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# Revisiting the Classification of Moderate and Mild Traumatic Brain Injury Based on the Admission Glasgow Coma Scale Score

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## Abstract

**Objective** We study the clinical relevance of classifying traumatic brain injury (TBI) into moderate and mild categories based on the Glasgow Coma Scale (GCS) score at admission with respect to the treatment intensity and 6-month mortality and morbidity rates.

**Methods** Analysis of patients from a prospectively maintained database admitted at a level I trauma center from 2013 to 2019 with an admission GCS score between 9 and 15 and a minimum follow-up of 6 months post-TBI was done to study the treatment intensity and 6-month morbidity and mortality rates for each GCS score from 9 to 15.

**Results** In all, 2,060 patients met the study criteria, of which 1,684 were males (81.7%). Road traffic accident was the most common cause of TBI (83.7%). There was a significant linear increase in the proportion of patients who had good outcomes with increasing GCS scores from 9 to 15 ($p \leq 0.001$). When the variables in each GCS score were compared with a GCS score of 15, there was an increase in the odds ratio of mortality and poor outcome with decreasing GCS scores ($p \leq 0.001$). Patients with a lower admission GCS score required more intense treatment in the form of surgery and ventilation ($p \leq 0.00001$). There was a higher incidence of pupillary asymmetry in patients with lower GCS scores ($p \leq 0.00001$).

**Conclusions** The classification of TBI patients into moderate and mild based on the GCS score at admission is not of any practical value, and TBI patients may be more usefully classified based on the admission GCS score into severe and not severe groups.

**Keywords**
- TBI classification
- GCS score
- outcomes
- mild and moderate TBI
- GOS-E

## Introduction

Traumatic brain injury (TBI) is a leading cause of morbidity and mortality worldwide and remains a public health challenge in resource-constrained low- to middle-income countries.[1] More than 1 million individuals sustain TBI in India annually and many of them remain disabled.[2] The Glasgow Coma Scale (GCS) score introduced in 1974 is widely used for assessment of a patient's level of consciousness following TBI.[3] The score has been shown to have excellent interobserver reliability, which improves with training.[4] Postresuscitation GCS score has a strong influence on the outcome of patients with TBI and studies have shown a linear relationship between the GCS score at admission and the risk of mortality.[5,6]

The postresuscitation GCS score is used to classify TBI into mild (GCS score of 13–15), moderate (GCS score of 9–12), and

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severe (GCS score ≤ 8). The traditional classification included patients with a GCS score of 13 in the moderate category, but the advanced trauma life support (ATLS) reclassified GCS score of 13 as mild head injury based on the findings from the Canadian Computed Tomography (CT) Head Rule Study and other studies.[7–10]

Severe head injury (GCS score ≤8) has been shown to be associated with poor outcomes, but data on the difference in outcomes between mild and moderate TBI are scarce. A study by Norwood et al showed that a prehospital GCS score < 14 accurately predicts the need for full trauma team activation and patient hospitalization after motor vehicle collisions.[11] Studies have also shown that patients with a GCS score of 13 harbor intracranial lesions at a frequency similar to patients with moderate head injury defined as GCS score of 9 to 12.[12,13]

In this study, we analyzed whether dividing head injuries into moderate and mild categories based on the admission GCS score is of any clinical relevance, based on treatment required and 6-month morbidity and mortality rates in patients with an admission GCS score of 9 to 15.

## Materials and Methods

The study was conducted on a prospectively maintained database of TBI patients admitted at a level I trauma care center between 2013 and 2019. Patients whose GCS score at admission was between 9 and 15 and had a minimum follow-up of 6 months post-TBI were included in the study. All the patients were treated at our center largely in line with the Brain Trauma Foundation (BTF) guidelines.[10] They were followed up in a dedicated outpatient clinic at 1, 3, and 6 months after discharge during which a detailed assessment was done. Patient outcomes were recorded using the Extended Glasgow Outcome Scale (GOS-E).[14] The incidence of anisocoria, need for surgery and ventilation, mortality, and GOS-E at 6 months was assessed for each GCS score from 9 to 15.

The mortality and outcome for each GCS score was compared against the mortality and outcome for patients with a GCS score of 15 for statistical analysis. The need for surgery and ventilation for each GCS score was similarly compared against the requirements for the patients with a GCS score of 15. Surgeries included in the analysis were craniotomy for hematoma evacuation and decompressive craniectomy with or without hematoma evacuation. Surgeries for depressed fractures, cerebrospinal fluid (CSF) leak, or other indications were not included as they are unlikely to be a reflection of the severity of the injury. Patients in whom one or both pupils could not be assessed due to local causes were excluded only from the analysis on anisocoria.

### Statistical Analysis

Data were entered into a spreadsheet and statistical analysis was performed using SPSS (Version 21.0, IBM Corp., Armonk, NY). Categorical variables were reported as frequency and percentage. Mean ± standard deviation (SD) and median (interquartile range [IQR]) were used for continuous variables, as applicable. Association of the categorical variables was reported using the chi-squared test. The odds ratio was calculated using unadjusted regression analysis. A $p$-value of <0.05 was considered statistically significant.

## Results

Among 2,204 patients with TBI and a GCS score of 9 to 15 admitted at our center during the study period, 2,060 had adequate follow-up and were included in the study. Of these, 293 patients were <18 years of age and 1,684 were males. The most common cause of head injury was road traffic accidents (83.7%). The clinical and demographic characteristics are described in ►**Table 1**.

There was an almost linear increase in the proportion of patients who had a good outcome (GOS-E of 5–8) with an increasing admission GCS score, ranging from 82.5% for a GCS score of 9 to 95.8% for a GCS score of 15. The number of patients with a GOS-E of 8 also showed a similar increase from 66.8 to 88.7% (►**Table 2**).

As mentioned earlier in the earlier section, all measures of significance were generated by comparing the variable for each GCS score with that for patients with a GCS score of 15. There was a linear increase in mortality with decreasing GCS scores, with an odds ratio for mortality of 5.0 (confidence interval [CI]: 2.75–9.08) for an admission GCS score of 9 when compared to a GCS score of 15 (►**Table 3**). Similarly the odds ratio of a poor outcome was 4.76 (CI: 2.82–8.01) for an admission GCS score of 9 when compared with a GCS score of 15 (►**Table 4**).

Patients with a lower admission GCS score were more likely to require surgical intervention (26.5% for a GCS score of 9 but only 12.2% for a GCS score of 15). A patient with a GCS

**Table 1** Clinical and demographic profile of patients

| Variable | Number of patients (%) |
|---|---|
| **Gender** | |
| Male | 1,684 (81.7) |
| Female | 376 (18.3) |
| **Age (y)** | |
| ≤18 | 293 (14.2) |
| 19–64 | 1,625 (78.8) |
| ≥65 | 142 (7) |
| **Etiology** | |
| RTA | 1,724 (83.6) |
| Fall | 220 (10.7) |
| Assault | 47 (2.3) |
| Others | 69 (3.4) |
| **GCS score** | |
| 9 | 298 (14.5) |
| 10 | 265 (12.9) |
| 11 | 282 (13.7) |
| 12 | 123 (5.9) |
| 13 | 281 (13.6) |
| 14 | 294 (14.3) |
| 15 | 517 (25.1) |

Abbreviations: GCS, Glasgow Coma Scale; RTA, road traffic accident.

**Table 2** Patient outcomes at 6 months for each GCS score

| GCS score | GOS-E, *n* (%) | | | |
|---|---|---|---|---|
| | 1 | 1–4 | 5–8 | 8 |
| 9 (298) | 41 (13.8) | 52 (17.5) | 246 (82.5) | 199 (66.8) |
| 10 (265) | 28 (10.6) | 42 (15.9) | 223 (84.1) | 185 (69.8) |
| 11 (282) | 28 (9.9) | 40 (14.2) | 242 (85.8) | 214 (75.9) |
| 12 (123) | 14 (11.3) | 18 (14.6) | 105 (85.4) | 90 (73.2) |
| 13 (281) | 24 (8.5) | 36 (12.8) | 245 (81.2) | 220 (78.3) |
| 14 (294) | 25 (8.5) | 31 (10.5) | 263 (89.5) | 234 (79.6) |
| 15 (517) | 16 (3.1) | 22 (4.2) | 495 (95.8) | 459 (88.7) |

Abbreviations: GCS-E, Extended Glasgow Coma Scale.

score of 9 was also significantly more likely to require ventilatory support ($p < 0.0001$) when compared to a patient with a GCS score of 15 (►**Table 5**).

Seventy-one patients had a local injury to one or both eyes and therefore only 1,989 patients were included in the analysis for anisocoria. A little more than 20% of patients with a GCS score of 9 had clinically detected pupillary asymmetry, while this was less than 5% in patients with a GCS score of 15 (►**Table 6**).

## Discussion

When the severity of head injury was initially categorized into severe, moderate, and mild, a GCS score of 13 was considered a moderate TBI.[15] This was changed later by the ATLS group with a GCS score of 13 being classified as a mild TBI. Defining an injury as mild implies that most patients in this category will not require significant interventions. Although the majority of patients with TBI who present to the hospital will fall under this "mild" category, there are no clear guidelines for managing these patients in the emergency department. Some authors consider a GCS score 15 alone as mild head injury, with evidence suggesting that injuries in patients with GCS score of 13 and 14 tend to be more severe.[16] In a meta-analysis of 24 studies that included 24,249 patients with a GCS score of 15, Geijerstam et al found that the mortality rate was 0.1% and complication rate was about 0.9%.[17] Norwood et al reported that a prehospital GCS score of ≤14 most reliably predicted the need for patient hospitalization after motor vehicle collisions.[11] Culotta et al reported that patients with an admission GCS scores of 13 were significantly more likely to have abnormal CT scans and were more likely to require neurosurgical intervention within the first 24 hours than were those with GCS scores of 14 or 15. Those with GCS

**Table 3** Mortality in patients with GCS score ranging from 9 to 15, compared with mortality in patients with a GCS score of 15 for statistical significance

| GCS score | Mortality (GOS-E1), *n* (%) | Univariate | Odds ratio (OR) | | |
|---|---|---|---|---|---|
| | | *p* value | OR | 95% CI | *p* value |
| 9 | 41/298 (13.8) | <0.00001 | 5.00 | 2.75–9.08 | <0.001 |
| 10 | 28/265 (10.6) | 0.00001 | 3.70 | 1.96–6.97 | <0.001 |
| 11 | 28/282 (9.9) | 0.00005 | 3.45 | 1.83–6.50 | <0.001 |
| 12 | 14/123 (11.3) | 0.00009 | 4.02 | 1.91–8.49 | <0.001 |
| 13 | 24/281 (8.5) | 0.00075 | 2.92 | 1.53–5.60 | <0.001 |
| 14 | 25/294 (8.5) | 0.00072 | 2.91 | 1.53–5.55 | 0.001 |
| 15 | 16/517 (3.1) | – | 1.00 | | |

Abbreviations: CI, confidence interval; GCS-E, Extended Glasgow Coma Scale.

**Table 4** Poor outcome at 6 months of follow-up for each GCS score from 9 to 15, comparing each GCS score with the outcome for a GCS score of 15 for statistical significance

| GCS score | Death/poor outcome | Univariate | Odds ratio (OR) | | |
|---|---|---|---|---|---|
| | GOS-E1–4, *n* (%) | *p* value | OR | 95% CI | *p* value |
| 9 | 52/298(17.5) | <0.00001 | 4.76 | 2.82–8.01 | <0.001 |
| 10 | 42/265(15.9) | <0.00001 | 4.24 | 2.47–7.27 | <0.001 |
| 11 | 40/282(14.2) | <0.00001 | 3.72 | 2.16–6.40 | <0.001 |
| 12 | 18/123(14.6) | 0.00001 | 3.86 | 2.00–7.45 | <0.001 |
| 13 | 36/281(12.8) | <0.00001 | 3.31 | 1.90–5.74 | <0.001 |
| 14 | 31/294(10.5) | 0.00049 | 2.65 | 1.51–4.67 | 0.001 |
| 15 | 22/517 (4.2) | – | 1.00 | – | – |

Abbreviations: CI, confidence interval; GCS-E, Extended Glasgow Coma Scale.

**Table 5** Proportion of patients requiring surgery and ventilation for each GCS score of 9 to 15. Each is compared against a GCS score of 15 for statistical significance

| GCS Score | Ventilation | | Surgery | |
|---|---|---|---|---|
| | Yes *n* (%) | Univariate *p* value | Yes *n* (%) | Univariate *p* value |
| 9 | 140/298 (47) | <0.00001 | 79/298 (26.5) | <0.00001 |
| 10 | 87/265 (32) | <0.00001 | 61/265 (23) | <0.00008 |
| 11 | 79/282 (28) | <0.00001 | 65/282 (23) | <0.00006 |
| 12 | 29/123 (23.6) | <0.00001 | 23/123 (18.7) | <0.056 |
| 13 | 63/281 (22.5) | <0.00001 | 58/281 (20.6) | <0.001 |
| 14 | 50/294 (17) | <0.00002 | 50/294 (17) | <0.00002 |
| 15 | 38/517 (7.3) | – | 63/517 (12.2) | – |

**Table 6** Proportion of patients with anisocoria in each GCS score ranging from 9 to 15. Each group is compared against the GCS score of 15 for statistical significance

| GCS score | Pupillary anisocoria *n* (%) | Univariate *p* value |
|---|---|---|
| 9 | 64/293 (21.8) | <0.00001 |
| 10 | 35/255 (13.7) | <0.00001 |
| 11 | 37/276 (13.5) | <0.00002 |
| 12 | 11/119 (9.3) | <0.06 |
| 13 | 28/265 (10.6) | <0.002 |
| 14 | 21/282 (7.5) | 0.12 |
| 15 | 24/499 (4.8) | – |

score of 14 were more likely to have an abnormal CT and require an intervention than those with GCS score of 15. They concluded that patients with GCS scores of 13 and 14 should be segregated from those with a GCS score of 15.[16] Stein and Ross reported that nearly 40% of patients with a GCS score of 13 have a CT abnormality and 10% require surgical intervention; hence, they suggested these patients should be classified as moderate rather than mild in severity and risk.[18] Mena et al also found that a GCS score of 13 classified as moderate TBI predicted mortality better than when classified as mild TBI in a regression model.[7]

Most of these studies have been performed in an attempt to decide whether a patient with a GCS score of 13 should be classified as mild or moderate. None of them, however, have clearly delineated the differences in the approach to patients depending on whether they are classified as mild or moderate, and the only conclusion is that patients with a GCS score of 15 generally do not require as much attention as the other patients. Our data show that the risk of mortality and poor outcome increase with decreasing GCS score, as does the likelihood of having asymmetric pupils and requiring surgery or ventilation. The probability of a good outcome and return to work improves with increasing GCS score. We also have data that we have not included for reasons of clarity showing that the patients with a lower GCS score have progressively higher Rotterdam CT scores and need for tracheostomy.

In all these data, there is no step between two GCS scores that could indicate a point at which the patients can be categorized into moderate or mild. Instead we have a continuum where the variables and outcome change in practically a linear fashion as the GCS score increases or decreases, making this division into moderate and mild TBI an artificial construct with no definite influence on treatment required or the outcome.

## Limitations

This study deals only with patients who were admitted to our hospital and not all patients with TBI who were referred to neurosurgery in the emergency department. The decision to admit a patient is made on our criteria that reflect the available resources, and this decision-making process may not be the same in other institutions. This could be an explanation for the comparatively higher mortality and need for aggressive treatment in our patients with a GCS score of 15, since the majority of the milder injuries were not admitted. However, we believe that even if the proportions differ, the overall trend will be the same in all hospitals.

## Conclusion

The admission GCS score linearly correlates with mortality, outcome, and intensity of treatment required for TBI patients with a GCS score of $\geq$9. The classification of TBI patients into moderate and mild based on the admission GCS score does not provide guidance of any practical value, and TBI patients may be more usefully classified based on the admission GCS score into severe and not severe groups.

Note
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Authors' Contributions
Conception and design were done by M.J., A.P.A., and G.S. Drafting of the article was done by G.S. and M.J. Statistical analysis was performed by T.M. M.J. is the guarantor.

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**Conflict of Interest**
None declared.

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