

Original Article

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Traumatic Brain Injury in Older Adults Presenting to the Emergency Department: Epidemiology, Outcomes and Risk Factors Predicting the Prognosis

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Abstract

Introduction: The continuing-to-grow number of older adults with traumatic brain injury (TBI) presenting to emergency departments (EDs) and hospitals necessitates the investigation of TBI in these patients.

Objective: The present study was conducted to investigate the epidemiology of TBI and the factors affecting intracranial lesions and patient outcomes in older adults.

Method: The present retrospective cross-sectional study was performed between March 2016 and March 2018. The study population comprised all TBI patients with a minimum age of 60 years presenting to the ED. The eligible candidates consisted of patients presenting to the ED within 24 hours of the occurrence of traumas and requiring head CT scan as part of their examination. The patients' baseline information was also recorded.

Results: A total of 306 older adult patients with a mean age of 70.61±8.63 years, of whom 67.6% were male, underwent CT scan for TBI during the study period. Falls were the major cause of head injuries, and intracranial lesions were observed in 22.9% (n=70) of the patients. Subdural hematoma (SDH) was observed as the most prevalent injury in 27.6% of the patients, 22.9% (n=16) were transferred to the operating room, and 7.5% (n=23) died. Moreover, the severity of trauma was significantly different between the two genders (P=0.029). Midline shift, SDH, subarachnoid hemorrhage (SAH) and moderate-to-severe head injuries were also significantly associated with poor outcomes (P<0.05).

Conclusion: Death from TBIs was more likely in the patients with SDH, SAH and midline shift or in those with an initial Glasgow coma scale (GCS) of below 13. These predictions are clinically relevant, and can help improve the management of older adults with TBI.

Key words: Aged; Brain Injuries, Traumatic; Epidemiology; Emergency Department; Geriatrics; Outcome

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INTRODUCTION

As a major cause of mortality and incapacitation, traumatic brain injuries (TBIs) account for almost half of all admissions for major traumas in older adults (1). Most patients with TBI suffer lifelong disabilities, and around 50,000 mortalities annually reported in the US are associated with TBI (2, 3). Mortality within the first month of head injuries was estimated at 21% in developed countries and 50% in developing countries (4). TBI is potentially asymptomatic, prevalent in older adults, and can be associated with minimal head injuries. The risk of sustaining a TBI increases with age (2, 5). In recent years, the epidemiological patterns of injuries have changed, with more injuries occurring among older adults aged over 60 years and caused by low-energy accidents such as falls (6). The incidence of TBI has doubled in older adults over the past 18 years, with the maximum

increase observed in 83-90 year olds (7). The age-adjusted rate of hospitalization for nonfatal TBI is 60.6 per 100,000 in the general population, and increases by more than 100% to 155.9 in older adults aged at least 65 (8). Given their different brain anatomy, heavier comorbidity burdens and more frequent use of anticoagulants and anti-platelets, older adults with TBI suffer more complications, longer morbidity and higher mortality compared to their younger counterparts (9, 10). Cost-analysis models also suggest older adults with TBI incur higher costs of hospitalization (2). Furthermore, diagnosing TBI is more difficult in older adults given that the increased intracranial free space can allow the accumulation of blood without changes in the mental status (7, 11). With an aging population, older adults represent a growing percentage of TBI

patients who are treated at hospitals and trauma centers (8, 10). The number of older adults is expected to reach 2 billion by 2050 (10-12), and the population of Iranians aged at least 60 continues to rise, and their share of the national population is expected to increase from 8% in 2010 to 31% in 2050 (13, 14). Trauma is the second leading cause of death in Iran after heart disease (4), and the fifth leading cause in people aged at least 65 (13). Despite the epidemic of older adults with TBI, evidence-based geriatric TBI guidelines have rarely been developed to help with complicated medical decision makings made for acute and long-term management. In addition, scalp lacerations are classified as the medium-risk TBI with a risk of surgical hematoma of 1%-3% (15). The correlations between scalp lacerations and intracranial findings are yet to be investigated in older adults. Given the definition of older adults proposed in literature as individuals aged at least 60-65 years, the present study defined them as those aged at least 60. The present retrospective cohort study was conducted to explain the epidemiology of TBI, the role of scalp lacerations and the factors affecting geriatric TBI outcomes in older adults, and to identify the risk factors affecting mortality in TBI patients.

Methods

Study design

The present cross-sectional study was performed from March 2016 to March 2018 in Alzahra hospital, Isfahan, Iran, as the largest referral hospital in the center of Iran, affiliated to Isfahan University of Medical Sciences. The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences and the code IR.MUI.REC.1396.2.118 has been assigned.

Study setting and population

The study population comprised all TBI patients aged at least 60 presenting to the ED of Alzahra Hospital during the study period. The eligible candidates consisted of patients presenting to the ED within 24 hours after traumas and requiring head CT scan as part of their examination. Patients with comorbid traumas involving other parts of their body with an abbreviated injury scale score of over 2 were excluded.

Data gathering

The data obtained from the hospital registry database were collected using a checklist, including demographic information, i.e. age and gender, mechanisms of injury, including road traffic accidents (RTA), falls and assaults, the timing of the trauma, the severity of trauma as measured with

the emergency severity index-version 4 (ESI) and trauma severity based on Glasgow coma scale (GCS: Mild=13-15, Moderate=9-12, severe≤8), imaging findings and final outcomes, i.e. discharge from the ED, admission to the ward or ICU, transfer to the operating room and death. All the patients were examined and managed by the trauma team as per standard protocols. An attending radiologist confirmed all the head CT scan reports.

Statistical analysis

The data collected were analyzed in SPSS-20 (IBM Corp., Armonk, N.Y., USA). The descriptive variables were expressed as mean and standard deviation, and the qualitative variables as numbers and percentages. The t-test was used to compare the parametric variables and the chi-square test and Fisher's exact test to compare the proportions. Stepwise logistic regression was used for the occurrence of the events, accounting for all significant univariate parameters. According to the univariate tests, the risk factors in CT findings, i.e. subdural hematoma (SDH), subarachnoid hematoma (SAH), extradural hematoma (EDH), skull fractures and midline shift, gender and severity of injury (based on GCS) were selected for the stepwise logistic regression. Binary logistic regression was also used to estimate the odds ratio for risk factors affecting TBI-associated hospital mortality. $P < 0.05$ was also set as the level of statistical significance.

RESULTS

A total of 306 older adults with TBI underwent CT during the study period. Table 1 presents their baseline characteristics. The patients were 60-98 years old, had a mean age of 70.61 ± 8.63 , and included 207 (67.6%) men and 99 (32.4%) women, suggesting a male-to-female ratio of 2.1:1. Falls (42.5%) and motor vehicle collision (26.8%) were also the most prevalent mechanisms of injury.

The GCS suggested the severity of the head injuries was mild in 85.3% ($n=261$) of the patients, moderate in 8.8% ($n=27$) and severe in 5.9% ($n=18$). Evidence of lesions was identified on the brain CT scan of 22.9% ($n=70$) of the patients. The frequency distribution of different CT findings included 27.6% for SDH as the most prevalent injury, followed by 21.6% for SAH, 17.2% for skull fractures, 13.8% for parenchymal contusion, 12.9% for diffuse axonal injury and 6.9% for extradural hematoma. Evidence of intracranial lesions was observed in 14% of the patients presenting with mild brain injuries to the ED. Surgery for the urgent evacuation of hematoma was required in 16 cases (5%), and 23 cases (7.5%)

Table 1: Details of the older adult patients with head traumas

Variable	Total (n=306)	Gender		p
		Male (n=207)	Female (n=99)	
Number (%)				
Injury mechanism				
Falls	130 (42.5)	95 (45.9)	35 (35.4)	0.067
Motor vehicle collision	82 (26.8)	50 (24.2)	32 (32.3)	
Assaults	34 (11.1)	23 (11.1)	11 (11.1)	
Others	60 (19.6)	39 (18.8)	21 (21.2)	
Time of events				
2-8 a.m.	34 (11.1)	17 (8.2)	17 (17.2)	0.064
8 a.m.-2 p.m.	73 (23.9)	50 (24.2)	23 (23.2)	
2-8 p.m.	109 (35.6)	81 (39.1)	28 (28.3)	
8 p.m.-2 a.m.	90 (29.4)	59 (28.5)	31 (31.3)	
Trauma severity				
Mild	261 (85.3)	169 (81.6)	92 (92.9)	0.029
Moderate	27 (8.8)	22 (10.6)	5 (5.1)	
Severe	18 (5.9)	16 (7.7)	2 (2.0)	
Triage level (ESI)				
1	35 (11.4)	28 (13.5)	7 (7.1)	0.025
2	141 (46.1)	102 (49.3)	39 (39.4)	
3	76 (24.8)	42 (20.3)	34 (34.3)	
4	54 (17.6)	35 (16.9)	19 (19.2)	
Scalp lacerations	63 (20.6)	47 (22.7)	16 (16.2)	0.185
Intracranial lesions	70 (22.9)	55 (26.6)	15 (15.2)	0.026
Neurosurgical interventions	16 (5.2)	14 (6.8)	2 (2.0)	0.102
Mortality	23 (7.5)	19 (9.2)	4 (4.0)	0.163

Table 2: Associations of the variables with intracranial lesions

Variable	Intracranial lesions		p
	Yes (n=70)	No (n=236)	
Number (%)			
Age (year)			
60-70	36 (51.4)	125 (53.0)	0.953
70-80	21 (30.0)	72 (30.5)	
80-90	10 (14.3)	32 (13.6)	
>90	3 (4.3)	7 (3.0)	
Gender			
Male	55 (78.6)	152 (64.4)	0.026
Female	15 (21.4)	84 (35.6)	
Injury mechanism			
Falls	35 (50.0)	95 (40.3)	0.068
MVC	16 (22.9)	66 (28.0)	
Assaults	2 (2.9)	32 (13.6)	
Others	17 (24.2)	43 (16.3)	
Trauma severity			
Mild	37 (52.9)	224 (94.9)	<0.001
Moderate	21 (30.0)	6 (2.5)	
Severe	12 (17.1)	6 (2.5)	
Scalp lacerations	13 (18.6)	50 (21.2)	0.635

MVC: motor vehicle collision

died.

Between 2 p.m. and 8 p.m. (35.6%) and between 8 p.m. and 2 a.m. of the following day (29.4%) were the most common times of the day the patients presented to the ED.

Table 1 presents the associations of baseline characteristics of the study participants with the gender. The mean age of men and women had no significant difference (70.21 ± 8.56 vs. 71.44 ± 8.75 ; $p=0.243$). The findings suggest a higher incidence of intracranial lesions (26.6% versus 15.2%, $p=0.026$) in the males than in the females. Although the two genders were significantly different in terms of the severity of trauma ($p=0.029$), their mean ages were comparable ($p=0.243$), and no significant differences were observed in terms of the final outcome, i.e. mortality ($p=0.163$). Moreover, the two genders were not significantly different in terms of the mechanism of injury ($p=0.067$) and neurosurgical intervention ($p=0.102$).

Table 2 presents the associations of intracranial lesions with the sociodemographic variables, suggesting a significant difference between the two genders ($p=0.026$). The two groups (with and without intracranial lesions) were significantly different in terms of the severity of trauma ($p<0.001$), and not significantly different in terms of the frequency of scalp lacerations ($p=0.635$).

Table 3 presents the distribution of the variables in the patients who survived or died, suggesting no significant differences between the groups in age, gender and mechanism of injury ($p>0.05$). In

Table 3: Association of the variables with the outcome

Variable	Mortality		p
	Yes (n=23)	No (n=283)	
	Number (%)		
Age (year)			
60-70	11 (6.8)	150 (93.2)	0.311
70-80	5 (5.4)	88 (94.6)	
80-90	6 (14.3)	36 (85.7)	
>90	1 (10.0)	9 (90.0)	
Gender			
Male	19 (9.2)	188 (90.8)	0.163
Female	4 (4.0)	95 (96.0)	
Injury mechanism			
Falls	11 (8.5)	119 (91.5)	0.728
MVC	5 (6.1)	77 (93.9)	
Assaults	1 (12.5)	7 (87.5)	
Others	6 (7.0)	80 (93.0)	
Trauma severity			
Mild	2 (0.8)	259 (99.2)	<0.001
Moderate	5 (18.5)	22 (81.5)	
Severe	16 (88.9)	2 (11.1)	
CT scan findings			
SDH	11 (34.4)	21 (65.6)	0.001
EDH	2 (25.0)	6 (75.0)	0.115
SAH	6 (24.0)	19 (76.0)	0.001
Contusion	2 (11.1)	16 (88.9)	0.634
Skull fractures	3 (15.0)	17 (85.0)	0.182
Midline shift	16 (41.0)	23 (59.0)	0.000

MVC: motor vehicle collision; SDH: subdural hematoma; EDH: epidural hematoma; SAH: subarachnoid hemorrhage

Table 4: Multivariate logistic regression analysis of the factors associated with death from traumatic brain injury

Variable	Odds Ratio	95% CI		p
		Lower Limit	Upper Limit	
Gender	1.41	0.54	3.71	0.483
Trauma severity				
Mild	-	-	-	-
Moderate	4.43	1.34	7.76	0.056
Severe	19.88	5.49	66.43	<0.001
CT scan findings				
SDH	2.21	0.35	9.62	0.112
EDH	1.24	0.04	3.13	0.228
SAH	3.29	0.60	12.09	0.061
Skull fractures	1.32	0.05	3.67	0.236
Midline shift	11.44	3.69	30.28	<0.001

SDH: subdural hematoma; EDH: epidural hematoma; SAH: subarachnoid hemorrhage

addition, the frequencies of SDH, SAH, midline shift and moderate-to-severe head injuries were significantly higher in the mortality group ($p < 0.05$).

According to the univariate tests, risk factors such as SDH, SAH, extradural hematoma, skull fractures and midline shift as well as gender and severity of injury (based on GCS) were selected for the stepwise logistic regression.

After controlling for the factors significantly

affecting the outcome (all $P_s < 0.05$) (Table 3), mortality from TBI was found to be more likely in the patients who had midline shift (OR=11.44, 95% CI 3.69-30.28, $p < 0.001$) or in those with an initial GCS of below 9 compared to in those with a GCS of over 13 (OR 19.88, 95% CI 5.49-66.43, $p < 0.001$) (Table 4). The additional risk factors, which were initially significant in the univariate analysis, were not found significant in the multiple model.

DISCUSSION

The present study determined the frequency of intracranial lesions in older adults with TBI. Mild head injuries were observed in the majority (85.3%) of the patients, which was consistent with the studies reporting mild injuries in 67.5%-70.4% of the patients (10, 16). In contrast, Hsiao et al. found mild injuries in 38.2% of the subjects (17). The present study reported intracranial lesions in 22.9% of the patients. A meta-analysis of 16 articles conducted by Dunning et al. reported the wide range of 1.3%-36% for CT-positive cases (5). Hawley et al. reported intracranial lesions in 45% of the subjects (10). This discrepancy of results can be explained by the recent increase in the incidence of TBI in older adults, as Ramanathan et al. reported the incidence of TBI in older adults has doubled over the previous 18 years (7).

The present study found falls and road traffic accidents to be respectively the most prevalent mechanisms of injury, which is consistent with other studies, reporting falls as the leading cause of TBI in older adults followed by motor vehicle crashes (5-10, 17-19). Yousefzadeh et al. also found motor vehicle crashes and falls to be respectively the most prevalent causes of TBI in adults aged at least 65 (20).

Furthermore, the risk factors related to the positive findings in these patients were analyzed. A higher incidence of TBI was found in the older male adults, which was consistent with previous studies conducted on head traumas in developing and developed countries (8, 18, 21-24).

The present study found the two genders to be significantly different in term of the severity of trauma measured with the emergency severity index-version 4 and the GCS, which was consistent with the findings reported by Munivenkatappa et al. (16), though inconsistent with a study by Onwuchekwa et al., who reported insignificant differences between the two genders in terms of the GCS (23). These subjects have rarely been addressed in literature, and the discrepancy of the results in the study population can be further explained.

The present research found significant associations between intracranial lesions and the severity of head trauma based on the scores obtained from the GCS and the emergency severity index (ESI), which is consistent with similar studies (10-12, 16, 17).

Evidence of intracranial lesions was observed in 14% of the patients presenting to the ED with mild brain injuries. In line with the present study, Mack et al. reported the evidence of lesions on the CT of 14% of older adult patients with mild head injuries (3). Overall, CT scans positive (intracranial lesions) were reported in 11%-21% of adults with mild TBI aged at least 65 (18-25). Head CT scans are therefore recommended for the diagnosis of TBI in all adults aged at least 65 presenting with a history of head traumas to the ED. SDH was the most prevalent injury (27.6%) in the present study, which is consistent with similar studies (2, 10, 17, 19). In contrast to the survival group, the majority of patients in the mortality group had a GCS of below 9. Moreover, a low upon-admission GCS has been reported to be associated with significantly higher mortality and poor outcomes, especially in older adult patients (12, 17, 26). Several studies also found severe head injuries to be associated with mortality as high as 68%-92.5% in older adults (2). The present study found the initial GCS to be a risk factor for mortality in older adults. This score is known to be affected by several factors unrelated to TBI, including hypotension, hypoxia, alcohol or drug intoxication, chronic health conditions and GCS changes after the initial management in the ED; nevertheless, some authors found the GCS to be much more reliable upon admission than after the treatment (11, 17, 27). Similarly, the present study found this score can be used as a predictor of the prognosis.

Ostermann et al. found respiratory failure, pathological pupillary reaction, basal cistern injuries, high injury severity scores and degree of midline shift to be associated with poor outcomes in older adult patients with isolated severe TBI (12). Hsiao et al. found skull bone fractures, SAH, brain herniation and SDH observed on CT to be associated with mortality (17). In line with these findings, the present study found midline shift and initial GCS to be significantly associated with poor outcomes, although skull fractures were insignificantly associated with mortality.

Between 2 p.m. and 8 p.m. (35.6%) and between 8 p.m. and 2 a.m. of the following day (29.4%) were the most common times of the day the patients presented to the ED. Most of the patients (65%) presented from 2 p.m. to 2 a.m. of the following day, which was consistent with the studies by Asadian

et al. in Sari, Iran and Yousefzadeh et al. in Rasht, Iran (20, 21). Increasing the number of staff and providing the necessary facilities in the ED are therefore essential for managing patients with head traumas during these periods.

Limitation

The main limitations of the present study included its retrospective design and the small sample, especially in terms of the number of patients with severe TBI. Patients with severe and multiple traumas were excluded, which might have contributed to the selection bias, as their mortality can be associated with injuries caused by brain traumas. The unicenter type of this study and failing to perform long-term evaluations of post-discharge clinical outcomes constituted the other limitations.

CONCLUSIONS

Investigating TBI in older adults is crucial given that the number of these patients presenting to EDs and hospitals and admitted for TBI management is expected to continue to grow in the upcoming years. Moreover, older adult TBI patients are currently managed only based on the instructions proposed in previous studies, which mainly address younger adults with different physiological and psychological needs. The present study therefore addressed the epidemiology of TBI and the factors positively affecting CT scans and patient outcomes in older adult patients. The present study found intracranial lesions to be significantly associated with the male gender and the severity of trauma, i.e. moderate-to-severe head injuries, whereas no significant differences were observed in terms of the frequency of scalp lacerations. Although the present study found the initial GCS, SDH, SAH and midline shift on the initial CT scan to be the risk factors for mortality in older adult patients and isolated TBI, further studies are recommended to be conducted to confirm this potential. Falls were found to be the main cause of head traumas in the older adult patients, and the frequency of presentation to the ED by patients with head injuries to be higher in the evening and at night between 2 p.m. and 2 a.m. of the following day.

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AUTHORS' CONTRIBUTION

All the authors collected the data, contributed to

writing and commented on the final manuscript. FH and SM designed the study and MG analyzed the data.

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CONFLICT OF INTEREST

None declared.

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