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Original Research Article

Comparison of GCS (Glasgow Coma Scale) Score and FOUR (Full Outline of UnResponsiveness) Score as Predictors of Mortality and Morbidity in Traumatic Brain Injury Patients in an Emergency Department of a Tertiary Care Hospital – A Prospective Observational Study

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Abstract:

Background: Traumatic brain injury remains a major cause of morbidity and mortality globally, with road traffic accidents being the most common cause. Prompt and accurate neurological assessment is crucial for prognosis. Although widely used, the Glasgow Coma Scale (GCS) has limitations, particularly when dealing with intubated patients. The FOUR (Full Outline of UnResponsiveness) score was developed to address these limitations by including brainstem reflexes and respiratory patterns. This study compares the effectiveness of GCS and FOUR scores in predicting mortality and morbidity among TBI (Traumatic Brain Injury) patients.

Methods: A hospital-based prospective observational study was conducted in the emergency and neurosurgery departments of Valluvanad Hospital Complex, Ottapalam, from August 2022 to December 2023. Seventy-three patients with TBI, aged above 12 years, were enrolled. GCS and FOUR scores were recorded at presentation. Mortality and morbidity were assessed using the mRS (modified Rankin Scale) at discharge and at 30-day follow-up. Statistical analyses included ROC curve analysis, Pearson correlation, and comparison of sensitivity, specificity, and predictive values.

Results: Among 73 patients, 80.8% were male and 82.2% sustained TBI due to road traffic accidents. The overall mortality rate was 21.9%. Mean GCS and FOUR scores were significantly higher in survivors (GCS: 9.6 ± 2.6, FOUR: 12.1 ± 2.5) compared to non-survivors (GCS: 6.4 ± 2.8, FOUR: 6.8 ± 2.7). ROC analysis revealed an AUC of 0.7840 for GCS and 0.9139 for FOUR in predicting mortality. FOUR score had higher sensitivity (87.5%) and specificity (80.7%) compared to GCS (sensitivity: 68.75%, specificity: 73.68%). There was a statistically significant negative correlation between both scores and mortality, as well as poor functional outcome at 30 days.

Conclusion: Both GCS and FOUR scores are effective in predicting mortality and morbidity in TBI patients, but the FOUR score demonstrates superior predictive accuracy, especially in intubated patients or those with impaired verbal communication. It provides a more comprehensive assessment by including brainstem and respiratory functions, making it a more reliable tool in emergency settings.

Keywords: Traumatic Brain Injury, Glasgow Coma Scale, Full Outline of Unresponsiveness, Mortality Prediction, Morbidity, Emergency Department, Neurological Assessment.

Introduction

Traumatic brain injury, often referred to as the "silent epidemic," is a major contributor to global mortality and disability, surpassing other types of trauma despite advancements in prevention and care. In India, the majority of TBIs are caused by road traffic accidents (60%), followed by falls (20–25%) and violence (10%).[1] TBI accounts for nearly one-third to half of all trauma-related deaths and is the leading cause of disability among individuals under 40 years of age.[2] The national burden is staggering, with an estimated 1.5–2 million injuries and around 1 million fatalities annually due to TBI in India.[1] Despite the profound socio-economic impact, the associated economic losses remain unquantified.[3]

TBI can be open (penetrating) or closed (non-penetrating) and is classified based on clinical severity into mild, moderate, or severe. Patients may present with varied symptoms ranging from mild confusion to coma and death. Clinical signs such as

headache, vomiting, nasal/ear bleeding, and cerebrospinal fluid leaks often accompany TBI.[4] Early assessment within the first 24 hours is critical for guiding emergency interventions.

The GCS is the most widely used tool for initial neurological evaluation, assessing eye, motor, and verbal responses. However, its limitations include the inability to assess intubated or aphasic patients and variability in scoring between observers. To overcome these shortcomings, the FOUR score was introduced by Wijdicks et al., in 2005.[5] It evaluates eye response, motor response, brainstem reflexes, and respiratory pattern, offering advantages in patients with severe or non-verbal presentations. GCS only considers eye opening to pain, but the eye response component of the FOUR score allows differentiation between a vegetative state (eyes open but do not track) and a locked in syndrome(eyes open blink and track vertically on command).[6,7] Given the limited studies comparing GCS and FOUR in TBI outcome prediction, this study was undertaken to evaluate their utility in forecasting mortality and morbidity in a tertiary care hospital setting.

Aims and Objectives

The aim of this study was to evaluate and compare the effectiveness of the GCS and the FOUR score in predicting morbidity and mortality among patients with TBI admitted to the emergency department of a tertiary care hospital. Specifically, the study seeks to assess patient outcomes using both scoring systems and determine their relative accuracy in prognosticating clinical outcomes in terms of both survival and functional recovery.

Materials and Methods

This hospital-based prospective observational study was conducted in the Emergency and Neurosurgery Departments of Valluvanad Hospital Complex, Ottapalam, over a period from August 2022 to December 2023. The study population included all patients admitted or referred with TBI who met the predefined inclusion criteria.

Inclusion and Exclusion Criteria: The study included all patients aged above 12 years who were admitted with TBI and provided a valid signed consent form. Patients were excluded if they were intubated prior to admission, had received sedative or paralytic agents before arrival, or had known pre-existing impairments in speech, vision, hearing, or motor function.

Sample Size Calculation: The sample size was calculated on the basis of following formula:

$SS = (Z\text{-score})^2 * p(1-p) / (e)^2$

SS = Sample Size.

Z-score = critical value for standard normal distribution (1.96 for 95%CI).[1]

e = Margin of error.

$SS = \{(1.96)^2 * 0.15 (1-0.15)\}/ (0.10)^2$

SS = 48

Considering the drop-out rate or loss of data of 20%, the adjusted sample size was 58. However, 73 patients were enrolled throughout the study period.

Data Collection Procedure: After obtaining informed consent, detailed clinical history and examination were performed for each patient at the time of admission. Data were collected using a standardized abstraction tool, including demographic details such as age, gender, mechanism and type of head injury, and initial assessment using the GCS and FOUR score. GCS was scored based on eye, verbal, and motor responses, while the FOUR score included eye and motor responses, brainstem reflexes, and respiratory pattern. Relevant laboratory investigations were also recorded. Functional outcomes were assessed using the mRS (modified Rankin Scale), with patients monitored until discharge and followed up after 30 days for outcome evaluation.

Statistical Analysis: The collected data were compiled using a pre-designed template and entered into an Excel spreadsheet for analysis. Descriptive statistics were applied, with categorical variables presented as numbers and percentages and continuous variables expressed as mean ± standard deviation based on normal distribution. Data analysis was performed using GraphPad Prism version 9.2.0. Comparisons between study groups were conducted using the Student's t-test and one-way ANOVA for parametric and non-parametric data, respectively. Chi-square or Fisher's exact test was used for analyzing categorical variables. Pearson correlation analysis assessed the relationship between the GCS and FOUR scores with functional outcomes and mortality. ROC (Receiver Operating Characteristic) curve analysis was performed to evaluate the predictive accuracy of both scoring systems, with interpretation of the AUC (Area Under the Curve) values ranging from 0.5 (no discrimination) to >0.9 (very strong prediction). A p-value of ≤ 0.05 was considered statistically significant.

Results

Table 1: Gender Distribution of the Enrolled Patients

Gender	Survivors (N=57)	Non-Survivors (N=16)	Total (N=73)
Male	47 (79.7%)	12 (20.3%)	59 (80.8%)
Female	10 (71.4%)	4 (28.6%)	14 (19.2%)

In Table 1, the majority of patients were male (80.8%). The mortality rate was slightly higher among females (28.6%) compared to males (20.3%), but this difference was not statistically significant (P = 0.1651).

Table 2: Age Group Distribution of the Enrolled Patients

Age Group (in years)	Survivors	Non-Survivors	Total
18–39	29 (80.6%)	7 (19.4%)	36 (49.3%)
40–60	19 (76.0%)	6 (24.0%)	25 (28.8%)
≥ 60	9 (75.0%)	3 (25.0%)	12 (21.9%)

In Table 2, the highest proportion of patients was in the 18–39 age group. Mortality increased slightly with age, but the association between age group and outcome was not statistically significant (P = 0.8786).

Table 3: Distribution of Patients Based on Mechanism of Injury

Injury Mechanism	Survivors	Non-Survivors	Total
RTA (Road Traffic Accidents)	46 (76.7%)	14 (23.3%)	60 (82.2%)
Falls	8 (88.9%)	1 (11.1%)	9 (12.3%)
Others	3 (75.0%)	1 (25.0%)	4 (5.5%)

According to Table 3, RTAs were the leading cause of TBI (82.2%). Mortality was highest in the "others" category and lowest in fall-related injuries, though differences were not statistically significant (P = 0.7023).

Table 4: Mean GCS and FOUR Scores in Survivors and Non-Survivors

Scoring System	Survivors (Mean ± SD)	Non-Survivors (Mean ± SD)	P-Value
GCS	9.6 ± 2.6	6.4 ± 2.8	0.001
FOUR	12.1 ± 2.5	6.8 ± 2.7	< 0.0001

According to Table 4, both GCS and FOUR scores were significantly lower in non-survivors, indicating their usefulness in mortality prediction.

Table 5: Mean mRS Score at Discharge and 30-Day Follow-Up

Scoring System	At Discharge (Mean ± SD)	At 30-Day Follow-Up (Mean ± SD)	P-Value
mRS	3.47 ± 0.92	3.08 ± 1.14	0.0468

Table 5 shows that functional outcomes improved slightly by the 30-day follow-up, with a statistically significant reduction in mRS scores.

Table 6: ROC Analysis for GCS and FOUR Score in Predicting Poor Functional Outcome

Parameter	GCS	FOUR
AUC	0.8158	0.8794
95% CI	0.7106–0.9210	0.7933–0.9655
Std. Error	0.0536	0.0439

According to Table 6, the FOUR score showed a higher AUC than GCS in predicting poor functional outcomes at 30 days, indicating stronger predictive ability.

Table 7: ROC and Diagnostic Performance for Mortality Prediction

Statistics	GCS (Value, 95% CI)	FOUR (Value, 95% CI)
Sensitivity	68.75% (41.34–88.98%)	87.50% (61.65–98.45%)
Specificity	73.68% (60.34–84.46%)	80.70% (68.09–89.95%)
PPV	42.31% (29.82–55.86%)	56.00% (42.04–69.07%)
NPV	89.36% (79.98–94.64%)	95.83% (86.21–98.83%)
Accuracy	72.60% (60.91–82.39%)	82.19% (71.47–90.16%)

Table 7 demonstrated FOUR score, superior sensitivity, specificity, and overall accuracy compared to GCS in predicting in-hospital mortality.

Discussion

Accurate assessment of consciousness levels in TBI is essential for effective communication among healthcare providers and prognostication. The GCS, developed in 1974, has long served as the most widely accepted and utilized tool for evaluating TBI severity due to its simplicity and reproducibility. However, it presents limitations—particularly in intubated or aphasic patients-due to its dependence on verbal responses and lack of assessment of brainstem reflexes or respiratory patterns. To address these shortcomings, the FOUR score was introduced, offering a more comprehensive evaluation, especially in patients with altered communication abilities.

This prospective observational study enrolled 73 TBI patients. A male predominance was noted (male:female ratio = 4.2:1), aligning with findings from Agrawal N et al. (2.8:1) and Fakhry T et al. (2.3:1).[8,9] Mortality rates showed no significant differences by gender or age group ($P > 0.05$), though mortality was slightly higher among females (28.6%) than males (20.3%), similar to findings by Goswami et al.[10] Road traffic accidents were the most frequent mechanism of injury (82.2%), consistent with data from Sri K et al.[11] and Chamoun RB et al.[12]

The mean GCS and FOUR scores were significantly higher in survivors than in non-survivors, indicating their prognostic value (GCS: $P = 0.001$; FOUR: $P < 0.0001$). These findings align with those of Guruge K et al. [13] Jalali R et al. [14] and Amrit S et al. [15] A strong correlation was observed between the two scores ($r = 0.839$) and with mortality prediction (GCS $r = -0.454$; FOUR $r = -0.646$), confirming the inverse relationship between score and mortality. Similarly, in predicting poor functional outcomes (mRS 3–6), the FOUR score showed a stronger negative correlation ($r = -0.793$) compared to GCS ($r = -0.673$), as reported by Eken C et al. [16]

When evaluating predictive accuracy, the AUC for the FOUR score in predicting in-hospital mortality was 0.9139, indicating strong discriminative power, compared to GCS with an AUC of 0.7840. These findings are in agreement with studies by Keykha A et al. [17] Jalali R et al. [14] and Gujjar et al.,[18] who found FOUR to be superior to GCS. Although some researchers like Sahin AS et al. [19] and Ghelichkhani P et al. [20] suggested comparable utility between the two scores, Amrit S et al. [15] reported no superiority of FOUR over GCS. Such differences could be attributed to variations in study design, patient populations, or clinical settings.

In conclusion, our study reinforces the utility of both GCS and FOUR scores in TBI outcome prediction, with FOUR offering a more comprehensive assessment, especially in patients who cannot be evaluated using GCS verbal components.

Limitations

One limitation of this single-center study is the relatively small sample size, though this allowed for consistency in care and management across participants. Additionally, as both the FOUR score and GCS assessments were performed by the same investigator, inter-rater reliability was not evaluated; however, the well-established inter-rater reliability of these tools reduces the need for redundancy. Lastly, since the study focused on early mortality, the predictive value of these scores for long-term functional outcomes was not assessed.

Conclusion

Road traffic accidents remain a leading cause of trauma, particularly among males, highlighting the need for reliable neurological assessment tools in emergency settings. This study found the FOUR score to be superior to the GCS, offering a more comprehensive evaluation and better predictive accuracy for both mortality and functional outcomes in TBI patients. With its higher AUC, strong sensitivity, and moderate specificity, the FOUR score emerges as a valuable tool for improving prognostication and guiding management in traumatic brain injury cases.

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