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The Outcome Predictors of the Patients with Traumatic Brain Injury; A Cross-Sectional Study

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ABSTRACT

Objective: To probe the factors associated with the outcomes of traumatic brain injury (TBI) patients admitted to emergency department (ED).
Methods: This is a cross-sectional study that data gathering was performed via census methods, retrospectively. During one year, all head injury's patients who admitted to the ED of a tertiary center in Tehran, Iran were included. Age, gender, mechanism of injury, Glasgow coma scale (GCS) and injury severity score (ISS) on admission, presence of extra-cranial injuries, findings of brain computed tomography (CT), duration of hospitalization, and in hospital outcomes were recorded. Outcome's assessment for survivors was performed within a 6 months-period after discharge based on Glasgow outcome scale (GOS). The variables and outcomes' association were assessed.
Results: Totally, 506 patients were evaluated with the mean age of 36.77±21.1 years that 411 (81.2%) were men. Follow up at 6-months post injury was feasible in 487 (96.2%) patients; 59 (11.7%) out of 506 eligible patients died. Logistic regression analysis showed the association between assessed variables and patients' outcome as follows: age>65 years (OR: 12.21; $p<0.001$), GCS on admission <8 (OR: 62.99; $p<0.001$), presence of traumatic Intracerebral hemorrhage (ICH) in brain CT scan (OR: 20.11; $p=0.010$), duration of hospitalization ≥ 5 days (OR: 0.28; $p=0.001$).
Conclusion: The findings of the current study distinguished some variables that were associated with the poor outcome of the patients with TBI. Therefore, TBI patients with any of these risk factors may need close continues monitoring, early ICU admission, and some other special extra care in ED.

Keywords: Emergency department; Glasgow outcome scale; Patient outcome assessment; Prognosis; Traumatic brain injuries (TBI).

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Introduction

Traumatic Brain Injury (TBI) is a common cause of neurological disability and death. It is estimated that about 1.5 million people die worldwide following TBI. TBI also is one of the leading causes of mortality in the intensive care units (ICU) and emergency department (ED) of major trauma centers [1].

An accurate assessment of prognosis after TBI is very important to make decisions of using specific treatment's method, preventing nosocomial infections, counseling patients and relatives, and identify the specific rehabilitation of the patient needs [2, 3]. Most patients with severe TBI are unconscious, intubated, anesthetized, and sedated, which makes the use of clinical evaluation of the injury severity less reliable like applying the Glasgow Coma Scale (GCS) [4]. Therefore, mostly required undergoing emergent computed tomography (CT) scan is as a part of their secondary survey in the ED for providing information on the patients' outcome prediction [5].

In previous studies, some factors have been linked to increase mortality and worse outcome after TBI such as age, the coexistence of other injuries, history of previous head injury, alcohol and drug abuse, low socioeconomic and educational status [6, 7]. Available data revealed that the risk of TBI is high in the 15-24 years of age that decrease in the midlife, and then increases again after 70 years which mostly due to falls. Men sustain a TBI approximately 3 to 4 times as likely as women, but this ratio narrows in the elderly [8]. Half of fatal and non-fatal TBIs are due to motor-vehicle-collisions (MVCs), whereas the 2nd most frequent cause of TBI is falls [9].

These findings are often derived from studies conducted in developed countries and less information are available from other societies. In developing and the third world countries, the societies' characteristics are noticeably different from developed countries such as the job's type and frequency, the health system, the quality of cars, traffic laws and many other factors. Therefore, there is a need to conduct studies on a large scale in these communities. In this study, our purpose was to evaluate the epidemiological aspects of TBI patients and also to probe the affecting factors on the patients' outcomes with TBI who admitted to ED.

Materials and Methods

This was a cross-sectional study conducted in Tehran, Iran. Data gathering was performed via census manner. We retrospectively recruited TBI patients of all ages and gender with any level of consciousness who admitted to the ED of Sina hospital, Tehran, Iran during 2017-2019. Those with distorted evidence or incomplete data were excluded.

The required data were extracted by using a pre-prepared checklist for further analysis. We were recorded age (further categorized as <4, 5-14, 15-24, 25-44, 45-64 and ≥65 years), gender, mechanism of injury, Glasgow coma scale (GCS) on admission, ISS (Injury Severity Score), presence of extra-cranial injuries, CT scan findings, duration of hospitalization, and in hospital outcomes. Therefore, the required information was collected in advance by trained experts in the form of "National Trauma Registry of Iran". Although, outcome assessment was performed for the survivors within a 6 months-period after discharge based on Glasgow outcome scale (GOS). Unfavorable outcome (death or severe disability) was defined in six months with the Glasgow outcome scale (GOS). The scale comprises five categories: death, vegetative state, severe disability, moderate disability, low disability and good recovery.

Patients' data was collected and analyzed statistically with SPSS software (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp; 2016). Logistic regression was used to study the effective factors as univariate and multivariate. Chi-square analysis, analysis of variance and comparison of means were used to investigate the effect of each of the independent factors and variables with the outcome according to the nature of the variable.

Results

During the one-year study period, 506 patients were admitted due to TBI. Baseline characteristics of the study patients are presented in Table 1. A preponderance of injuries occurred among men (81.2%) and the age between 25-44 years (35.6%). The minimum and maximum age of the patients was 1 and 94 years, respectively. The mean age of the patients was 36.77 (SD: 21.1) years which was 36.27 (SD: 20.4) years for men and 38.98 (SD: 24.0) years for women. Mean corpuscular volume (MVCs) were the most frequent leading cause of TBI (73.99%), mostly in the youngest, followed by falls injury (20.6%) which more pronounced in the elderly population. Subarachnoid hemorrhage followed by epidural hematoma were the most frequent abnormal findings in brain CT scan of the patients. The ISS mean of the patients was 6.99 ± 8.28 and the proportion of the patients did not differ significantly in all injury severity categories and was almost equal. Follow up and outcome assessment was feasible in 487 (96.2%) patients after 6 months. According to GOS, patients' outcome post-injury revealed 59 (11.7%) of cases who were in emerged death at six-months while good recovery was seen in 397 (78.5%) patients, and we missed 19 (3.8) cases at this step.

The univariate regression analysis showed that below variables had significant relation with the outcome (Table 2): age categories of 45-64 (p=0.030) and ≥65 (p=0.003); GCS<14 (p<0.0001); sever ISS (p<0.0001); presence of ICH (p<0.0001),

Table 1. Baseline characteristics of the study patients (n=506).

Variable	Frequency	Percentage (%)
Age (year)		
0-4	23	4.5
5-14	32	6.3
15-24	101	20.0
25-44	180	35.6
45-64	112	22.1
≥65	58	11.5
Gender		
Male	411	81.2
Female	95	18.8
Mechanism of injury		
Traffic	374	73.9
Falling	104	20.6
Occupation	22	4.3
Others	6	1.2
GCS on admission		
3-8	57	11.3
9-13	57	11.3
>13	392	77.3
Injury severity score		
Mild	158	31.2
Moderate	162	32.0
Severe	163	32.2
Missing	23	4.5
CT scan finding		
Cerebral edema	5	1.0
Epidural hematoma	41	8.1
Subdural hematoma	38	7.5
Intracerebral hemorrhage	7	1.4
Subarachnoid hemorrhage	46	9.1
Brain contusion	36	7.1
Other injuries	69	13.6
Unspecified injuries	264	52.2
Duration of Hospitalization (day)		
<5	286	53.4
>5	220	46.6
Extra-cranial injuries		
Isolated TBI[a]	433	85.6
Multiple trauma	73	14.4
Outcome[b]		
Death	59	11.7
Vegetative state	2	0.4
Severe disability	3	0.6
Moderate disability	5	1.0
Low disability	21	4.2
Good recovery (cure)	397	78.5
Missing	19	3.8

[a]TBI: Traumatic Brain Injury; [b]According to GOS at 6 months after hospitalization

subarachnoid hemorrhage (p=0.029) and subdural hematoma (p<0.0001) in brain CT scan.

Table 3 shows the results of multivariate regression analysis on mortality rate distribution by assessed variables. Patients above 65-years-old had worse outcome in comparing with the other age groups [adjusted OR: 12.21 (4.48, 33.24)]. As expected, GCS on admission was highly associated with mortality [adjusted OR: 62.99 (23.28, 170.46) for GCS 3-8]. Presence of abnormal findings in patients with brain CT scan was also another associated factor with mortality [adjusted OR: 20.11 (2.03, 199.27)]; and finally hospital length of stay more than 5 days was also associated with mortality [adjusted OR: 0.28 (0.12, 0.62)]. Gender, ISS and mechanism of injury did not show any significant association in this regard. Meanwhile, the proportion of isolated TBI patients were higher than those who suffered from

Table 2. The independent predictors assessment of univariate analysis of in-hospital mortality.

Variable	Alive n (%)	Died n (%)	Crude odds ratio (95% CI[a])	*p* value
Age				
0-14	54 (11.92)	1 (1.89)	Ref.[g]	
15-24	96 (21.19)	5 (9.43)	2.81 (0.32, 24.70)	0.351
25-44	167 (36.87)	13 (24.53)	4.20 (0.54, 32.88)	0.171
45-64	95 (20.97)	17 (32.08)	9.66 (1.25, 74.63)	0.030
≥65	41 (9.05)	17 (32.08)	22.39 (2.86, 175.19)	0.003
Gender				
Male	365 (80.57)	46 (86.79)	Ref.[g]	
Female	88 (19.43)	7 (13.21)	0.63 (0.28, 1.44)	0.267
GCS[c] on admission				
14-15	377 (83.22)	14 (26.42)	Ref.[g]	
9-13	47 (10.38)	11 (20.75)	6.30 (2.70, 14.68)	<0.0001
3-8	29 (6.40)	28 (52.83)	26.00 (12.35, 54.74)	<0.0001
ISS[e]				
Mild	149 (32.89)	9 (16.98)	Ref.[g]	
Moderate	155 (34.22)	7 (13.21)	0.75 (0.27, 2.06)	0.574
Severe	128 (28.26)	35 (66.04)	4.53 (2.10, 9.77)	0.0001
Missing	21 (4.64)	2 (3.77)	1.58 (0.32, 7.80)	0.577
CT[b] scan finding				
Normal	245 (54.08)	19 (35.85)	Ref.[g]	
Brain contusion	33 (7.28)	3 (5.66)	1.17 (0.33, 4.18)	0.806
Skull fracture	51 (11.26)	1 (1.89)	0.25 (0.03, 1.93)	0.185
Other ICH[d]	16 (3.53)	1 (1.89)	0.80 (0.10, 6.40)	0.838
Cerebral edema	5 (1.10)	0 (0.00)	0.85 (0.04, 16.92)	0.913
Epidural hematoma	47 (8.17)	4 (7.55)	1.39 (0.45, 4.32)	0.565
Traumatic ICH[d]	2 (0.44)	5 (9.43)	32.24 (5.86, 177.3)	<0.0001
Subarachnoid hemorrhage	38 (8.39)	8 (15.09)	2.71 (1.11, 6.64)	0.029
Subdural hematoma	26 (5.74)	12 (22.64)	5.95 (2.60, 13.62)	<0.0001
Mechanism of injury				
Traffic	338 (74.61)	36 (67.92)	Ref.[g]	
Falling	90 (19.87)	14 (26.42)	1.46 (0.76, 2.82)	0.260
Occupation	20 (4.42)	2 (3.77)	0.94 (0.21, 4.18)	0.934
Others	5 (1.10)	1 (1.89)	1.88 (0.21, 16.52)	0.570
Duration of hospitalization (day)				
<5	236 (52.10)	34 (64.15)	Ref.[g]	
≥5	217 (47.90)	19 (35.89)	0.61 (0.34, 1.10)	0.099
Co-injury				
TBI[f]	393 (86.75)	40 (75.74)	Ref.[g]	
Multiple trauma+TBI[f]	60 (13.25)	13 (24.53)	2.13 (1.08, 4.21)	0.030

[a]CI: Confidence interval; [b]CT: Computed tomography; [c]GCS: Glasgow coma scale; [d]ICH: Intracranial hemorrhage; [e]ISS: Injury severity score; [f]TBI: Traumatic brain injury; [g]Ref.: Reference category

Table 3. The results of multivariate logistic regression for assessment of the independent predictors of in-hospital mortality.

Variable	Adjusted odds ratio (95% CI[a])	*p* value
Age		
45-64	4.02 (1.63, 9.88)	0.002
>65	12.21 (4.48, 33.24)	<0.0001
GCS[c] on admission		
9-13	8.64 (3.26, 22.92)	<0.0001
3-8	62.99 (23.28, 170.46)	<0.0001
CT[b] scan finding		
Traumatic ICH[d]	20.11 (2.03, 199.27)	0.010
Duration of hospitalization (day)		
≥5	0.28 (0.12, 0.62)	0.0017

[a]CI: Confidence interval; [b]CT: Computed tomography; [c]GCS: Glasgow coma scale; [d]ICH: Intracranial hemorrhage

multiple trauma, but we did not find that presence of extra-cranial injuries could aggravated the prognosis of the patients.

Discussion

A preponderance of injuries occurred among middle aged men. MVCs were the most frequent leading cause of TBI, mostly in the youngest patients, followed by falls' injury that were more pronounced in the elderly population. Subarachnoid hemorrhage was the most frequent findings in patients' CT scan. We reached the 11% mortality among our study patients. Elderly patients had worse outcome compared to the others. As expected, GCS on admission was highly associated with mortality. In general, logistic regression analysis showed that older age, lower GCS, presence of abnormal CT scan findings and duration of hospitalization more than 5 days were associated with the outcome of the patients with TBI.

Previous studies revealed that demographics characteristics, mechanism of injury, GCS and abnormal brain CT scan findings may affect the outcome of TBI patients [1, 10-12]. Gender does not have statistical significance in predicting outcome, although men are more likely to sustain a TBI than women [1, 5, 10]. This has been attributed to more men being drivers and involved in MVCs [13]. These are in line with the findings of the present study, except for mechanism of injury that did not show any association with the outcome.

In the present study, the overall mortality rate is lower than other studies, usually varying between 32-49% [5, 14, 15]. One of the reason is that the present study was conducted in a single center. But more importantly, the recorded information was used in a registry department. It is necessary to explain that this registry does not include patients who died before being transferred to inpatient departments in the early hours of ED admission, or cases of pre-hospital death.

The GCS score was described in 1974 by Teasdale and Jennett. They were assessed the degree of unconsciousness in patients with traumatic brain injury [16, 17]. Evidence shows that GCS is a strong predictor of outcome in TBI [1, 10]. However, it may be affected by sedation, paralysis or intoxication with alcohol and affected by presence of facial swelling [5, 18]. As expected, the results of the present study also showed that the mortality rate of the patients with lower on admission GCS, was higher than the other TBI patients.

Brain CT scan plays a crucial role in early assessment of patients with TBI. In poor resource settings, CT scan findings may be used as an important tool to predict the TBI patients' outcome where intracranial pressure monitoring is not readily available [11]. In the present study, we report the highest mortality rate in patients with findings of subdural hematoma, while the most frequent image finding was intracranial hemorrhage.

If we want to speak about the role and impact of hospitalization length on the outcome of TBI patients, we must consider various aspects. It is expected that high-risk TBI patients, especially those with a lower level of consciousness at the time of ED admission or those with abnormal brain CT scan findings, will be admitted to the intensive care unit (ICU), and if they pass the critical phase, they will be transferred to the ward units, while they may also undergo one or more surgical interventions [19, 20]. On the other hand, the length of stay prolonged in the hospital, especially in the ICUs is associated with some problems such as the possibility of hospital infections affect, ventilator-associated pneumonia in intubated patients, occurring of deep venous thromboembolism and many other issues which will prolong the hospitalization duration of high risk in TBI patients [21-23]. Due to the existing restrictions in some parts of the world like Iran, it may not be possible to quickly transfer high-risk TBI patients to the ICU which is another important points, and the patients will be cared for a period of time in the ED which may sometimes last more than a few days. This is the maximum care that can be performed inevitably, but we believe that the quality of care in ED cannot be compared with the ICU. Of course, this is a hypothesis and perhaps a study should be conducted to show that delay in transferring patients from ED to ICU or other inpatient departments can affect the outcome of high risk TBI patients.

There may be require to develop a specific evidence-based guideline or at least a national protocol to manage high risk TBI patients in ED by considering the current study results and also the same studies conducted in the same era in various parts of the world including in developing countries.

In conclusion, we suggest to perform a systematic literature review for finding the risk factors and thereafter, distinguish the effective interventions that could alter the high risk TBI patient's outcome. Albeit, increasing the level of person's awareness, establishing and implementing rules will probably be very beneficial for using of safety devices and to prevent injuries following MVCs.

Limitations

This was a single center study in which we were used the recorded information of "Iran National Trauma Registry". It is necessary to explain that this registry does not include patients who died before being transferred to inpatient departments in the early hours of ED admission, or cases of pre-hospital death. Therefore, and due to the retrospective nature of the study, an important part of the information of TBI patients was not available. In the future studies, fixing this shortcoming may bring different and at the same time more valuable results.

Declarations

Ethics approval and consent to participate: This study was approved by ethical committee of Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1397.289). The extracted data were recorded, analyzed and reported anonymously.

Consent for publication: None declared.

Conflict of interests: The authors declared that there is no conflict of interest.

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Authors' contributions: The conception and design of the work by SR, AS and AB; Data acquisition by SR, AJ and KK; Analysis and interpretation of data by SR and AS; Drafting the work by SR and AJ; Revising it critically for important intellectual content by AS, KK and AB; All the authors approved the final version to be published; AND agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work.

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References

1. MRC CRASH Trial Collaborators, Perel P, Arango M, Clayton T, Edwards P, Komolafe E, Poccock S, et al. Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. *BMJ*. 2008;**336**(7641):425-9.
2. Hukkelhoven CW, Steyerberg EW, Rampen AJ, Farace E, Habbema JD, Marshall LF, et al. Patient age and outcome following severe traumatic brain injury: an analysis of 5600 patients. *J Neurosurg*. 2003;**99**(4):666-73.
3. Koulenti D, Rejeb MB, Mhamdi S. Factors Influencing Outcomes in Intensive Care Unit Patients with Nosocomial Infections/Author's Reply. *Archives of Iranian Medicine*. 2016;**19**(9):677..
4. Baratloo A, Shokravi M, Safari S, Aziz AK. Predictive Value of Glasgow Coma Score and Full Outline of Unresponsiveness Score on the Outcome of Multiple Trauma Patients. *Arch Iran Med*. 2016;**19**(3):215-20.
5. Kolias AG, Guilfoyle MR, Helmy A, Allanson J, Hutchinson PJ. Traumatic brain injury in adults. *Pract Neurol*. 2013;**13**(4):228-35.
6. Brazinova A, Rehorcikova V, Taylor MS, Buckova V, Majdan M, Psota M, et al. Epidemiology of Traumatic Brain Injury in Europe: A Living Systematic Review. *J Neurotrauma*. 2021;**38**(10):1411-1440.
7. Baguley IJ, Nott MT, Howle AA, Simpson GK, Browne S, King AC, et al. Late mortality after severe traumatic brain injury in New South Wales: a multicentre study. *Med J Aust*. 2012;**196**(1):40-5.
8. Coronado VG, Xu L, Basavaraju SV, McGuire LC, Wald MM, Faul MD, et al. Surveillance for traumatic brain injury-related deaths--United States, 1997-2007. *MMWR Surveill Summ*. 2011;**60**(5):1-32.
9. Feigin VL, Theadom A, Barker-Collo S, Starkey NJ, McPherson K, Kahan M, et al. Incidence of traumatic brain injury in New Zealand: a population-based study. *Lancet Neurol*. 2013;**12**(1):53-64.
10. Husson EC, Ribbers GM, Willemse-van Son AH, Verhagen AP, Stam HJ. Prognosis of six-month functioning after moderate to severe traumatic brain injury: a systematic review of prospective cohort studies. *J Rehabil Med*. 2010;**42**(5):425-36.
11. Mata-Mbemba D, Mugikura S, Nakagawa A, Murata T, Ishii K, Li L, et al. Early CT findings to predict early death in patients with traumatic brain injury: Marshall and Rotterdam CT scoring systems compared in the major academic tertiary care hospital in northeastern Japan. *Acad Radiol*. 2014;**21**(5):605-11.
12. Bullock R. Management and prognosis of severe traumatic brain injury. Part 1 Guideline for the management of severe traumatic brain injury. *J Nerotrauma*. 2000;**17**:451-553.
13. Khaleghi-Nekou M, Moradi A, Zafarghandi M, Fayaz-Bakhsh A, Saeednejad M, Rahimi-Movaghar V, et al. Epidemiology of fatal injuries among patients admitted at Sina hospital, the national trauma registry of Iran, 2016-2019. *Frontiers in Emergency Medicine*. 2021;**5**(1):e9-e.
14. Andriessen TM, Horn J, Franschman G, van der Naalt J, Haitsma I, Jacobs B, et al. Epidemiology, severity classification, and outcome of moderate and severe traumatic brain injury: a prospective multicenter study. *Journal of neurotrauma*. 2011;**28**(10):2019-31.
15. Kamal VK, Agrawal D, Pandey RM. Epidemiology, clinical characteristics and outcomes of traumatic brain injury: Evidences from integrated level 1 trauma center in India. *J Neurosci Rural Pract*. 2016;**7**(4):515-525.
16. Rizoli S, Petersen A, Bulger E, Coimbra R, Kerby JD, Minei J, et al. Early prediction of outcome after severe traumatic brain injury: a simple and practical model. *BMC Emerg Med*. 2016;**16**(1):32.
17. Middleton PM. Practical use of the Glasgow Coma Scale; a comprehensive narrative review of GCS methodology. *Australas Emerg Nurs J*. 2012;**15**(3):170-83.
18. Munakomi S, Bhattarai B, Srinivas B, Cherian I. Role of computed tomography scores and findings to predict early death in patients with traumatic brain injury: A reappraisal in a major tertiary care hospital in Nepal. *Surg Neurol Int*. 2016;**7**:23.
19. Heydari F, Golban M, Majidinejad S. Traumatic Brain Injury in Older Adults Presenting to the Emergency Department: Epidemiology, Outcomes and Risk Factors Predicting the Prognosis. *Adv J Emerg Med*. 2019;**4**(2):e19.
20. Pozzato I, Tate RL, Rosenkoetter U, Cameron ID. Epidemiology of hospitalised traumatic brain injury in the state of New South Wales, Australia: a population-based study. *Aust N Z J Public Health*. 2019;**43**(4):382-388.
21. Zhang M, Parikh B, Dirlikov B, Cage T, Lee M, Singh H. Elevated risk of venous thromboembolism among post-traumatic brain injury patients requiring pharmaceutical

immobilization. *J Clin Neurosci*. 2020;**75**:66-70.

22. Mehrpour S, Najafi A, Ahmadi A, Zarei T, Pleqi V, Basiri K, et al. Relationship of the optic nerve sheath diameter and repeated invasive intracranial pressure measures in traumatic brain injury patients; a diagnostic accuracy study. *Frontiers in Emergency Medicine*. 2022;**6**(1):e6-e.

23. Gwarzo IH, Perez-Patron M, Xu X, Radcliff T, Horney J. Traumatic Brain Injury Related Hospitalizations: Factors Associated with In-hospital Mortality among Elderly Patients Hospitalized with a TBI. *Brain Inj*. 2021;**35**(5):554-562.