

Assessment of Glasgow Coma Scale (GCS) as Predictor of Mortality in Patients with Severe Head Injury

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ABSTRACT

Objective: To assess the predictive accuracy of the admission Glasgow Coma Scale (GCS) for 30-day in-hospital mortality with patients of severe head injury.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: Neurosurgery Department, Allama Iqbal Teaching Hospital, DG Khan, Pakistan, from Aug 2025 to Feb 2026.

Methodology: A total of 196 adult patients with severe head injury (GCS ≤ 8) confirmed by CT scan were enrolled using non-probability consecutive sampling. Data on demographics, clinical parameters, CT reports, and interventions were collected. The primary result was 30 day in-hospital mortality. To recognize independent predictors of mortality, Univariate and multivariate logistic regression analyses were performed for data analysis.

Results: The 30-day mortality rate was 68 (34.7%). Non-survivors had significantly lower admission GCS (5.2 ± 1.4 vs. 6.9 ± 1.2 , $p < 0.001$), high rates of pupillary non-reactivity (73.5% vs. 25.8%, $p < 0.001$), and greater occurrence of midline shift ≥ 5 mm (77.9% vs. 44.5%, $p < 0.001$). Multivariate analysis identified GCS ≤ 5 (aOR=4.8, $p < 0.001$), pupillary non-reactivity (aOR=5.2, $p < 0.001$), midline shift ≥ 5 mm (aOR=3.1, $p < 0.001$) and age > 60 years (aOR=2.9, $p = 0.002$) as independent forecasters of mortality.

Conclusion: Admission GCS, particularly a score ≤ 5 , along with pupillary response and CT findings are strong independent predictors of mortality in severe head injury, supporting their use in early risk stratification.

Keywords: Glasgow Coma Scale, Head Injury, Mortality, Prognosis, Traumatic Brain Injury, Triage.

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INTRODUCTION

Traumatic brain injury (TBI) represents a critical public health challenge, accounting for significant mortality and disability worldwide.¹ The Global Burden of Disease study reports approximately 50 million new TBI cases annually, with low and middle income countries (LMICs) bearing 90% of this burden due to limited neurosurgical capacity.^{2,3} In South Asia, road traffic accidents are the predominant mechanism, driving high incidence rates among young males.⁴ Specifically in Pakistan, neurotrauma constitutes a major portion of emergency surgical admissions, yet standardized outcome registries are scarce.⁵

The Glasgow Coma Scale (GCS) remains the cornerstone for initial assessment, with scores ≤ 8 indicating severe injury.⁶ Although widely adopted, recent evidence suggests variable prognostic accuracy for mortality across different trauma systems.⁷ Complex scoring models require radiological and

biochemical inputs often inaccessible in resource constrained emergency departments.⁸ Furthermore, literature indicates inconsistency in the independent predictive value of GCS, particularly regarding mortality stratification within the severe range (GCS 3–5 versus 6–8).⁹ Existing studies originate from high income settings, creating a knowledge gap regarding its utility in Pakistani trauma centers where pre-hospital care is variable.

Identifying that road traffic accidents are the leading cause of severe TBI in south east Asia region could reform public health campaigns on helmet and seatbelt use while high mortality in elderly fall related TBI might prompt geriatric fall prevention programs. Accurate early prognostication is essential for triage, family counseling, and optimizing critical care resources. Validating simple clinical tools against local mortality data addresses the need for evidence-based protocols tailored to regional infrastructure. Therefore, there is a need to re-evaluate predictive performance of GCS particularly in settings with varying levels of trauma care infrastructure. This study assessed the predictive accuracy of the admission Glasgow Coma

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Scale for in-hospital 30-day mortality in patients presenting with severe head injury.

METHODOLOGY

This analytical cross-sectional study was conducted at neurosurgery department of Allama Iqbal Teaching Hospital, affiliated with DG Khan Medical College, Dera Ghazi Khan, Pakistan, from August 2025 to February 2026 after taking approval from the Institutional Ethical Review Committee (ref: 008/312/med/dgkmc, dated 07-03-2025).

Inclusion Criteria: Adult patients of either gender, admitted with a diagnosis of severe head injury, defined as a GCS score of 8 or less at initial clinical assessment were included.

Exclusion Criteria: Patient with isolated non traumatic causes of coma (stroke, metabolic encephalopathy and intoxication) pre-existing neurological conditions affecting consciousness (advanced dementia and Parkinson's disease) or those with incomplete GCS documentation or missing outcome data were excluded.

The required sample size was calculated as expected mortality rate of 15% in severe traumatic brain injury (TBI), yielding a minimum sample size of 196 participants.¹⁰

A non-probability consecutive sampling technique was employed to enroll eligible patients during the 12-month study period, and informed consent was obtained prior to data collection. Data were collected using pre-formed data collection form that captured demographic characteristics (age, sex), clinical parameters at admission (GCS total score and subscores, systolic blood pressure, pupillary reactivity), mechanism of injury (e.g., road traffic accident, fall from height), radiological findings on CT scan (including intracranial hemorrhage, cerebral contusions, midline shift and traumatic subarachnoid hemorrhage) and clinical interventions (endotracheal intubation, neurosurgical procedures). The primary result was in-hospital mortality within 30 days of admission, recorded as a binary variable (alive vs deceased). All cases were confirmed by non-contrast computed tomography (CT) scan of the brain, performed within 6 hours of admission.

The data was analyzed statistically by using Statistical Package for Social Sciences (SPSS) version 23. Baseline characteristics were summarized using descriptive statistics whereas categorical variables like gender, mechanism of injury, pupillary reactivity and

CT scan findings were represented as frequencies and percentages, and continuous variables like age and GCS were presented as Mean $\pm$ SD. Data was assessed for normality using the shapiro-wilk test. Univariate analyses, including independent samples t-tests for continuous variables and Chi-square tests for categorical variables were conducted to compare clinical and demographic features between survivors and non-survivors. The multivariate logistic regression model was used to find independent predictors of mortality based on variables that showed a *p*-value <0.25 in univariate analysis or were considered clinically significant. The results were presented as adjusted odds ratios (aOR) and 95% confidence intervals (CI). Age categories (≤ 60 vs. >60 years) and injury mechanisms (blunt trauma from RTA vs falls) were used to conduct subgroup analyses. For all tests, a *p*-value of less than or equal to 0.05 was deemed statistically significant. Patient confidentiality was maintained through anonymized data entry.

RESULTS

A total of 196 patients with severe traumatic head injury (GCS ≤ 8) were included in this cross-sectional analytical study. The primary outcome 30-day in hospital mortality occurred in 68 patients (34.7%). The mean age of the patients was 42.6 $\pm$ 16.3 years with a male predominance 152(78.1%). Road traffic accidents (RTAs) were the main causes of injury (n=124, 63.3%) followed by falls from height (n=52, 26.5%). The majority of patients (n=165, 84.2%) required endotracheal intubation upon admission and 94(48.0%) underwent neurosurgical intervention.

Baseline demographic clinical and radiological characteristics of the study participants were stratified by survival status. Survivors (n=128) were significantly younger than non-survivors, with a mean age of 38.4 $\pm$ 15.1 years vs 51.2 $\pm$ 15.6 years (*p*<0.001). Non-survivors were more likely to present with non-reactive pupils (73.5% vs. 25.8%; *p*<0.001) and lower mean systolic blood pressure (108.4 $\pm$ 18.7 mmHg vs. 124.6 $\pm$ 19.3 mmHg; *p*<0.001). The mean admission GCS was significantly lower in non-survivors (5.2 $\pm$ 1.4) compared to survivors (6.9 $\pm$ 1.2; *p*<0.001). Radiologically, non-survivors had a higher prevalence of midline shift ≥ 5 mm (77.9% vs. 44.5%, *p*<0.001), traumatic subarachnoid hemorrhage (66.2% vs. 40.6%; *p*=0.001) and cerebral contusions (72.1% vs. 48.4%; *p*=0.002), which can be seen in Table-I.

In the crude analysis, age >60 years, admission GCS ≤ 5 , pupillary non-reactivity, and midline shift ≥ 5

mm were significantly associated with increased odds of mortality ($p<0.001$). Pupillary non-reactivity demonstrated the strongest univariate association (crude OR 62.4, 95% CI 18.4–210.5), indicating that patients with non-reactive pupils had over 60 times higher odds of mortality compared to those with reactive pupils. Following adjustment for potential confounders in the multivariate logistic regression model, four variables remained independent predictors of mortality: age >60 years (aOR 2.9, $p=0.002$), admission GCS ≤ 5 (aOR 4.8, $p<0.001$), pupillary non-reactivity (aOR 5.2, $p<0.001$), and midline shift ≥ 5 mm (aOR 3.1, $p<0.001$). After controlling for covariates, each of these factors corresponded to an approximately 3 to 5-fold increase in the odds of death, with pupillary non-reactivity retaining the strongest independent association despite substantial attenuation from its crude estimate. In contrast, cerebral contusion was not significantly associated with mortality in either the univariate or adjusted models ($p>0.05$), indicating that it did not independently contribute to mortality risk after accounting for other clinical and radiological severity markers (Table-II).

Table-I: Baseline Characteristics of Patients with Severe Head Injury by Survival Status (n = 196)

Variable	Total (n=196) n(%)	Survivors (n=128) n(%)	Non-Survivors (n=68) n(%)	p-value
Age in years (Mean $\pm$ SD)	42.6 $\pm$ 16.3	38.4 $\pm$ 15.1	51.2 $\pm$ 15.6	<0.001
Male	153(78.1%)	103(80.5%)	50(73.5%)	0.24
Mechanism of Injury				
Traffic Accident	124(63.3%)	74(57.8%)	50(73.5%)	0.024
Fall from Height	52(26.5%)	40(31.3%)	12 (17.6%)	
Other	20(10.2%)	14(10.9%)	6(8.8%)	
SBP at Admission, mmHg (mean $\pm$ SD)	118.7 $\pm$ 20.4	124.6 $\pm$ 19.3	108.4 $\pm$ 18.7	<0.001
Pupillary Reactivity				
Reactive	98(50.0%)	95(74.2%)	3(4.4%)	<0.001
Non-reactive	98(50.0%)	33(25.8%)	65 (95.6%)	
GCS at Admission (Mean $\pm$ SD)	6.3 $\pm$ 1.6	6.9 $\pm$ 1.2	5.2 $\pm$ 1.4	<0.001
GCS ≤ 5 , n (%)	82(41.8%)	32(25.0%)	50(73.5%)	<0.001
CT Scan Findings				
Midline Shift ≥ 5 mm	104(53.1%)	57(44.5%)	47(69.1%)	<0.001
Traumatic SAH	84(42.9%)	52(40.6%)	32(47.1%)	0.001
Cerebral Contusion	95(48.5%)	62(48.4%)	33(48.5%)	0.002
Epidural Hematoma	38(19.4%)	26(20.3%)	12(17.6%)	0.67
Subdural Hematoma	78(39.8%)	48(37.5%)	30(44.1%)	0.36
Interventions				
Intubation at Admission	165(84.2%)	104(81.3%)	61(89.7%)	0.11
Neurosurgical Procedure	94(48.0%)	64(50.0%)	30(44.1%)	0.43

*SBP: Systolic Blood Pressure, GCS: Glasgow Coma Scale

DISCUSSION

The present study demonstrates that admission Glasgow Coma Scale (GCS) ≤ 5 , pupillary non-reactivity, midline shift ≥ 5 mm and age >60 years are independent predictors of 30-day mortality in severe traumatic brain injury (sTBI), with an overall mortality

rate of 34.7%. This mortality figure remains higher than the 28% reported in a multicenter Pakistani trauma registry study by Shaukat *et al.*¹¹ The discrepancy may be attributed to single-center tertiary care setting which receives more complex referrals, alongside regional delays in pre-hospital care.¹² In contrast, Lin *et al.* reported a mortality of 41%, suggesting that while LMICs share burdens of delayed presentation, local variations in neurosurgical capacity significantly influence survival outcomes.¹³

Multivariate analysis identified GCS ≤ 5 as a potent predictor (aOR 4.8), reinforcing the prognostic utility of scale despite known limitations in inter-rater reliability.¹⁴ This odds ratio is comparable to the findings of Khan *et al.* in a local ICU setting, where low GCS scores correlated strongly with prolonged ventilation and death, though their study did not isolate GCS ≤ 5 as a specific cutoff.¹⁵ Pupillary non-reactivity emerged as the strongest predictor (aOR 5.2), consistent with international data indicating brainstem compromise as a terminal event.¹⁶ However, the magnitude of this association in this study exceeds the aOR of 3.5 reported in recent meta-analyses from high-income countries, potentially reflecting a lower threshold for surgical intervention in resource-constrained environments where fixed pupils often signify irreversible herniation.¹⁷

Table-II: Association of Clinical and Radiological Variables with 30-day In-Hospital Mortality (n=196)

Variable	Category	Mortality n (%)	No-Mortality n (%)	p-value	Crude OR (95% CI)	p-values	Adjusted OR (95% CI)	p-value
Age >60 years	Yes	20 (29.4)	10 (7.8)	<0.001	4.9 (2.1–11.4)	<0.001	2.9 (1.48 – 5.70)	0.002
	No	48 (70.6)	118 (92.2)					
GCS ≤ 5 at admission	Yes	50 (73.5)	32 (25.0)	<0.001	8.3 (4.3–16.3)	<0.001	4.8 (1.89 – 12.22)	<0.001
	No	18 (26.5)	96 (75.0)					
Pupillary non reactivity	Yes	65 (95.6)	33 (25.8)	<0.001	62.4 (18.4–210.5)	<0.001	5.2 (1.95 – 13.88)	<0.001
	No	3 (4.4)	95 (74.2)					
Midline shift ≥ 5 mm	Yes	47 (69.1)	57 (44.5)	0.002	2.8 (1.5–5.2)	<0.001	3.1 (1.58 – 6.08)	<0.001
	No	21 (30.9)	71 (55.5)					
Traumatic SAH	Yes	32 (47.1)	52 (40.6)	0.449	1.29 (0.7–2.3)	0.449	–	–
	No	36 (52.9)	76 (59.4)					
Cerebral Contusion	Yes	33 (48.5)	62 (48.4)	1.000	1.003 (0.6–1.8)	1.00	–	–
	No	35 (51.5)	66 (51.6)					

*SAH: Subarachnoid Hemorrhage, GCS: Glasgow Coma Scale. –: Not included in multivariable model

Radiological evidence of mass effect, specifically midline shift ≥ 5 mm, independently increased mortality risk (aOR 3.1). This supports the Brain Trauma Foundation guidelines but contrasts with studies from established trauma systems where decompressive craniectomy may mitigate this risk.¹⁸ In this setting, the high mortality associated with midline shift underscores the critical need for timely CT imaging, which remains a bottleneck in many

Pakistani district hospitals.¹⁹ Regarding demographics, age >60 years doubled the odds of death (aOR 2.9), corroborating with the findings on geriatric TBI in urban Pakistan, where comorbidities and reduced physiological reserve exacerbate secondary injury.²⁰ While road traffic accidents accounted for 63.3% of injuries mirroring national epidemiology mechanism lost significance in multivariate analysis.¹¹ This suggests that physiological severity (GCS, pupils) outweighs etiology in prognostication, a finding consistent with global IMPACT model validations.²¹

Head injuries were caused because road traffic accidents (RTAs) that initially linked to higher mortality. This association lost significance after adjustment and suggesting that injury severity rather than mechanism is the primary determinant of outcome. This supports the need to prioritize physiological and anatomical markers over etiology in triage and prognostication protocols.

Strengths of this study include its design while use of standardized outcome measures (Glasgow Outcome Scale) and comprehensive data collection in a dedicated neurosurgery ICU. The sample size was calculated a priori, enhancing statistical power and all enrolled patients had complete outcome data. Well defined group of severe TBI patients evaluated using standardized clinical and radiological criteria at a tertiary care center. The use of multivariate analysis allowed for adjustment of confounders enhancing the validity of the identified predictors. Additionally the inclusion of both clinical (GCS, pupillary response) and radiological (CT findings) variables provides a comprehensive assessment of prognostic factors relevant to low-resource settings.

Recommendations on the basis of findings includes the routine documentation of GCS and pupillary response in all head injury cases and early access to brain CT scanning and integration of these predictors into local triage and counseling protocols. The prognostic significance of these variables should be emphasized in emergency and paramedical staff training. In order to improve prognostication models in this population and future research should examine the potential for head injuries and multicenter studies that incorporate biomarkers, long-term outcomes and serial neurological assessments.

LIMITATIONS OF STUDY

Limitations include the single-center design which may limit generalizability to rural or non-neurosurgical centers. Functional outcomes were assessed only at

discharge without long-term follow up to evaluate cognitive or psychosocial recovery. Additionally, variables such as helmet use and pre-existing comorbidities were not systematically recorded. The relatively low use of ICP monitoring (34.7%) reflects resource constraints and may have influenced management decisions.

CONCLUSION

In patients with severe head injury GCS $\leq$ 5 pupillary non-reactivity midline shift on CT and age >60 years are strong independent predictors of 30-day mortality. Early assessment of these parameters can enhance risk stratification and clinical decision making in resource limited countries.

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Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

AURK & AAN: Conception, study design, drafting the manuscript, approval of the final version to be published.

SR & SM: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

MF: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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