

Comparative study of the diagnostic power of full outline of unresponsiveness score and Glasgow coma scale in patients with traumatic brain injury in an emergency department



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ABSTRACT

Background: The Glasgow coma scale (GCS) is the most commonly used scale, and the full outline of unresponsiveness (FOUR) score is new validated coma scale as an alternative to GCS to measure the level of consciousness and evaluate the severity of the injury in traumatic brain injury (TBI) patients. **Aims and Objectives:** The present study compared the performance of FOUR scores and GCS in outcome predictions of TBI cases. **Materials and Methods:** This prospective and cross-sectional study was conducted over a year by the Emergency Department of a tertiary care hospital, Kovai Medical Center and Hospital, Coimbatore, India. Of 159, 123 patients were recruited from intensive care unit (ICU), and 36 from the ward were included in this study. Data were collected using an observation checklist to determine the similarities and differences in predicting outcomes using the two assessment scales (GCS and FOUR). **Results:** Most patients were 51–60 years (38%), with a mean age of 41.57. About 82% were male, 18% were female, and 31% had comorbidity of hypertension. Data analysis showed a significant statistical difference in mean FOUR and GCS scores between ICU and ward admission. A multivariate logistic regression study revealed that the probability of ICU admission in trauma patients from the emergency department was associated with a decline in GCS and FOUR scores. The range of predicted ICU admission was similar in both GCS and FOUR score models. **Conclusion:** Although both scores are good predictors of TBI patients, we concluded that the FOUR score is a recommended predictive model for patients admitted to the medical ICU.

Key words: Traumatic brain injury; Glasgow coma scale; FOUR score

INTRODUCTION

Traumatic brain injury (TBI) is a significant source of morbidity and mortality in the adult population. In general, TBI can range from mild to severe. Patients with severe injuries are hospitalized in an emergency intensive care unit (ICU).¹ In recent years, the frequency of injuries has considerably grown in all developing countries. According to the World Health Organization's most recent reports, injuries are globally ranked as the 10th leading cause of death.² Appropriate tools will be used to measure the level of consciousness and evaluate the severity of the injury in

head trauma patients to lessen the disability and mortality of trauma patients. With the aid of these tools, healthcare practitioners will be better able to plan for and carry out vital injury-related measures quickly and effectively, hence lowering mortality.³

Many scoring models have been proposed to evaluate the level of consciousness in patients affected by traumatic brain injuries, the most famous of which is the Glasgow coma scale (GCS). GCS can predict the primary outcome of TBI (mortality and morbidity) and help healthcare professionals devise a model for care delivery.⁴ The GCS is a

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tool that determines the level of consciousness of patients in three identified classes of responsiveness; eye response, motor activity, and verbal response. The examiner has to assess each of these three responses independently of each other and then give a score. The sum of the scores from each component response is the GCS score. The GCS has remained the most objective way to measure the mental status of the patients.⁵ Independently, the component was summed from best eye response, which has scores of four to one. Best verbal response scores of 5–1 and motor response scores of 6–1.⁶

Even though GCS is the most widely used tool, it falls into the second category, coz it does not allow for cranial nerve examination or help to determine if the patient is “locked in” (aware but unable to respond except by blinking or tracking). Furthermore, it can give a misleading picture of the cognitive status of an intubated patient.⁷ Researchers have developed another scale to avoid these shortcomings, that is, the full outline of unresponsiveness (FOUR) score for measuring consciousness in TBI patients. This score consists of four components: Eye responses, motor responses, brainstem reflexes, and respiration patterns. This scale is more reliable in determining the patient’s neurological status. It is a 16-point scale, with scores ranging from 0 to 16.⁸ The FOUR scores have shown to be a more reliable tool in the assessment of ICU patients because it assesses the brain stem reflexes and takes into account the inability to assess the verbal component of these clients, unlike the GCS.⁹ Therefore, in this study, we have compared the performance of FOUR scores and GCS in outcome predictions of TBI cases in emergency ICU and also studied the reliability of the FOUR scales and its ability in predicting outcomes of critically ill patients in ICU.

Aims and objectives

To compare the performance of GCS with FOUR score in predicting patient outcomes in Emergency dept. KMCH Hospitals.

1. To determine the survival rate and mortality rate of critically ill patients in Emergency dept. KMCH Hospitals.
2. To determine the reliability of the GCS and FOUR scales in the prediction of patient outcomes in Emergency dept. KMCH Hospitals.

MATERIALS AND METHODS

This prospective and cross-sectional study was conducted in the Emergency Department of a tertiary care hospital, Kovai Medical Center and Hospital, Coimbatore, Tamil

Nadu, for 1 year. This study included 159 patients with TBI in the emergency department of KMCH Hospital. Of 159, 123 patients were recruited from ICU, and 36 from the ward were included in the study.

Inclusion criteria

Inclusion criteria were as follows: Patients above 18–60 in the Emergency Department with isolated TBI were included and informed patients’ kin duly signed consent.

Exclusion criteria

Exclusion criteria were as follows: Patients with spinal cord injury with paralysis of the limbs were excluded because it interfered with assessing the motor system appropriately. Patients heavily sedated or receiving neuromuscular blockers were also left out from this study as the drugs taken by them will affect their response to stimuli and decrease the GCS and FOUR scores.

Written approval from the Institutional Ethics Committee was obtained beforehand. The aim of the study and data collection process was explained to the patient’s kin. The patient’s family member duly signed informed consent, and data were collected using the observation checklist. After obtaining informed consent from the patient’s kin, all cases were included in the study.

Data were collected using an observation checklist to determine the similarities and differences in predicting outcomes using the two assessment scales. The observation checklist was organized into three sections: The first section includes demographic characteristics (including gender and age) of patients. The second section is about the GCS score, used to evaluate the level of consciousness of the participant and also considered the most objective way to measure the mental status of the patients. The GCS comprises three categories: Eye-opening, verbal response, and motor response. Independently, the component is summed from the best eye response, which scores between 4 and 1. The best verbal response scores are between 5 and 1, and the best motor response is between 6 and 1. The score is determined by the sum of the scores in each of the three categories, with a maximum score of 15 and a minimum score of 3 (Table 1). The third section had the FOUR score tool with four parts, a column of FOUR scores on admission and the day of evaluation of outcomes during hospital discharge. The FOUR score covers eye and motor responses, brainstem reflexes, and respiration patterns. Each category is given 0–4 points, 0 being the worst and 4 being the best. The FOUR score ranges from 0 to 16, depending on the patient’s condition (Table 1). The lower scores denote an increasing deviation from normal for both the FOUR scores and GCS.

Table 1: Grading of GCS and FOUR scale

FOUR score	GCS
Eye response 4=Eyelids open or opened, tracking, or blinking to command 3=Eyelids open but not tracking 2=Eyelids closed but open to a loud voice 1=Eyelids closed but open to pain 0=Eyelids remain closed with pain	Eye-opening 4=Spontaneous 3=To speech 2=To pain 1=None
Motor response 4=Thumbs-up, fist, or peace sign 3=Localizing to pain 2=Flexion response to pain 1=Extension response to pain 0=No response to pain or generalized myoclonus status	Best motor response 6=Obeying commands 5=Localizing to pain 4=Withdrawal from pain 3=Abnormal flexion response to pain 2=Extension response to pain 1=None
Brainstem reflexes 4=Pupil and corneal reflexes present 3=One pupil wide and fixed 2=Pupil or corneal reflexes absent 1=Pupil and corneal reflexes absent 0=Absent pupil, corneal, and cough reflex	Verbal response 5=Orientated 4=Confused 3=Inappropriate words 2=Incomprehensible sounds 1=None
Respiration 4=Not intubated, regular breathing pattern 3=Not intubated, Cheyne-Stokes breathing pattern 2=Not intubated, irregular breathing 1=Breathes above the ventilator rate 0=Breathes at ventilator rate or apnea	

GCS: Glasgow coma scale, FOUR: Full outline of unresponsiveness

Statistical analysis

Data collected were analyzed using statistics is a statistical software suite version 24. Categorical data were analyzed using percentages, while continuous data were analyzed using standard deviation and mean. A Chi-square test for association was conducted to evaluate patients' demographic characteristics and determine the association between the predicted GCS and FOUR scores with the patient's actual outcome at the evaluation's end. The performance of the GCS and FOUR scores in predicting patient outcomes was analyzed using binary logistic regression. Survival analysis was performed using the Kaplan–Meier method. Sensitivity analysis was used to determine the reliability of GCS and FOUR scales in predicting actual outcomes. The receiver operating characteristic (ROC) curves were computed to assess the accuracy of the GCS and FOUR scales based on the area under the curve analysis. Calculation of cutoff points was calculated, and the determination of overall accuracy of prediction of results, sensitivity, and specificity was identified.

RESULTS

Most patients were 51–60 years (38%), with a mean age of 41.57 years, of which 82% were male, and 18% were female. Of the 159 patients, 77% of the cases were admitted to the ICU, and 23% only were admitted to the ward. Furthermore, 31% of the patients had comorbidity of hypertension, followed by 19% with diabetes mellitus

and 17% with hypothyroidism; however, 33% had no comorbidities (Table 2).

The average GCS score for the study group was 10.6. There was a statistical significance ($P=0.0001$) was observed when comparing the mean GCS score of ward patients (14.77) with that of ICU patients (8.72). Regarding the FOUR scores, the mean score value for the study was 11.22. The mean FOUR score for ICU patients was 9.97, while the mean FOUR score for ward patients was 15.77, substantially higher than for ICU patients (Table 3).

Based on the GCS score, patients recruited in this study were categorized into mild, moderate, and severe. Out of 159 cases, 48% of them were mild, whereas 11% and 41% were shown to be moderate and severe, respectively. Regarding the correlation of severity based on the GCS score between ICU and ward admission, all severe (65 cases) and moderate (18 cases) patients were admitted to ICU. In contrast, in 76 mild cases, 40 patients were admitted to the ICU, whereas 36 were admitted to the ward (Table 4).

Regarding the correlation between the GCS severity and the FOUR score in this study, it indicates that mild cases had a mean FOUR score of 15.39, moderate cases had a mean FOUR score of 11.17, and severe cases had a mean FOUR score of 6.35, which was considerably lower than the mild and moderate patients ($P<0.0001$) (Table 5).

The ROC curve was drawn to assess the predictive accuracy of two scores. Based on the area under ROC curve calculation, GCS showed a value of 0.95 with a 95% of Confidence interval (CI) mean range from 0.77 to 0.98, whereas for the FOUR scores, the values were calculated as 0.94 (95% CI: 0.90–0.97) (Table 6).

Comparison of area under the ROC curve of GCS and FOUR scores showed that this value was not different between the two systems on admission ($P < 0.0001$). The correlation between predicted ICU admission and the two scales (GCS and FOUR scores) were similar (Figure 1). A multivariate logistic regression study revealed that the probability of ICU admission in trauma patients from the emergency department was associated with a decline in GCS and FOUR scores. The range of predicted ICU admission was similar in both GCS and FOUR score models.

DISCUSSION

Predicting results in neurocritical care is always challenging due to the broad variability in the brain’s capacity for recovery following brain damage and the typical amount of time required before establishing the recovery limit.

Thus, in this study, we used two predictive models (FOUR scores and GCS) to evaluate the TBI patients in ICU and ward admission.

Comparable to our demographic characteristics (age and gender) results, a study by Ghelichkhani et al., reported among 90 trauma patients hospitalized in the ICU, the mean age of the study group was 39.4 years, and most of them were male gender (74.4%).¹⁰ Another similar study by Gorji et al., reported among 53 TBI patients, the age range was 16–60 years, and the mean age was 33.80 ± 12.60 years. Regarding gender, 20.8% of patients were females, and the remaining 79.2% were males seven. McNett et al., reported the mean age of the study sample was 53.1 (range 18–92, SD 21.40, median 52). Most patients were male (75%).^{11,12}

Nevertheless, Ghelichkhani et al., reported that the mean GCS and FOUR scores were lower in those with poor outcomes than in those who survived. The area under the ROC curve calculated for GCS on admission was 0.87 (95% CI: 0.77–0.98), and for FOUR score was 0.88 (95% CI: 0.77–0.99).¹⁰ Some studies reported that the FOUR score is superior to GCS in assessing changes in patient’s level of consciousness in the hospital wards.^{13,14}

Similar to our result, some studies have reported that statistical differences existed between the FOUR scores and GCS in evaluating the severity of head injuries.^{15,16} Thus, the two tools have similar predictive power and are useful in critically ill patients’ neurological assessment. However, most studies have shown a higher sensitivity of the FOUR scores. Nevertheless, all our results showed that the GCS and FOUR were admitted to the emergency department with TBI. We found that FOUR is an applicable tool for the high predictive power of outcomes in discharge time for patients with TBI than GCS.

However, the present study had some limitations, and the sample may not have covered enough severely injured patients. Only one investigator determined GCS and FOUR scores within 5 min of admission in the emergency department. A larger group of stuporous or comatose

Table 2: Demographic characteristics of patients

Variable	Frequency	Percentage
Age (years)		
<20	7	4
21–30	36	23
31–40	35	22
41–50	21	13
51–60	60	38
Gender		
Male	131	82.4
Female	28	17.6
Admission		
ICU	123	77
Ward	36	23
Comorbidities		
Diabetes mellitus	31	19
Hypertension	49	31
Hypothyroid	27	17
No comorbidity	52	33

ICU: Intensive care unit

Table 3: Distribution and comparison of two scores between ICU and ward admission patients

Score	Admission	Mean±SD	95% CI mean		F value	P-value
			Lower CI	Upper CI		
GCS	ICU (n=123)	8.72±4.39	7.93	9.51	23.594	<0.0001
	Ward (n=36)	14.77±0.43	14.63	14.92		
	Total (n=159)	10.06±4.65	9.33	10.78		
FOUR	ICU (n=123)	9.97±4.453	9.17	10.77	22.875	<0.0001
	Ward (n=36)	15.77±0.426	15.63	15.92		
	Total (n=159)	11.22±4.687	10.49	11.95		

GCS: Glasgow coma scale, FOUR: Full outline of unresponsiveness, ICU: Intensive care unit, CI: Confidence interval

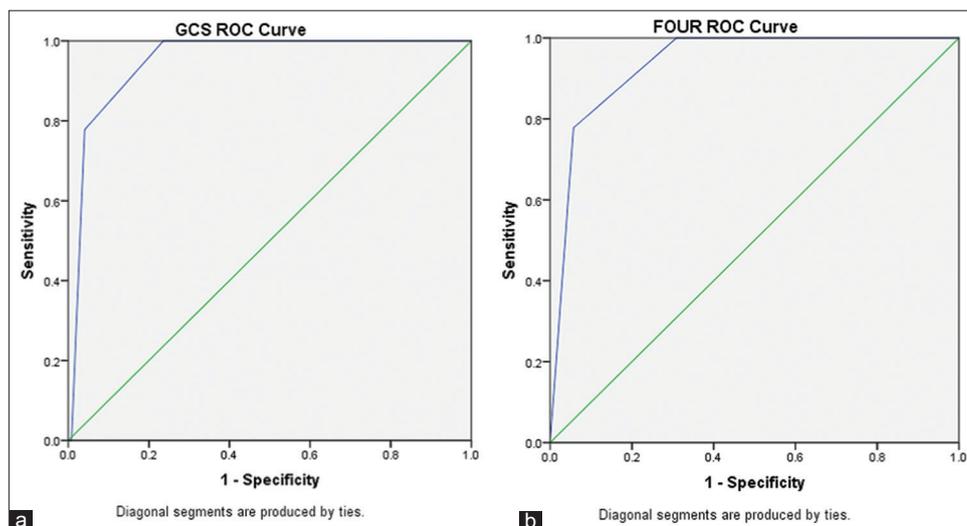


Figure 1: Area under the receiver operating characteristic curve of Glasgow coma scale (a) full outline of unresponsiveness scores and (b) for predicting the intensive care admission of trauma patients

Table 4: Correlation of severity with ward and intensive care unit patients

Severity	Admission				Total		χ^2 -value	P-value
	ICU		Ward		n	%		
	n	%	n	%				
GCS								
Severe	65	52.8	0	0	65	40.9	58.051	<0.0001
Moderate	18	14.6	0	0	18	11.3		
Mild	40	32.5	36	100	76	47.8		
Total	123	100	36	100	159	100		

GCS: Glasgow coma scale, ICU: Intensive care unit

Table 5: Correlation of GCS score severity with FOUR score

Correlation	FOUR	Mean±SD	95% CI mean		Min	Max	F-value	P-value
			Lower CI	Upper CI				
GCS severity	Severe (65)	6.35±2.75	5.67	7.04	0	13	367.683	<0.0001
	Moderate (18)	11.17±2.38	9.98	12.35	6	16		
	Mild (76)	15.39±6.0	15.26	15.53	14	16		
	Total (159)	11.22±4.69	10.49	11.95	0	16		

GCS: Glasgow coma scale, FOUR: Full outline of unresponsiveness, CI: Confidence interval, SD: Standard deviation

patients would be desirable to study. This was a single-center study, so the generalizability to other ICUs has not been proved yet.

Even though both scores are good predictors of TBI patients. We concluded that the FOUR score is a recommended predictive model for patients admitted to medical ICUs due to its higher accuracy than GCS. Since patients in the emergency department are on intubation and sedation, the FOUR score is important and reliable in assessing comatose patients.

Limitations of the study

There are some limitations in this study. The sample may not have covered enough severely injured patients. Only

one investigator determined GCS and FOUR scores within 5 min of admission in the emergency department. A larger group of stuporous or comatose patients would be desirable to study. This was a single-center study, so the generalizability to other ICUs has yet to be proved.

CONCLUSION

We conclude from the study that the FOUR scores have proved to be a more reliable tool in patient assessment in the emergency department. Most of the studies have revealed that both GCS and FOUR scores are significant in the prediction of outcomes in patients. However, the FOUR score is more reliable, superior, and convenient for

Table 6: Multiple logistic regression analysis for the values of GCS and FOUR scores for predicting ICU admission of trauma patients with a 95% CI

Variable	Area	SE	Asymptotic sig	Asymptotic 95% CI	
				Lower bound	Upper bound
GCS	0.95	0.017	<0.0001	0.92	0.98
FOUR	0.94	0.019	<0.0001	0.9	0.97

GCS: Glasgow coma scale, FOUR: Full outline of unresponsiveness, CI: Confidence interval

predicting a patient's severity in the emergency department. The FOUR scale is easy to apply with fewer requirements on assessing the nervous system in checking mental status and, most importantly, identifying some unconscious states. The new scoring system classifies coma and identifies relevant conditions in patients with altered consciousness levels, allowing additional distinction. Since patients in the emergency department are on intubation and sedation, the FOUR score is important and reliable to apply in assessing comatose patients. This shows that the GCS and FOUR scores are good predictors of patients admitted to the emergency department with TBI.

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