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Initial Glasgow Coma Scale and Mortality after Traumatic Brain Injury: A Systematic Review and Narrative Synthesis of Prognostic Evidence

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Abstract: **Original Research**

***Background*:** Traumatic brain injury (TBI) is a major cause of death and disability worldwide. Early neurological assessment is essential for risk stratification and clinical decision-making. The Glasgow Coma Scale (GCS) remains one of the most widely used tools for evaluating level of consciousness after acute brain injury. A lower initial GCS is generally associated with increased mortality, but its prognostic value may be modified by age, pupillary reactivity, computed tomography findings, hypoxia, hypotension, and extracranial injury. ***Objective*:** This review aims to evaluate the association between initial GCS and mortality in patients with traumatic brain injury. ***Methods*:** A systematic review framework was designed according to PRISMA 2020 recommendations. Eligible studies included observational cohorts, prognostic model studies, and meta-analyses reporting initial GCS and mortality after TBI. The main outcome was mortality, including in-hospital mortality, 14-day mortality, 30-day mortality, and 6-month mortality. Because of expected clinical and methodological heterogeneity, the present version provides a narrative synthesis supported by quantitative data from major studies. ***Results*:** Evidence from large international cohorts and prognostic models supports an inverse relationship between initial GCS and mortality. In the CRASH study, 10,008 adult patients with GCS ≤14 were included, and prognostic models were developed for 14-day mortality and 6-month death or severe disability. In the IMPACT study, 8,509 patients with moderate or severe TBI were used for model development and 6,681 patients for external validation. The strongest predictors of outcome were age, motor score, pupillary reactivity, and CT characteristics. A meta-analysis including 102,132 patients found that GCS predicted mortality with an area under the curve of 0.90. ***Conclusion*:** Initial GCS is an important predictor of mortality after traumatic brain injury. However, it should not be interpreted in isolation. Prognostic assessment should integrate GCS with age, pupillary response, CT findings, hypoxia, hypotension, and extracranial injury.

Keywords: Traumatic Brain Injury, Glasgow Coma Scale, Mortality, Prognosis, Systematic Review.

INTRODUCTION

Traumatic brain injury is a major public health problem and remains an important cause of mortality, long-term disability, and socioeconomic burden worldwide [1]. Early assessment of injury severity is crucial because initial clinical decisions may influence airway management, neuroimaging, neurosurgical referral, intensive care admission, and prevention of secondary brain injury.

The Glasgow Coma Scale was introduced by Teasdale and Jennett in 1974 as a practical method for assessing impaired consciousness and coma [2]. The scale evaluates three components: eye opening, verbal response,

and motor response. The total score ranges from 3 to 15, with lower scores indicating more severe impairment of consciousness. In clinical practice, TBI is commonly classified as mild when GCS is 13–15, moderate when GCS is 9–12, and severe when GCS is 3–8 [3].

Mortality after TBI is multifactorial. It is influenced not only by the neurological condition at presentation but also by age, pupillary reactivity, CT abnormalities, hypoxia, hypotension, extracranial injury, and the quality and timing of acute care [4, 5]. Among these variables, the initial GCS has a central role because it is simple, rapid, inexpensive, and available in both prehospital and emergency department settings.

Large prognostic studies such as CRASH and IMPACT have confirmed that GCS, particularly the motor component, is strongly associated with mortality and unfavorable neurological outcome after TBI [4, 5]. However, several factors may affect the reliability of the initial GCS, including sedation, intubation, alcohol intoxication, shock, hypoxia, and facial injuries. Therefore, the prognostic interpretation of GCS should be contextual rather than isolated.

This review synthesizes the available evidence on the association between initial GCS and mortality in patients with traumatic brain injury, with emphasis on major quantitative studies and prognostic models.

Objective

The primary objective of this review is to evaluate the association between initial Glasgow Coma Scale score and mortality in patients with traumatic brain injury.

The secondary objectives are:

1. To summarize mortality risk according to TBI severity defined by initial GCS.
2. To identify clinical factors that modify the association between GCS and mortality.
3. To summarize quantitative evidence from major cohorts, prognostic models, and meta-analyses.
4. To discuss the limitations of using GCS as an isolated prognostic marker.

Methods

Study Design

This manuscript follows a systematic review framework and is structured according to PRISMA 2020 recommendations [6]. The current version provides a narrative synthesis of major prognostic studies and meta-analyses. For final journal submission, the review should include a complete PRISMA flow diagram, the exact search date, the number of records identified, screened, excluded, and included, and a formal risk-of-bias assessment.

Research question

In patients with traumatic brain injury, is the initial Glasgow Coma Scale score associated with mortality?

PICO framework

Population: Patients with traumatic brain injury.
Exposure: Low initial GCS, particularly GCS ≤8.
Comparator: Moderate or high initial GCS, including GCS 9–12 and GCS 13–15.
Outcome: Mortality, including in-hospital mortality, 14-day mortality, 30-day mortality, or 6-month mortality.

Eligibility Criteria

Studies were considered eligible if they met the following criteria:

- Included patients with traumatic brain injury;
- Reported initial GCS or one of its components;
- Reported mortality as an outcome;
- Used an observational, cohort, registry-based, prognostic model, or meta-analytic design;
- Were published in English or French.

Studies were excluded if they did not report GCS, did not report mortality, focused exclusively on non-cranial trauma, or were case reports, editorials, letters, or narrative opinions without original data.

Information sources and search strategy

The following databases should be searched for the final systematic review: PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, and Google Scholar.

A proposed PubMed search strategy is: ("traumatic brain injury" OR "head injury" OR "cranioencephalic trauma") AND ("Glasgow Coma Scale" OR GCS) AND (mortality OR death OR survival) AND (initial OR admission OR prehospital) Reference lists of included studies and relevant reviews should also be manually screened.

Data Extraction

The following data should be extracted from each included study:

- Author and year of publication;
- Country and setting;
- Study design;
- Sample size;
- Age and sex distribution;
- TBI severity;
- Timing of GCS assessment;
- GCS categories or GCS components;
- Mortality endpoint;
- Adjustment variables;
- Effect estimate or predictive performance.

Risk-of-bias assessment

The methodological quality of observational studies may be assessed using the Newcastle-Ottawa Scale [7]. For non-randomized studies evaluating prognostic associations, ROBINS-I may also be considered [8]. For meta-analyses of prediction accuracy, methodological limitations should be discussed according to the design and quality of the included studies.

Data Synthesis

Because of expected heterogeneity in populations, timing of GCS assessment, mortality definitions, and adjustment variables, a narrative synthesis is appropriate. If sufficiently homogeneous data are available after full screening, a meta-analysis may be conducted using odds ratios, risk ratios, hazard ratios, or pooled AUC values with 95% confidence intervals.

RESULTS

Overall, the available evidence supports an inverse association between initial GCS and mortality after TBI. Lower GCS values are associated with higher mortality, particularly when associated with abnormal pupillary response, older age, CT abnormalities, hypoxia, hypotension, or major extracranial injury.

Table 1: Major studies reporting quantitative evidence on initial GCS and mortality after traumatic brain injury

Author, year	Study design and population	Sample size	Mortality endpoint	Key quantitative findings	Interpretation
MRC CRASH Trial Collaborators, 2008 [4]	International cohort of adult TBI patients with GCS ≤14 enrolled within 8 hours after injury	10,008	14-day mortality; 6-month death or severe disability	Prognostic models included age, GCS, pupillary reactivity, major extracranial injury, and CT findings	Initial GCS was a major predictor of early mortality and 6-month outcome
Steyerberg *et al.*, 2008, IMPACT model [5]	Individual patient data from 11 studies of moderate and severe TBI	8,509 for development; 6,681 for external validation	6-month mortality and unfavorable outcome	Strongest predictors: age, motor GCS, pupillary reactivity, CT characteristics; core model AUC 0.66–0.84; external validation AUC approximately 0.80	The motor component of GCS had strong prognostic value
Singh *et al.*, 2013 [12]	Systematic review and meta-analysis comparing GCS	5 retrospective studies; 102,132	Mortality and other TBI outcomes	Mortality prediction: GCS AUC 0.90, 95% CI 0.88–0.91;	GCS predicted mortality slightly better than

	with Simplified Motor Score	patients		Simplified Motor Score AUC 0.87, 95% CI 0.86–0.88; p=0.01	Simplified Motor Score
Reith *et al*., 2017 [14]	Observational analysis of TBI patients	54,069	Mortality and clinical outcome	The three GCS components provided complementary prognostic information; component profiles were more informative than total score alone	Separate reporting of eye, verbal, and motor components may improve prognostic assessment
Roozenbeek *et al*., 2012 [16]	External validation of IMPACT models in the Brain Trauma Foundation TBI-trac database, severe TBI with GCS ≤8	3,125 in database; 2,513 included	14-day mortality	Observed 14-day mortality 23%; AUC 0.79 for Core model and 0.83 for Extended model	IMPACT models showed good discrimination for early mortality in severe TBI

Table 2: Clinical interpretation of mortality risk according to GCS severity and associated prognostic modifiers

Clinical category	Definition or quantitative anchor	Expected mortality pattern	Key modifiers	References
Mild TBI	GCS 13–15; CRASH included mild TBI in approximately 30% of 10,008 patients	Generally low mortality, but not negligible in elderly patients or in patients with abnormal CT findings	Age, anticoagulation, CT lesions, clinical deterioration	[4, 5]
Moderate TBI	GCS 9–12; IMPACT focused on moderate to severe TBI with GCS ≤12	Intermediate mortality risk	Age, motor response, pupils, CT classification, hypoxia, hypotension	[5]
Severe TBI	GCS 3–8; BTF TBI-trac severe TBI cohort reported 14-day mortality of 23% among included patients	High mortality risk	Pupillary non-reactivity, hypotension, hypoxia, mass lesion, raised intracranial pressure	[9, 16]
Low motor GCS	Motor score included in IMPACT Core model	Lower motor response is associated with worse 6-month outcome	Sedation, paralysis, spinal cord injury, intoxication	[5, 14]
Low GCS with abnormal pupils	Included as a major prognostic pattern in CRASH and IMPACT models	Very high mortality risk compared with low GCS alone	Bilateral non-reactive pupils, intracranial mass lesion, raised intracranial pressure	[4, 5]
Low GCS with hypoxia or hypotension	Secondary insults included in the IMPACT Extended model	Mortality risk increases compared with isolated low GCS	Oxygenation, blood pressure, time to resuscitation	[5, 9]
GCS plus CT abnormalities	CT characteristics improved model discrimination in IMPACT	Higher risk when GCS depression is associated with traumatic subarachnoid hemorrhage, mass lesion, or compressed basal cisterns	CT class, tSAH, epidural hematoma, midline shift	[5]
Prognostic models including GCS	CRASH and IMPACT models	Good discrimination for mortality and unfavorable outcome	Local case-mix, treatment setting, quality of acute care	[4, 5, 16]

Synthesis of Findings

The evidence consistently indicates that initial GCS is associated with mortality after traumatic brain injury. Patients with GCS ≤8 represent a high-risk group, especially when low GCS is accompanied by non-reactive pupils, hypoxia, hypotension, or severe CT abnormalities [4, 5, 9, 16].

The IMPACT model demonstrated that age, motor GCS, pupillary response, and CT findings are among the strongest predictors of 6-month outcome [5]. The CRASH model similarly incorporated GCS as a key variable for predicting 14-day mortality and 6-month death or severe disability [4].

The meta-analysis by Singh et al. showed that GCS had strong predictive accuracy for mortality, with an AUC of 0.90 [12]. However, the clinical significance of the difference between GCS and Simplified Motor Score was considered uncertain, and the included studies were retrospective.

The study by Reith *et al*., supports the multidimensional use of GCS components rather than reliance on the sum score alone [14]. This is clinically important because the total GCS may conceal different neurological patterns. For example, two patients may have the same total score but different eye, verbal, and motor responses, leading to different prognostic implications.

DISCUSSION

This review supports the prognostic value of the initial Glasgow Coma Scale in traumatic brain injury. Across large cohorts, prognostic models, and meta-analytic evidence, lower GCS is associated with higher mortality. However, the strength of this association depends on patient characteristics, injury severity, and the presence of secondary insults.

The main advantage of GCS is its simplicity. It can be assessed rapidly in prehospital, emergency department, and intensive care settings. It provides a common clinical language for describing consciousness and helps guide early triage and management.

Nevertheless, GCS has limitations. The score can be affected by intubation, sedation, alcohol intoxication, drugs, facial trauma, aphasia, hypoxia, hypotension, or spinal cord injury. In intubated patients, the verbal component may be impossible to assess. In sedated or paralyzed patients, the motor response may not reflect the true neurological state.

The evidence from IMPACT suggests that the motor component of GCS may be particularly important for outcome prediction [5]. This is clinically relevant because the motor response is often more reliable than the verbal response in severely injured or intubated patients.

Another important finding is that GCS should not be used alone. The CRASH and IMPACT models improved prognostic assessment by combining GCS with other variables such as age, pupillary reactivity, CT findings, hypoxia, hypotension, and extracranial injury [4, 5]. This multidimensional approach is more appropriate for clinical decision-making than an isolated GCS threshold.

The Brain Trauma Foundation guidelines also emphasize the importance of preventing secondary brain injury in severe TBI, particularly by avoiding hypotension, treating intracranial hypertension, and maintaining adequate cerebral perfusion [9]. Therefore, a low GCS should trigger urgent assessment and management, but it should not be used as the sole determinant of prognosis or treatment limitation.

Strengths and limitations

This review summarizes evidence from large international studies, validated prognostic models, and meta-analytic data. It highlights both the clinical usefulness and the limitations of initial GCS as a mortality predictor after TBI.

However, several limitations must be acknowledged. First, the included studies differ in population, setting, injury severity, timing of GCS assessment, and mortality endpoint. Second, some studies report total GCS, whereas others emphasize the motor component or individual GCS components. Third, confounding is a major issue, because patients with low GCS often have other markers of severity, including abnormal pupils, CT lesions, hypoxia, hypotension, and extracranial trauma.

Finally, this manuscript should be completed with a full PRISMA search and screening process before journal submission. The final version should include the exact number of records identified, duplicates removed, studies screened, full-text articles assessed, and studies included.

Clinical Implications

Initial GCS should be systematically assessed in all patients with traumatic brain injury. A GCS ≤8 should be considered a high-risk finding and should prompt urgent evaluation, airway protection when clinically indicated, correction of hypoxia and hypotension, early CT imaging, intensive monitoring, and neurosurgical consultation when appropriate.

However, prognosis should never be based solely on GCS. Clinical interpretation should integrate age, pupillary response, CT findings, physiological status, extracranial injuries, and the effects of sedation or intoxication.

CONCLUSION

Initial Glasgow Coma Scale is strongly associated with mortality after traumatic brain injury. Lower GCS scores, particularly GCS ≤8, are associated with a higher risk of death. The motor component appears especially important for prognostic assessment.

However, GCS should be interpreted within the broader clinical context. Age, pupillary reactivity, CT abnormalities, hypoxia, hypotension, and extracranial injury substantially modify prognosis. Prognostic models such as CRASH and IMPACT provide a more comprehensive approach by integrating GCS with other clinically relevant variables.

For publication as a high-quality systematic review, this manuscript should be finalized with a complete PRISMA flow diagram, formal risk-of-bias assessment, and, if feasible, a quantitative meta-analysis.

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