)	156 (52.3)
Electrical	1 (4.3)	3 (13.1)	19 (82.6)
Contact	11 (40.7)	10 (37.0)	6 (22.3)
Chemical	3 (30.0)	2 (20.0)	5 (50.0)
Friction	0	1 (50.0)	1 (50.0)
Statistical test value	p<0.001a		

a chi-square test was used $\chi 2=276.6$, 10df

Table 3 Distribution of mechanism of burn and in relation to infection. (Total No.=1307)

Mechanism of burn	Total No. (%)	Not infected No. (%)	Infected No. (%)	Statistical test value
Scald a	947 (72.5)	750 (79.2)	197 (20.8)	$\chi 2=21.6$, 5df, p=0.001
Flame	298 (22.8)	203 (60.9)	95 (39.1)	
Electric	23 (1.8)	14 (68.1)	9 (31.9)	
Contact	27 (2.1)	24 (88.9)	3 (11.1)	
Chemical	10 (0.8)	8 (80.0)	2 (20.0)	
Friction	2 (0.2)	2 (100.0)	0 (0.0)	
Total	1307(100.0)	1001(76.3)	306 (23.4)	

[a] A total of 947 scald cases; 78.99% caused by hot water, 6.86% by hot soup, 6.76% by hot oil, 4.54% by hot tea, 2.77% by hot milk, and 0.08% by hot sugar.

Degree of burn (depth), measurement burn size, and hospital stays of patients

Children with second degree of burn were the majority of burns 949 (72.6%) and children who sustained third and mix degree burns were 358 (27.4%). Third and mix degree of burn were more likely to be infected (131 out of 358, 36.6%) than second degree burn (175 out of 949, 18.4%) p<0.001 (Table 4). The frequency of Patients with TBSA burnt of <20% were making the majority of the cases 1075 (82.2%), followed by 20-40% 184 (14.1%). The frequency become least with increasing body burnt %. Patients with TBSA burnt of 20-40% were more likely to have infection compared to patient with TBSA% burnt of <20% and >40% (p<0.001) (Table 4).

Table 4 Distribution of depth (degree) and TBSA burnt in relation to infection. (Total No.=1307)

		Not infected No. (%)	Infected No. (%)	Total No. (%)	Statistical test value
Degree of burn	Second	774 (81.6)	175 (18.4)	949 (72.6)	$\chi 2=44.76$, 1df, p<0.001
	Third and mix	227 (63.4)	131 (36.6)	358 (27.4)	
TBSA group	<20	894 (83.2)	181 (16.8)	1075 (82.2)	$\chi 2=157.52$, 2df, p<0.001
	20-40	76 (41.3)	108 (58.7)	184 (14.1)	
	>40	31 (64.6)	17 (35.4)	48 (3.7)	

Mean TBSA was 14.06 (95%CI 13.40-14.72) and Mean Hospital stay/days was 7.6 (95%CI 7.21-7.98). Patients with higher TBSA burnt were found to be more likely to develop infection and the relation was found to be statistically significant p<0.001. Also patients with infection had a longer duration of stay in the hospital as compared to those not infected and this comparison was found to be statistically significant p<0.001 (Table 5).

Mortality

The study shows 1246 (95.3%) cases are survived and 61 (4.7%)

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cases were died. The mean TBSA of survived patients was 12.39 (95%CI 11.92-12.86) and died patients was 48.22 (95%CI 42.51-53.92). There was a significant relation between TBSA and mortality p<0.001. Patients with >40% of TBSA marked high proportion rate for death 55.7% (Table 6). The majority of died patients caused by flame was 40 (65.6%), followed by scald 18 (29.5%), electric 2 (3.3%) and contact 1 (1.6%). Mortality rate from flame burn was highly significant P<0.001. A total of 1001 not infected patients, 963 (77.3%) were survived and 38 (62.3%) were died. From 306 infected patients, 283 (22.7) were survived and 23 (37.7%) were died p=0.007 (Table 7).

From 38 of non-infected died patients, the highest percent of died were 71.1% with >40% of TBSA. Patients with <20% of TBSA has 100.0% of inhalation injury followed by 20-40% of TBSA 80.0% and >40% TBSA 48.1% (Table 8).

Table 5 Comparison of infected and non-infected burn patients according to TBSA% burnt and hospital stay in days. (Total patients = 1307)

	Mean tbsa (95% CI)	Mean hospital stay (days) (95% CI)
Total mean	14.06 (13.40-14.72)	7.6 (7.21-7.98)
Not-Infected	12.41 (11.68-13.14)	5.58 (5.29-5.86)
Infected	19.48 (18.13-20.84)	14.20 (13.12-15.28)
Mean differences	7.07	8.62
Statistical test value	t=9.1, p<0.001	t=21.5, p<0.001
a Independent t-test was used for two mean		

Table 6 Distribution of patients TBSA according outcome. (Total patient=1307)

Outcome	No. (%)	TBSA group No. (%)			TBSA
		<20	20-40	>40	Mean (95% CI)
Survival	1246 (95.3)	1069 (85.8)	163 (13.1)	14 (1.1)	12.39 (11.92-12.86)
Died	61 (4.7)	6 (9.8)	21 (34.5)	34 (55.7)	48.22 (42.51-53.92)
Statistical test value	-	p<0.001a			p<0.001b
a Chi square was used $\chi2$=535.91, 2df					
b Independent t-test was used for two mean					

Table 7 Mechanism of burn injuries and infection in relation to mortality. (Total patients=1307)

Outcome	Mechanism of burn						Not infected	Infected
	Scald No. (%)	Flame No. (%)	Electric No. (%)	Contact No. (%)	Chemical No. (%)	Friction No. (%)	No (%)	No. (%)
Survivors	929(74.6)	258(20.7)	21(1.7)	26(2.0)	10 (0.8)	2(0.2)	963(77.3)	283(22.7)
Died	18 (29.5)	40 (65.6)	2 (3.3)	1 (1.6)	0	0	38 (62.3)	23 (37.7)
Test value	$\chi2$=92.7, 5df, p<0.001						$\chi2$=7.29, 1df, p=0.007	

Table 8 Distribution died burn patients with TBSA burnt and Inhalation injury. (No=38 died patients)

TBSA%	Inhalation injury No. (%)		Total
	Yes	No	
<20	1 (100.0)	0	1 (2.6)
20-40	8 (80.0)	2 (20.0)	10 (26.3)
>40	13 (48.1)	14 (51.9)	27 (71.1)
Total	**22 (58.0)**	**16 (42.0)**	**38 (100)**

Locations of body burn positive samples

The study included 748 of positive cultures from 306 infected patients. Number of positive samples per patients ranged from 1 to 10 samples. 49.3% had one sample, 30.7% had two samples, 7.3% had three positive samples, and 12.7% with more than three samples. Majority of positive sample results were in the burn wounds 688 (92.0%), followed by blood 41 (5.5%), and urine 19 (2.5%) (Table 9).

Table 9 Distribution of positive sample according to body parts. (Total positive samples =748)

Location of positive cultures		No.	(%)
Wound positive samples	Upper limb	122	-16.3
	Lower limb	285	-38.1
	Anterior trunk	116	-15.5
	Posterior trunk	85	-11.4
	Head & neck	41	-5.5
	Buttock & genital	39	-5.2
Non wound positive samples	blood culture	41	-5.5
	urine culture	19	-2.5
Total		**748**	**-100**

With regard to the anatomical location of burn wound injuries, the lower limb was the most frequently involved area with positive

samples 285 (38.1%), followed by upper limb 122 (16.3%), anterior trunk 116 (3801%), posterior trunk 85 (11.4%), head & neck 41 (5.5%), and buttock & genital 39 (5.2%) (Table 9).

Microbiological finding:

From the total of 748 positive samples, the most common organism found was gram-positive bacteria *MRSA* 256(34.2%), followed by gram-negative *P.* aeruginosa and A. baumannii 125(16.7%), 123(16.4%) respectively. Other organism included Non MRSA S. aureus, K. pneumoniae, E. cloacae, E. coli, Proteus species, S. epidermidis, CoNS and fungi (Candida albicans) 86(11.5%), 78(10.4%), 39(5.2%), 17(2.3%), 8(1.1%), 8(1.1%), 3(0.4%) and 5(0.7%) respectively. The mean TBSA of burn was proportional in fungal infection 27.4(95%CI 11.29-43.51) and gram-negative bacterial infections 25.49(95%CI 24.19-26.79) as compared with gram-positive bacterial infection 19.92 (95%CI 18.70-21.14) p<0.001. Similarly we found that the mean hospital stay in fungal infection 24.4(95CI 20.41-28.38) and gram-negative bacterial infection 20.62(95%CI 19.45-21.79) that is higher than gram-positive bacterial infection 16.54(95%CI 15.53-17.56) p<0.001 (Table 10).

Table 10 Distribution type of organisms, association with TBSA and hospital stays. (Total No. =748)

Type of organisms		No. (%)	TBSA	Hospital stay
			Mean (95% CI)	**Mean (95% CI)**
Gram-positive	MRSA	256 (34.2)	21.5 (20.06-22.95)	18.73 (17.53-19.93)
	S. aureus	86 (11.5)	16.32 (14.01-18.63)	10.78 (9.27-12.27)
	S. epidermidis	8 (1.1)	11.21(7.50-14.93)	8.88 (4.44-13.30)
	CoNS	3 (0.4)	11.33 (0.13-22.53)	15.33 (-2.11-32.78)
	Total	**353 (47.2)**	**19.92 (18.70-21.14)**	**16.54 (15.53-17.56)**
Gram-negative	P. aeruginosa	125 (16.7)	25.67 (23.37-27.98)	20.33 (18.19-22.68)
	A. baumannii	123 (16.4)	26.03 (23.63-28.45)	20.78 (18.78-22.68)
	K. pneumonia	78 (10.4)	26.03 (23.21-28.85)	20.31 (17.69-22.91)
	E. cloacae	39 (5.2)	22.29 (17.91-26.68)	23.49 (18.68-28.28)
	E. coli	17 (2.3)	25.17 (18.44-31.98)	16.47 (12.18-20.75)
	Proteus species	8 (1.1)	25.22 (16.65-33.80)	20.63 (9.66-31.58)
	Total	**390 (52.1)**	**25.49 (24.19-26.79)**	**20.62 (19.45-21.79)**
Fungi	Candida albicans	5 (0.7)	27.4 (11.29-43.51)	24.4 (20.41-28.38)
p- value		-	p<0.001a	p<0.001a

a One-way ANOVA t-test with Tukey's comparison was used

Discussion

Age

In the current study children in preschool stage (2-6 years of age) shows high proportion of burn injury than other age groups (Table 1). This finding is nearly consistent to the previous studies which are done in Iraq,[23] and in Brazil.[24] It is also supported by the WHO injury reports stating that children under 5 years are at the highest risk of burn injuries.[25] Nevertheless, many studies around the world have reported that infants (less than 2 years old) are the most frequent groups injured by burning, such as in China,[26] USA,[27] India[28] and Ghana.[29] This is probably because these children in our country spend most of their times at home near different types of heating and cooking equipment's. Another fact may be due to the hyper mobility of children and lack of judgment which makes them difficult to control.

Sex

In the current study males (56.5%) were more affected to burn injury than females (43.5%) (Table1). It is nearly consistent with many studies in low-income and middle income countries such as 60% in Iran,[30] 53.2% in Turkey,[31] 50.9% in Pakistan.[32] Also studies from high-income countries is nearly reported the same proportions; 60.3 % in Saudi Arabia,[33] 62% in Japan,[34] 66% in UK,[35] 56% in Morocco[36] and 67.2% in USA.[37] The high percent of male burn injured in our study could be due to increased exposure to activities, males are more active than females that produce injuries and the pattern of more risk taking and rougher players than females. So, a previous study has the same explanation.[38]

Place of injury

Our study showed that more of pediatric burn injuries happened at home (Table1). This finding nearly in accordance with the previous studies which revealed that most of burn injuries were at home.[39,40] This is because of in our society children spend more of their times at home rather than other places.

Mechanisms of burn injury

Our study showed that scald burns were the most frequent cause of burn injuries (Table 3). Similarly the various observations had reported that scald burns are the most common cause of burn injuries.[29,41–44] This can be explained that children especially infants and preschool children stay with their parents or caregiver at home, and would

probably be left playing indoor around the kitchen environment. In our study scalds were commonly caused by hot or boiling water (Table 3), which is consistent with the finding of the previous study.[45] This may be explained that hot liquids are of high importance at our homes and most frequently used in many life aspects.

In our study flame burns were the second cause of burn injury 22.8% (Table 3). Many of studies around the world have similar results[36,43,44,46,47] Equipment and products were more responsible for flame burn diverse, but the most important of them were home equipment's used for cooking or heating. Another factor contributing to the risk of these cylinders usually places it near the cooker equipment's inside the kitchen, especially in old buildings.

We found that flame burn injuries were more prevalent in children aged more than six years (Table 2), which is in agreement with the finding of the study conducted in Tanzania.[39] This may be related to the raise of physical mobility and social independence in our country of older children especially girls for preparing foods and other works related cooking and lighting fires. Also this difference is highly statistical significant p<0.001.

In our study patients with flame burns more likely to be infected than other burns with statistically significant p=0.001 (Table 3). Similar findings showed by Abbas Atiya H.[48] The main reasons for this finding may be due to production of large and deepest burn wound surface which is a protein-rich environment consisting of excessive necrotic tissue (eschar) that provides more favorable niche for microbial colonization and proliferation, this explanation has been currently supported by many of scientific researcher studies.[18,49–51]

Seasonal of injury

The study showed that majority of burn injury occurred in cold season especially in winter comprising all burn (Table 1).This finding agree with the other previous studies.[23,52] This is because of using kerosene-operated space-heating equipment in houses, especially in cold seasons in our city. Sometimes families put this equipment around seats and it drives to cause burn injury.

Degree of burn (depth)

This study revealed that majority of burn injuries with second degree of burn (Table 4). This finding is nearly in agreement with the other previous studies.[53,54,26,55] But another study showed that the majority of burn patients admitted have the third degree of burn injuries.[56] For this reason longer period of burn exposure results in a potential longer time of contact with body surface, resulting in degree (depth) of burn.

In our study, patients who have third and mix degree of burn more likely to be infected as compared with other second degree of burn patients, this is highly statistical significant p<0.001 (Table 4). This is in agreement with the study has done by Larry Kramer for third degree of burn and infection.[57] This may be due to the loss of more parts of skin and layers under skin which play an important role in protecting the body against infection and act as a barrier that prevent microbes from entering the body.[18]

TBSA burnt

In this study majority of TBSA burnt patients were less than 20% (Table 4). This finding is consistent with a study conducted in Israel.[58] This variation of TBSA burnt percent is probably due to variations in distribution of the mechanism of burn injury. As well as severity and amount of causative agents indicated to produce variation of TBSA burnt percent.

We observed that patients with TBSA burnt 20-40% were more likely to be infected which accounted 58.7% and highly statistical significant p<0.001 (Table 4). This finding is similar to the study done by Church, D. and his coauthors.[18] This could be due to increasing body surface area which lets organisms to invade body and loss of more epithelium skin covering tissues which is a good indicator to survive and lets pathogens to colonize easily.[59] Other reasons for this finding may be due to delay excision which increase the reservoir of bacteria made up by the collective burn wound surfaces of patients in a burn management, which is mentioned by Mayhall, C.G.[60] However, in our study the proportion of infection decreased with increasing TBSA burnt when more than 40% which accounted 35.4% (Table 4). This is because of greater TBSA burnt percent has a good independent risk factor for patient to die before infected with organisms. This is Similar to a study done by Rosanova, M.T. and his coauthors in Argentina on risk factor for mortality in burned children.[61]

Hospital stays of patients

In the current study, the mean hospital stay was 7.6 days (Table 5). This result nearly in accordance to the previous studies were done in pediatric burn wards.[3,30,62–64] In our study the mean hospital stay was statistically significant and greater in patients with infection (14.20 days) rather than in patients with no infection (5.58 days) p<0.001 (Table 5). This result is in consistent with a study done in Spain,[65] also another French study is agree with the above finding.[9] More prolonged of hospital stay enhance the microbes to colonize and cause infection in burn patients. In addition, type and extent of wound, as well as the therapeutic procedure for management of organisms, debridement wound, skin grafting, and blood transfusion are other factors which related to the colorizations, this explanation has currently supported by a previous study.[66]

Microbiological finding

In our study a total of 1307 patients, almost 306 (23.4%) of admitted patients (Table 1) had developed infections and the most common developed infection in the burning patient was wound infection (Table 9). This finding is in agreement with the other previous studies.[32,67–69] But in the study conducted by Behzadnia S et al.[62] showed that the rate of nosocomial infection in burn patients is more developed in blood stream.[62] Burn patients will facilitate wound infection which is a serious complication occurs in sub-acute period following burn injury.[69]

A total of 748 positive samples, Number of positive samples per patients ranged from 1 to 10 samples, we found that the highest proportion of positive samples were gram-negative bacteria followed by gram-positive bacteria and few cases of fungi (Table 10). Our result in accordance with the previous study conducted by Mayhall, C.G. in USA.[60] This finding has several interpretations; first, gram-negative organisms are major determinant of morbidity.[32] Second, endogenous gram-negative bacteria come from the patient's gastrointestinal flora and rapidly colonize the burn wound surface after injury. On the other hand, delaying burn wound excision increases bacterial load, especially gram-negative and supports the rationale of early burn wound excision. Surgical excision decreases an average of 102 organisms per gram of tissue in both the early and delayed excision groups for gram-negative infection this is mentioned by Barret JP & DN Herndon.[49]

In our study a total of 748 positive samples, among gram-positive infections; the first common isolated bacteria were *MRSA* 34.2% (Table 10). This is in consistent to other previous studies in pediatric burn wards.[70–72] More recently, a 20- years review of the changes in bacterial isolates from pediatric burn wounds and their antibiograms in Europe showed that MRSA remain the most frequent gram-positive pathogen.[73] The prevalence of MRSA is various in clinical samples of pediatric burn patients as the result of distribution of Panton-Valentine Leukocidin (PVL) gene of the bacteria, Staphylococcal Cassette Chromosome mec (SCCmec) types and antibiotic resistant genes of the MRSA isolates. The disruption of the normal skin barrier and the immune compromised status make burn an easy target for MRSA colonization. Additionally, using various types of penicillin too much without changing and self uses of antibiotic randomly are risks for development of MRSA colonization in which supported by Branski, L.K., et al.[68] On the other hand, gram-positive bacterial infection, especially MRSA comes from the patient's endogenous skin flora or the external environment predominantly colonizes the burn wounds.[68] In spite of that ,children's parent need to mind the most because they cannot stand the pain, so this should make the mother to emotionally take care of her child, hug him/her be very near to her child, and bring him/her things (toys) to the child busy to forget about his/her pain or wound. These all lead to transmission of microbes to the child quickly specifically MRSA; because it is found in a high rate on these out ward things which are not censored by the hospital.

In our study the second common isolated organism was *P. aeruginosa* 16.7% (Table 10). This is in contrast to other studies which are shown that a *Pseudomonas* bacterium was the most common pathogen in pediatric burn patients.[32,62,74]

The incidence of *P. aeruginosa* infection in the pediatric burn wards may be due to the fact that this bacterium thrives in a moist environment, and its ability to resist killing by more of antimicrobials. The minimal nutritional requirements of Pseudomonas, its ability to grow in distilled water and its tolerance to a wide variety of physical conditions in which contribute to its ecological success and ultimately to its role as an effective opportunistic pathogen.[75]

In our study, MRSA was in highest prevalence as compared with the other gram-positive bacteria (34.2%), while both P. aeruginosa and A. baumannii were the commonest gram-negative bacteria (33.1%), thus our Sulaimani health directorate must try to take high precaution about them and provide good antibiotics for their eradication.

In the present study, the incidence of gram-negative bacteria is highly statistical significant with the increasing of TBSA burnt percent $p<0.001$; this mean patients with greater TBSA percent more likely to be infected with gram-negatives bacteria compared to gram-positives bacteria (Table 12). This finding is in agreement with the previous study which was done by Chang, P.H. in USA.[76] This may be due to inappropriate common use of broad spectrum antibiotic and increasing cross contamination of gram-negative bacteria; because of the lack of stringent infection control adherences. On the other hand, another study in USA by Barber, R.C., et al showed that gram-negative colonization is in relation with increasing TBSA burnt percent, and suggested that clinically the risk established in the biological implication of the observation, may be that reduce total pathway signaling Toll-like receptor 4 (TLR4 +896 G-allele) carriers fails to control local infection. Carriers of the G-allele at this single nucleotide polymorphism (SNP) exhibit reduced lipopolysaccharide (LPS) responsiveness as well as an increased risk for septic shock and susceptibility to Gram-negative sepsis.[77]

In the present study, we found that the higher incidence of gram-negative bacteria statistically significant with more prolonged hospital stays $p<0.001$ (Table 10). Inanimate environment of patient infected with gram-negative bacteria was frequently contaminated with those organisms considered a factor for infection. Another factor may be due to gram-negative bacteria characterized by making conjugation between themselves; this conjugation lead to make changes in their virulently facts to resist for more antibiotic and antiseptics. However, its ability to establish itself widely in hospital equipment's such as bed pans and medicines like lotions, ointments and eye drops and even stocks and distilled water for plants and flower.[78] On the other hand patients or physician perception dosages do not complete the course of prescribed dose of antibiotic because of the blithesome effect of the control of the infection from the start of the course, it results to involving major genetic and biochemical mechanisms, bacterial transformation, hyper mutability, and plasmid mediated improvements resistant, ending with drug efflux mechanism and gaining of characters to synthesize endogenous and exogenous antibiotic degrading enzymes, because of these the gram-negative bacteria become more MDR and lead to increase patients duration of hospitalization.[79]

Mortality

The overall fatality rate of hospitalized children due to burn in our study was 4.7% (Table 6). This finding is consistent to the results of a study by Arslan, H., and his coaouthores 4.3%.[43] It was higher than the other previous literatures from high income countries such as 1.3% in Kuwait,[80] 0.7% in America, and 1.1% in Europe,[25] but was less than the result obtained by Golshan, et al in South Asia 9%.[81] An important point is that the burnt patients from other provinces treated or died as outpatients and were excluded. In addition, hospitals mortality rates are likely to be related to the quality of hospital care and case mix in terms of factors associated with mortality.

In our study, we found that burn size is the strongest predictor of death and statistically highly significant $p<0.001$ (Table 6); this mean patient who have greater TBSA more likely to be died rather than the patients have smaller TBSA. This finding is consistent to the previous pediatric burn studies,[61,82.55,54,83,84] It is important, to report hospital mortality rate that relate to TBSA burnt. However, various studies published on burn epidemiology; reported that TBSA and its relation to mortality in different ways make comparisons difficult.[85] Such differences may be due to other risk factors such as age and inhalation injury, but could also be related to differences in quality of care. As well as immature immune system and increased fluid requirement may lead to higher burn mortality rate, which place children at high risks for sepsis and hypovolemic shock after burn injury.[3]

In our study, flame burns were more fatal than other types of burn 65.6% and it is highly statistical significant $p<0.001$ (Table 7). It is consistent to the global WHO burns that showed fire is more fatal among pediatric populations and it records the highest mortality rate.[25] The same result was seen in many of previous studies around the world.[3,82,86–88] This is because of, the large proportion of the total body surface area affected among flame burn victims, in which the flame produced by flammable substance spread to wide space area of the body. As well as these patients were more prone to mortal complications especially in pediatric populations such as burn shock, acute renal failure and sepsis.[43]

Burn wound infection is a serious problem leading to death. It needs critical monitoring in pediatric burn patients. So, we found that died patients statistically significant have relation with infection p=0.007 (Table 7); this means infection is the serious problem resulting mortality. This finding is in agreement with the most of previous studies.[61,89,90] The highest level of death caused by infection is probably due to the lack of early wound swab and blood culture for bacteria and sensitivity of organism which is leading to septicemia and then death. Furthermore, a study by Ramakrishnan, M., et al showed that early management and empirical antibiotic regimes decrease wound sepsis resulting to the increase of survival.[91]

Despite of those, we saw that mortality rate in non-infected patients is too high (Table 7), this is because (27/38) of these dead patients' TBSA burnt was more than 40% (Table 8). As we mentioned about this finding before; patients with greater TBSA% were at high risk of death. According to the forensic medicine death reports, from non-infected patients who died; inhalation injury were the main factors leading to death from patients who have smaller TBSA burnt percent (of less than 40%) (Table 8). Our result is consistent to Karimi, H., and his coauthores study [6464]. This indicates that inhalation injury seriously contributes with TBSA as a major risk for death in burn patient, especially in children.

Conclusion

Burn infection is an important cause of morbidity among burn children in hospital. Burn injuries among pediatrics in our community need to critical care and monitoring. Preschool stages and males children were at risk for burn injury. Home environment is not safe for children. Burn infection is a major issue for hospital morbidity. Our study showed that the major risks for pediatric burn infection were flame burns, long duration of hospitalization, and third/mix degree of burn. Patients with greater TBSA burnt more likely to get infection. Overall, gram-negative bacteria were the commonest pathogens followed by gram-positives and then fungi. In additional, MRSA was the commonest frequent gram-positive bacteria detected and it is the major cause for infection. Fungal and Gram-negative colonization more associated with higher TBSA burnt and prolonged hospitalization. We recommended that regular microbial surveillance of burn patient and hospital Environment microbiological surveillance of potential nosocomial pathogens indicated inanimate environment of patients should be done to find out the presences of our pathogens which are contaminated.

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Conflict of interest

Author declares there is no conflict of interest in publishing the article.

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