Trauma Monthly 2024; 29(5): 1249-1254

10.30491/tm.2024.451135.1711

Trauma Monthly

Research Article

Predictors of Traumatic Brain Injury Mortality: in Adults (18-45 years) Trauma Patients

Majid Rezvani [1], Amirreza Shahmohammadi [2], Amir Mahabadi[1], Naser Abbasi [2], Mehdi Mahmoodkhani [1*], Donya Sheibani Tehrani [3]

[1] Department of Neurosurgery, Isfahan University of Medical Sciences, Isfahan, Iran.

[2] Medical Student, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.

[3] MSc, Department of IT, Shahid Beheshti University, Tehran, Iran.

***Corresponding Authors**: Mehdi Mahmoodkhani, Department of Neurosurgery, Isfahan University of Medical Sciences, Isfahan, Iran; Tel: +989136863733; E-mail: mahmoodkhani@med.mui.ac.ir.

Received 2023-05-06; **Accepted** 2024-09-25; **Online Published** 2024-10-29

Abstract

Introduction: Traumatic brain injury represents a significant public health concern that can manifest at any age. It also stands as one of the primary causes of disability and mortality in the ensuing years of a patient's life. The present study aims to discern predictors of mortality stemming from traumatic brain injury among individuals aged 18 to 45 in Isfahan City.

Methods: This retrospective cross-sectional study included all TBI adult cases (18-45 years) presented to the trauma registry (Kashani and Al-Zahra Hospitals) in Esfahan City - from September 2020 to February 2023. The data was exported into SPSS (version 16) for analysis.

Results: A total of 1942 individuals with TBI aged 18 to 45 years were enrolled in the study. The frequency of mortality from traumatic brain injury was 482 (24.8 %) of patients During the study period (30 months). 191 (39.63%) patients with severe trauma died. When these variables were tested at multivariate logistic regression, being low GCS level, having concomitant injury, patients' condition at presentation SBP, hyperthermia during hospital stay, and high ISS Score were found to be statistically significant with p-value < 0.05 at 95% CI.

Conclusion: Most studies, spanning all age groups, identified the GCS, followed closely by the Injury Severity Score and accompanying injuries, as principal indicators of mortality risks. Moreover, there is a pressing need to routinely monitor adults for variations in systolic blood pressure and episodes of hyperthermia during their hospital stay.

Keywords: Traumatic Brain Injury; Mortality; Trauma; Adults.

Introduction

At the global level, accidents are the primary cause of unintentional injuries and fatalities [1]. These accidents can arise from various demographic factors like age and gender and socio-economic factors such as residing in low-income countries, alcohol consumption, and substance abuse [2]. Accidents account for 2.5% of total deaths worldwide, and the World Health Organization (WHO) projections suggest that by 2030, their contribution to global deaths will escalate to 2.6% [3]. Additional research also underscores that violence and accidents will play substantial roles in the incidence of traumatic brain injuries in the approaching decade [4].

Traumatic brain injury (TBI) is damage inflicted upon the brain due to external physical forces, excluding degenerative or congenital origins [5]. Such injury can reduce or alter an individual's level of consciousness [6]. Often, neural damage caused by TBI might not immediately manifest but rather surface in the minutes, hours, and days following the triggering event. Consequently, this phenomenon assumes a pivotal role in the context of prolonged disability and the overall societal burden [7].

Age, preexisting medical conditions, tumors, repeated trauma, and alcohol misuse are factors that intensify the consequences of TBI [8]. Several studies concentrating on TBI consistently regard age as a robust predictive element. Nevertheless, noteworthy disparities emerge when comparing the age threshold with other predictive variables like the Glasgow Coma Scale (GCS) and findings from computed tomography (CT) scans [9-11].

Certain studies propose that the older the patient, the graver the outcomes of TBI tend to be. However, contrasting viewpoints suggest that while an advanced age at the time of injury might lead to a less comprehensive recovery than younger individuals with analogous injuries, this could stem from a diminished capacity for compensation or a reduced cognitive reserve associated with aging [12-17].

TBI is a significant cause of mortality and morbidity within the 18- to 45-year-old age group, imposing significant socio-economic burdens on families and society at large. The prevalence of TBI among younger individuals primarily results from collisions and accidents (recognized as the eighth leading cause of global mortality); the present study aims to discern predictors of mortality stemming from TBI among individuals aged 18 to 45 in Isfahan City.

Methods

This is a retrospective cross-sectional study that included all TBI adult cases (18-45 years) presented to the trauma registry (Kashani and Zahra Hospitals) in Esfahan City from September 2020 to February 2023. The trauma registry consists of aggregated trauma data from participating trauma centers in Esfahan. Patients with TBI were identified using a standard approach using the International Classification of Diseases, Tenth Revision, and Clinical Modification (ICD-10-CM) codes.

All admitted patients with a history of TBI and complete medical records were included in the study. While incomplete patient records for baseline clinical features (GCS), the outcome variable and follow-up time of fewer than 24 hours, patients with a previous history of head trauma or head surgery, patients who died at the scene or during transportation, and patients with prior central nervous system disorders were excluded from the study (Fig 1).

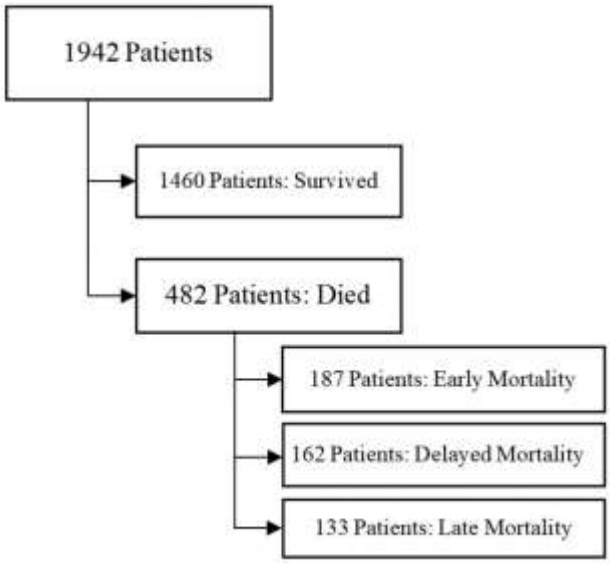

Figure 1: Diagram of the Patient

The demographics file contained information on the patient's age, sex, and Body Mass Index. The discharge file contained information on the length of stay (i.e., the total length of hospital stay).

Glasgow Coma Score (GCS) was obtained from the vitals file to assess injury severity; the first recorded GCS was used to assess a patient's TBI severity level. GCS (range 3 to 15) was divided into three groupings: 3–8 for severe TBI, 9–12 for moderate TBI, and 13–15 for mild TBI.

The intent and mechanism of the injury were categorized based on the CDC-recommended external cause of injury mortality matrix for ICD-10. Mechanism and intent were identified using ICD-10-CM codes, applying a standard approach for unintentional, intentional, and undetermined injuries.20 Unintentional injuries were broken down into four mechanisms: falls, motor vehicle crashes, struck by objects, and others (Unintentional injuries were broken down into self-harm/suicide and assault).

The Injury Severity Score (ISS) is the sum of the squares of the highest Abbreviated Injury Scale (AIS) code (AIS 1) – Minor, AIS 2 – Moderate, AIS 3 – Serious, AIS 4 – Severe, AIS 5 – Critical, AIS 6 – Maximal (currently untreatable)) in each of the three most severely injured ISS body regions.

Outcomes consisted of in-hospital mortality (survived or died) and length of hospital stay (<48 hours, between 48 hours and 7 days, and >7 days). Data from trauma registries often include vital signs (body temperature, pulse rate, respiration rate, blood pressure) at admission, which are essential for computing patient physiological scoring systems. Various studies define early mortality as occurring within the first 24 hours, delayed mortality as occurring between 1 and 7 days' post-trauma, and late mortality as occurring 8 to 30 days afterward. The data was exported into SPSS (version 16) for analysis. The data's normality was tested using the Shapiro–Wilk normality test. Non-normally distributed data were presented as median ± IQR and categorical data as count and percentage. Before computing logistic regression, a cross-tabulation was performed to identify whether the variables fulfilled the assumption for bivariate logistic regression. In the bivariate regression, predictor variables with a p-value of <0.2 were fitted for multivariate logistic regression. In multivariate logistic regression, p-value < 0.05 at 95% CI has been considered statistically significant.

Results

A total of 1942 individuals with TBI aged 18 to 45 were enrolled in the study. The frequency of mortality from TBI was 482 (24.8 %) of patients. During the study period (30 months), 1266 deaths were reported, of which 482 people (38.1%) were in the age group of 18-45. A total of 187 (38.8 %) patients experienced early mortality within the first 24 hours, 162 (33.61%) experienced delayed mortality 1 to 7 days after trauma, and 133 (27.59%) experienced late mortality 8 to 30 days after trauma. A summary of patient demographics and clinical characteristics is provided in Table 1.

Table 1: summary of patients with TBI

Variable	Died 482 (24.8)	Total 1942	Mortality		
			Early	Delayed	Late
Sex, N (%)					
Male	414 (85.9)	1553 (80)	188 (83.2)	147 (89.6)	79 (85.9)
Female	68 (14.1)	389 (20)	38 (16.8)	17 (10.4)	13 (14.1)
GCS, N (%)					
Mild	139 (28.84)	728 (37.49)	65 (28.8)	54 (32.9)	20 (21.7)
Moderate	152 (31.54)	615 (31.67)	69 (30.5)	46 (28)	37 (40.2)
Severe	191 (39.63)	599 (30.84)	92 (40.7)	64 (39)	35 (38)
Cause of injury, N (%)					
Falls	91 (18.88)	213 (10.97)	33 (36.26)	30 (32.97)	28 (30.77)
Motor Vehicle Crashes	336 (69.71)	1547 (79.66)	113 (33.63)	111 (33.04)	112 (33.33)
Struck by objects	31 (6.43)	107 (5.51)	9 (29.03)	10 (32.26)	12 (38.71)
Other	24 (4.98)	75 (3.86)	7 (29.17)	9 (37.5)	8 (33.33)
Age, year, mean±SD	30.67±8.14	30.57±7.91	30.8±8.33	30.99±7.94	30.08±7.56
BMI, mean±SD	28.47±2.33	26.29±2.05	27.31±2.54	28.38±2.94	27.11±2.92
Length of hospital stay, N (%)					
<48 hours	267 (55.39)	599 (30.84)	88 (32.96)	89 (33.33)	90 (33.71)
between 48 hours and 7 days	134 (27.8)	788 (40.58)	49 (36.57)	39 (19.1)	46 (34.33)
>7 days	81 (16.8)	555 (28.58)	21 (25.93)	29 (35.8)	31 (38.27)
Diagnosis by CT scan, N (%)					
Epidural hematoma	111 (23.03)	534 (27.39)	38 (34.23)	39 (35.14)	34 (30.63)
Skull fractures	53 (11)	149 (7.67)	19 (35.85)	16 (30.19)	18 (33.96)
Subdural hematomas	71 (14.73)	327 (16.84)	19 (26.76)	25 (35.21)	27 (38.03)
Contusion	105 (21.78)	339 (17.46)	37 (35.24)	26 (24.76)	42 (40)
Hemorrhage	142 (29.46)	585 (30.12)	54 (38.03)	48 (33.8)	40 (28.17)
ISS, median (IQR)	54 (19-65)	37 (13-49)	51 (20-52)	53 (22-58)	55 (29-58)
Concomitant injury, yes, N (%)	285 (59.12)	639 (32.9)	107 (37.54)	87 (30.53)	91 (31.93)
Follow-up, month, mean±SD	31.56±3.21	29.45±4.46	30.21±3.09	31.89±2.14	30.23±3.38

ISS: Injury Severity Score, IQR: Interquartile Range, GCS: Glasgow Coma Scale, SD: Standard Deviation, N: Number, BMI: Body Mass Index.
Diagnosis by CT scan: Skull fractures: basilar, linear vault, depressed vault.
Cause of injury: Others: Sports, Violence, Self-harm.

Bivariate logistic regression analysis showed that sex, patients' condition at presentation (SBP, HR, hyperthermia), GCS at presentation, BMI, Concomitant injury, and ISS Score were statistically significant at 95% CI (Table 2).

When these variables were tested at multivariate logistic regression, being low GCS level, having concomitant injury, patients' condition at presentation SBP, hyperthermia during hospital stay, and high ISS Score were found to be statistically significant with p-value < 0.05 at 95% CI. The odds of death in concomitant injured patients were around three times as compared to those without concomitant injury (OR: 2.78, 95% CI: 1.13–4.21).

The odds of death were 7 times (OR: 6.8;95% CI: 2.26–11.43) higher in low GCS 3–8 than higher GCS level 13–15. The odds of mortality for a patient with SBP of 100–149 mm Hg had (OR: 0.44, 95% CI: 0.13–0.76) lower compared with patients having SBP of <100 and >149 mmHg. Patients with hyperthermia during hospital stay had (OR: 4.65, 95% CI: 2.98–6.32) times the odds of mortality as compared with those with no documented pupil abnormality. The odds of death among patients with high ISS scores were 8.5 times higher compared to low ISS scores (OR: 8.56; 95% CI: 3.45–13.67) (Table 2).

Table 2: Bivariate and Multivariate Logistic Regression Showing the Factors Associated with Mortality Among Patients

Variable	Bivariate Logistic Regression		Multivariate Logistic Regression	
	Odds	OR (95%CI)	Odds	OR (95%CI)
Sex, Female	0.001	1.123 (0.098-1.435)	-	-
BMI, Normal	0.002	0.093 (0.023-0.165)	-	-
SBP, Normal	0.012	0.045 (0.031-0.214)	0.002	0.44 (0.13-0.76)
HR, Normal	0.001	0.088 (0.65-0.177)	-	-
Hyperthermia, Normal	0.001	0.143 (0.121-0.156)	0.012	4.65 (2.98-6.32)
GCS, High	0.0001	4.452 (2.342-5.609)	0.001	6.8 (2.26-11.43)
ISS, Low	0.001	5.447 (2.313-6.598)	0.0001	8.56 (3.45-13.67)
Concomitant Injury, No	0.001	2.265 (1.134-4.376)	0.0001	2.78 (1.13-4.21)

OR=Odds Ratio, CI= Confidence Interval, BMI= Body Mass Index, SBP= Systolic Blood Pressure, HR= Heart Rate, GCS = Glasgow Coma Scale, ISS = Injury Severity Score, *= P-value<0.05

Discussion

This study focused on identifying the predictors of mortality resulting from TBI in individuals between the ages of 18 and 45 in Isfahan City. The results revealed that a low Glasgow Coma Scale (GCS) score, concurrent injuries, a patient's systolic blood pressure (SBP) status, hyperthermia during hospitalization, and a high Injury Severity Score (ISS) were statistically significant predictors of mortality resulting from TBI in this age group. The first-month mortality rate stood at 24.8%. Identifying the predictors of death from a head injury may help primary care physicians refer patients promptly to advanced care centers so that they get quality care.

Several studies have delved into traumatic brain injuries, particularly concerning the elderly and children. In 2021, Guilherme [18] researched 133 elderly individuals with TBI in São Paulo. His findings pointed to the TBI's severity, pupil response, indications of acute hemorrhage in the head CT scan, blood coagulation status, and the requirement for blood transfusions as influential predictors of mortality among the elderly. The overall mortality rate within the first month after the injury was 42.1%. Interestingly, the current study found the one-month post-injury mortality rate for adults (aged 18 to 45) to be lower than that of the elderly. Both studies emphasized a lower GCS score as a death predictor.

In 2022, Yang [19] analyzed 2,415 elderly individuals over 65 who had experienced a TBI in China. The overall in-hospital mortality rate was 24.8%. For 58% of these patients, the GCS score was between 13 and 15. Notably, this study's mortality rate for adults in the first month post-injury exceeded that of the elderly Chinese demographic. Such a difference could be attributed to the majority of the Chinese elderly having sustained mild injuries, thereby leading to a decreased mortality rate. This observation might reflect the broader lifestyle and cultural habits in China.

Ghneim, in 2022 [20], surveyed 2,028 patients over 65 who had suffered TBIs at various medical centers in the US. Of these, 16.7% had injuries ranging from moderate to severe. The reported mortality rate was a staggering 64%. Predictors of mortality for these elderly individuals included a GCS score under 9, cerebral edema, being over 75 years old, and a higher-than-average ISS score. When juxtaposed with Ghneim's study, the present research indicated that while the 18 to 45 age bracket in our study witnessed more severe injuries, their mortality rate in the initial month post-injury was markedly lower than that observed in Ghneim's cohort. Both studies concur that GCS and ISS scores are reliable predictors of mortality.

In a study by Lenell (2019) [21], 220 elderly individuals in Sudan with traumatic brain injuries (TBI) were assessed. The results revealed that factors such as an age exceeding 75, multiple injuries, a low Glasgow Coma Scale (GCS) score at admission, and the need for mechanical ventilation independently negatively impacted survival outcomes. The estimated mortality rate among these elderly individuals was 27%. In both the studies above, the GCS score emerged as a predictor of mortality. Additionally, the prevalence of death showed similar patterns in these studies.

Skaansar (2020) [17] evaluated 1,571 individuals aged 15 to 98 who suffered from TBI in Norway. The findings demonstrated that 45% of these patients experienced mild injuries. Critical factors associated with mortality included advanced age, comorbidities, severe TBI, and a Rotterdam score exceeding 3. Notably, the GCS and accompanying conditions were consistent predictors of mortality, not just in adults aged 18 to 45, as per the present study, but also in the broader age group of 15 to 98, as indicated in Skaansar's research.

Wang (2018) [22] examined 3,356 TBI patients in China. A significant 19.5% of these patients succumbed to their injuries. Epidural, subdural, and intracranial hematomas exhibited greater prevalence among the young, middle-aged, and elderly populations. The current study observed that hemorrhages were more frequent among adults aged 18 to 45. This discrepancy could be attributed to differences in trauma mechanisms between the two countries. Intriguingly, the mortality rate among adults in the present study surpassed the overall mortality rate for Chinese patients across all age brackets.

Riemann (2020) [23] conducted a study on 227 children with TBI in Germany. Most of these children presented with severe TBI, resulting in a mortality rate of 3%. Notably, intracranial abnormalities were identified in 60% of the initial CT brain scans. Both the GCS and the occurrence of secondary medical complications were discerned as determinants of child mortality post-TBI.

In conclusion, the GCS has consistently been acknowledged as a pivotal and independent predictor of mortality across various age demographics. A notable limitation of this research was the inability to ensure long-term follow-up of the patients. Thus, subsequent studies should incorporate follow-up periods extending over ten years or longer to analyze patient outcomes comprehensively.

Conclusion

An interesting observation was the higher incidence of severe TBI among adults aged 18 to 45 compared to those with moderate and mild TBIs. The post-injury mortality rate within the first month stood at 24.8%. Most studies, spanning all age groups, identified the GCS, followed closely by the Injury Severity Score (ISS) and accompanying injuries, as principal indicators of mortality risks. Moreover, there is a pressing need to routinely monitor adults for variations in systolic blood pressure (SBP) and episodes of hyperthermia during their hospital stay.

Acknowledgments

We would like to thank all the neurosurgical attending professors, medical residents and nursing staff in data collection and their meticulous patient care.

Conflict of Interest Disclosures

The authors declare that they have no competing interests.

Funding Sources

None.

Authors' Contributions

All authors read and approved the final manuscript Mehdi Mahmoodkhani contributed as the main author with the concept of planning the study. Amirreza Shahmohammadi and Naser Abbasi contributed in study design, patient selection and follow ups. Donya Sheibani Tehrani performed the statistical analysis and interpreted the data. Amir Mahabadi helped write the manuscript and Majid Rezvani mentored the edition of the final version.

Ethical Statement

The current study was approved by the Isfahan University of Medical Sciences Ethics Committee with the code of IR.MUI.MED.REC.1398.591.

References

1. Reddy Venkatashiva B, Pundhir A. Unintentional injury and its determinants among adolescents. J Public Health Res. 2021; 10(4): 2359.

2. El-Gabri D, Toomey N, Moraes Gil N. Association Between Socioeconomic and Demographic Characteristics and Non-fatal Alcohol-Related Injury in Maring6, Brazil. Front Public Health. 2020; 8: 66.

3. Global status report on road safety 2015 [Internet]. World Health Organization. 2015. Available at: http://www.who.int/violence_injury_prevention/road_safety_status/2015/en. Accessed November 3, 2018

4. Maresca G, Lo Buono V, Anselmo A. Traumatic Brain Injury and Related Antisocial Behavioral Outcomes: A Systematic Review. Medicina (Kaunas). 2023; 59(8): 1377.

5. Goldman L, Mehmood Siddiqui E. Understanding Acquired Brain Injury: A Review. Biomedicines. 2022; 10(9): 2167.

6. Rana A, Singh S. Traumatic Brain Injury Altered Normal Brain Signaling Pathways: Implications for Novel Therapeutics Approaches. Curr Neuropharmacol. 2019; 17(7): 614–629.

7. Hara Dash H, Chavali S. Management of traumatic brain injury patients. Korean J Anesthesiol. 2018; 71(1): 12–21.

8. Ahmed S, Venigalla H, Madhuri Mekala H. Traumatic Brain Injury and Neuropsychiatric Complications. Indian J Psychol Med. 2017; 39(2): 114–121.

9. Peter Thelin E. Evaluation of novel computerized tomography scoring systems in human traumatic brain injury: An observational, multicenter study. PLoS Med. 2017; 14(8): e1002368.

10. Salottolo K, Panchal R. Incorporating age improves the Glasgow Coma Scale score for predicting mortality from traumatic brain injury. Trauma Surg Acute Care Open. 2021; 6(1): e000641.

11. Agrawal N, Iyer Shivakumar S. Comparison of admission GCS score to admission GCS-P and FOUR scores for prediction of outcomes among patients with traumatic brain injury in the intensive care unit in India. Acute Crit Care. 2023; 38(2): 226–233.

12. Gardner Raquel C., Dams O'Connor K. Geriatric Traumatic Brain Injury: Epidemiology, Outcomes, Knowledge Gaps, and Future Directions. J Neurotrauma. 2018; 35(7): 889–906.

13. Jochems D, Rein E. Incidence, causes and consequences of moderate and severe traumatic brain injury as determined by Abbreviated Injury Score in the Netherlands. Scientific Reports. 2021; 11: 19985.

14. Karibe H, Hayashi T, Narisawa A, et al. Clinical Characteristics and Outcome in Elderly Patients with Traumatic Brain Injury: For Establishment of Management Strategy. Neurol Med Chir (Tokyo) 2017;57(8):418–425.

15. Siman-Tov M, Radomislensky I, Knoller N, et al. Incidence and injury characteristics of traumatic brain injury: Comparison between children, adults and seniors in Israel. Brain Inj. 2016;30(1):83–89.

16. McIntyre A, Mehta S, Aubut J, et al. Mortality among older adults after a traumatic brain injury: a meta-analysis. Brain Inj. 2013;27(1):31–40.

17. Skaansar O, Tverdal C. Traumatic brain injury—the effects of patient age on treatment intensity and mortality. BMC Neurol. 2020; 20: 376.

18. Guilherme G Podolsky-Gondim, Cardoso R. Traumatic Brain Injury in the Elderly: Clinical Features, Prognostic Factors, and Outcomes of 133 Consecutive Surgical Patients. Cureus. 2021; 13(2): e13587.

19. Yang C, Lang L. Epidemiological Characteristics of Older Patients with Traumatic Brain Injury in China. J Neurotrauma. 2022;39(11-12):850-859.

20. Ghneim M, Brasel K. Traumatic Brain Injury in Older Adults: Characteristics, Outcomes, and Considerations. Results From the American Association for the Surgery of Trauma Geriatric Traumatic Brain Injury (GERI-TBI) Multicenter Trial. Journal of the American Medical Directors Association. 2022; 23 (4): 568-575.e1.

21. Lenell S, Nyholm L. Clinical outcome and prognostic factors in elderly traumatic brain injury patients receiving neurointensive care. Acta Neurochir (Wien). 2019; 161(6): 1243–1254.

22. Wang J, Han F. Clinic pathological Characteristics of Traumatic Head Injury in Juvenile, Middle-Aged and Elderly Individuals. Med Sci Monit. 2018; 24: 3256–3264.

23. Riemann L, Zweckberger K. Injury Causes and Severity in Pediatric Traumatic Brain Injury Patients Admitted to the Ward or Intensive Care Unit: A Collaborative European Neurotrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) Study. Neurotrauma. 2020; 11.