

Validity of FOUR (Full Outline of Unresponsiveness) Score in the Prediction of ICU Admissions in Traumatic Brain Injury Patients in Accident & Emergency Department

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ABSTRACT

Background: Traumatic brain injury (TBI) is a major cause of morbidity and mortality worldwide. Early assessment of neurological status is essential for predicting outcomes and determining the need for intensive care. The Full Outline of UnResponsiveness (FOUR) score has been proposed as a reliable alternative to the Glasgow Coma Scale (GCS), particularly in critically ill and intubated patients.

Objectives: To determine the diagnostic accuracy of the FOUR score in predicting the need for ICU admission among patients with traumatic brain injury presenting to the Emergency Department.

Study Design & Setting: This descriptive cross-sectional study was conducted in the Emergency Department of Mayo Hospital Lahore from 15 December 2025 to 15 April 2026.

Methodology: A total of 151 patients aged ≥ 12 years with traumatic brain injury were included using non-probability consecutive sampling. Demographic and clinical data were recorded. FOUR score and GCS were assessed at presentation. A cutoff value of ≤ 10 for FOUR score was used to predict ICU admission. Patients were followed for up to 24 hours to determine their disposition. Diagnostic accuracy measures were calculated using a 2×2 contingency table.

Results: The mean age was 38.58 ± 17.64 years, with 67.5% males. Road traffic accidents were the most common cause (60.9%). The mean FOUR score was 9.25 ± 3.97 and mean GCS was 10.32 ± 2.91 . ICU admission was required in 53.6% of patients. The FOUR score demonstrated a sensitivity of 88.9%, specificity of 78.6%, positive predictive value of 82.8%, negative predictive value of 85.9%, and overall accuracy of 84.1%.

Conclusion: The FOUR score is a reliable and accurate tool for predicting ICU admission in patients with traumatic brain injury and may be used effectively in emergency settings.

Keywords: Diagnostic Accuracy, FOUR score, Glasgow Coma Scale, intensive care unit, Traumatic Brain Injury

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INTRODUCTION

Traumatic brain injury is one of the leading causes of mortality and morbidity in road traffic accidents (RTAs). In Pakistan, one-third of patients of RTAs suffer from traumatic brain injury (TBI), out of which 10% fall into the major or severe category.¹ Evaluation of consciousness is a part and parcel of the primary survey in trauma patients. Various scoring systems have been devised to date for this purpose. A scoring model with high sensitivity, specificity, and accuracy is required to define the outcome and prognosis of the patient and alter the management strategies if needed.²

For years, the Glasgow Coma Scale (GCS) has been used for the assessment of the severity of traumatic brain injury in emergency departments (ED). In 1974, Teasdale and Jennett introduced this highly effective tool to standardize

the assessment of a patient's level of consciousness. It is not only convenient and precise but also delivers an accurate evaluation of the patient's consciousness level, making it an indispensable part of clinical practice. Additionally, the score obtained has an excellent correlation with the patient's outcome, indicating its high reliability among observers.³ Despite having several advantages, GCS has some significant drawbacks that cannot be overlooked. One of the most concerning downsides is its low efficiency in intubated patients. Patients with altered sensorium who require assisted ventilation are not well represented in the scoring system, which can significantly impact its efficacy. Additionally, the scoring system is prone to errors in the motor component of GCS where the withdrawal response may be mistaken for a flexor response, leading to incorrect scores. Finally, the scoring system neglects brainstem reflexes,

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which have been found to be closely related to mortality in several studies. These drawbacks must be taken into account to ensure accurate and effective scoring.⁴

Given these shortcomings, Wijdicks et al. introduced the FOUR (Full Outline of UnResponsiveness) score in 2005. Apart from addressing the shortcomings discussed above, the new score also includes the assessment of the breathing pattern. The need for assisted ventilation correlates with the severity of the disease and hence with the outcome.^{5,6} Moreover, the FOUR score can help identify a locked-in state (also known as pseudo-coma) and a persistent vegetative state where the patient's eyes are open, but they cannot track the examiner's finger. The motor response components of the FOUR score have been modified. Generalized myoclonus status is given a score of "zero," and withdrawal from pain is grouped into decorticate response (flexion response), as it can be difficult to differentiate between the two. The component "obeying commands" has been replaced by a more specific response: "thumbs up," "fist," or "peace sign." These modifications have the added advantage of testing the patient's alertness. These changes are believed to enhance the effectiveness of this score in reliably predicting outcomes.^{7,8} Since the introduction of the FOUR score, there have been several studies comparing it with the GCS. Most of them concluded that the FOUR score is better than the GCS score in predicting mortality and morbidity. Oshaka et al. conducted a study in 2014 for predicting mortality and ICU length of stay of TBI patients using the FOUR score and found it to be superior than GCS in predicting mortality but similar results for functional outcomes.⁹ A systematic review of these studies by Almojuela et al. in 2019 concluded FOUR of having good inter-observer reliability, prognostication for mortality and functional outcomes.¹⁰

The majority of studies on traumatic brain injury (TBI) patients focus on predicting mortality or functional outcomes, but there is little evidence on using the FOUR score to predict the need for intensive care in such patients. Our study intends to evaluate the validity of using the FOUR score to predict the requirement for intensive care based on the severity of the disease. Such prediction models are most useful in emergency departments because they can reduce the length of stay and enable earlier decision-making regarding patient disposition, resulting in more efficient use of resources in developing countries. For GCS, a score of less than 8 is recommended for shifting to ICU, but no such validated criteria is available for the FOUR score; hence, it requires further study to maximize its utilization to its full potential. The objective of this study is to determine the validity of FOUR score in the prediction of intensive care need in traumatic brain injury patients in the Emergency Department.

MATERIALS AND METHODS

This descriptive cross-sectional study was conducted in the Emergency Department of Mayo Hospital Lahore from 15 December 2025 to 15 April 2026 after approval of the synopsis from CPSP. The sample size of 151 patients was

calculated using a 95% confidence level, considering an expected sensitivity of 90%(7) with and 10% absolute precision and specificity of 75%(7) and 8% absolute precision of the FOUR score in predicting ICU admission, along with an estimated prevalence of ICU admission among traumatic brain injury patients of approximately 30% based on previous study.¹¹ Patients were selected using a non-probability consecutive sampling technique. All patients presenting with new onset traumatic brain injury to the Emergency Department, irrespective of severity, aged 12 years and above and of either gender were included in the study. Patients with a past history of brain injury, those requiring ICU admission for conditions other than traumatic brain injury, patients with concomitant abdominal trauma requiring surgical intervention, and those with hemodynamic instability were excluded from the study.

Demographic details including age and gender were recorded. Written informed consent was obtained from all patients, and confidentiality of data was ensured. The FOUR score was assessed at the time of presentation in the Emergency Department. A cutoff value of ≤ 10 was considered predictive of severe neurological impairment and need for ICU admission. All patients were followed during their Emergency Department stay and up to 24 hours to determine their final disposition to ICU or ward admission.

The FOUR (Full Outline of UnResponsiveness) score is a neurological assessment tool used to evaluate the level of consciousness in patients with traumatic brain injury, comprising four components: eye response, motor response, brainstem reflexes, and respiratory pattern, each scored from 0 to 4. The total score ranges from 0 to 16, with lower scores indicating deeper levels of impaired consciousness. It incorporates assessment of brainstem reflexes and breathing patterns, making it more comprehensive than GCS, particularly in intubated patients. Traumatic brain injury (TBI) is defined as a non-degenerative, non-congenital insult to the brain caused by external mechanical force, resulting in temporary or permanent impairment of neurological functions and altered consciousness. Severity of TBI is classified using the Glasgow Coma Scale (GCS) as mild (13–15), moderate (8–12), and severe (≤ 8), along with duration of loss of consciousness. The FOUR score is used to assess neurological status, with lower scores indicating more severe brain injury; a cutoff value (e.g., ≤ 10) is used to predict the need for ICU admission. Outcome measures were defined as true positive (FOUR score ≤ 10 with ICU requirement), false negative (FOUR score > 10 but requiring ICU), false positive (FOUR score ≤ 10 without ICU requirement), and true negative (FOUR score > 10 without ICU requirement).

All the collected data were entered and analyzed using SPSS version 24. Qualitative variables such as gender, need for interventions, and ICU admission were presented as frequencies and percentages. Quantitative variables including age, FOUR score, and Glasgow Coma Scale (GCS) score were presented as mean $\pm$ standard deviation.

The predictive accuracy of the FOUR score was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy using a 2×2 contingency table.

RESULTS

The mean age of the study participants was 38.58 ± 17.64 years, with the majority of patients belonging to the 12–30 years age group (38.4%), followed by 31–50 years (32.5%) and >50 years (29.1%). Males constituted a higher proportion of the sample (67.5%) compared to females (32.5%). The most common mode of injury was road traffic accidents (60.9%), followed by falls (24.5%), assault (9.9%), and other causes (4.6%). A majority of patients (72.2%) had a history of loss of consciousness, while 27.8% did not report loss of consciousness, as given in Table 1.

Table 1: Demographic and Clinical Characteristics of Study Participants (n = 151)

Variables	Category	n (%)
Age (years)	Mean $\pm$ SD	38.58 ± 17.64
	12–30	58 (38.4)
	31–50	49 (32.5)
	>50	44 (29.1)
Gender	Male	102 (67.5)
	Female	49 (32.5)
Mode of Injury	Road Traffic Accident	92 (60.9)
	Fall	37 (24.5)
	Assault	15 (9.9)
	Other	7 (4.6)
Loss of Consciousness	Yes	109 (72.2)
	No	42 (27.8)

The mean FOUR score of the patients was 9.25 ± 3.97 , while the mean Glasgow Coma Scale (GCS) score was 10.32 ± 2.91 . Based on the predefined cutoff, 57.6% of patients had a FOUR score ≤ 10 (predicted to require ICU admission), whereas 42.4% had a score > 10 . Regarding outcomes, 53.6% of patients were admitted to the ICU, while 46.4% were managed in the ward, as given in Table 2

Table 2: Distribution of FOUR Score, GCS, Categories and Patient Outcomes (n = 151)

Variables	Category	n (%) / Mean $\pm$ SD
FOUR Score	Mean $\pm$ SD	9.25 ± 3.97
GCS Score	Mean $\pm$ SD	10.32 ± 2.91
FOUR Score	≤ 10 (Predicted ICU)	87 (57.6)

Category	>10 (Not Predicted ICU)	64 (42.4)
Outcome	ICU Admission	81 (53.6)
	Ward Admission	70 (46.4)

Among patients with a FOUR score ≤ 10 , 72 (47.7%) were true positives (correctly predicted ICU admissions) while 15 (9.9%) were false positives. In contrast, among those with a FOUR score > 10 , 9 (6.0%) were false negatives and 55 (36.4%) were true negatives. Overall, 81 (53.6%) patients required ICU admission and 70 (46.4%) were managed in the ward, as given in Table 3.

Table 3: Diagnostic Accuracy of FOUR Score (2×2 Contingency Table) (n = 151)

FOUR Score	ICU Admission (Yes)	ICU Admission (No)	Total n (%)
≤ 10	72 (47.7) _{TP}	15 (9.9) _{FP}	87 (57.6)
> 10	9 (6.0) _{FN}	55 (36.4) _{TN}	64 (42.4)
Total	81 (53.6)	70 (46.4)	151 (100)

TP = true positive; FP = false positive; FN = false negative; TN = true negative; ICU = intensive care unit

The FOUR score demonstrated a sensitivity of 88.9% and a specificity of 78.6% in predicting ICU admission. The positive predictive value (PPV) was 82.8%, while the negative predictive value (NPV) was 85.9%. The overall diagnostic accuracy of the FOUR score was 84.1%, as given in Table 4.

Table 4: Diagnostic Accuracy Measures of FOUR Score

Parameter	Value (%)
Sensitivity	88.9
Specificity	78.6
Positive Predictive Value (PPV)	82.8
Negative Predictive Value (NPV)	85.9
Overall Accuracy	84.1

DISCUSSION

Early and accurate assessment of neurological status is crucial for predicting patient outcomes and guiding management decisions. The FOUR score was developed to overcome these limitations by incorporating brainstem reflexes and respiratory patterns. It provides a more comprehensive neurological assessment and may improve prognostication.¹¹ Therefore, evaluating the diagnostic accuracy of the FOUR score in predicting ICU admission is essential for optimizing emergency care.

The present study evaluated the diagnostic accuracy of the FOUR score in predicting ICU admission among patients with traumatic brain injury and demonstrated a sensitivity of 88.9%, specificity of 78.6%, positive predictive value (PPV) of 82.8%, negative predictive value (NPV) of 85.9%, and overall accuracy of 84.1%, indicating good discriminatory ability. These findings are in strong agreement with previously published literature, supporting the utility of the FOUR score as a reliable clinical tool in emergency settings.

In comparison, Pashaei et al. (2023) reported exceptionally high diagnostic performance of the FOUR score with an AUC of 0.991, sensitivity of 98.8%, and specificity of 88.9%, which are higher than those observed in our study. This difference may be attributed to variations in study outcomes, as Pashaei et al. evaluated mortality rather than ICU admission, as well as the use of a lower cutoff value (≤ 6 vs ≤ 10), which tends to increase sensitivity.¹² Similarly, Omar et al. (2024) reported a sensitivity of 94.0% and specificity of 70.6%, showing a pattern comparable to our findings, particularly with slightly higher sensitivity but somewhat lower specificity.¹⁵ Ahmed et al. (2025) evaluated the predictive accuracy of the FOUR score for extubation outcomes and reported an AUC of 0.63, with a high PPV of 94.7% but very low NPV of 12.8%. In contrast to our findings (PPV 82.8%, NPV 85.9%, accuracy 84.1%), their study had demonstrated lower overall discriminative ability, possibly due to differences in outcome measures (extubation success vs ICU admission) and patient population.¹⁶ On the other hand, Ansari et al. (2021) reported comparatively lower diagnostic values, with sensitivity of 65.6%, specificity of 71.5%, and overall accuracy of 75%, yet still demonstrated better performance of the FOUR score compared to GCS.¹³ Likewise, Zaidi et al. (2025) reported sensitivity of 67.33%, specificity of 88.79%, PPV of 73.91%, NPV of 85.2%, and accuracy of 81.9%, which are broadly consistent with our findings, particularly in terms of specificity and NPV. The relatively lower sensitivity in their study may be due to differences in pediatric population and outcome measures.¹⁴

Furthermore, Jain et al. (2025) demonstrated sensitivity of 79.4% and specificity of 77.5% at a cutoff value of ≤ 12 , which closely aligns with our results, reinforcing the robustness of the FOUR score across different thresholds.¹⁸ Additionally, Jasmin et al. reported sensitivity of 87.5% and specificity of 80.7%, values that are nearly identical to those observed in our study, further validating the consistency of the FOUR score in predicting clinical outcomes.²¹

Studies evaluating discriminative ability using ROC analysis also support our findings. Abbas et al. (2025) reported an AUROC of 0.851 for the FOUR score,¹⁷ while Hosseini et al. (2016) reported AUC values of 0.92 for early mortality and 0.89 for delayed mortality, indicating strong predictive performance. These findings are comparable to our observed accuracy of 84.1%, suggesting that the FOUR score maintains good prognostic value across different clinical endpoints.¹⁹ Interestingly, Keerthi

et al. (2023) reported a very high sensitivity of 96.2% but extremely low specificity of 6.7% at a higher cutoff value, highlighting the significant impact of cutoff selection on diagnostic performance.²⁰

Study Limitations

This study was conducted at a single center, which may limit the generalizability of the findings. The sample size, although adequate, may still be insufficient for subgroup analyses.

CONCLUSION

The FOUR score demonstrated good diagnostic accuracy in predicting ICU admission among patients with traumatic brain injury. It serves as a reliable and practical alternative to conventional assessment tools in emergency settings. Its use may facilitate early decision-making and improve patient management outcomes.

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