ORIGINAL ARTICLE

# Comparison of Glasgow Coma Scale Full Outline of UnResponsiveness and Glasgow Coma Scale: Pupils Score for Predicting Outcome in Patients with Traumatic Brain Injury

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## Abstract

**Background:** Glasgow coma scale (GCS) score is the most widely used clinical score for the initial assessment of neurologically injured patients and is also frequently used for prognostication. Other scores such as the Full Outline of UnResponsivness (FOUR) score and the Glasgow Coma Scale-Pupils (GCS-P) score have been more recently developed and are gaining popularity. This prospective cohort study was conducted to compare various scores in terms of their ability to predict outcomes at 3 months in patients with traumatic brain injury (TBI).

**Materials and methods:** The study was carried out between October 2020 and March 2022. Patients who presented to the hospital with TBI were assessed for inclusion. Initial coma scores were assessed in the emergency department and again after 48 hours of admission. Outcome was assessed using the extended Glasgow outcome score (GOSE) at 3 months after injury. The receiver operating curve (ROC) was plotted to correlate coma scores with the outcome, and the area under the curve (AUC) was compared.

**Results:** A total of 355 patients with TBI were assessed for eligibility, of which 204 patients were included in the study. The AUC values to predict poor outcomes for initial GCS, FOUR, and GCS-P scores were 0.75 each. The AUC values for 48-hour coma scores were 0.88, 0.87, and 0.88, respectively.

**Conclusion:** The GCS, FOUR, and GCS-P scores were found to be comparable in predicting the functional outcome at 3 months as assessed by GOSE. However, coma scores assessed at 48 hours were better predictors of poor outcomes at 3 months than coma scores recorded initially at the time of hospital admission.

**Keywords:** Extended Glasgow outcome score, Full outline of UnResponsiveness score, Glasgow coma scale – Pupils score, Glasgow coma score, Traumatic brain injury.

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## Highlights

- Glasgow coma scale (GCS), Full Outline of UnResponsivness (FOUR) score, and Glasgow Coma Scale-Pupils (GCS-P) scores are the scores used for the prediction of outcomes in patients with traumatic brain injury (TBI).
- All three when compared among themselves, were found to be comparable in predicting the functional outcome at 3 months as assessed by extended Glasgow outcome score (GOSE).
- Coma scores assessed at 48 hours were better predictors of poor outcomes at 3 months than coma scores recorded initially at the time of hospital admission.

## Introduction

Traumatic brain injury is a serious public health burden, as this patient population mostly belongs to young and economically productive age groups. The spectrum of TBI can range from relatively trivial injuries to very severe injuries. Initial clinical assessment and proper documentation are of paramount importance. Several clinical scales and scoring systems have been developed to predict the outcome of these patients. The most widely used among these scales is the GCS developed by Teasdale and Jennett in 1974. Also, GCS is based on an assessment of eye opening (E) score of 1–4, verbal response (V) score of 1–5, and best motor response (M) score of 1–6. Though originally meant to be used as a scale with specific mention of scores for each of the three components, it is also widely used as a numerical score of 3–15.[1] Furthermore, GCS has been the gold standard for clinical assessment of consciousness on which many other scales or scores are based.

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**Conflict of interest:** None

Over time, various shortcomings of GCS came to notice. First, in intubated and tracheostomized patients, it was not possible to test the verbal component of the GCS score. Second, abnormal brainstem reflexes and changing respiratory patterns are not reflected in the GCS score. Third, subtle changes in neurological status may not be detected by GCS score alone. This led to the development of newer scores that incorporate other parameters in addition to the standard eye, motor, and verbal response of GCS. Full Outline of UnResponsivness score which was developed by Wijdicks et al. in 2005 is based on an assessment of eye response, motor response, brainstem reflex, and respiration; all of which have scores of 0–4, making a total possible score range from 0 to 16.[2]

The GCS – pupils score, which was developed in 2018, consists of GCS score (possible score ranging between 3 and 15) minus pupil reactivity score (PRS) (0, no unreactive pupil; 1, one pupil unreactive; and 2, both pupils unreactive), making a total possible score of 1–15. The authors concluded that the addition of information about pupil reactivity increased the predictive power of prognostication.[3]

Prognostication after TBI helps guide the treatment plan, allocation of resources, discussion, and preparation of the families accordingly. No doubt, it is challenging and requires the application of complex probabilistic models. However, clinical scores offer significant information about outcome probability, both when used alone or as part of complex prognostication models.[4–6] Thus, we conducted this prospective cohort study to compare various coma scores in terms of their ability to predict outcomes at 3 months in patients with TBI. The primary objective of our study was to compare the predictive power of GCS, FOUR, and GCS-P scores in terms of functional outcome by means of the extended Glasgow outcome scale (GOSE) at 3 months after TBI. Secondary objectives were to compare the correlation of the above coma scores with length of intensive care unit (ICU) stay, length of hospital stay, and in-hospital mortality.

## Materials and Methods

The study protocol was approved by the institutional ethics committee (letter no: IECPG-270/22.07.2020) and was registered with the Central Trial Registry of India (registration No.: CTRI/2020/10/028433 dated 16 October 2020). This study was carried out between October 2020 and March 2022. We prospectively enrolled all patients of either gender, with TBI who presented to the hospital within 24 hours of injury. Written informed consent was taken from the relatives of patients. The exclusion criteria were as follows:

- Patients who presented after 24 hours of injury.
- Patients with eye injury or cataracts in whom assessment of pupillary response was not possible.
- Patients with cervical spine injury and moderate or severe extracranial injuries such as abdominal and thoracic trauma.
- History of any psychiatric illness or psychological problem, alcoholics, and drug addicts.
- Patients who were sedated precluding the examiner from obtaining scores.

Demographic data, details of injuries, treatment received in another hospital, and co-morbid conditions were noted. Patients were managed and resuscitated according to the standard advanced trauma life support (ATLS) protocol in the emergency department. The patient's GCS, FOUR, and GCS-P scores (Appendix) were assessed in the emergency department by the primary investigator soon after stabilization of vitals before administration of any sedative drug or tracheal intubation. Computerized tomography (CT) scan findings and details of surgical intervention if any, were also noted. After appropriate medical/surgical treatment, patients were shifted to the neurotrauma ICU for further management. The patients' coma scores were assessed again at 48 hours of admission. Surgical interventions, length of ICU, and hospital stay were noted. Complications observed during ICU stay were also noted. Central nervous system complications (intracranial infections, hydrocephalus, pneumocephalus, hematoma expansion, etc.), cardiovascular complications {hypotension [systolic blood pressure (SBP) < 90 mm Hg], hypertension [SBP > 160 mm Hg], arrhythmias, and bradycardia [heart rate (HR) <50 beats per minute]}, respiratory complications (pneumothorax, ventilator-associated pneumonia, COVID-19 pneumonia, and pulmonary edema), metabolic and electrolyte abnormalities (hyperglycemia and hypoglycemia, hyponatremia, hypernatremia, hypokalemia, and hyperkalemia) and infectious complications (surgical site infection and bedsores) observed during ICU stay were also noted. The patient's outcome was assessed by GOSE (Appendix) at discharge from the hospital and telephonically 3 months after injury by an investigator who was blinded to the patient's initial coma score. Functional outcomes as assessed by GOSE were dichotomized as good (5–8) and poor (1–4).

Due to the dearth of the literature comparing these three scores, we planned this cohort study. Since the sample size could not be calculated from other studies, we decided to conduct it as a cohort study over a period of 1 year. Data were entered in Microsoft Excel, coded appropriately, and analyzed using statistical package for the social sciences (SPSS) for Windows, version 16.0 (SPSS, IBM Inc., Chicago, Illinois, USA). Qualitative data were expressed using frequency and percentage while quantitative data were expressed by using mean ± standard deviation (SD). An Independent *t*-test was used to compare initial coma scores with coma scores at 48 hours postadmission. Spearman's correlation test was used to estimate the correlation between coma scores and with number of ICU and hospital days. The receiver operating curve (ROC) was plotted for all coma scores with in-hospital mortality and with 3 months GOSE, for comparison of area under the curve (AUC). The value of *p* less than 0.05 was considered statistically significant.

## Results

A total of 355 adult patients with TBI were assessed for eligibility on arrival at the emergency department (ED) over a period of 1 year, out of which 211 patients were enrolled. After discharge, seven patients were lost to follow up and 204 patients were assessed for outcome at 3 months (Fig. 1). The demographics of patients are given in Table 1. Various mechanisms of injury included 90 road traffic accidents, 16 pedestrians hit by moving vehicles, 38 cases of fall, 13 assaults, and 1 gunshot wound, and the rest 46 patients were found unconscious with unknown history. On admission, 58/204 (28.43%) patients had mild TBI (GCS score of 14–15), 48/204 (23.53%) patients had moderate TBI (GCS score of 9–13) and 98/204 (48.04%) patients had severe TBI (GCS score of 3–8). Out of 204 patients analyzed, 123 patients (60.29%) underwent craniotomy/craniectomy, and the rest 81 patients (39.71%) were managed conservatively. Of these 123 patients, 12 patients also underwent nonneurological surgeries such as external screw fixation of a long bone, open reduction and internal fixation (ORIF), fasciotomy, and wound debridement. Various ICU complications noted during ICU stay are tabulated (Table 1).

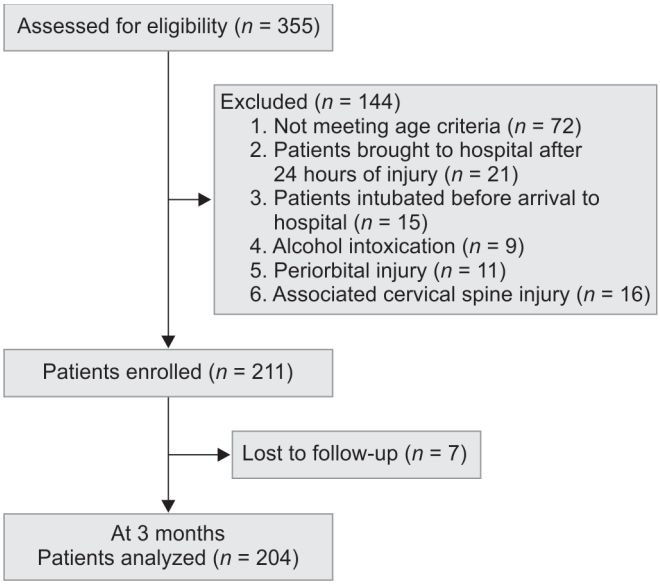


**Fig. 1:** Flow diagram for the study

Coma scores (GCS score, FOUR score, and GCS – pupils score) were assessed after initial resuscitation, and again at 48 hours after admission (Table 2). There was no statistically significant difference between the coma scores and components of coma scores noted initially and at 48 hours of admission, except for the verbal response component of the GCS score which was statistically significant ($p < 0.001$).

The correlation of coma scores with duration of ICU and hospital stay is shown in Table 3. All the scores had an inverse correlation with the duration of ICU and hospital 48-hour stay, however, the 48 hours scores correlated better than the initial admission scores.

To compare the predictive ability of coma scores for in-hospital mortality, ROC for initial and 48-hour coma scores were plotted and the area under the ROC curve (AUROC) was calculated (Fig. 2). The AUROC value for initial admission GCS, FOUR, and GCS-P scores for in-hospital mortality are 0.65 [confidence interval (CI): 0.56–0.74], 0.66 (CI: 0.58–0.75), and 0.65 (CI: 0.56–0.74), respectively. The AUROC value for 48 hours GCS, FOUR, and GCS-P scores for in-hospital mortality are 0.80 (CI): 0.74–0.87, 0.81 (CI: 0.74–0.88), and 0.80 (CI: 0.74–0.87), respectively. The AUROC values to correlate coma scores with poor outcomes at 3 months are shown in (Fig. 3). The ROC analysis was also done to calculate the cut-off value to best predict poor outcomes for the coma scores; eight was the best cut-off value for the GCS score with a sensitivity of 77.8% and a specificity of 82.1%; 8 was also the best cut-off value for GCS – pupils score with a sensitivity of 76.9% and a specificity of 81.4%; and 9 was best cut-off value for FOUR score with sensitivity of 73.6%, and specificity of 81.4%.

Various covariates were assessed for their impact on in-hospital mortality and poor outcome (GOSE, 1–4) at 3 months (Table 4). The mean age of patients who had poor outcomes at 3 months was 31.92 ± 10.29 years. About 15.22% of patients with mild injury, 19.56% of patients with moderate injury, and 65.22% of patients with severe TBI died in hospital. Similarly, 12.09% of patients with mild injury, 15.38% with moderate injury, and 72.53% with severe head injury had poor outcomes at 3 months, respectively.

**Table 1:** Demography and clinical characteristics of the patients

| *Parameters* | *n (%)* |
|---|---|
| Age in years (mean ± SD) | 34 ± 11.67 |
| Gender | |
| Male | 167 (81.86%) |
| Female | 37 (18.14%) |
| Comorbid conditions | |
| Hypertension | 2 (0.98%) |
| Diabetes | 1 (0.49%) |
| Asthma | 1 (0.49%) |
| Liver disease | 2 (0.98%) |
| Severity | |
| Mild (GCS 14–15) | 58 (28.43%) |
| Moderate (GCS 9–13) | 48 (23.53%) |
| Severe (GCS 3–8) | 98 (48.04%) |
| CT scan findings | |
| Extradural lesion | 36 (17.65%) |
| Subdural lesion | 81 (39.71%) |
| Parenchymal laceration or contusion | 108 (52.94%) |
| Blood in subarachnoid and intraventricular spaces | 52 (25.49%) |
| Skull vault fractures | 60 (29.41%) |
| Rotterdam CT grade | |
| Grade I | 26 (12.75%) |
| Grade II | 58 (28.43%) |
| Grade III | 95 (46.57%) |
| Grade IV | 19 (9.31%) |
| Grade V | 5 (2.45%) |
| Grade VI | 1 (0.49%) |
| Treatment | |
| Operated | 123 (60.29%) |
| Conservatively managed | 81 (39.71%) |
| Complications | |
| CNS | 42 (20.59%) |
| CVS | 13 (6.37%) |
| Respiratory | 38 (18.63%) |
| Metabolic and electrolyte abnormalities | 13 (6.37%) |
| Infectious complications and others | 56 (27.45%) |
| Tracheostomized | 74 (36.27%) |
| Duration of ICU stay in days (Mean ± SD) | 9.6 ± 7.10 |
| Duration of hospital stay in days (Mean ± SD) | 19.1 ± 17 |
| Mortality | |
| In-hospital mortality | 46 (22.55%) |
| Mortality after discharge | 4 (1.96%) |
| GOSE at discharge | |
| Good outcome (5–8) | 61 (29.90%) |
| Poor outcome (1–4) | 143 (70.10%) |
| GOSE at 3 months | |
| Good outcome (5–8) | 113 (55.39%) |
| Poor outcome (1–4) | 91 (44.61%) |

CNS, central nervous system; CT scan, computerized tomography scan; CVS; cardiovascular system; GCS; Glasgow coma scale; GOSE, Extended Glasgow outcome score; Rotterdam CT grade, Rotterdam computerized tomography grade

**Table 2:** Coma scores on arrival to hospital and after 48 hours of arrival (Mean ± SD)

| *Coma scores* | *Admission score* | *48 hours score* | *p-value* |
|---|---|---|---|
| Total GCS score | 9.37 ± 4.25 | 9.20 ± 4.16 | 0.69 |
| GCS subscores Eye response (E) | 2.28 ± 1.28 | 2.39 ± 1.40 | 0.43 |
| Verbal response (V) | 2.70 ± 1.63 | 2.12 ± 1.77 | <0.001* |
| Motor response (M) | 4.37 ± 1.66 | 4.66 ± 1.57 | 0.08 |
| Total FOUR score | 10.89 ± 4.07 | 10.26 ± 4.53 | 0.14 |
| FOUR subscores Eye response (E) | 1.58 ± 1.69 | 1.80 ± 1.84 | 0.21 |
| Motor response (M) | 2.67 ± 1.27 | 2.90 ± 1.20 | 0.06 |
| Brainstem reflex (B) | 3.60 ± 0.87 | 3.64 ± 0.96 | 0.69 |
| Respiration (R) | 3.05 ± 0.97 | 1.91 ± 1.42 | 1.55 |
| GCS – P score[#] | 9.11 ± 4.57 | 8.96 ± 4.40 | 0.74 |
| PRS | 0.26 ± 0.58 | 0.23 ± 0.60 | 0.58 |

*$p < 0.05$. [#]GCS – P score = GCS score total – PRS. GCS, Glasgow coma scale; FOUR score, Full Outline of UnResponsivness score; GCS – P score, Glasgow coma scale – pupils score; PRS, pupil reactivity score

**Table 3:** Bivariate correlation of coma scores to ICU and hospital stay

| | *Days in ICU* | | *Days in hospital* | |
|---|---|---|---|---|
| *Coma scores* | *Spearman's coefficient (ρ)* | *p-value* | *Spearman's coefficient (ρ)* | *p-value* |
| Admission GCS score | –0.41** | <0.001 | –0.26** | <0.001 |
| Admission FOUR score | –0.40** | <0.001 | –0.25** | <0.001 |
| Admission GCS-P score | –0.41** | <0.001 | –0.26** | <0.001 |
| 48-hour GCS score | –0.52** | <0.001 | –0.31** | <0.001 |
| 48-hour FOUR score | –0.50** | <0.001 | –0.29** | <0.001 |
| 48-hour GCS-P score | –0.50** | <0.001 | –0.30** | <0.001 |

**Significance at 99% confidence. FOUR score, Full Outline of UnResponsivness score; GCS score, Glasgow coma scale score; GCS-P, Glasgow coma scale – Pupils; ICU, intensive care unit

Higher Rotterdam CT scores (3 or more) had higher odds of having poor outcomes, which was found to be significant. The odds of poor outcome at 3 months were highest for the development of complications [14.54 (CI: 6.50–32.52); $p < 0.001$].

## Discussion

In our study, GCS, FOUR, and GCS-P scores were found to be comparable for predicting in-hospital mortality and functional outcomes at 3 months.

We observed that coma scores noted initially on admission were higher than the ones recorded 48 hours later, although the difference was not statistically significant. McNett et al. observed no significant difference between the FOUR score and the GCS score recorded at the initial 24 hours and 72 hours.[5,6] In our study, 146 patients (71.57%) belonged to the moderate–severe head injury group, possibly requiring airway intervention between 24–72 hrs. Thus, we found the verbal response component of the GCS score to be statistically lower at 48 hours which could be due to tracheal intubation performed in these patients. However, this lower verbal response at 48 hours, did not amount to any statistically significant difference when the total GCS score was taken into consideration.

### In-hospital Mortality

Coma scores assessed at 48 hours were all comparable and were excellent predictors of mortality (AUROC, 0.8–0.9). Coma scores noted on admission were also comparable and were good predictors of mortality (AUROC, 0.6–0.7). We did not find GCS-P superior to GCS in predicting mortality, contrary to Brennan et al.[3] who found the addition of two lower points in GCS-P (GCS-P scores 1 and 2) extended the information about the severity of the injury from a mortality of 51% at GCS score three to mortality rate of 74% at GCS-P score one. This could be due to differences in their study design, as it was a retrospective analysis. Khanal et al. carried out a prospective study in 97 mixed neurological and neurosurgical ICU patients and concluded that the FOUR score is superior in predicting mortality.[7] This difference could be because they recruited mixed ICU patients while we included only adult patients with TBI in our study. Another similar prospective study including 104 TBI patients found the FOUR score to be a better predictor of mortality compared to the GCS score. This is also not in accordance with the

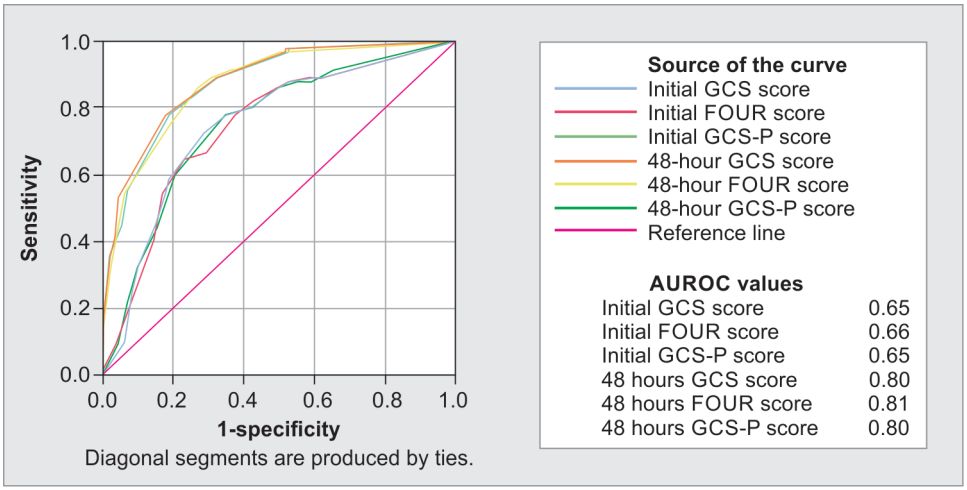


**Fig. 2:** Receiver operating curve to predict hospital mortality

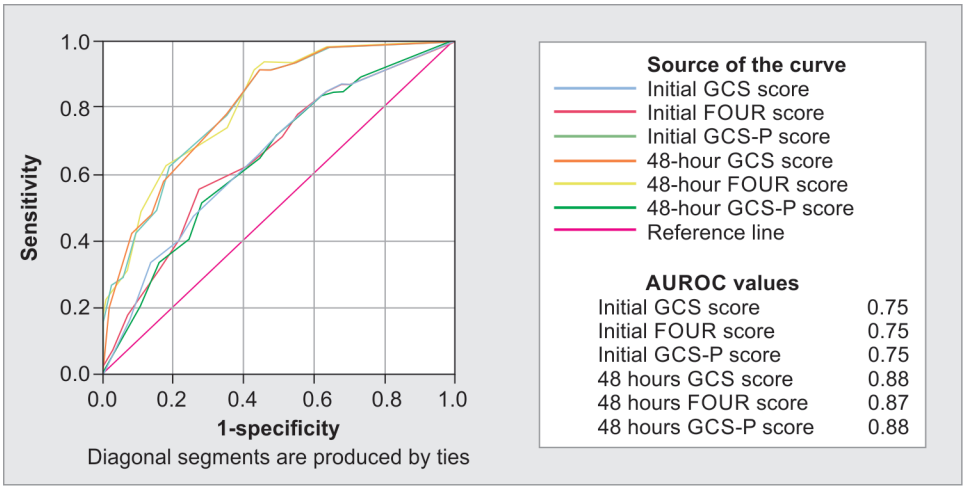


**Fig. 3:** Receiver operating curve to predict outcome (good or poor) at 3 months

**Table 4:** Multivariate analysis of covariates [mean ± SD; *n* (%)]

| *Covariates* | *In-hospital mortality (n = 46) n (%)* | *Odds ratio (95% CI)* | *p-value* | *3 months poor outcome (n = 91) n (%)* | *Odds ratio (95% CI)* | *p-value* |
|---|---|---|---|---|---|---|
| Age (mean ± SD) | 38.13 ± 13.80 | 1.03 (0.99–1.05) | 0.07 | 31.92 ± 10.29 | 0.99 (0.96–1.01) | <0.01 |
| Gender (male) | 38 (82.61%) | 3.38 (1.36–8.43) | 0.99 | 76 (83.52%) | 0.30 (0.13–0.78) | 0.43 |
| Severity of TBI | | | | | | |
| Mild | 7 (15.22%) | – | – | 11(12.09%) | – | – |
| Moderate | 9 (19.56%) | 2.29 (0.62–8.45) | 0.99 | 14 (15.38%) | 1.59 (0.20–1.73) | 0.84 |
| Severe | 30 (65.22%) | 2.35 (0.69–7.90) | 0.99 | 66 (72.53%) | 1.75 (0.61–4.76) | 0.05 |
| Rotterdam CT | | | | | | |
| Grade I | 1 (2.17%) | – | – | 4 (4.40%) | – | – |
| Grade II | 8 (17.39%) | 5.90 (1.47–23.61) | 0.46 | 17 (18.68%) | 0.35 (0.11–1.13) | 0.19 |
| Grade III | 29 (63.05%) | 1.65 (0.47–5.80) | 0.16 | 54 (59.34%) | 0.89 (0.28–2.83) | 0.02 |
| Grades IV–VI | 8 (17.39%) | 2.50 (0.54–11.59) | 0.24 | 16 (17.58%) | 0.85 (0.17–4.09) | 0.11 |
| Surgery (yes) | 27 (58.70%) | 0.83 (0.33–2.04) | 0.67 | 58 (63.74%) | 1.10 (0.45–2.65) | 0.84 |
| Complications (yes) | 46 (100%) | 20.64 (9.03–56.87) | 0.99 | 79 (86.81%) | 14.54 (6.50–32.52) | <0.001 |
| Tracheostomy (yes) | 21 (45.65%) | 2.42 (1.01–5.83) | 0.08 | 52 (57.14%) | 1.47 (0.64–3.30) | 0.32 |

GCS, Glasgow coma scale; Rotterdam CT, Rotterdam computerized tomography; TBI, traumatic brain injury

findings of our study, which is possibly due to less representation of severely injured patients in their study cohort.[8] When these scores were studied in critically ill patients, authors found the FOUR score to be a better prognostic tool for ICU mortality than the GCS score.[9] In another prospective observational study including 100 patients admitted to the critical care unit, authors found GCS and FOUR scores to be comparable in predicting mortality in both stroke and nonstroke cases.[10] Ghelichkhani et al.[11] also found GCS and FOUR scores to have the same value in predicting mortality in general trauma patients.

## Functional Outcome at 3 Months

All coma scores were found to be good predictors of poor outcome at 3 months after injury. Between the two time points, the coma scores recorded at 48 hours were better predictors of poor outcomes at 3 months than coma scores recorded initially at admission. This is contrary to the findings of the study including 138 adult TBI patients that found coma scores recorded at 24 hours of ICU admission predict GOSE at 6 months better than coma scores assessed at 72 hours post-ICU admission.[6] This can be explained based on their patient recruitment which was, after ICU admission while we recruited patients soon after the primary survey in the emergency department. In a recent comparative study of GCS and GCS-P, the predictive performance of both, for in-hospital mortality and functional outcome at discharge as well as at 6 months was found to be comparable.[12] In a meta-analysis including 2,083 patients with TBI, the value of GCS and FOUR scores in the prediction of mortality and unfavorable outcome was found to be comparable.[13] Both these recent studies are in agreement with our results.

Cut-off values to best predict the poor outcome at 3 months were: 8 for the GCS score and GCS-pupils score, and 9 for the FOUR score. The best cut-off value for FOUR and GCS scores has been estimated earlier in a few studies for mortality prediction.

The cut-off calculated was 6.5 for both GCS and FOUR scores in a study by Khanal et al.[7] while Wijdicks et al.[2] found cut-off value to be 7 for GCS and 9 for FOUR. The estimated cut-off value was 10 for GCS and 14 for FOUR in a study done by Akavipat et al.[14] The difference in the cut-off points can be due to differences in the severity of TBI in the sample studied as well as different outcomes assessed by the authors.

There are limited studies for comparing GCS-P with other coma scores. Lin et al. retrospectively studied 4,372 neurocritical care patients and found GCS-P to be slightly better at predicting in-hospital mortality than GCS alone.[15] In another retrospective study involving pediatric severe TBI patients, authors found that incorporating PRS into GCS makes it more strongly associated with mortality and poor functional outcomes at the time of ICU discharge.[16] The findings of both these studies are not in concordance with our findings, as we found no significant difference with the addition of PRS to GCS on the prediction of 3-month functional outcome or mortality in our study. The results are possibly different because of the prospective nature and longer follow-up time in our study.

Published literature comparing GCS and FOUR scores either found the FOUR score to be a better or an equivalent predictor of outcome.[5,6,17] On comparison of GCS and GCS-P, the latter is considered a better predictor of outcome than GCS alone.[15,16] Our study found all three coma scores to be comparable for prediction of mortality and 3 months poor outcome, which is in agreement with another recent study by Agrawal et al.[18] This can be largely due to differences in study design, severity of TBI in sampled patients and sample size in the earlier studies.

### Length of Stay in Intensive Care Unit and Hospital

We observed that all three coma scores correlated well with the duration of ICU and hospital stay, however, scores slightly better correlated with days in ICU than with hospital stay. While one study found the FOUR score to be better than GCS in predicting the duration of both ICU and hospital stay, another study found them comparable in predicting the duration of ICU stay.[19,20] The length of hospital stay is affected by several factors such as surgical interventions and the development of various complications, thus explaining the difference.[21] Spearman coefficient correlating coma scores with the duration of both ICU and hospital stay were all found to have negative value in our study; this shows that increasing coma score values are inversely proportional to the number of days in ICU or hospital. This is expected as more severely injured TBI patients having lower coma scores (if survive) are likely to stay longer in ICU/hospital. Mkubwa et al.[22] studied the correlation of ICU stay with GCS score; and found median days in ICU were more with increasing severity of TBI, which is similar to our finding.

Our study has a few limitations. First, the study was carried out during the COVID-19 pandemic affecting the overall incidence of TBI during lockdown. Moreover, movement restrictions imposed by the government limited the number of patients that could be recruited for the study. Second, increased mortality and morbidity due to COVID-19 infection prevalent during the study period could have affected our study outcomes. Third, the duration of ICU stay, and hospital stay were also shortened in some cases due to constraints of hospital bed availability due to the pandemic. Follow-up care after discharge might also have been compromised, possibly affecting 3-month outcome of these patients.

## Conclusion

The GCS, FOUR, and GCS-P scores were found to be comparable in predicting the functional outcome at 3 months as assessed by GOSE. However, coma scores assessed at 48 hours were better predictors of poor outcomes at 3 months than initial admission coma scores. For the prediction of in-hospital mortality, all three coma scores were found to be comparable to each other. Patients with low coma scores are likely to have prolonged ICU and hospital stays.

## Authors' Contributions

Designing the study: ALC, CM, IK, TPS, and AC; Data collection: ALC, TPS, and CM; Analysis: ALC; Writing: ALC and CM; Reviewing: CM, IK, HP, TPS, and AC.

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# Appendix

## Clinical Scores and Grades

### Glasgow Coma Scale Score

| *Eye opening (E)* | |
|---|---|
| 1 | None |
| 2 | To pain/pressure |
| 3 | To speech |
| 4 | Spontaneous |
| *Verbal response (V)* | |
| 1 | None |
| 2 | Sounds |
| 3 | Words |
| 4 | Confused |
| 5 | Oriented |
| *Best motor response (M)* | |
| 1 | None |
| 2 | Extension |
| 3 | Abnormal flexion |
| 4 | Normal flexion (withdrawal) |
| 5 | Localizing |
| 6 | Obeying commands |

### GCS Pupils Score = GCS – Pupil Reactivity Score

| *Pupil reactivity score* | *Description* |
|---|---|
| 0 | Neither pupil is unreactive to light/ both are reacting |
| 1 | Only 1 pupil unreactive to light |
| 2 | Both pupils unreactive to light |

### Full Outline of UnResponsiveness Score

| *Eye response* | |
|---|---|
| 4 | Eyelids open or opened, tracking, or blinking to command |
| 3 | Eyelids open but not tracking |
| 2 | Eyelids closed but open to loud voice |
| 1 | Eyelids closed but open to pain |
| 0 | Eyelids remain close to pain |
| *Motor response* | |
| 4 | Thumbs-up, fist, or peace sign |
| 3 | Localizing to pain |
| 2 | Flexion to pain |
| 1 | Extension to pain |
| 0 | No response to pain or generalized myoclonus |
| *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 reflexes |
| *Respiration* | |
| 4 | Not intubated, regular breathing pattern |
| 3 | Not intubated, Cheyne–Stokes breathing pattern |
| 2 | Not intubated, irregular breathing |
| 1 | Breathes above ventilator rate |
| 0 | Breathes at ventilator rate or apnoea |

## Extended Glasgow Outcome Score

| *GOSE score* | *Description* |
|---|---|
| Dead | |
| Vegetative state (VS) | Condition of unawareness with reflex responses but with periods of spontaneous eye opening. |
| Low severe disability (SD–) | Patients who are dependent on daily support for mental or physical disability, usually a combination of both. The patient cannot be left alone at home for more than 8 hours. |
| High severe disability (SD+) | Patients who are dependent on daily support for mental or physical disability, usually a combination of both. Patients can be left alone at home for more than 8 hours. |
| Low moderate disability (MD–) | Patients have some disability such as aphasia, hemiparesis or epilepsy, and/or deficits of memory or personality but are able to look after themself. Patients are independent at home but dependent outside. Unable to return to work even with special arrangements. |
| High moderate disability (MD+) | Patients have some disability such as aphasia, hemiparesis or epilepsy, and/or deficits of memory or personality but can look after themself. Patients are independent at home but dependent outside. Able to return to work with special arrangements. |
| Low good recovery (GR–) | Resumption of normal life with the capacity to work even if preinjury status is not achieved. Patients may have minor neurological or psychological deficits, which is disabling. |
| High good recovery (GR+) | Resumption of normal life with the capacity to work even if preinjury status is not achieved. Patients may have minor neurological or psychological deficits, which is not disabling. |

CT scan, computerized tomography scan; CNS, central nervous system; CVS, cardiovascular system; GOSE, extended Glasgow outcome score; ICU, intensive care unit; Rotterdam CT grade, Rotterdam computerized tomography grade