Original Article

Traumatic Brain Injury in Child Burn

Behnam Sobouti[1], Iman Ansari[1], Soheila Naderi Garahgheshlagh[1], Hossein Rahbar[1], Arya Rahbar[2], Reza Alizadeh-Navaei[3], Hamid Karimi[4], Zahra Hosseini Rad[5], Mohsen Saberi[6], Mahnoush Momeni[7*]

1. Burn Research Center, Iran University of Medical Sciences, Tehran Iran.
2. International Baccalaureate Student, Ontario, Canada.
3. Gastrointestinal Cancer Research Center, Non-communicable Diseases Institute, Mazandaran University of Medical Sciences, Sari, Iran.
4. Department of Plastic Surgery, Iran University of Medical Sciences, Tehran, Iran.
5. Motahari Hospital, Burn Research Center, Iran University of Medical Sciences, Tehran, Iran
6. Medicine, Quran and Hadith Research Center & Department of Community Medicine, Faculty of Medicine, Baqiyatallah University of Medical Sciences, Tehran, Iran.
7. Department of General Surgery, School of Medicine, Burn Research Center, Shahid Motahari Burns Hospital, Iran University of Medical Sciences, Tehran, Iran.

***Corresponding Author:**

Mahnoush Momeni, M.D.

Assistant Professor of General Surgery, Department of General Surgery, School of Medicine, Burn Research Center, Shahid Motahari Burns Hospital, Iran University of Medical Sciences, Tehran, Iran.

Tel.: +98 21 88884275
Email: momeni.m@iums.ac.ir
mahnoushmomeni@gmail.com

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ABSTRACT

BACKGROUND

Burns are one of the most important health problems in communities. Traumatic injuries, especially Traumatic Brain Injury (TBI) associated with burns, may increase disability and mortality. In addition to preventing burns, any action for a better treatment approach and early detection of concomitant traumatic injuries can reduce complications, disability, and treatment costs. We aimed to investigate the outcome of children with burn injury with and without TBI.

METHODS

In this cross-sectional study, 392 children with burn injuries treated at Motahari Hospital in Tehran, Iran from 2018-2019 were enrolled. Patient demographics, burn injury information and TBI-related information including head trauma and fracture were recorded in a checklist. Patients were divided into two groups of death (24 people) or discharge (368 people) in terms of outcome and the underlying variables were compared in the two groups.

RESULTS

There was no significant difference between the mean age of patients and gender in the two groups. The difference in the length of hospital stay, inhalation injury and skull fracture in the two groups was not statistically significant. The mean burn severity based on Total Body Surface Area (TBSA) and the frequency of TBI in the deceased group was significantly higher (P=0.001).

CONCLUSION

The severity of burns based on TBSA and TBI is associated with increased mortality among children with burn injuries. The results suggest the need to examine children with burn injuries for TBI using clinical examination or imaging.

KEYWORDS

Burns; Mortality; Brain trauma

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INTRODUCTION

One of the most serious injuries and major health concerns is burns. Burns cause irreparable physical, mental, psychological, and socio-economic consequences. Furthermore, burns are the fourth most common cause of traumatic injuries in the world[1]. According to a recent report by the WHO, more than 265,000 cases occur each year except

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from burns, and more than 96% of these cases are in low- to middle-income countries. It is not only deaths from burns which are more common in areas with lower socioeconomic status, but also injuries in people are more common in areas with lower social and economic status[2].

Although the incidence of burn injuries is declining, it is still a common cause of injury, with about 9 million burn injuries occurring worldwide in 2017[3]. In Iran, burn injury is the 13th leading cause of illness[4]. Moreover, more than 100,000 burn injuries occur each year, of which about 6% are hospitalized and 9 to 10 patients per 100,000 die[5, 6]. The average length of hospitalization of burn patients in Iran is 8 to 16.7 days and the average cost of hospitalization of patients is more than $600 per patient[1]. Hot liquids, flame burns, fire burns due to the explosion of explosive gases, hot contact burns and self-immolation are the most common burn mechanisms among burn patients. Children, on the other hand, suffer from burns due to greater mobility and curiosity, through hot liquids or hot surfaces such as irons and electrical conductors[7]. Most burns in children occur randomly and at home, and the incidence of burns in children is inversely related to the amount of care taken. Unfortunately, injuries caused by child burns are very common in Iran, especially in boys and in urban areas, and the resulting mortality has been 5.18 to 7.1 per 10,000 people, and mainly due to hot liquids[8].

Children, like other burn injury patients, need immediate and serious action in the early hours of symptoms, the most important of which are fluid therapy to prevent shock, antibiotic therapy to prevent sepsis, pain relief, and other supportive measures. In addition to the initial steps, it is important to investigate other burn-related injuries, including traumatic injuries. Traumatic injuries following burns are common and can lead to increased mortality in patients[9]. Although in patients with burn injuries, trauma may be associated with major accidents such as falls or hitting a hard object following an explosion or electrical injury, in children due to greater vulnerability, traumatic injuries may follow minor accidents, for example, turning the container containing liquids on their heads, which in turn can lead to traumatic brain injury (TBI), which requires careful examination of children with burn injuries at the time of admission to the emergency room. This measure is important because it can first help determine the prognosis of patients and lead to better planning for the treatment of patients, because patients with burn injuries with TBI need advanced care and treatment with careful monitoring. TBI can lead to episodes of shock, pulmonary embolism, office infection, or bacteremia, and can increase the length of hospital stay or cause the use of a ventilator[10, 11].

Although some studies have suggested TBI as an effective factor in increasing mortality[12], there is disagreement in some studies[10]. In addition, no comprehensive study has been conducted to investigate the role of TBI in mortality due to burn injury in children.

We aimed to evaluate the outcome of children with burn injury with and without TBI. Our hypothesis is that mortality is higher in children with burn injuries with TBI, so in the initial examination of these patients after resuscitation, a more obsessive examination should be performed with TBI in mind.

MATERIALS AND METHODS

In this cross-sectional study, all children with burn injuries admitted from 2018 to 2019 to Motahari Hospital, Tehran, affiliated to Iran University of Medical Sciences, which is the largest burn accident center in Iran, were analysed.

The present study was conducted under the supervision of the Vice Chancellor for Research and Technology of Iran University of Medical Sciences and the researchers adhered to the ethical and professional principles set out in the Helsinki Convention; therefore, the results of the project are reported without disclosing the identification information of patients and their families.

The sampling method was census, so all children under 13 yr of age were examined. Patients who died before reaching the emergency room, returned after 24 h, or children who had intentional burns were excluded from the study. The patient assessment and treatment approach were based on the American Burn Association (ABA) criteria. All patients were evaluated for TBI after initial resuscitation, and if there was positive evidence, consultation with a neurosurgeon was performed so that the child could undergo further examinations, including CT scans, if necessary.

The data collection tool was a four-part checklist. The patients' demographic indicators including age,

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gender, nationality, and place of residence, burn injury information including type and percentage of burns and the presence of inhaled burns, hospital information including the length of hospital stay and patients' outcome and information related to TBI including head trauma and fracture was recorded in this checklist. The percentage of burns in all patients was determined using the Total Body Surface Area (TBSA), which is an important indicator of burn severity in children and adults[13], and LA50, which indicates the quality of hospital care, was calculated[6]. Then, the patients were divided into two groups of death or discharge in terms of final outcome, and the underlying variables were compared in the two groups. The primary outcome of the study included determining the association of TBI with mortality in patients. Examining the relationship between other underlying factors and mortality was considered as a secondary outcome of the study.

The data obtained from the study were analyzed using SPSS software version 24 (IBM Corp., Armonk, NY, USA), and Chi-square, Mann-Whitney U tests and the odds ratio (OR) was obtained using logistic regression model. Significance level was considered $P<0.05$.

This research was approved by the ethics committee of Iran University of Medical Sciences and an ethics certificate was issued with the code IR.IUMS.REC. 1400.670. The legal guardians of all patients signed a consent form agreeing to participation in the study.

RESULTS

During the one-year study period, 1930 patients were admitted to the hospital. Out of these patients, 438 were less than thirteen years old. After viewing if these 438 patients fit the criteria of the study, 392 patients fit the criteria and were included as a part of this study.

The mean age of patients was 42.73 ± 33.88 months

Table 1: Basic characteristic of children with burn injury

Variable	Mean±SD	Range
Age (month)	42.73±33.88	0-145
Hospital Stay (day)	8.32±6.88	1-44
TBSA (%)	15.16±13.1	0.5-75
	Frequency	**Parentage Frequency**
Gender		
Male	248	63.3
Female	144	36.7
Nationality		
Iranian	363	92.6
Non-Iranian	29	7.4
Type of Burning		
Electrical	14	3.6
Contact	28	7.1
Flame	70	17.9
Chemical	6	1.5
Hot Liquid	274	69.9
Inhalation Injury		
Yes	25	6.4
No	367	93.6
TBI		
Yes	39	9.9
No	353	90.1
Skull Fracture		
Yes	21	5.4
No	371	94.6
Outcome		
Discharged	368	93.9
Died	24	6.1

SD: Standard Deviation; TBSA: Total Body Surface Area; TBI: Traumatic Brain Injury

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(range 0-145 months). Overall, 248 patients (63.3%) were boys, and the rest were girls. 363 patients (92.6%) were of Iranian nationality and the rest were non-Iranians. The most common types of burns were hot liquid burns (69.9%), flame burns (17.9%), contact burns (7.1%), electrical burns (3.6%), and chemical burns (1.5%), respectively. There were 25 patients (6.4%) with inhalation injury, 39 patients (9.9%) with TBI, and 21 patients (5.4%) with skull fracture. Finally, 24 patients (6.1%) unfortunately died, and the rest were discharged. The mean length of hospital stay was 8.32 ± 6.88 (range 1-44 d). The mean burn severity based on TBSA was 15.16 ± 13.1% (range 0.5-75%) and LA50 in patients was 48.86 (Table 1).

The mean age of patients and gender were not significantly different in the two groups of deceased and discharged (P=0.63 and P=0.068, respectively). In addition, the difference between length of hospital stay, inhalation injury and skull fracture in the two groups was not statistically significant (P=0.069, P=0.057 and P=0.374, respectively). However, the mean severity of burns based on TBSA and the frequency of TBI in the deceased group were significantly higher (P<0.001 and P=0.001, respectively) (Table 2).

In addition, the results of logistic regression analysis showed that among the contextual variables TBI [OR=4.94 (95% CI 1.23–19.88), P=0.024], and TBSA [OR=1.11 (95% CI 1.07-1.15), P<0.001] were associated with burn-induced mortality (Table 3). In addition, TBSA was significantly higher in patients with skull fracture, inhalation injury, and TBI (Table 4).

Table 2: Relationship between study variables and patients' outcome

Variable	Discharged (n=368)	Died (n=24)	*P* value
Age (month)	42.98±34.04	38.91±31.78	0.63*
Hospital Stay (day)	8.14±6.73	11±8.6	0.069*
TBSA (%)	13.56±11.06	39.41±17.46	<0.001*
Gender			
Male	237 (95.6%)	11 (4.4%)	0.068#
Female	131 (90.8%)	13 (9.2%)	
Inhalation Injury			
Yes	21 (84%)	4 (16%)	0.057#
No	347 (94.6%)	20 (5.4%)	
TBI			
Yes	31 (79.5%)	8 (20.5%)	0.001#
No	337 (95.5%)	16 (4.5%)	
Skull Fracture			
Yes	19 (90.5%)	2 (9.5%)	0.374#
No	349 (94.1%)	22 (5.9%)	

*: Mann Whitney U test #: Chi-Square Test

TBSA: Total Body Surface Area; TBI: Traumatic Brain Injury

Table 3: Predictors of mortality among the study variables

Variable	Odds Ratio	95% CI	*P*-value
Age	0.984	0.964-1.004	0.115
Gender	1.87	0.646-5.417	0.249
TBI	4.945	1.23-19.879	0.024
Skull Fracture	0.140	0.018-1.115	0.063
Inhalation Injury	1.528	0.194-12.02	0.687
TBSA	1.113	1.073-1.155	<0.001
Hot Liquid Burning	0.528	0.097-2.875	0.46

CI: Confidence Interval; TBI: Traumatic Brain Injury; TBSA: Total Body Surface Area

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Table 4: Relationship between study variables and TBSA

Variable	Mean±SD	*P*-value
Inhalation Injury		
Yes	24.33±16.62	0.001*
No	14.55±12.63	
TBI		
Yes	26.35±14.45	<0.001*
No	14.05±12.35	
Skull Fracture		
Yes	26.14±13.62	<0.001*
No	14.54±12.82	

*: Mann Whitney U test
SD: Standard deviation; TBI: Traumatic Brain Injury

DISCUSSION

Burns are one of the most important health problems in communities, especially in developing countries and the Middle East. In addition to physical problems, burns in children can lead to mental problems and reduce the quality of life and increase disability[7]. According to the 2019 Global Burden of Disease report, the Disability-Adjusted Life Year Index (DALY) has been more than 8 million due to burn injuries[3]. Iran is no exception to the effect of burn injuries on disability, so that according to the results of the study, burns have been the eighth cause of disability due to disease in the country[4]. In addition, traumatic injuries, commonly associated with burns, can increase disability as well as mortality[10]. Therefore, in this regard, in addition to preventing burns, any action for a better treatment approach and early diagnosis of traumatic injuries can reduce complications, disability and treatment costs.

The present study showed that the mean age of patients was about 43 months (less than 4 years). In this regard, the results of a 10-year epidemiological study, in western Iran[14], and in Tehran[5], also showed that the mean age of patients was about 4 yr, which is similar to the results of the present study. In a 5-year study in China[15], the mean age of patients was less than 3 years. Furthermore, in Mexico[16], Nigeria[17], Bosnia[18], the average age of children with burns was lower. Therefore, the average age of children with burns in Iran is slightly higher than in other parts of the world; of course, meta-analysis studies are needed for greater certainty. In addition, in this study, the age of patients in the two groups of deceased or discharged was not significantly different. In this regard, in Cameroon [16,19] similar to the results of the present study, the age of patients was not related to their final outcome.

In the present study, most of the patients were boys. In this regard, in southwestern Iran[7] and northwestern Iran [20] also showed a higher frequency of boys among children with burn injuries, and in foreign studies such as Turkey[21], Switzerland[22], and the United States[23], a similar result was seen. In addition, in the present study, gender had no significant effect on the final outcome of patients. In this regard, the results of another study [19] were consistent with the results of the present study, however, the gender of the boy was identified as a risk factor for mortality due to burns[20]. However, the study was conducted with a much larger sample size, which could justify the difference in results.

The most common types of burns were burns with hot liquids, flame, contact injury, electrical burns, and chemical burns, respectively. In other studies in Iran [7,24], as well as in Germany and Austria[25], and in China[26], the results were similar to the results of the present study. Moreover, in the present study, the type of burn was not related to the final outcome of patients, which is consistent with the results of the study in the United States[23], and China[15].

The mean length of hospital stay in this study was about 8 d (range 1-44 days). In this regard, the averages obtained in Iranian studies[14,20,27] were 11, 9 and 7 d, respectively. The values obtained in the external studies [19,28,29] were 10, 8 and 7 d, which could be due to differences in treatment approaches, as well as different severity of burns in different studies. Moreover, in the present study, the length

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of hospital stay had no significant relationship with the final outcome of patients. In contrast, in Egypt[30] length of hospital stay for less than a week was an independent risk factor for burn-related mortality, while longer length of hospital stay were not associated with disease outcome.

In the present study, the mean severity of burns based on TBSA was approximately 15% and this value was significantly higher in deceased patients. The average obtained corresponds to the report of Iran[8]. In addition, in studies by Keshavarz et al.,[7] and Hosseini et al.,[20] similar to the results of the present study, mortality was significantly higher among patients with higher TBSA. Moreover, in this study, the mean TBSA and associated injuries such as inhalation injury were significantly associated with this finding, which is consistent with other results in India[31].

In this study, about 10% of patients developed TBI. This finding was higher than the study in the United States[12] which reported a prevalence of TBI of 3.3%. In addition, in the present study, the frequency of TBI was significantly higher in the deceased group, and TBI is an independent factor in the mortality of patients. In this regard, Martin et al.,[12] similar to the present results, concluded that the mortality due to burns in patients with TBI is higher than other traumas, as well as burns alone. In addition, trauma and burns had a synergistic effect on mortality[9], and this synergistic effect was not related to the level of Trauma Center[32]. Contrary to the results of the present study, TBI, although it increases morbidity in patients, has no effect on mortality[10]. Of course, in that study, the general population was studied, but in the present study, children, who have a higher chance of vulnerability were studied, and this difference in the studied samples may explain the difference in results. In addition, in the present study, skull fractures were associated with the final outcome of patients, which is consistent with another study[32] and showed the need for neuroimaging in patients with traumatic injury. Edema and swelling from burns to the head and neck may mask the symptoms of TBI. TBI may be obscured, especially when the accident occurred in the absence of the parents and the exact mechanism of the injury is not known.

TBI is an important factor in increasing mortality and morbidity in children with burn injuries. Therefore, examination of these patients for TBI as soon as possible using clinical examinations and imaging at the beginning of hospitalization, and after initial resuscitation is very necessary, and can lead to increased survival, and reduced complications of burns. This is important because the treatment approach may be different in burn patients with or without TBI, and even when left untreated can lead to worsening of patients with TBI; extensive fluid therapy, for example, is very effective in patients with burn injuries, while it should be done with extreme caution in patients with TBI. Furthermore, similar to TBI, hypernatremia in patients with burn injury can lead to increased mortality[12]. Therefore, the concurrence of these two injuries is a very important therapeutic challenge for emergency physicians and surgeons. Children who have probable TBI or when the burn injury occurred without the presence of parents and the exact mechanism of the injury is not clear, children should be examined for TBI.

Limitations: Long-term follow-up of patients in the design of a cohort study, considering children with non-trauma burn injury or non-brain trauma as a comparison group, can lead to valuable information about patients' long-term complications, which is one of the limitations of the present study. However, one of the strengths of this study is the report of TBI injuries with burns, and the determination of mortality caused by it for the first time in Iran, which has a relatively high prevalence in burn injuries.

CONCLUSION

The severity of burns based on TBSA and TBI is associated with increased mortality among children with burn injuries. The results of this study suggest the need to examine children with burn injuries for TBI using clinical examination or imaging.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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