

Comparative Prognostic Performance Of The Four Score And Glasgow Coma Scale For Mortality Prediction In Adults With Traumatic Brain Injury

Yashaswini S^{1*}, Vijayalakshmi P B²

¹Department of Emergency Medicine, Shri Dharmasthala Manjunatheshwara College of Medical Sciences, Dharwad, Karnataka, India, 580009. Email: yashaswiniem@gmail.com

²Department of Emergency Medicine, Shri Dharmasthala Manjunatheshwara College of Medical Sciences, Dharwad, Karnataka, India, 580009.

Abstract

Background

Early prognostication after traumatic brain injury (TBI) is important for clinical decision-making and monitoring. The Glasgow Coma Scale (GCS) has limitations, particularly in intubated patients and assessment of brainstem function. The Full Outline of UnResponsiveness (FOUR) score incorporates eye and motor responses, brainstem reflexes, and respiratory pattern and may provide additional prognostic information.

Objective

To assess the prognostic validity of the FOUR score and compare its diagnostic performance with the GCS for predicting mortality in adults with isolated TBI.

Methods

A prospective observational study included 100 adults with isolated TBI presenting within 48 hours of injury. GCS and FOUR scores were assessed at admission and 6 hours after initial resuscitation. Demographic characteristics, injury mechanism, and survival outcomes were recorded. Pearson correlation assessed the relationship between scores. Receiver operating characteristic analysis evaluated discriminatory performance using area under the curve (AUC), sensitivity, specificity, positive predictive value, and negative predictive value.

Results

The mean age was 39.28 ± 14.53 years, and 81% were male. Road traffic accidents accounted for 85% of injuries. GCS and FOUR scores showed strong positive correlations at admission ($r = 0.927$, $p < 0.001$) and 6 hours ($r = 0.977$, $p < 0.001$). At admission, GCS ≤ 7 had an AUC of 0.905, sensitivity 97.73%, and specificity 83.33%, while FOUR had an AUC of 0.708, sensitivity 100%, and specificity 41.67%. At 6 hours, GCS had an AUC of 0.989, sensitivity 97.73%, and specificity 100%, whereas FOUR had an AUC of 0.833, sensitivity 100%, and specificity 66.67%. Both scores significantly discriminated mortality ($p < 0.001$).

Conclusion

Both GCS and FOUR scores demonstrated significant prognostic utility for mortality in adults with isolated TBI. FOUR showed consistently high sensitivity, whereas GCS demonstrated higher observed discriminatory performance and specificity, particularly at 6 hours. Larger multicentre studies are warranted to validate these findings and assess the incremental prognostic value of the FOUR score.

Keywords: Traumatic brain injury; Glasgow Coma Scale; FOUR score; mortality.

Introduction

Digital transformation is often less about swapping paper processes for digital versions and more about Traumatic brain injury (TBI) is among the leading causes of death and long-term disability worldwide, and its burden falls disproportionately on low- and middle-income countries. In India, an estimated 1.5 to 2 million persons sustain traumatic brain injuries each year and approximately 1 million deaths are attributed to them, with road traffic injuries accounting for around 60% of cases, followed by falls (20–25%) and violence (10%) [1]. Hospital-based Indian series confirm that the burden is concentrated in economically productive young men injured on the road; in a level-1 trauma centre cohort of 1527 patients with moderate or severe TBI, half were aged 21–40 years, road traffic accidents caused 64.96% of injuries, and 34.58% died in hospital [2].

Early, reproducible stratification of injury severity therefore determines triage, intensity of neuromonitoring,

counselling of relatives and allocation of scarce critical-care resources. Since its description in 1974, the Glasgow Coma Scale (GCS) has remained the reference instrument for grading impaired consciousness [3]. Its verbal component, however, cannot be elicited in intubated, sedated, aphasic or intoxicated patients, and the scale captures neither brainstem reflexes nor respiratory drive precisely the functions that deteriorate with herniation. The Full Outline of UnResponsiveness (FOUR) score was developed to address these deficiencies by adding brainstem and respiration domains while omitting verbal response [4].

Comparative evidence remains inconsistent. A prospective neuro-ICU cohort reported high internal consistency for both scales [5], whereas a study of 138 patients with moderate and severe TBI found both total scores significantly lower among non-survivors [6], and an ICU comparison found the FOUR score superior on Youden index (45.7% vs 32.0%) [7]. Reported optimal cut-offs vary widely, most studies score patients only once at admission, and Indian emergency-department data are sparse [8].

Accordingly, this study compared the correlation and prognostic accuracy of the GCS and FOUR score, applied both on arrival and after 6 hours of resuscitation, in adults with isolated TBI.

Methodology

Study design and setting

This was a prospective observational study conducted over a one-year period in the Department of Emergency Medicine, SDM College of Medical Sciences and Hospital, Dharwad, Karnataka, India.

Participants

Consecutive patients of either sex, aged >18 years, presenting with isolated traumatic brain injury (TBI) to the Emergency Department were screened for eligibility.

Inclusion criteria: Adults (>18 years) with isolated TBI presenting within 48 hours of injury.

Exclusion criteria: Age <18 years; pregnancy; TBI initially managed at another facility before referral; presentation beyond 48 hours of injury; non-traumatic intracranial haemorrhage; refusal of consent; and discharge against medical advice.

Ethical considerations

The study was conducted after approval from the Institutional Ethics Committee and in accordance with the Declaration of Helsinki. Because the neurological status of most patients precluded self-consent at enrolment, written informed consent was obtained from the first-degree relative or legally authorised representative of each patient.

Sample size

Sample size was calculated using the standard formula for estimating a proportion, $n = Z^2pq/d^2$, with an anticipated sensitivity (p) of 78%, q = 22%, a 95% confidence level (Z = 1.96), and an allowable margin of error (d) of 8%, yielding a calculated requirement of 103 patients. One hundred patients were enrolled during the study period.

Clinical assessment and data collection

Baseline demographic details, mechanism of injury, and presenting symptoms were recorded for all patients. Vital parameters were assessed and patients resuscitated per Advanced Trauma Life Support (ATLS) protocols. Consciousness level was scored simultaneously using both the Glasgow Coma Scale (GCS) and the Full Outline of UnResponsiveness (FOUR) score at three time points: on arrival, at 6 hours after admission, and on day 28 following injury. In intubated patients, the verbal component of the GCS was scored as per standard convention. All scoring was performed by a single principal observer to minimise inter-observer variability. The primary outcome was survival status (alive/deceased).

Statistical analysis

Data were analysed using SPSS version 21. Categorical variables are presented as frequencies and percentages; continuous variables as mean $\pm$ standard deviation or median (minimum, maximum). The association between GCS and FOUR scores across time points was assessed using Pearson correlation. Discriminative accuracy of each score for survival status was evaluated by the area under the receiver operating characteristic curve (AUC), with cut-off values selected to jointly maximise sensitivity and specificity; sensitivity, specificity, positive predictive value, and negative predictive value are reported with 95% confidence intervals. A two-tailed p-value ≤ 0.05 was considered statistically significant.

Results

A total of 100 patients with isolated traumatic brain injury were enrolled during the study period. The mean age was 39.28 ± 14.53 years (median 38, range 18–76 years). Eighty-one patients (81%) were male and 19 (19%) were female. Road traffic accidents were the predominant mechanism of injury, accounting for 85 (85%) of cases, followed by fall from height in 8 (8%), assault in 3 (3%), slip and fall in 3 (3%), and bull-gore injury in 1 (1%) (Table 1).

Table 1. Baseline characteristics of study subjects (N = 100)

Variable	Subcategory	n (%)
Age (years)	Mean $\pm$ SD	39.28 ± 14.53
	Median (min, max)	38 (18, 76)
Sex	Male	81 (81)
	Female	19 (19)
Mechanism of injury	Road traffic accident	85 (85)
	Fall from height	8 (8)
	Assault	3 (3)
	Slip and fall	3 (3)
	Bull-gore injury	1 (1)

Correlation between GCS and FOUR score

A strong, statistically significant positive correlation was observed between GCS and FOUR score at all assessed time points (Table 2). On-arrival GCS correlated strongly with on-arrival FOUR score ($r = 0.927$, $p < 0.001$), with 6-hour GCS ($r = 0.889$, $p < 0.001$), and with 6-hour FOUR score ($r = 0.896$, $p < 0.001$). The correlation between 6-hour GCS and 6-hour FOUR score was the strongest observed ($r = 0.977$, $p < 0.001$).

Table 2. Correlation between GCS and FOUR score at arrival and at 6 hours

	On arrival–GCS	On arrival–FOUR	6 h–GCS	6 h–FOUR
On arrival–GCS	1	0.927**	0.889**	0.896**
On arrival–FOUR	0.927**	1	0.870**	0.879**
6 h–GCS	0.889**	0.870**	1	0.977**
6 h–FOUR	0.896**	0.879**	0.977**	1

N = 100 for all pairs; $p < 0.001$ for all correlations. *Correlation significant at the 0.01 level (2-tailed).

Predictive accuracy of GCS and FOUR score for outcome

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the accuracy of GCS and FOUR score in predicting survival status, at cut-offs of ≤ 7 for GCS and ≤ 6 for FOUR score (Table 3).

On arrival, GCS demonstrated an AUC of 0.905, with sensitivity of 97.73% (95% CI 92.03–99.72) and specificity of 83.33% (95% CI 51.59–97.91). FOUR score on arrival showed an AUC of 0.708, with sensitivity of 100% (95% CI 95.89–100) but lower specificity of 41.67% (95% CI 15.17–72.33).

At 6 hours, discriminative accuracy improved for both scales. GCS achieved an AUC of 0.989, sensitivity 97.73% (95% CI 92.03–99.72), and specificity 100% (95% CI 73.54–100). FOUR score at 6 hours achieved an AUC of 0.833, sensitivity 100% (95% CI 95.89–100), and specificity 66.67% (95% CI 34.89–90.08). All models were statistically significant ($p < 0.001$).

Table 3. ROC analysis of GCS and FOUR score for predicting outcome (alive vs deceased)

Parameter	GCS – Arrival	FOUR – Arrival	GCS – 6 h	FOUR – 6 h
Cut-off	≤ 7	≤ 6	≤ 7	≤ 6
AUC	0.905	0.708	0.989	0.833
Sensitivity (95% CI)	97.73 (92.03–99.72)	100 (95.89–100)	97.73 (92.03–99.72)	100 (95.89–100)

Specificity (95% CI)	83.33 (51.59–97.91)	41.67 (15.17–72.33)	100 (73.54–100)	66.67 (34.89–90.08)
PPV (95% CI)	85.43 (62.32–95.41)	63.16 (51.52–73.44)	100 (95.80–100)	75 (57.41–86.98)
NPV (95% CI)	97.35 (90.10–99.33)	100 (47.82–100)	97.78 (91.79–99.43)	100 (63.06–100)
p-value	<0.001	<0.001	<0.001	<0.001

AUC: Area Under the ROC curve, PPV: Positive Predictive Value, NPV: Negative Predictive Value

Discussion

This prospective observational study compared the prognostic performance of the Glasgow Coma Scale (GCS) and Full Outline of UnResponsiveness (FOUR) score for mortality prediction in adults with isolated traumatic brain injury (TBI). Both scores demonstrated strong positive correlations at admission and 6 hours, indicating substantial concordance in assessing neurological impairment. However, GCS showed greater discriminatory performance for mortality, particularly at 6 hours, whereas FOUR demonstrated consistently high sensitivity.

The strong correlation between GCS and FOUR is consistent with previous studies demonstrating substantial agreement between the two instruments in patients with TBI [9, 10]. The correlation was strongest at 6 hours in the present study, potentially reflecting greater clinical stability following initial resuscitation. Although both scales assess impaired consciousness, their structures differ. GCS incorporates eye, verbal and motor responses, whereas FOUR evaluates eye and motor responses together with brainstem reflexes and respiratory pattern. Thus, FOUR provides additional neurological information that may be particularly relevant in patients who are intubated or unable to provide a reliable verbal response [11].

In the present cohort, GCS demonstrated greater mortality discrimination than FOUR. At admission, the AUC was 0.905 for GCS compared with 0.708 for FOUR, increasing to 0.989 and 0.833, respectively, at 6 hours. Previous studies have reported variable findings, with some demonstrating comparable prognostic performance and others suggesting an advantage for FOUR, particularly in critically ill or intubated patients [12–14]. A systematic review and meta-analysis also concluded that both scores have significant prognostic value, while comparative superiority varies according to population and clinical setting [15]. Therefore, the present findings support the continued prognostic utility of GCS rather than suggesting that FOUR should replace it.

An important observation was the 100% sensitivity of FOUR at both assessment points, although specificity was lower than that of GCS. This finding suggests that FOUR may be useful for identifying patients at increased risk of death, while its additional brainstem and respiratory components may increase detection of severe neurological dysfunction. Nevertheless, the lower specificity indicates that a low FOUR score does not necessarily correspond to mortality in every patient. Consequently, the two scales may have complementary rather than interchangeable roles in clinical assessment.

The improvement in discrimination at 6 hours for both instruments emphasizes the importance of serial neurological assessment after initial stabilization. Early GCS or FOUR measurements may be influenced by reversible factors associated with trauma and resuscitation. Reassessment after stabilization may therefore provide a more reliable representation of neurological status [16]. However, the very high 6-hour AUC observed for GCS should be interpreted cautiously because of the relatively small sample size and single-centre design.

The clinical relevance of FOUR is particularly evident in patients in whom the verbal component of GCS cannot be assessed reliably. By incorporating brainstem reflexes and respiratory pattern, FOUR may provide additional

information regarding neurological deterioration and brainstem dysfunction [17]. Thus, the findings of this study support the use of FOUR as a complementary assessment tool rather than as a universal replacement for GCS. Several limitations should be considered. The study included only 100 patients from a single tertiary-care centre, limiting statistical precision and generalizability. Mortality was evaluated as the outcome, without assessment of long-term functional or neurological recovery. Assessment by a single observer reduced inter-observer variability but may limit applicability across different clinical settings. Furthermore, the observational design precludes conclusions regarding whether either scoring system improves clinical decision-making or patient outcomes.

Conclusion

Both GCS and FOUR demonstrated significant prognostic utility for mortality in adults with isolated TBI. GCS showed superior discriminatory performance, particularly at 6 hours after resuscitation, while FOUR demonstrated high sensitivity and provided additional assessment of brainstem reflexes and respiratory pattern. Thus, FOUR may be used as a complementary neurological assessment tool alongside GCS, particularly when verbal assessment is unreliable.

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Ethical consideration

The study was conducted after obtaining ethical clearance from the institutional ethics committee.

Consent

Written informed consent was obtained from the first-degree attendants of participants as documented in the study protocol.

Conflict of interest

All authors have no conflict of interest

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