ORIGINAL ARTICLE

Prognostic factors in traumatic brain injuries in emergency department

Mohammad Javad Behzadnia[1,2], Mousareza Anbarlouei[2], Seyed Morteza Hosseini[3], Amir Bahador Boroumand[4]

[1]Department of Emergency Medicine, Baqiyatallah University of Medical Sciences, Tehran, Iran, [2]Trauma Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran, [3]Quran and Hadith Research Center, Baqiyatallah University of Medical Sciences, Tehran, Iran, [4]Department of Emergency Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Background: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality in young adults. The Extended Glasgow Outcome Score (GOSE) has been introduced to assess the global outcome after brain injuries. Therefore, we aimed to evaluate the prognostic factors associated with GOSE. **Materials and Methods:** This was a multicenter cross-sectional study conducted on 144 patients with TBI admitted at trauma emergency centers. The patients' information, including demographic characteristics, duration of hospital stay, mechanical ventilation and on-admission laboratory measurements, and on-admission vital signs, were evaluated. The patients' TBI-related symptoms and brain computed tomography (CT) scan findings were recorded. **Results:** GOSE assessments showed an increasing trend by the comparison of on-discharge (7.47 ± 1.30), within a month (7.51 ± 1.30) and within 3 months (7.58 ± 1.21) evaluations ($P < 0.001$). On-discharge GOSE was positively correlated with Glasgow Coma Scale (GCS)($r = 0.729$, $P < 0.001$), motor GCS ($r = 0.812$, $P < 0.001$), Hb ($r = 0.165$, $P = 0.048$), and pH ($r = 0.165$, $P = 0.048$) and inversely with age ($r = -0.261$, $P = 0.002$), hospitalization period ($r = -0.678$, $P < 0.001$), pulse rate ($r = -0.256$, $P = 0.002$), white blood cell (WBC) ($r = -0.222$, $P = 0.008$), and triglyceride ($r = -0.218$, $P = 0.009$). In multiple linear regression analysis, the associations were significant only for GCS ($B = 0.102$, 95% confidence interval [CI]: 0–0.202; $P = 0.05$), hospitalization stay duration ($B = -0.004$, 95% CI: −0.005–−0.003, $P = 0.001$), and WBC ($B = 0.00001$, 95% CI: 0.00000014–0.000025; $P = 0.024$). Among imaging signs and trauma-related symptoms in univariate analysis, intracranial hemorrhage (ICH), interventricular hemorrhage (IVH) ($P = 0.006$), subarachnoid hemorrhage (SAH) ($P = 0.06$; marginally at $P < 0.1$), subdural hemorrhage (SDH) ($P = 0.032$), and epidural hemorrhage (EDH) ($P = 0.037$) was significantly associated with GOSE at discharge in multivariable analysis. **Conclusion:** According to the current study findings, GCS, hospitalization stay duration, WBC and among imaging signs and trauma-related symptoms ICH, IVH, SAH, SDH, and EDH are independent significant predictors of GOSE at discharge in TBI patients.

Key words: Computed tomography, Glasgow Coma Scale, Glasgow Outcome Scale, traumatic brain injuries, X-ray

How to cite this article: Behzadnia MJ, Anbarlouei M, Hosseini SM, Boroumand AB. Prognostic factors in traumatic brain injuries in emergency department. J Res Med Sci 2022;27:83.

INTRODUCTION

It has been notified that a growing number of injuries are associated with industrialized life and motorization. Traumatic brain injury (TBI) is a great leading cause of morbidity and mortality in young adults that has an upward trend worldwide. This type of injury accounts for two-thirds of traumatic deaths.[1]

TBI management is generally done clinically using the Glasgow Coma Scale (GCS), which presents a comprehensive framework of the three clinical aspects of verbal, visual, and motor responsiveness, used to stratify neural impairment and head injury severity. Accordingly, the patients are divided into mild, moderate, and severe TBI groups with GCS >13, 9–12, and ≤8, respectively. Extensive observational studies have declared 93%–96% mild, 5%–6% moderate, and <1% severe brain injuries using the GCS stratification rule.[2] Neuroimaging brain computed tomography (CT) is routinely applied to detect intracranial lesions according to the symptoms

Access this article online

Quick Response Code:

Website: www.jmsjournal.net

DOI: 10.4103/jrms.jrms_290_22

Address for correspondence: Dr. Amir Bahador Boroumand, Department of Emergency Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran. E-mail: ab.boroumand@med.mui.ac.ir

Submitted: 15-Apr-2022; **Revised:** 28-May-2022; **Accepted:** 20-Jun-2022; **Published:** 25-Nov-2022

associated with brain injuries and prevent unnecessary interventions.[3]

By 1975, the Glasgow Outcome Score (GOS) was published to assess the global outcome after brain injuries. When the GOS was developed, increasing evidence showed that TBI might lead to prolonged physical and mental consequences. The GOS was designed to capture how the injury affected functioning in major areas of life.[4] Shortly, an extended version, the Extended Glasgow Outcome Score (GOSE), was introduced to cover a more comprehensive view.[5]

Since then, numerous evaluations have been designed to distinguish the factors associated with more severe adverse outcomes of TBIs.[6-8] The factors such as age, glycemic state, on-admission GCS or motor score, platelet count, and coagulation status are among the most popular presented ones in the literature.[9-11] Nevertheless, the information in this regard is still limited and controversial. Accordingly, the current study aims to evaluate the on-admission, neurological symptoms, and neuroimaging factors associated with GOSE.[4]

METHODS

Study design and patients evaluation

This is a multicenter cross-sectional study conducted on 144 patients with TBI admitted at trauma emergency centers affiliated with Baqiyatallah and Isfahan University of Medical Sciences from March 2019 to February 2021.

The Ethics Committee of Baqiyatallah University of Medical Sciences approved the study proposal according to code number IR.BMSU.BAQ.REC.1399.038. Therefore, the protocol was presented to the patients or their legal guardians, they were reassured about the confidentiality of personal information, and written consent was obtained.

All the patients with isolated TBI who were mentally and physically healthy before the trauma entered the study, while those with trauma to other parts of the body presented unwillingness for participation in the study or with over 20% defect in the recruited information excluded.

Patients evaluation

The patient's Glasgow Coma Scale (GCS) was assessed at the admission time, and the patients were divided into three groups of mild, moderate, and severe TBI based on GCS of 14–15, 9–13, and <9, respectively.[12]

Accordingly, the patients with severe TBI (GCS ≤8) were sedated by 3 μg/kg of fentanyl, 0.3 mg/kg of etomidate, and 0.15 mg/kg of succinylcholine and were mechanically intubated using the rapid sequence intubation technique. Up to 30% head elevation was done immediately after the successful intubation. Besides, midazolam (5 mg/h) or fentanyl (150 μg/h) was infused to preserve the sedation of the intubated patients or the agitated patients with GCS of 9–13.[12] An expert neurosurgeon decided on surgical interventions using the standard guidelines. Thus, the patients were immediately transmitted to the operation room; if needed. In addition, the on-admission venous blood gas (VBG) was taken, and then, the ventilator was set up on $PaCO_2$ of 35–45 mmHg.

The severity of pain was assessed in patients who were not intubated using the visual analog scale (VAS) by intravenous ketorolac (30 mg every 6 h) or morphine sulfate (MS, 0.07 mg/kg every 4 h) with < 6 or ≥ 6 score of VAS, respectively.[13] Vomiting was controlled using 4–8 mg of intravenous ondansetron.

Standard protocols for TBI-associated seizure prevention were applied using intravenous diazepam (10 mg) or midazolam (5 mg), and anticonvulsant maintenance therapy was done using intravenous phenytoin (loading dose of 20 mg/kg).

Data collection

Demographic characteristics of the patients, including age, gender, and duration of hospital stay (hours), were entered into the study checklist. On-admission vital signs, including systolic blood pressure (SBP) and diastolic blood pressure (DBP) (mmHg), pulse rate (per minute), respiratory rate (per minute), and oxygen saturation (O_2Sat %) were evaluated primarily. Besides, VBG, complete blood count and differentiation, troponin, blood glucose, hemoglobin A_{1C}, triglyceride, cholesterol, partial thromboplastin time, prothrombin time, and international normalized ratio were assessed by taking on-admission blood samples.

The patients' TBI-related symptoms, including nausea, vomiting, otorrhagia, rhinorrhagia, seizure, headache, and amnesia, were entered into the checklist.

Brain CT scan was performed for the patients and interpreted by a panel consisting of an emergency specialist and a radiologist as intracranial hemorrhage (ICH), interventricular hemorrhage (IVH), subarachnoid hemorrhage (SAH), subdural hemorrhage (SDH), epidural hemorrhage (EDH), brain contusion, and depressed and linear skull fracture.

The study's primary aim was to assess the prognostic factors associated with the on-discharge Glasgow Outcome Scale Extended (GOSE), evaluated by the emergency specialists. The GOSE assessments were performed using the standard protocols presented by Wilson *et al*.[4] This assessment was made on discharge, within a month, and 3 months after discharge.

Besides, the duration of hospital stay, mechanical ventilation, and intensive care unit stay was entered into the study checklist.

Statistical analysis

Continuous and categorical data were reported as mean ± standard deviation (SD) and frequency (percentage), respectively. The normality of continuous data was evaluated using Kolmogorov-Smirnov test and Q-Q plot. Nonnormally positive and negative distributed data were subjected to logarithmic and exponential transformation. Independent samples *t*-test and Mann-Whitney *U*-test were used for comparing normally and nonnormally distributed continuous data between categories of binary variables, respectively. Spearman's rank correlation coefficient was used for evaluating the bivariate correlation between continuous potential determinants of GOSE at discharge and bootstrapping linear regression was used for multivariable associations. Those variables in bivariate association with $P < 0.1$ were entered in multiple linear regression. Bootstrapping produces confidence intervals that are more robust to violations of regression assumptions than are standard methods. Regression coefficients were reported along with 95% confidence interval. Repeated measure analysis variance was used for evaluating the mean change over time for GOSE scores; Mauchly's test was used for evaluating sphericity assumption and when it was violated multivariate analysis variance approach was adopted. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 23.

RESULTS

The current study has been conducted on 144 patients admitted to the target emergency wards due to isolated head trauma. The studied population was predominantly males (76.4%) and had the mean ± SD age and hospital stay of 39.33 ± 17.95 years old and 255.44 ± 143.62 h. On-admission mean ± SD GCS and motor assessments of the patients were 13.07 ± 2.75 and 5.51 ± 0.98, respectively. GCS in most of the patients (65.3%) was categorized as mildly disturbed GCS. Table 1 represents further detailed information.

Table 2 demonstrates the signs on brain CT scans and symptoms associated with head trauma. The most frequent types of lesions in noncontrasted CT scan were linear fracture (25%), subdural hematoma (SDH) (12.94%), and brain contusion (12.94%), respectively. The most prevalent symptoms were headache (77.1%), nausea (65.3%), followed by vomiting (43.1%), respectively.

Repeated measure ANOVA showed a significant increasing trend in on-discharge (7.47 ± 1.30), within a month (7.51 ± 1.30), and within 3 months (7.58 ± 1.21), GOSE over time follow up ($P < 0.001$). Bonferroni *post hoc* test showed a significant difference between GOSE measured 3 months after the trauma with on-discharge ($P < 0.001$) and within a month ($P = 0.041$). The mean change GOSE

Table 1: The baseline demographic and clinical characteristics of the studied population on admission time

Variable	Descriptive statistics
Age (year)	39.33±17.95
Gender (male)	110 (76.4%)
Hospitalization duration (h)	255.44±143.62
On-admission meaurements	
GCS	13.07±2.75
Motor	5.51±0.98
GCS severity (%)	
Mild	94 (65.3)
Moderate	38 (26.4)
Severe	12 (8.3)
SBP (mmHg)	122.53±20.69
DBP (mmHg)	68.68±11.47
Pupil size (%)	
Normal size	127 (88.2)
Other	17 (11.8)
Respiratory rate (per min)	14.88±3.39
Pulse rate (per min)	93.94±16.30
Oxygen saturation (%)	95.88±3.50
On-admission laboratory assessments	
WBC ($\times 10^3$/ml)	9.18±0.44
Hb (mg/dl)	13.99±2.27
Platelet ($\times 10^6$/ml)	182.2±0.33
Triglycerides (mg/dl)	151.14±46.74
Cholesterol (mg/dl)	120.69±44.35
pH	7.39±0.06
HbA1c	4.67±1
FBS	125.75±51.20
PTT (s)	27.83±4.69
PT (s)	13.14±1.33
INR	1.04±0.08

*Continuous and categorical data were reported as mean±SD and frequency (%). GCS=Glasgow Coma Scale/Score; SBP=Systolic blood pressure; DBP=Diastolic blood pressure; WBC=White blood cells; Hb=Hemoglobin; HbA1c=Glycated hemoglobin A1c; FBS=Fasting blood sugar; PTT=Partial thromboplastin time; PT=Prothrombin time; INR=International normalized ratio; SD=Standard deviation

Table 2: The distribution of imaging signs and trauma-related symptoms in the study participants

Lesion type	Frequency (%)	Symptoms	Frequency (%)
Linear fracture	36 (25)	Headache	111 (77.1)
Intracranial hemorrhage	11 (7.6)	Nausea	94 (65.3)
Inter-ventricular hemorrhage	4 (2.8)	Vomiting	62 (43.1)
Subarachnoid hemorrhage	23 (16)	Otorrhagia	8 (5.6)
Subdural hematoma	33 (22.9)	Rhinorrhagia	21 (14.6)
Epidural hematoma	11 (7.6)	Seizure	12 (8.3)
Brain contusion	33 (22.9)	Amnesia	33 (22.9)
Depressed fracture	8 (5.6)	Chest pain	2 (1.4)

on-discharge and within a month after discharge was significantly different ($P = 0.002$).

Bivariate association between GOSE and demographic and on-admission continuous clinical and laboratory data of participants evaluated using Spearman's rank correlation coefficient showed as significant correlation between on-discharge GOSE and following variables: GOSE was positively correlated with Glasgow Coma Scale total score (GCS) ($r = 0.729$, $P < 0.001$), motor GCS ($r = 0.812$, $P < 0.001$), Hb ($r = 0.165$, $P = 0.048$), and pH ($r = 0.165$, $P = 0.048$) and inversely with age ($r = -0.261$, $P = 0.002$), hospitalization period ($r = -0.678$, $P < 0.001$), pulse rate ($r = -0.256$, $P = 0.002$), white blood cell (WBC) ($r = -0.222$, $P = 0.008$), and triglyceride ($r = -0.218$, $P = 0.009$) [Table 3]. Correlation between all variables and GOSE is presented in Table 3. Bootstrap multiple linear regression analysis showed that the associations between on-discharge GOSE was significant only for GCS ($B = 0.102$, 95% CI: 0–0.202; $P = 0.05$), hospitalization period ($B = -0.004$, 95% CI: −0.005–−0.003, $P = 0.001$), and WBC ($B = 0.00001$, 95% CI: 0.00000014–0.000025; $P = 0.024$); those variables with $P < 0.1$ in bivariate analysis [Table 4].

Table 5 demonstrates the mean values of GOSE in categories related to head trauma signs in imaging or on-admission symptoms. The mean value of GOSE was significantly different between patients with and without the studied trauma signs in imaging or on-admission symptoms variables except for chest pain, headache, and amnesia [Table 5].

We entered all significant variables at $P < 0.1$ in univariate analysis into multiple linear regression. Significant association was detected between GOSE with ICH ($P = 0.006$), SAH ($P = 0.06$; marginally at $P < 0.1$), SDH ($P = 0.032$), and EDH ($P = 0.037$) in multivariable analysis [Table 4].

Table 3: The correlation of different demographic and clinical characteristics of patients with on-discharge Glasgow Outcome Score

Variable	*r*	*P*
Age	−0.261	0.002
Hospitalization duration	−0.678	<0.001
On-admission assessments		
GCS	0.729	<0.001
Motor GCS	0.812	<0.001
SBP	0.059	0.485
DBP	0.139	0.098
Pulse rate	0.259	0.002
Respiratory rate	0.062	0.465
Oxygen saturation	0.071	0.395
On-admission laboratory measurements		
Hb	0.211	0.011
WBC	−0.222	0.002
Platelet	−0.163	0.050
FBS	−0.146	0.083
HbA1c	0.066	0.439
Triglycerides	−0.218	0.009
Cholesterol	−0.082	0.331
pH	0.165	0.048
PTT	0.050	0.553
PT	−0.025	0.762
INR	0.016	0.847

GCS=Glasgow Coma Scale/Score; SBP=Systolic blood pressure; DBP=Diastolic blood pressure; WBC=White blood cells; Hb=Hemoglobin; HbA1c=Glycated hemoglobin A1c; FBS=Fasting blood sugar; PTT=Partial thromboplastin time; PT=Prothrombin time; INR=International normalized ratio

DISCUSSION

TBI is a critical etiology of mortality due to trauma worldwide that may lead to significant morbidities and fatal consequences. Accordingly, TBI outcome prediction, management, and therapeutic approaches are significant challenges for emergency medicine specialists who visit the patients primarily.[14] The current study evaluated the demographic, medical, symptoms, and imaging characteristics of the patients with TBI and the prognostic factors associated with TBI outcomes.

The studied patients were predominantly middle-aged males, a finding in agreement with most of the studies in the literature as males are responsible for most of the traffic accidents worldwide.[15-17] Although all the patients with TBI entered into the current study, traffic accidents were the primary underlying etiology of trauma. Nevertheless, the reports about the association of age with TBI are considered controversial. Some of the studies presented the highest rate among the elderly,[18] while the others declared age ranges <25 and over 75,[19-21] and some are in line with our findings.[22]

In agreement with the literature, headache, nausea, and vomiting were the most common symptoms of the patients with TBI,[7,23] while amnesia, rhinorrhagia, and seizure were the following presentations. Besides, linear fracture, SDH, and brain contusion were the most abundant findings in the brain CT scans, respectively. Szarpak evaluated 1049 patients with TBI and stated that contusion skins, open head wounds, and concussion injuries are the most common forms of craniocerebral injuries.[24] Another study by Nayebaghayee and Afsharian on 200 patients presented EDH, cerebral contusion, pneumocephalus, and SDH as the most frequent neuroimaging acute posttraumatic findings.[2]

The primary scope of this study was to figure out the factors associated with TBI outcomes based on GOSE. Accordingly, we found a direct correlation between on-admission GCS and motor GCS and on-admission pH, while hospital stay, on-admission pulse rate,

Table 4: Multiple linear regression analysis for the assessment of the association between prognostic variables and on-discharge Glasgow Outcome Score

Variable	B coefficient	SE	*t*	*P*	95% CI	
					Lower limit	Upper limit
Age	0.005	0.003	1.85	0.12	−0.001	0.011
Hospitalization duration	−0.004	0.00001	−11.32	<0.001	−0.005	−0.003
On-admission assessments						
GCS	0.102	0.05	1.97	0.05	0.0	0.203
Pulse rate	0.004	0.003	1.34	0.288	−0.003	0.009
On-admission laboratory tests						
WBC	0.00001	0.0000058	2.17	0.028	−0.00000014	−0.000025
Triglycerides	0.002	0.001	1.68	0.169	−0.001	0.004
pH	0.725	0.715	1.125	0.305	−0.874	2.054
CT scan sings						
ICH	−1.493	0.510	−5.361	0.006	−2.545	−0.475
IVH	−0.591	0.911	−1.24	0.492	2.478	1.135
SAH	−1.044	0.525	−1.988	0.063	−2.124	−0.015
SDH	−0.560	0.222	−2.957	0.032	−0.976	−0.093
EDH	−1.185	0.520	−4.024	0.037	−2.351	−0.225
Brain contusion	0.108	0.305	0.529	0.741	−0.478	0.691
Depressed fracture	0.473	0.717	1.43	0.516	−0.869	1.944
Linear fracture	0.226	0.260	1.168	0.392	−0.275	0.725
Head trauma-related symptoms						
Nausea	0.088	0.124	0.472	0.516	−0160	0.325
Vomiting	−301	0.171	−1.706	0.119	−0.663	0.029
Otorrhagia	−0.605	0.746	1.554	0.385	−2.342	0.604
Rhinorrhagia	−0.400	0.300	−1.71	0.202	−0.976	0.231
Seizure	−0.565	0.563	−1.00	0.319	−1.819	0.479

SE=Standard error; CI=Confidence interval; GCS=Glasgow Coma Scale/Score; WBC=White blood cells; CT=Computed tomography; ICH=Intracranial hemorrhage; IVH=Interventricular hemorrhage; SAH=Subarachnoid hemorrhage; SDH=Subdural hemorrhage; EDH=Epidural hemorrhage

Table 5: Mean of Glasgow Outcome Score in categories of imaging signs and trauma-related symptoms variables

Lesion type	Frequency	On-discharge GOSE (mean±SD)	*P**	Lesion type	Frequency	On-discharge GOSE (mean±SD)	*P**
ICH				Nausea			
Yes	11	5.27±2.05	<0.001	Yes	94	7.18±1.54	<0.001
No	133	7.65±1.05		No	50	8±0.0	
IVH				Vomiting			
Yes	4	4.25±2.63	<0.001	Yes	62	6.89±1.66	<0.001
No	140	7.56±1.14		No	82	7.90±0.69	
SAH				Otorrhagia			
Yes	23	5.65±2.17	<0.001	Yes	8	4.50±2.33	<0.001
No	121	7.81±0.65		No	136	7.64±0.98	
SDH				Rhinorrhagia			
Yes	33	6.39±2.08	<0.001	Yes	21	6.05±2.24	<0.001
No	111	7.78±0.72		No	123	7.71±0.87	
EDH				Seizure			
Yes	11	5.91±2.12	<0.001	Yes	12	6.00±2.59	<0.001
No	133	7.59±1.14		No	132	7.60±1.04	
Contusion				Chest pain			
Yes	33	6.76±1.84	<0.001	Yes	2	7.46±1.31	0.588
No	111	7.68±1.02		No	142	7.50±0.70	
Depressed fracture				Headache			
Yes	8	6.75±1.58	0.032	Yes	111	7.44±1.34	0.742
No	136	7.51±1.28		No	33	7.55±1.17	
Linear fracture				Amnesia			
Yes	36	7.14±1.44	0.008	Yes	33	7.33±1.31	0.276
No	108	7.57±1.25		No	111	7.50±1.30	

*Mann–Whitney test, values are reported as mean±SD. ICH=Intracranial hemorrhage; IVH=Interventricular hemorrhage; SAH=Subarachnoid hemorrhage; SDH=Subdural hemorrhage; EDH=Epidural hemorrhage; SD=Standard deviation; GOSE=Glasgow Outcome Score

on-admission WBC, and triglycerides had an inverse relation. Linear regression assessments revealed that hospitalization stay period and SAH type of injury were the negative predictors of on-discharge GOSE, while motor GCS and triglycerides were the prognostic factors for better GOSE. Surprisingly, none of the other types of brain injuries in the CT scan was associated with GOSE, which may have occurred due to the small size or the selected study population.

Kulesza *et al*. presented age, GCS motor score, pupil response, Marshall CT classification, and SAH as the prognostic factors for TBI outcomes. The other prognostic factors included hypotension, hypoxia, glucose, coagulopathy, hemoglobin, and category of CT characteristics.[25] The other study by Husson *et al*. stated on-admission GCS and motor score, SDH, and midline shift in brain imaging as the factors associated with adverse outcomes of TBI. Contrary to our study, they presented no predictive role for IVH and gender.[26]

Gender is another factor that has been noted in some studies to the extent that some of the studies presented a neuroprotective role for progesterone due to better outcomes for females,[27] whereas Munivenkatappa opposed it.[28] Nevertheless, most of the studies in the literature are in line with us and found no gender-based predictive role; however, TBI is considerably more frequent among males.[26,29]

Despite the agreement of most scientists on the standalone inverse relation between age and TBI outcomes, we found no association. However, some of the authors presented that < 40 years of age has no effect,[30] and the elderly, particularly over 60 years old patients are at increased risk for catastrophic outcomes following a TBI.[31] Therefore, we assume that our findings have been achieved because most of the studied population was under 40 years old, as accidents as the second etiology of mortality in Iran mainly affect young adults.[32]

Almost all researchers have unanimously declared a linear association between on-admission GCS and mortality.[33] Besides, an increasing number of evidence have presented that the motor entity of GCS has a substantial role in the outcomes of patients with TBI.[25,26]

A brain CT scan is an accessible modality to objectively determine the severity of brain injury in the acute phase. Poorer outcomes have been notified in the injuries leading to midline shift and its size. Besides, it is well-elucidated that SDH is associated with deteriorated outcomes than EDH to the extent that SDH is a prognostic factor for mortality.[34] Six-month follow-up of the patients revealed that traumatic SAH, obliteration of the basal cistern or third ventricle, and nonevacuated hematoma are the other imaging findings associated with significant adverse outcomes.[25,35]

On-admission vital signs are the other associated factors with TBI outcomes. SBP and DBP <90 and 50 mmHg, respectively, and oxygen saturation <90% are the prognostic factors of severe adverse outcomes following a TBI. Furthermore, it should be noted that SBP and respiratory rate have a U-shaped relationship with TBI.[30]

The direct association of on-admission triglycerides with TBI prognosis is the most novel finding of our study that has not been well-elucidated previously. However, we assume that high levels of triglycerides may be directly associated with the potential capability of the body to produce enough energy for the defense mechanisms of the body in harmful conditions, known as counterregulatory actions. Nevertheless, this studied population is insufficient to generalize the outcomes, and further evaluations are strongly recommended.

Due to the significance of road accidents in Iran, further studies to minimize morbidity and mortality are strongly recommended. It should be noted that young adults, who are the main socially active part of the community, are the largest group struggling with these events. Therefore, comprehensive schedules should be performed to prevent TBIs by educating the people and using seat belts or helmets routinely, to manage the patients ultimately by correct referrals to tertiary centers, and rehabilitate the injured cases.

Limitation

Despite all the valuable findings of this study, the small study population and short-term follow-up of the patients are the most significant limitations of the current study. Although it has been tried to consider diverse confounding variables in the analysis of the study, some of the probable variables that can confound the outcomes may have been neglected. Further studies are strongly recommended.

The emergence of COVID-19 infection had a two-sided effect. On one hand, less transportation in the city led to fewer road accidents; on the other hand, due to the decreased numbers of TBIs and the obligation of centers to admit COVID-19 patients only, the number of the studied population got fewer than what was estimated.

CONCLUSION

According to the findings of this study, hospital stay duration, the on-admission motor of GCS, on-admission

triglycerides, and SAH were the only standalone predictors for on-discharge GOSE.

Acknowledgment

We would like to thank the "Clinical Research Development Unit of Baqiyatallah Hospital" for their support, guidance, and advice. Besides, We are grateful to the officials of the emergency ward of Isfahan University of Medical Sciences affiliated hospitals.

Financial support and sponsorship

The study was sponsored by Baqiyatallah University of Medical Sciences.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, *et al.* Estimating the global incidence of traumatic brain injury. J Neurosurg 2018;130:1080-97.
2. Nayebaghayee H, Afsharian T. Correlation between Glasgow Coma Scale and brain computed tomography-scan findings in head trauma patients. Asian J Neurosurg 2016;11:46-9.
3. Marincowitz C, Lecky FE, Townend W, Borakati A, Fabbri A, Sheldon TA. The risk of deterioration in GCS13-15 patients with traumatic brain injury identified by computed tomography imaging: A systematic review and meta-analysis. J Neurotrauma 2018;35:703-18.
4. Wilson L, Boase K, Nelson LD, Temkin NR, Giacino JT, Markowitz AJ, *et al.* A manual for the Glasgow outcome scale-extended interview. J Neurotrauma 2021;38:2435-46.
5. Weir J, Steyerberg EW, Butcher I, Lu J, Lingsma HF, McHugh GS, *et al.* Does the extended Glasgow Outcome Scale add value to the conventional Glasgow Outcome Scale? J Neurotrauma 2012;29:53-8.
6. Willemse-van Son AH, Ribbers GM, Verhagen AP, Stam HJ. Prognostic factors of long-term functioning and productivity after traumatic brain injury: A systematic review of prospective cohort studies. Clin Rehabil 2007;21:1024-37.
7. Silverberg ND, Gardner AJ, Brubacher JR, Panenka WJ, Li JJ, Iverson GL. Systematic review of multivariable prognostic models for mild traumatic brain injury. J Neurotrauma 2015;32:517-26.
8. Cancelliere C, Cassidy JD, Côté P, Hincapié CA, Hartvigsen J, Carroll LJ, *et al.* Protocol for a systematic review of prognosis after mild traumatic brain injury: An update of the WHO Collaborating Centre Task Force findings. Syst Rev 2012;1:17.
9. Zufiría JM, Cuba BC, Rodriguez MS, Ramirez YL, Nunez PP, Degenhardt MT, *et al.* Severe head injury: Prognostic factors and clinical management. Asclepius Med Case Rep 2018;1:1-14.
10. de Almeida LP, Casarin MC, Rogério LP, Finger G, dos Santos SC, Schiavo FL. Prognostic factors trauma and epidemiologic related in surgically treated extradural hematoma. J Surg Res 2019;2:105-15.
11. Murray GD, Butcher I, McHugh GS, Lu J, Mushkudiani NA, Maas AI, *et al.* Multivariable prognostic analysis in traumatic brain injury: Results from the IMPACT study. J Neurotrauma 2007;24:329-37.
12. Jain S, Iverson LM. Glasgow coma scale. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2022.
13. Tverdal CB, Howe EI, Røe C, Helseth E, Lu J, Tenovuo O, *et al.* Traumatic brain injury: Patient experience and satisfaction with discharge from trauma hospital. J Rehabil Med 2018;50:505-13.
14. Mollayeva T, Mollayeva S, Pacheco N, D'Souza A, Colantonio A. The course and prognostic factors of cognitive outcomes after traumatic brain injury: A systematic review and meta-analysis. Neurosci Biobehav Rev 2019;99:198-250.
15. Peeters W, van den Brande R, Polinder S, Brazinova A, Steyerberg EW, Lingsma HF, *et al.* Epidemiology of traumatic brain injury in Europe. Acta Neurochir (Wien) 2015;157:1683-96.
16. Faul M, Coronado V. Epidemiology of traumatic brain injury. Handb Clin Neurol 2015;127:3-13.
17. de Almeida CE, de Sousa Filho JL, Dourado JC, Gontijo PA, Dellaretti MA, Costa BS. Traumatic brain injury epidemiology in Brazil. World Neurosurg 2016;87:540-7.
18. Herou E, Romner B, Tomasevic G. Acute traumatic brain injury: Mortality in the elderly. World Neurosurg 2015;83:996-1001.
19. Koskinen S, Alaranta H. Traumatic brain injury in Finland 1991-2005: A nationwide register study of hospitalized and fatal TBI. Brain Inj 2008;22:205-14.
20. Maegele M, Engel D, Bouillon B, Lefering R, Fach H, Raum M, *et al.* Incidence and outcome of traumatic brain injury in an urban area in Western Europe over 10 years. Eur Surg Res 2007;39:372-9.
21. Puljula J, Mäkinen E, Cygnel H, Kortelainen ML, Hillbom M. Incidence of moderate-to-severe traumatic brain injuries after reduction in alcohol prices. Acta Neurol Scand 2013;127:192-7.
22. Mauritz W, Wilbacher I, Majdan M, Leitgeb J, Janciak I, Brazinova A, *et al.* Epidemiology, treatment and outcome of patients after severe traumatic brain injury in European regions with different economic status. Eur J Public Health 2008;18:575-80.
23. Babcock L, Byczkowski T, Wade SL, Ho M, Mookerjee S, Bazarian JJ. Predicting postconcussion syndrome after mild traumatic brain injury in children and adolescents who present to the emergency department. JAMA Pediatr 2013;167:156-61.
24. Szarpak Ł, Madziała M. Epidemiology of cranio-cerebral injuries in emergency medical services practice. Pol Przegl Chir 2011;83:646-51.
25. Kulesza B, Nogalski A, Kulesza T, Prystupa A. Prognostic factors in traumatic brain injury and their association with outcome. J Pre Clin Clin Res 2015;9:163-6.
26. 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;42:425-36.
27. Groswasser Z, Cohen M, Keren O. Female TBI patients recover better than males. Brain Inj 1998;12:805-8.
28. Munivenkatappa A, Agrawal A, Shukla DP, Kumaraswamy D, Devi BI. Traumatic brain injury: Does gender influence outcomes? Int J Crit Illn Inj Sci 2016;6:70-3.
29. Mushkudiani NA, Engel DC, Steyerberg EW, Butcher I, Lu J, Marmarou A, *et al.* Prognostic value of demographic characteristics in traumatic brain injury: Results from the IMPACT study. J Neurotrauma 2007;24:259-69.
30. Saadat S, Akbari H, Khorramirouz R, Mofid R, Rahimi-Movaghar V. Determinants of mortality in patients with traumatic brain injury. Ulus Travma Acil Cerrahi Derg 2012;18:219-24.
31. Ostermann RC, Joestl J, Tiefenboeck TM, Lang N, Platzer P, Hofbauer M. Risk factors predicting prognosis and outcome of elderly patients with isolated traumatic brain injury. J Orthop Surg Res 2018;13:277.
32. Roshanfekr P, Khodaie-Ardakani MR, Malek Afzali Ardakani H, Sajjadi H. Prevalence and socio-economic determinants of disabilities caused by road traffic accidents in Iran; A national

survey. Bull Emerg Trauma 2019;7:60-6.
33. Fu TS, Jing R, McFaull SR, Cusimano MD. Recent trends in hospitalization and in-hospital mortality associated with traumatic brain injury in Canada: A nationwide population-based study. J Trauma Acute Care Surg 2015;79:449-54.
34. Maas AI, Steyerberg EW, Butcher I, Dammers R, Lu J, Marmarou A, *et al*. Prognostic value of computerized tomography scan characteristics in traumatic brain injury: Results from the IMPACT study. J Neurotrauma 2007;24:303-14.
35. Mattioli C, Beretta L, Gerevini S, Veglia F, Citerio G, Cormio M, *et al.* Traumatic subarachnoid hemorrhage on the computerized tomography scan obtained at admission: A multicenter assessment of the accuracy of diagnosis and the potential impact on patient outcome. J Neurosurg 2003;98:37-42.