Original Article

An Epidemiologic Study of Traumatic Brain Injury in Children, Middle-Aged, and Elderly Patients Presenting to the Emergency Department

Farhad Heydari, Babak Masoumi, Alireza Abootalebi, Amir Bahador Boroumand, Reyhane Qasemi

Department of Emergency Medicine, Faculty of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

ORCID:

Farhad Heydari: https://orcid.org/0000-0002-6296-0045

Babak Masoumi: https://orcid.org/0000-0002-5928-1770

Alireza Abootalebi: https://orcid.org/0000-0003-0775-2910

Amir Bahador Boroumand: https://orcid.org/0000-0001-5055-6881

Reyhane Qasemi: https://orcid.org/0000-0002-5287-7459

Abstract

Background and Objectives: Traumatic brain injury (TBI) is one of the major health and socioeconomic problems in the world. How clinicopathological features of TBI differ by age is unclear. The present study evaluated the epidemiology of TBI and identified any variable that differs among pediatric, middle-aged, and elderly patients. **Methods:** The descriptive cross-sectional study was conducted on patients with TBI from April 2019 to April 2021. The study population consisted of all patients with TBI who were admitted to the Emergency Department. The inclusion criteria were all TBI patients who were a candidate for head computed tomography (CT) scans. The patients' clinicopathological parameters were recorded. **Results:** Among 3513 patients with TBI who underwent CT scans, 212 patients died (6.0%). The mean age of subjects was 30.67 ± 19.42, and 69.2% of the patients (2430 cases) were male. Motor vehicle accidents (48.4%) were the most prevalent mechanisms of injury. Intracranial lesions were seen on the head CT scan in 509 (14.5%) patients. The highest mortality rate was shown in elderly patients and the lowest in children ($P < 0.001$). Falls were the most common mechanism of injury in the elderly subjects (65.2%), while motor vehicle accidents were the most common in the children and middle-aged groups (40.9% and 54.0%). The incidence of intracranial lesions and moderate-to-severe head injuries was significantly higher in the elderly subjects ($P < 0.001$). Subdural hematoma and subarachnoid hemorrhage were the most common CT findings in elderly patients (13.3% and 11.3%). Brain contusion and skull fracture were the most common findings in the children (6.0% and 4.3%). **Conclusions:** The present study found that the clinicopathological parameters were significantly different among children, middle-aged patients, and elderly patients.

Keywords: Brain injury, emergency department, epidemiology, trauma

Introduction

Traumatic brain injury (TBI) is one of the major health and socioeconomic problems in Iran and around the world.[1,2] According to the World Health Organization, TBI is the third leading cause of death and disability in the world in 2020.[3] About 37% of all deaths following injuries are caused by TBI.[4] Each year about 50,000 deaths after TBI are reported in the United States.[5] In recent years, the number of people with TBI has increased steadily in developed and developing countries.[6] In Iran, head-and-neck trauma is one of the most common types of injuries, and the most common mechanism is motor vehicle accidents.[7]

TBI is more common in the middle-aged, followed by teenagers and the elderly.[6] However, with the increase in the age of the population, the proportion of the elderly with TBI has increased compared to young patients.[8] Mortality and morbidity after TBI vary by age. The mortality rate in

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Address for correspondence: Dr. Reyhane Qasemi, Alzahra Hospital, Sofeh Ave., Keshvari Blvd., Isfahan, Iran. E-mail: r.qasemi. 74@gmail.com

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the elderly is higher than that of teenagers and middle-aged people.[4,5] This could be related to differences in brain anatomy, the presence of more comorbidities, and greater use of anticoagulants and antiplatelet drugs.[5,8,9] Older adults experienced more complications and had more injuries due to low-energy traumas such as falls, longer lengths of stay, higher triage levels, and lower discharge rates compared with younger adults.[5,10] The mortality rate in middle-aged people is higher than in juveniles. It can be related to more occurrences of motor vehicle accidents in these ages which cause more serious injuries.[11]

Age and gender have a significant effect on TBI outcome, either alone or in combination with Glasgow Coma Score (GCS).[6,11] GCS is the most common score used to describe the severity of brain injuries. GCS was developed to assess consciousness levels in patients with head trauma. Traditionally, mild head trauma is defined as a GCS = 14–15, moderate head trauma is defined as a GCS = 9–13, and severe head trauma is defined as a GCS ≤8.[12,13]

Due to the importance of head injury and its consequences, such as loss of consciousness and death, its costs in the health-care system, and disabilities caused by head trauma, an epidemiological study of this issue is necessary. Previous studies have reported the epidemiology of head trauma worldwide.[1,3,6] While, the different clinical and pathological characteristics of head trauma among pediatric, middle-aged, and elderly people are not well defined. Furthermore, the epidemiology of head trauma seems to be changing due to its increased incidence in the elderly.[1]

The present study was performed to evaluate the epidemiology of TBI and to identify any variable that differs among pediatric, middle-aged, and elderly patients.

Materials and Methods

Study design

The descriptive cross-sectional study was performed on patients with TBI from April 2019 to April 2021 in Alzahra and Kashani Hospitals, two university hospitals in Isfahan, Iran. The study protocol was approved by the Ethics Committee of the Isfahan University of Medical Sciences (IR.MUI.MED.REC.1400.135).

Study setting and population

The study population consisted of all patients with traumatic brain trauma who were admitted to the Emergency Department (ED) of Alzahra and Kashani Hospitals during the study period. The inclusion criteria were all patients with TBI who were a candidate for head computed tomography (CT) scans. Patients with trauma to other parts of their body, who had an abbreviated injury scale score of more than 2, were not included in the study.

Patients with a history of taking anticoagulant drugs, with a previous history of brain tumors or cerebrovascular diseases, pregnant women, and incomplete medical records were excluded from the study.

Data gathering

The data were obtained by reviewing the medical records of all patients, using a preestablished checklist. The data collected included demographic data (gender, age), triage level based on the Emergency Severity Index-version 4, mechanisms of injury, time of day and season of the event, the severity of trauma based on the GCS, head CT findings including subdural hematoma (SDH), epidural hematoma (EDH), subarachnoid hemorrhage (SAH), brain contusion, skull fracture, and others, scalp laceration, and outcomes (death or survived).

Patients were also classified into children (≤17 years), middle-aged patients (18–64 years), and elderly patients (≥65 years).[6,9,11,13] The attending radiologists reported all head CT scans.

Statistical analysis

Results were reported as frequencies (%) for qualitative data and mean and standard deviation (SD) for descriptive variables. The Chi-squared test and Mann–Whitney *U*-test were used to compare the variables.

A multivariate logistic regression analysis was used to assess the independent risk factors of death. Stepwise logistic regression was performed for the occurrence of death, considering the variables associated with a higher univariate association with death ($P < 0.1$). All statistical analyses were performed using SPSS (ver. 25.0; IBM, Armonk, NY, USA). $P < 0.05$ was considered statistically significant.

Results

A total of 3513 patients with traumatic brain trauma underwent CT analyses in the present study. Of these, 881 patients were under 18 years old, 256 patients were over 64 years old, and 2376 patients were between 65 and 80 years old. The mean (SD) age of subjects was 30.67 (19.42), and 69.2% of the patients (2430 cases) were male. 6.0% ($n = 212$) of patients died. Motor vehicle accidents (48.4%) were the most prevalent mechanisms of injury. In most patients, the severity of the head injuries was mild (86.9%).

Intracranial lesions were seen on the head CT scan in 509 (14.5%) patients. Parenchymal contusion was the most common CT finding (7.0%), followed by diffuse axonal injury (4.7%) and skull fracture (4.3%). Between 18:00 and 24:00 (36.0%) and between 12:00 and 18:00 (31.5%) were the most common times of the day when patients were admitted to the ED, and spring (27.5%) was the most common season to present to the ED. The baseline characteristics are presented in Table 1.

The associations of baseline characteristics with gender are reported in Table 1. The men were significantly younger than the women (27.59 ± 15.51 vs. 37.58 ± 24.79; $P < 0.001$). The prevalence of intracranial lesions between men and women had no significant difference ($P = 0.099$). There were significant differences in terms of the severity of trauma ($P = 0.041$), level

Table 1: Characteristics of elderly patients with head trauma

Variable	Total (n=3513), n (%)	Gender		P
		Men (n=2430; 69.2), n (%)	Women (n=1083; 30.8), n (%)	
Age (years)	30.67±19.42	27.59±15.51	37.58±24.79	<0.001
Mechanism of injury				
Fall	751 (21.4)	399 (16.4)	352 (32.5)	<0.001
Motor vehicle accidents	1700 (48.4)	1192 (49.1)	508 (46.9)	
Assault	789 (22.5)	623 (25.6)	166 (15.3)	
Others	273 (7.8)	216 (8.9)	57 (5.3)	
Time of event				
0–6	579 (16.5)	419 (17.2)	160 (14.8)	0.170
6–12	561 (16.0)	396 (16.3)	165 (15.2)	
12–18	1107 (31.5)	760 (31.3)	347 (32.0)	
18–24	1266 (36.0)	855 (35.2)	411 (38.0)	
Season of event				
Spring	965 (27.5)	656 (27.0)	309 (28.5)	0.561
Summer	854 (24.3)	594 (24.4)	260 (24.0)	
Fall	861 (24.5)	610 (25.1)	251 (23.2)	
Winter	833 (23.7)	570 (23.5)	263 (24.3)	
Severity of trauma				
Mild (GCS 13–15)	3053 (86.9)	2089 (86.0)	964 (89.0)	0.041
Moderate (GCS 9–12)	264 (7.5)	193 (7.9)	71 (6.6)	
Severe (GCS ≤8)	196 (5.6)	148 (6.1)	48 (4.4)	
Triage level (ESI)				
Level 1	373 (10.6)	275 (11.3)	98 (9.0)	0.020
Level 2	1120 (31.9)	787 (32.4)	333 (30.7)	
Level 3	1204 (34.3)	796 (32.8)	408 (37.7)	
Level 4	816 (23.2)	572 (23.5)	244 (22.5)	
Scalp laceration				
Yes	1167 (33.2)	926 (38.1)	241 (22.3)	<0.001
No	2346 (66.8)	1504 (61.9)	842 (77.7)	
Intracranial lesions				
Yes	509 (14.5)	368 (15.1)	141 (13.0)	0.099
No	3004 (85.5)	2062 (84.9)	942 (87.0)	
Death				
Yes	212 (6.0)	149 (6.1)	63 (5.8)	0.718
No	3301 (94.0)	2281 (93.9)	1020 (94.2)	

ESI: Emergency Severity Index, GCS: Glasgow Coma Score

of triage (P = 0.020), and mechanism of injury (P < 0.001). Moreover, the mortality of males and females had no significant difference (P = 0.718).

There were significant differences between the survived and death groups in age and mechanism of injury (P < 0.001). The frequencies of intracranial lesions, level 1 of triage, and moderate-to-severe head injuries were significantly higher in the death group (P < 0.001). The findings demonstrated a higher prevalence of death in the summer and fall (P = 0.004) [Table 2]. The logistic regression results for the death are shown in Table 3. The multivariate analysis resulted in older patients (odds ratio [OR] = 1.043, 95% confidence interval [CI]: 1.026–10.60, P = 0.006), who had intracranial lesions (OR = 7.940, 95% CI: 2.981–21.146, P < 0.001), low triage level (OR = 0.195, 95% CI: 0.089–0.430, P < 0.001), and severe head trauma (OR = 19.470, 95% CI: 5.491–66.582, P < 0.001) as predictors of mortality.

The associations of baseline characteristics with the age group (children, middle-aged patients, and elderly patients) are demonstrated in Table 4. The highest mortality rate was shown in elderly patients and the lowest in children (P < 0.001). Falls were the most common mechanism of injury in the elderly subjects (65.2%), while motor vehicle accidents were the most common in the children and middle-aged groups (40.9% and 54.0%). The prevalence of intracranial lesions and moderate-to-severe head injuries was significantly higher in the elderly subjects (P < 0.001). SDH and SAH were the most common CT findings in elderly patients (13.3% and 11.3%). Brain contusion and skull fracture were the most common findings in the children (6.0% and 4.3%). The findings showed

Table 2: Association of variables with outcome

Variable	Outcome		*P*
	Death (*n*=212), *n* (%)	Survived (*n*=3301), *n* (%)	
Age (years)	43.74±23.77	29.83±18.80	<0.001
Age (years)			
<10	10 (4.7)	490 (14.8)	<0.001
10–19	29 (13.7)	638 (19.3)	
20–29	46 (21.7)	834 (25.3)	
30–39	19 (9.0)	538 (16.3)	
40–49	17 (8.0)	306 (9.4)	
50–59	21 (9.9)	197 (6.0)	
60–69	34 (16.0)	162 (6.0)	
70–79	15 (7.1)	88 (2.7)	
80–89	21 (9.9)	35 (1.1)	
>90	0	10 (0.3)	
Gender			
Men	149 (70.3)	2281 (69.1)	0.718
Women	63 (29.7)	1020 (30.9)	
Mechanism of injury			
Fall	43 (20.3)	708 (21.4)	<0.001
Motor vehicle accidents	135 (63.7)	1565 (47.4)	
Assault	7 (3.3)	782 (23.7)	
Others	27 (12.7)	246 (7.5)	
Severity of trauma			
Mild (GCS 13–15)	2 (0.9)	3051 (92.4)	<0.001
Moderate (GCS 9–12)	29 (13.7)	235 (7.1)	
Severe (GCS ≤ 8)	181 (85.4)	15 (0.5)	
Triage level (ESI)			
1	181 (85.4)	191 (5.8)	<0.001
2	30 (14.2)	1141 (34.6)	
3	1 (0.4)	1169 (35.4)	
4	0	800 (24.2)	
Time of event			
0–6	40 (18.9)	539 (16.3)	0.240
6–12	41 (19.3)	520 (15.8)	
12–18	66 (31.1)	1041 (31.5)	
18–24	65 (30.7)	1201 (36.4)	
Season of event			
Spring	51 (24.1)	914 (27.7)	0.004
Summer	65 (30.7)	789 (23.9)	
Fall	63 (29.7)	798 (24.2)	
Winter	33 (15.6)	800 (24.2)	
Intracranial lesions			<0.001
Yes	199 (93.9)	310 (9.4)	
No	13 (6.1)	2991 (90.6)	

ESI: Emergency Severity Index, GCS: Glasgow Coma Score

a higher incidence of SDH, SAH, and diffuse axonal injury in the elderly group ($P < 0.001$).

Discussion

The present study is a population-based study assessing TBI that included both clinical and pathological characteristics. Most of the previous studies showed the epidemiology of TBI in young and elderly people, while in this study, we have assayed three age groups including juvenile, middle-aged, and elderly people.

The total number of TBI-related hospitalization and deaths has increased over time.[8,14] However, improvements in the care of patients with TBI have led to reduced mortality and improved outcomes. In this regard, a study conducted by Martins *et al*.[15] reported that mortality from TBI decreased over time.

In this study, the majority of hospitalized patients had a mild injury (86.9%), which was consistent with previous studies that reported mild injury in 39%–85.3% of TBI patients.[3,5] In another study, Peeters *et al*.[1] show that mild brain injuries vary between 71% and 97.5%. Furthermore, in the present study, head injury was more common in middle-aged people, followed by children and the elderly. These results were consistent with those reported by Wang *et al*.[6] and Onwuchekwa and Echem.[3]

The mean age of subjects was 30.67 years. Similarly, in another study conducted in Iran, it was 30.78 years.[2] In a systematic review, the mean age of patients varied from 22 to 49 years.[1] Similar to previous studies, the majority of patients were male (69.2%).[2,4,6,11] The male-to-female ratio ranged from 1.2:1.0 to 4.6:1.0.[1] In line with previous studies, in the elderly group, the number of women increased slightly and the ratio of men to women decreased.[14,16,17]

Motor vehicle accidents were the most prevalent mechanisms of injury in the present study (48.4%). It was consistent with some studies[3,16] and in contrast with other studies.[1,17] In a systematic review of 26 studies, falls were found as the most frequent cause of TBI in 13 studies and motor vehicle accidents were the most frequent mechanisms of injury in 11 studies.[1] In previous studies conducted in Iran, motor vehicle accidents have always been the most common injury mechanism.[2,7,18-20]

In the present study, parenchymal contusion was the most common CT finding (7.0%), followed by diffuse axonal injury (4.7%) and skull fracture (4.3%). Mebrahtu-Ghebrehiwet *et al*.[21] demonstrated that cerebral contusion or laceration was the most common CT finding followed by SDH and then skull fracture. Adeleye and Ogun[22] found that the occurrence of brain contusions was 18.8%, the EDH was 4.1%, and the SDH was 3.8%. Heydari *et al*.[5] reported that SDH was the most common injury (27.6%). Forouzan *et al*.[20] showed that EDH was the most common CT finding followed by parenchymal contusion and skull fracture. Asadian *et al*.[19] found that skull fracture was the most common CT finding followed by EDH and parenchymal contusion. The reason for the difference in the CT scan findings can be considered to be the difference in age, gender, the severity of the trauma, and the mechanism of trauma in different studies.

The present study indicated that the men were significantly younger than women (27.59 ± 15.51 vs. 37.58 ± 24.79;

$P < 0.001$). It was consistent with previous studies.[1,3,11] Similar to previous studies, the incidence of intracranial lesions between men and women had no significant difference ($P = 0.099$).[2,11]

Table 3: Logistic regression models for risk factors for death in head trauma patients

Variable	B	SE	OR (95% CI)	P
Age	0.042	0.008	1.043 (1.026–1.060)	0.006
Triage level (ESI)	−1.633	0.403	0.195 (0.089–0.430)	0.000
Intracranial lesions	2.072	0.500	7.940 (2.981–21.146)	0.000
Severity of trauma	4.286	0.371	19.470 (5.491–66.582)	0.000

OR: Odds ratio, CI: Confidence interval, ESI: Emergency Severity Index, SE: Standard error

In the current study, there was a significant difference in the mechanism of injury between men and women ($P < 0.001$). The most frequent mechanism of injury was motor vehicle accident in both groups but followed by assaults in men and fall in women. It was in contrast with previous studies that found no significant difference.[3,11,18]

In the present study, the associations of baseline characteristics with the age group (children, middle-aged patients, and elderly patients) were analyzed. The highest mortality rate was in elderly patients and the lowest was in children ($P < 0.001$). Previous studies showed that with increasing age, the OR of mortality was also increasing.[7,8] In another study, the mortality rate was 2.5% for children and 10.4% for adults.[22] Ogolo and Ibe[23] reported that older adults were 4.6 times more likely to

Table 4: Association of variables with age group

Variable	Age (years)			P
	<18 (n=881), n (%)	18–64 (n=2376), n (%)	≥65 (n=256), n (%)	
Gender				
Men	619 (70.3)	1676 (70.5)	135 (52.7)	<0.001*
Women	262 (29.7)	700 (29.5)	121 (47.3)	
Mechanism of injury				
Fall	259 (29.4)	325 (13.7)	167 (65.2)	<0.001
Motor vehicle accidents	360 (40.9)	1284 (54.0)	56 (24.9)	
Assault	205 (23.3)	566 (23.8)	18 (7.0)	
Others	57 (6.5)	201 (8.5)	15 (5.9)	
Severity of trauma				
Mild (GCS 13–15)	815 (92.5)	2112 (88.9)	126 (49.2)	<0.001
Moderate (GCS 9–12)	40 (4.5)	120 (5.0)	104 (40.6)	
Severe (GCS ≤8)	26 (3.0)	144 (6.1)	26 (10.2)	
Time of event				
0–6	132 (15.0)	412 (17.3)	35 (13.7)	0.148
6–12	139 (15.8)	381 (16.0)	41 (16.0)	
12–18	267 (30.3)	745 (31.4)	95 (37.1)	
18–24	343 (38.9)	838 (35.3)	85 (33.2)	
Season of event				
Spring	248 (28.1)	632 (26.6)	85 (33.2)	0.161
Summer	229 (26.0)	572 (24.1)	53 (20.7)	
Fall	212 (24.1)	586 (24.7)	63 (24.6)	
Winter	192 (21.8)	586 (24.7)	55 (21.5)	
Death				
Yes	27 (3.1)	142 (6.0)	43 (16.8)	<0.001
No	854 (96.9)	2234 (94.0)	213 (83.2)	
Intracranial lesions				
Yes	84 (9.5)	338 (14.2)	87 (34.0)	<0.001
No	797 (90.5)	2038 (85.8)	169 (66.0)	
CT characteristics				
SDH	20 (2.3)	87 (3.7)	34 (13.3)	<0.001
EDH	17 (1.9)	60 (2.5)	6 (2.3)	0.610
SAH	7 (0.8)	100 (4.2)	29 (11.3)	<0.001
Brain contusion	53 (6.0)	176 (7.4)	18 (7.0)	0.386
DAI	26 (3.0)	119 (5.0)	21 (8.2)	0.001
Skull fracture	38 (4.3)	98 (4.1)	14 (5.5)	0.598

SDH: Subdural hematoma, SAH: Subarachnoid hemorrhage, DAI: Diffuse axonal injury, EDH: Extradural hematoma, GCS: Glasgow Coma Score, CT: Computed tomography die from TBI than other age groups. In line with the present study, Munivenkatappa *et al*.[11] demonstrated that the highest and lowest mortality rates were in the elderly (>61 years) and pediatric (<18 years) groups. Furthermore, Wang *et al*.[6] reported that the elderly (≥65 years) had the highest mortality rates and the juvenile (≤17 years) had the lowest mortality rates.

In the present study, motor vehicle accidents were the most common mechanisms of injury in children and middle-aged individuals and falls were more common in older people. It was similar to the study conducted by Munivenkatappa *et al*.,[11] whereas other studies found that the rate of falls was highest in the juvenile and elderly groups and motor vehicle accidents were the most common cause in the middle-aged group.[1,6] In the United States, Taylor *et al*.[14] showed that hospitalizations due to TBI from motor vehicle accidents decreased over time. Other studies reported that falls were the leading cause of TBI in older adults, followed by traffic accidents.[1,5,24] The reason can be that older adults are more prone to falls.

Consistent with previous studies, the incidence of intracranial lesions was significantly higher in elderly subjects.[6,11,24] Studies have shown that the probability of intracranial hemorrhage in older patients is higher due to the presence of comorbidities and the frequent use of anticoagulants and antiplatelets.[14,24,25]

SDH and SAH were the most common CT findings in elderly patients (13.3% and 11.3%). Aligned with the present study, previous studies showed that the incidence of SDH in adults increased with age, and the highest incidence of SDH was in the elderly.[6,11,24] Similarly, Heydari *et al*.[5] found that SDH was the most common CT finding in elderly TBI followed by SAH. The current study demonstrated that brain contusion and skull fracture were the most common findings in the children (6.0% and 4.3%) which was consistent with Wang *et al*.[6]

The present study showed that there was a significant difference between the survived and death groups in the mechanism of injury ($P < 0.001$). Motor vehicle accident was the main mechanism of injury in the death group (63.7%), which is consistent with previous studies that reported motor vehicle accidents in 77.7%[3,7] and 75%[23] of the death group.

In the present study, the most admission hours of patients in the ED were between 18:00 and 24:00 (36.0%) and then between 12:00 and 18:00 (31.5%), which was consistent with the other studies conducted in Iran.[5,18,19] Therefore, it is necessary to increase the number of personnel and provide the necessary facilities in the emergency room to manage TBI patients during these hours.

Due to the difference in the severity of the injury, the type of intracranial injury, and the mortality rate at different ages, each ED must provide the necessary facilities and equipment according to the age of its patients. Furthermore, this point should be considered in the design of the ED. The study findings can provide new insights into the epidemiological characteristics of TBI in different age groups, leading to improved diagnosis and clinical treatment of patients with head trauma.

Limitations

The main limitation of the present study was its retrospective nature. Patients with incomplete medical records were excluded from the study, and this may affect the results of the study. Patients with severe and multiple trauma were not included in this study, which may lead to selection bias, as their mortality was not considered.

Conclusions

This population-based study evaluated TBI among three age groups. The result of the study demonstrated that the clinicopathological parameters were significantly different among children, middle-aged patients, and elderly patients. The highest mortality rate was shown in elderly patients and the lowest in children. The incidence of intracranial lesions and moderate-to-severe head injuries were significantly higher in the elderly subjects

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Conflicts of interest

There are no conflicts of interest.

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