Original Article

Compare the GCS and the Rotterdam CT Score in Predicting the Mortality and Disability of Patients with Traumatic Brain Injury

Mehdi Mahmoodkhani[1], Parham Behfarnia[2], Bahram Aminmansour[1]

[1]Department of Neurosurgery, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran, [2]School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Background: Given the dearth of extensive research comparing the Glasgow Coma Scale with the Rotterdam scoring system for predicting mortality in trauma patients, this study was conducted to determine which scale provides a more realistic prediction of mortality in trauma patients after three months.

Materials and Methods: This observational study was performed at Kashani Hospital in Isfahan, Iran. Patients with TBI who were admitted between February 2022 and February 2023 were included in the study. Approval from the Ethical Committee of Isfahan University of Medical Sciences was obtained prior to conducting this study.

Results: We included 152 adult patients who completed the GOS-E and the QOLIBRI-OS three-month post-injury. The median age was 35 years (IQR = 17–70). Most patients 139 (91.4%) were classified as having a severe TBI.

Conclusion: The results of the present study showed that both the use of GCS and Rotterdam CT scores can be effective in predicting the three-month mortality and QOLIBRI-OS scores of patients, with the difference that the predictive power of the three-month Rotterdam CT score is greater than that of the GCS.

Keywords: Disability, GCS, mortality, predicting, Rotterdam CT score, traumatic brain injury

Address for correspondence: Dr. Bahram Aminmansour, Department of Neurosurgery, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
E-mail: aminmansour@med.mui.ac.ir
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Introduction

Trauma remains one of the most pressing healthcare challenges in numerous countries worldwide, arising from various incidents such as road accidents, falls, acts of violence, surgical injuries, and occupational hazards.[1] Among the primary causes of death in trauma patients, traumatic brain injury (TBI) stands out as a critical concern.[2] Approximately, 10% of these patients require admission to specialized care units. Furthermore, hospital mortality rates and six-month ICU mortality rates have been reported at around 15% and 20%, respectively.[3] Notably, these patients exhibit significant differences in prognosis compared to other critically ill individuals, prompting the development of specialized prognostic models tailored specifically for TBI. Several scoring systems have been proposed for assessing the consciousness level of patients with brain injuries, with the Glasgow Coma Scale being the most widely recognized.[4]

Ordinarily, TBI patients are categorized into mild, moderate, and severe head injuries using the Glasgow Coma Scale. However, in cases where patients suffer severe head injuries and require intubation for airway protection or experience agitation, accurate GCS scoring may not be feasible. In such scenarios, the most viable and primary solution is to employ a model based on morphological criteria utilizing radiological images.[5,6]

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Computed tomography (CT) as the gold standard method for evaluating and diagnosing TBI patients aids in the diagnosis and management of potential intracranial injuries necessitating neurosurgical interventions.[7] Two scoring systems, the Marshall system (1991) and the Rotterdam CT score (2005), are used to predict outcomes based on CT imaging.[8] For individual injury characteristics and composite scoring systems, the utility of CT imaging in predicting mortality and functional outcomes has been evaluated. The Marshall score (1991) was established using the National Traumatic Coma Data Bank and remains one of the most widely used CT scoring systems for TBI. However, it is essential to note that neither the Marshall nor the Rotterdam scoring system has been validated for predicting mortality in children.[9,10]

Maas *et al*.[11] reported better predictive value for the Rotterdam scoring system compared to the Marshall score in TBI patients. However, another study in 2014 demonstrated good discriminatory power for both systems in early mortality prediction.[8] Given the dearth of extensive research comparing the Glasgow Coma Scale with the Rotterdam scoring system for predicting mortality in trauma patients, this study was conducted to determine which scale provides a more realistic prediction of mortality in trauma patients after three months.

Materials and Methods

This observational study was performed at Kashani Hospital in Isfahan, Iran. Patients with TBI who were admitted between February 2022 and February 2023 were included in the study. Approval from the Ethical Committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1401.113) was obtained prior to conducting this study.

Data were collected for patients with a clinical diagnosis of TBI and CT indication who were admitted to Kashani Hospital within 24 hours of injury. Patients who were at least 16 years old and had GOS-E, who were available, and had the Global Quality of Life Scale after Traumatic Brain Injury (QOLIBRI-OS) scores at three months after the injury, were included in the study, and informed consent was obtained from all of them.

Patients with a history of mild TBI and subacute head injuries (>24 h) were not considered and also the patients who were younger than 16 years, dead on arrival, and death before CT imaging and/or ICU admission were excluded as well as the pregnant patients and patients diagnosed with psychological problems.

Patient head CT scans were classified by a neurosurgeon (M.M.) according to the Rotterdam CT score.

The outcome was three-month mortality and health-related quality of life.

Outcome assessment

Disability

The Glasgow Outcome Scale-Extended (GOS-E) is widely used as a global measure of functional outcome and disability with the eight categories: (1) death, (2) vegetative state, (3) lower severe disability, (4) upper severe disability, (5) lower moderate disability, (6) upper moderate disability, (7) lower good recovery, and (8) upper good recovery.

Health-related quality of life

We used the Quality of Life after Brain Injury-Overall Scale (QOLIBRI-OS) to assess health-related quality of life (HRQoL). The QOLIBRI-OS is a six-item patient-reported HRQoL outcome measure specifically developed for post-TBI patients and measures satisfaction with aspects of life (cognition, self, daily life and autonomy, social relationships, current status, and eye future measures) and ranges from 0 (worst possible HRQoL) to 100 (best possible HRQoL). Scores of 61 and above are in the normal range, 52 to 60 are borderline, and scores below 52 are considered low or weak.

The Rotterdam classification, like the Marshall system, consists of four independent elements, including 1) the degree of base reservoir compression and 2) the degree of midline shift. However, it does not include contusion but rather limits mass lesions to 3) epidural hematoma and 4) intraventricular and/or subarachnoid blood. Each of these is given one point, and these points are calculated by adding 1 to the total points. In other words, a perfectly normal-looking scan has a Rotterdam score of 1 and a worst possible score of 6.

Classification

- basal cisterns
  - 0: normal
  - 1: compressed
  - 2: absent
- midline shift
  - 0: no shift or <=5 mm
  - 1: shift >5 mm
- epidural mass lesion
  - 0: present
  - 1: absent
- intraventricular blood or traumatic Subarachnoid Hemorrhage (SAH)
  - 0: absent
  - 1: present

Prognosis

In adults, the mortality at six months' increases with the score: score 1: 0%, score 2: 7%, score 3: 16%, score 4: 26%, score 5: 53%, and score 6: 61%

We studied the following personal and injury-related factors that are relevant to HRQoL: age, sex, cause of injury, and injury severity.

Results

We included 152 adult patients who completed the GOS-E and the QOLIBRI-OS three-month post-injury. The median age was 35 years (IQR = 17–70) [Table 1]. Most patients

Table 1: Patients' demographic and injury characteristics

Characteristics	All patients	Moderate TBI	Severe TBI
Age median (IQR)	38.34±15.71	37.91±16.18	42.92±8.24
Male sex, *n* (%)	116 (76.3)	6 (5.2)	110 (94.8)
Cause of injury, *n* (%)			
Road traffic incident	104 (68.42)	9 (8.7)	95 (91.3)
Incidental fall	36 (23.68)	4 (11.1)	32 (88.9)
Other non-intentional injury	12 (7.89)	0	12 (100)
CT brain appearance, *n* (%)			
Brain edema	30 (19.7)	25 (83.3)	5 (16.7)
Subarachnoid blood	19 (12.5)	18 (94.7)	1 (5.3)
Epidural hematoma	33 (21.7)	31 (93.9)	2 (6.1)
Subdural hematoma	6 (3.9)	0	6 (100)
Intraventricular hemorrhage	8 (5.3)	3 (37.5)	5 (62.5)
Contusions	33 (21.7)	0	33 (100)
Depressed fracture	5 (3.3)	0	5 (100)
MIX	18 (11.9)	2 (11.1)	16 (88.9)
Median length of ICU stay (IQR)	8.21±7.67	-	8.21±7.67
Median length of hospitalization (IQR)	9.49±5.55	3.58±1.27	15.41±9.84
Glasgow Outcome Scale-Extended three-month post-injury			
Dead	17 (11.2)	0	17 (100)
Vegetative State	38 (25)	0	38 (100)
Lower Severe Disability	13 (8.6)	0	13 (100)
Upper Severe Disability	28 (18.4)	0	28 (100)
Lower Moderate Disability	35 (23)	0	35 (100)
Upper Moderate Disability	12 (7.9)	4 (33.3)	8 (66.7)
Lower Good Recovery	7 (4.6)	7 (100)	0
Upper Good Recovery	2 (1.3)	2 (100)	0
QOLIBRI-OS scores	59.19±5.80	67.21±5.23	51.18±6.38
Rotterdam CT score, (mean±SD)	3.63±1.21	2.23±0.72	3.76±1.16

TBI was considered mild in patients with GCS 13–15, moderate in patients with GCS 9–12, and severe in patients with GCS of 3–8; IQR: interquartile range; n: number; TBI: traumatic brain injury; CT: computerized tomography (CT) scan; QOLIBRI-OS: Quality of Life after Traumatic Brain Injury overall scale; MIX: mix depressed fracture+contusions and epidural+contusions and subdural

139 (91.4%) were classified as having a severe TBI. The most common mode of injury was road traffic accident in 104 (68.42%) cases. Rotterdam score and QOLIBRI-OS scores were 59.19 ± 5.80 and 3.63 ± 1.21, respectively.

A statistically significant positive correlation was observed between patient age and Glasgow Outcome Scale, indicating an increase in mortality after TBI with increasing age. Because the majority of patients in our study were male, there was no statistically significant association between gender and outcome. Also, there was no significant relationship between injury status and Glasgow Outcome Scale.

As seen in Table 2, QOLIBRI-OS scores in GCS (6.76 ± 2.16) were lower than the Rotterdam CT score (7.32 ± 1.68) while the GOS-E in GCS (5.37 ± 1.96) was higher than the Rotterdam CT (5.32 ± 1.45).

According to the results of this study, both the use of GCS and Rotterdam CT scores can be effective in predicting the three-month mortality and QOLIBRI-OS scores of patients but Rotterdam CT scores have more power to predict the incidence of mortality [Table 3].

Discussion

TBI is a medical and surgical disease of great importance globally. According to the World Health Organization, traffic accidents were the third cause of illness and injury worldwide in 2020 and it is one of the most common causes of TBI. Prognosis is important when considering the outcome, especially when a potential rescue is considered.[12,13]

Traditionally, neurosurgeons have relied on individual clinical parameters such as age, initial GCS score, and pupillary response along with radiologic evaluation to guide clinical decisions and when consulting with family members and surrogate decision-makers regarding prognosis.[14]

Various models have been described to predict mortality and adverse neurological outcomes in TBI patients, the most well-known of which are Marshall CT score, Rotterdam CT score, and IMPACT CRASH.[15]

Mohammadifard *et al*.[8] revealed that the Rotterdam CT score was more accurate for the prediction of mortality at 2 weeks, at one month, and at three months.

Table 2: Comparison of mean Rotterdam CT score and GCS in terms of CT brain appearance, GOS-E, and QOLIBRI-OS scores

Cerebral lesion	Mean±SD	Middle	95% CI	Values
GCS				
Age	5.68±1.68	-	-	Spearman Test: *P*=0.035, *r*=-0.564
Sex	-	-	-	Mann–Whitney: *P*=0.380
Brain edema	8.23±1.87	7.30	(5.32-8.42)	Kruskal–Wallis: *P*=0.456
Subarachnoid blood	5.47±2.13	6.20	(4.19-6.98)	
Epidural hematoma	4.21±3.45	4	(3.78-4.33)	
Subdural hematoma	3.67±0.95	3.98	(1.96-4.78)	
Intraventricular hemorrhage	5.67±3.21	6.22	(5.34-6.83)	
Contusions	8.40±3.82	9.34	(7.45-9.92)	
Depressed fracture	7.21±4.37	7.32	(6.82-8.51)	
MIX	4.94±3.78	5.65	(4.11-6.14)	
QOLIBRI-OS scores	6.76±2.16	7.35	(5.32-8.09)	Spearman Test: *P*=0.043, *r*=0.786
GOS-E	5.37±1.96	6	(4.76-7.43)	Mann–Whitney: *P*=0.0001, *r*=0.231
Rotterdam CT score				
Age	4.76±0.98	-	-	Spearman Test: *P*=0.023, *r*=0.453
Sex	-	-	-	Mann–Whitney: *P*=0.587
Brain edema	4.32±1.94	4.67	(3.21-5.87)	Kruskal–Wallis: *P*=0.012
Subarachnoid blood	5.56±2.46	5	(4.37-7.12)	
Epidural hematoma	3.47±0.99	3.87	(2.76-4.01)	
Subdural hematoma	3.67±1.26	3	(2.15-4.32)	
Intraventricular hemorrhage	3.82±1.55	3.26	(2.78-4.26)	
Contusions	4.40±2.87	4.76	(3.26-5.34)	
Depressed fracture	4.35±2.34	4	(2.88-5.32)	
MIX	5.51±3.22	6.20	(4.65-7.31)	
QOLIBRI-OS scores	7.32±1.68	6.60	(5.13-7.43)	Spearman Test: *P*=0.0001, *r*=-0.456
GOS-E	5.32±1.45	5.87	(4.26-6.72)	Mann–Whitney: *P*=0.001, *r*=-0.845

Table 3: The mean of Rotterdam CT score and GCS in predicting patient's mortality and QOLIBRI-OS scores during three-month by using logistic regression analysis

Variable	Estimated (*B*)	Standard deviation	*P*	OR
Mortality (3-month)				
Rotterdam CT score	-0.89	0.450	0.0001	6.142
GCS	-0.72	0.117	0.0001	4.480
QOLIBRI-OS scores (3-month)				
Rotterdam CT score	-0.75	0.882	0.001	4.678
GCS	-0.53	0.456	0.0001	3.521

Elkbuli *et al*.[16] showed that higher scores in the Marshall classification and the Rotterdam system are associated with increased odds of mortality in adult patients in come from severe TBI after blunt injury.

Charry *et al*.[14] conducted a study and reported that six-month mortality was 29.13%, and the Rotterdam CT score predicted a mortality of 26% ($P < 0.0001$).

Mikolić *et al*.[17] concluded that men and women had differences in post-TBI care. Women typically report worse six-month outcomes. Also, GCS was a better predictor for women younger than 45 years and older than 65 years than men of the same age. In the present study, there was a significant and inverse relationship between age and GCS.

A study by Javeed *et al*. reported that the Rotterdam score is a useful tool to evaluate and predict outcomes in head trauma patients which is in accordance with our results that showed the more power of this sore.[7]

Conclusion

The results of the present study showed that both the use of GCS and Rotterdam CT scores can be effective in predicting

the three-month mortality and QOLIBRI-OS scores of patients, with the difference that the predictive power of the three-month Rotterdam CT score is greater than that of the GCS. It is suggested to do more studies considering the other methods such as score 4 and also with a longer follow-up duration of at least six months.

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Conflicts of interest

There are no conflicts of interest.

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