REVIEW ARTICLE

TRAUMATIC BRAIN INJURY ASSESSMENT USING GLASGOW COMA SCALE: A LITERATURE REVIEW

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Objective: The objective of this study was to analyse the Glasgow Coma Scale (GCS) reporting and recognize causes for inaccuracy of GCS implications. **Literature selection and critical appraisal:** Literature search was carried out by using specific keywords on PubMed, Google Scholar, and Science Direct. The GCS definitions, present status of GCS reporting, frequency and time of assessment, assessment schemes and confounders were critically analysed. **Results:** More than 90% of the publications using GCS scoring cite the 14-item GCS rather than the 15-item GCS. The timing of the initial GCS assessment is inconstant. GCS components are seldom utilized, contributing to the loss of information. Confounders are often not reported and, if they are, not in a standardized manner. The order of the GCS components is not consistent. **Conclusion:** The current inconsistent and inappropriate use of GCS diminishes its reliability in both clinical and scientific context. A consensus statement is needed to correct this situation. Citing the correct references, early and repeated GCS assessments at defined intervals, standardized reporting of confounders and GCS component and scores. Utilization of a uniform assessment scheme is recommended.

Keywords: Neurological evaluations, Glasgow Coma Scale, Coma, Brain injury, Accident, Trauma

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INTRODUCTION

The Glasgow Coma Scale (GCS) score has become the standard criterion to assess the neurological status of brain-injured patients. The GCS was developed in 1974 as an effort to assess different groups of patients with altered levels of consciousness[1], and to improve communication between healthcare personnel caring for patients with impaired consciousness. After modification, a new GCS based on a 15-point numeric score was adopted for the assessment of traumatic brain injury (TBI).[2]

The three components (eye-opening, verbal and motor response) of the GCS assess the function of the cerebral cortex and the upper brainstem, the reticular activating system. The eye-opening response measures the arousal mechanism of the brainstem; the verbal response, the integration of cerebral cortex and brainstem; and the motor response, the integrity of cerebral cortex and spinal cord.[3]

The GCS has some limitations. For example, brainstem reflexes and eye movements are not considered. The GCS is, however, an important instrument for decision making, which is used in combination with other diagnostics such as CT scan and pupillary reaction. These evaluations can indicate the need for referral to a tertiary hospital with on-site neurosurgical facilities like CT scanning after brain injury or surgery.[2]

The purpose of this review was to describe the current state of inter-rater reliability and accuracy of GCS scoring and to identify reasons for any shortcomings. In addition, this study proposes strategies for more consistent and accurate scoring, hopefully initiating a consensus process for improved GCS scoring.

SELECTION OF LITERATURE

By using specific keywords on PubMed, Google Scholar, and ISI web, literature was searched for period of publication from 2012 to 2021. Two comprehensive searches were conducted. Firstly, the term GCS and Glasgow Coma Scale were distinctly combined as acronym with agreement, inter-rater, accuracy, precision and performance. Secondly, GCS and Glasgow Coma Scale were combined with instrument, education, and training. For further articles there were no language-related restrictions in searches.

All types of research methods like randomized control trials, registered case studies, cohort studies, databases, case series, case studies, and abstracts were included for search. Letters and comments were excluded for the study. Present situation of GCS reporting, its time, definitions, confounders and frequency of assessment, assessment plans, and scoring were critically analysed.

MAJOR FINDINGS FROM LITERATURE

Latest picture of GSC scoring

Many studies were conducted in early 1990s, focused on diverse professional cohorts and diversity of approaches, but GCS were not documented in pre-hospital setting. Lack of 56% of cases of pre-hospital GCS assessment in traumatic brain injury patients was noted. This lack of performance based on experience of healthcare professionals. Highly experienced

professionals showed greater inter-rater consistency as show in Table-1. This inter-rater consistency was not absolute even in trained physicians. A recent study conducted in Emergency Department showed only 32% of cases were assessed by well-trained physicians.[4]

One study investigating inter-rater reliability and accuracy of GCS in nurses working in different acute medical settings was based on videotaped patients.[5] Among non-physicians and physicians, inter-rater reliability was observed, however same limitations were observed between nurses and physicians (Table-2). Only one-third of these nurses correctly rated the motor component of the GCS, about one-half the eye-opening component, and >80% correctly rated the verbal component. Nurses with more neurosurgical experience and a higher educational qualification rated more accurately.[5] Similar results were observed as among physicians or among nurses (Table-3, 4).

In one-third of cases, assessment is inappropriate scoring of GCS. Accuracy and inter-rater reliability differ according to variety of healthcare professionals and their experience. Differences were observed between the same specialties, and also in inter- and intra-canter GCS assessment. In patients with unchanged state of consciousness and high variability, GCS scoring will be misleading low, and this will be misleading healthcare professionals for needless referrals, CT-scans and surgical interventions. It is astonishing that in last 25 years, there were insufficient initiatives for quality improvement of GCS scoring accuracy.[6,7] Contributing factors to inappropriate GSC scoring are stated below (Table-5, 6).

Table-1: Comparison studies of (EMS-GCS) pre-hospital GCS assessment, and (ED-GCS) hospital GCS assessment

Sample size	Study setting	Types of patients	Pre-hospital HCP	Hospital HCP	Major research findings	Research limitations	Reference
n= 12882	ED, field	Major injury	Paramedics	ED staff	Strongly correlated	Some registered data was missing	8
n= 3052	ED, field	Injury	Paramedics	ED staff	GCS agreement: moderate-high	Time difference > 20 mints	9
n=7823	Not defined	Injury	Paramedics	ED physician	Very strong relationship	Short description of GCS categories	10
n= 33	Field, ED,	TBI	Paramedics	ED staff	No correlation	Small sample size	11
n= 60	ED, Field	TBI	Pre-hospital physician	Senior physician	2 points under estimation of (EMS-GCS)	Time gap 32 mints	12

*n: Number of Patients, HCP: Health Care Provider

Table-2: GCS performance comparison between inexperienced and experienced healthcare provider

Research Setting	Type of patients	Inexperienced HCP	Experienced HCP	Major findings	Limitations	Reference
ED	Neurological	Nurses with <2 years' experience	Experienced Nurses	Incompetent eye assessment in GCS among inexperienced nurses	No regularity of verbal stimulus	13
Computer lab	Trauma	4th Professional medical students	Senior physician	Correct response was moderate (>75%)	14 points tool	14
Neurosurgical wards	Multiple trauma	4th Professional medical students	Senior physician	Correct response was mild (<50%)	Various countries setting	15
Trauma Centres	Traumatic brain injury	Nursing students	Registered nurses	Mild accuracy among nursing students	Small sample size	16
	Traumatic brain injury	Medical assistants	Physicians	Variability was greater among inexperienced HCP	Small sample size	17

ED: Emergency Department, TBI: Traumatic Brain Injury, HCP: Healthcare Provider

Table-3: Studies regarding GCS performance comparison between physicians

Research Setting	Type of patients	Physician 1	Physician 2	Major findings	Limitations	Reference
ED	Neurological	Residents	Emergency physicians	Inter-rater compatibility was moderate	Small sample size	18
Paediatric ED	Blunt TBI	Emergency physicians	Emergency physicians	Inter-rater compatibility was Good	Most of GCS was high	13
ED	Medical Neuro	Emergency physicians	Emergency physicians	Inter-rater compatibility was moderate	None for field exposure	19
ED	ND	Community physicians	Neuro Surgeon	63% similarity in GCS Assessment	Small sample	20
ED	Surgical trauma	Emergency physicians	Emergency physicians	Inter-rater compatibility was good	GCS was high as 15 in 41%	21
Neuro Wards	Vascular and tumour disorders	Neuro surgeon	Neuro surgeon	Inter-rater compatibility was low	Small sample	22
Neuro ICU	Brain haemorrhage	ICU physicians	ICU physicians	Inter-rater compatibility was moderate	Assessment interval was long	17

ED: emergency department, ND: not defined, ICU: intensive care unit

Table-4: Studies regarding GCS performance comparison between nurses

Research Setting	Type of Patients	Nurse 1	Nurse 2	Major Findings	Limitations	Reference
Videotapes, class room	Trauma	CCU, ICU, PACU, ED, NICU Nurses	Experienced nurses	Congruence and accuracy was moderate	No Field Work	14
Emergency Unit	Poisoned	Emergency nurses	Emergency nurses	Inter-rater congruence was Good	Sample size was small	15
Intensive Care Unit	Unconscious, intubated	Intensive care Unit Nurses	Intensive care unit nurses	Inter-rater congruence was good	Sample size was small	20

PACU: post-anesthesia care unit, CCU: coronary care unit, GCS: Glasgow Coma Scale, NICU: neonatal intensive care unit, ICU: intensive care unit. ED: emergency department

GCS sub-scoring

Mattei and Teasdale[1] initially recommended presenting the sub-score information by means of a profile, but in subsequent publications the use of a sum score was proposed.[23] Accordingly, many studies that include patients with TBI report only the GCS sum score. Providing only the total score results is a significant loss of information and may diminish predictive validity.

Different Definitions of the GCS

A 14-item GCS tool consisting of three components: best verbal response (5 points) the best motor response (5 levels) and best eye-opening response (4 points), appeared in 1974.[1] Two years later, articles with 15 points GCS scale were published.[2] One point increased in the best motor response as kind of flexion was categorized into two categories of abnormal flexion and withdrawal. Later in 30 years, mostly researchers adopted the 15-points GCS, however several most referenced articles were not succeeded to even referring the 14-point GCS[24], which mislead researchers as inaccurate GCS scoring in clinical practices and clinical research and educational programs.

GCS assessment time and frequency

The GSC scoring was recognized for in-hospital practice for untreated patients in intensive care emergency units, and neurosurgical wards (Post resuscitation GCS).[7] Later on, when modern emergency medical services were established, GCS performed as pre-hospital assessment[25] exposed no association in pre-hospital and hospital GCS evaluation. There was no analytical value of pre-hospital GCS about the outcome. It was recommended that GCS was efficiently associated with hospital admission.

More than 9,000 moderate to severe non-intubated traumatic brain injury patients had correlation coefficient of 0.67. The mean GCS was 11.4 on scene and 11.5 on hospital admission. There was difference between emergency department and pre-hospital GCS assessment findings in patients with different transport timings. It also reported by Leitgeb *et al*[6], but in contrast no change over time was observed by another study[17]. In Europe where physicians' practice outside the hospital is common, GCS is less common in hospital assessments, often based on inappropriate analysis of data.

Confounding Factors

Managing traumatic brain injury patients with anaesthesia, neuromuscular blockers, and endotracheal intubation makes GCS evaluation a challenge. There are different methods for assessing the oral and ocular opening of the GCS in patients who are intubated and/or sedated. GCS scoring is valid in neuromuscular blockers, irreversible tetraplegia and polyneuropathy. In some hospitals, medical professionals rate each eye open and 1 point for oral response to narcotics and intubated patients. Some defer the rate of the eye-opening component until the anaesthesia and analgesia subside, although they rate the noise response by a score of 1.[26]

There are other factors that affect GCS accuracy in traumatic brain injury. The GCS can predict brain injury in 13% of patients with traumatic brain injury. GCS scoring is low and inaccurate in narcotic and intubated patients.[26] Pharmacologically induced coma also lowers GCS scoring ratings and many research studies ignore to discuss these confounders.

GCS Assessment Planning

Currently, there are two GCS schemes in use each with different sequences of the three components. One sequence is listed as best eye opening, best motor, and best verbal responses (E-M-V sequence); and the other, as best eye-opening, best verbal and best motor responses (E-V-M sequence). Studies that do not mention the sequence of tested GCS components tend to use the E-V-M sequence. This sequence may be preferable as it follows the sequence of a systematic clinical investigation of the patient as well as the increasing number of the maximal sub-score (E: 4, V: 5, and M: 6), making memorization and application easier.

Implication for Practice

Literature suggests the best use of GCS scoring (E4, V5, M6). Correct referencing is important for accurate use of an instrument, otherwise biases and uncertainty may be introduced.[18]

Table-5: Comparison studies about GCS scoring between physician and non-physician

Research Setting	Type of patients	Physicians	Non-physicians	Major findings	Limitations	Reference
Emergency Unit	Neurological	Emergency physicians	Emergency nurse	Inter-rater congruence was low	Self-selection bias, most with high GCS	27
Emergency Unit	Neurological	Not defined	Emergency medical technician	Inter-rater congruence was good	Fluctuations of GCS assessment time	28
Videotapes	Not defined	Emergency physicians	Paramedical staff	2 points GCS under assessment by paramedics	Sample size	29
Emergency Department and community setting	Trauma patients	Emergency physicians	Paramedical staff	Inter-rater congruence was excellent	No field experience	15
Videotapes	Neurological patients	Intensive Care physicians	ICU and emergency nurses	Inter-rater congruence was moderate	No field experience	26
Films	Not defined	Neurosurgeons	Neuro surgical and medical nurses	Inter-rater congruence was moderate	Only motor response, 14-point scale	17

Table-6: Studies about major trials regarding use of GCS among brain trauma patients

Study content	Research design	Study setting	Assessment sequence	GCS scoring	GCS definition	References
Data Bank about traumatic coma	Prospective Cohort	Emergency and intensive care units	Eye, verbal, motor	Sum score	Not defined	17
TBI and emergency services	Prospective Cohort	Emergency ward	Motor	Components score (As Eye, Verbal, Motor)	6 points	11
TBI risk factors and seizures in TBI	Prospective Cohort	Not defined	Eye, verbal, motor	Sum score	15 points	13
Rules for CT scan	Randomized Control Trial	Field	Not defined	Sum score	15 points	1
TBI and hypothermia	Randomized Control Trial	Emergency unit	Not defined	Sum score	15 points	9
TBI and hypertonic saline	Randomized Control Trial	Emergency unit	Not defined	Sum score	15 points	16
TBI and corticosteroids	Randomized Control Trial	Emergency unit	Eye, verbal, motor	Sum Score	Not Defined	3

Initial and Subsequent GCS Reassessment

Out-of-hospital emergency medical services are key players in the assessment of consciousness. They have the opportunity to assess the patient at an early stage before beginning resuscitation. Therefore, in the pre-hospital setting this study proposes to assess the GCS upon initiating the ABCDE resuscitation, but before endotracheal intubation. To obtain the most reliable information, GCS assessment should be performed repeatedly within the first 24 hours and include data from the prehospital setting. All assessments should be reported. This proposition is based on the observation that GCS scores of up to 30% of all TBI patients deteriorated or improved secondarily when compared to initial values.[20]

Accurate documentation of the time point of GCS assessments including the approximate time of injury or the documented time could be highly relevant for the estimation of brain injury severity and for research purposes.[16]

Confounder identification

GCS scoring is evidently affected by many confounding reasons like sedation, alcohol, and endotracheal intubation (Table-7).

Table-7: Confounders that affect GCS scoring

Injury
Multiple injuries
Periorbital swelling in facial trauma
Eye injury
Spinal injury
Hypoxia in thoracic injury
Hypotension in shock
Neuromuscular diseases
Medical disorders
Cerebral diseases
Sedatives
Medicines
Mechanical devices

Component reporting

As others[14], this study proposes to report the GCS components in addition to the sum score. This component reporting may avoid loss of information, and improve accuracy as verified with GCS of 4. The E1, V2, M1 had a mortality rate of 28%, while the mortality rate was twice high (52%) with E1, V1, M2 combination.

Uniform Scheme utilization

The same GCS scheme is easy to communicate and memorize. This study highlight the components of GCS

in the pattern of best eye openings, positive verbal, and motor responses (4-5-6) that sequence demonstrates sound clinical trials.

1. Talk patiently (Open eyes)
2. Try to respond quickly with words
3. Assess for motor response

An identical plan also improved the accuracy and inters-rater reliability as proven by 4th year students from Switzerland, Basel University.[27]

Consensus Statement Call

Many distracting factors are associated to inaccurate, variables and absent characterizations are involved in GCS assessment. Hence an agreement supported by international experts and based on best evidence are required. Following situations should require for GCS assessment:

1. During a primary examination prior to difficult interventions
2. For sedated and intubated patients

Leads for Quality Improvement Plans

The local quality improvement plan will be mandatory for the effective use of the GCS as it proves that GCS scores and confusing test training are important. A study emphasized that complicated programmes are capable, if provision of Pre- and Post-GCS assessment training Programme is added.[19] For GCS assessment, written checklist must be part of these training sessions. Practical skills for GCS assessment for exercise on real life simulation scenarios for knowledge enhancement for patient management and treatment as well as computer-based training tools are also useful.[18]

Research for Level of Consciousness Assessment

Elements made easier to report only part of the motor assessment that may increase road reliability and accuracy reduced each analysis as evidenced by Alhassan *et al*[14], an increase inter-rater reliability between 83%, compared to 71% of motor assessment and 42% of GCS through motor component. However, these results are less reliable because they have been tested in undiagnosed trauma patients, not in traumatic brain patients.

The independent variables that were related to the GCS scores were pupillary reaction, CT visibility and age. Opening of the eyes and oral constituents were also very essential. The most appropriate analysts were the period for prothrombin, glucose, platelets, haemoglobin, hypoxia, and hypotension. GCS during hospitalization and other forecasts play an important role in long-term outcomes. It is important to inspect the GCS motor component from pre-hospital admission to within 24 hours after injury.

A new scale for coma having four points was recently introduced in the emergency departments and in Intensive Care Units.[20] These four points have four elements (visual response, motor response, mental thinking, and breathing) but they do not have an oral response, they are important for intubated patients. Recent studies have proven that four points are better for decision making compared to GCS motor component. With long-term results, the motor component of GCS segment with student responses has shown strong analysists.

CONCLUSION

All possible factors of inaccuracy in assessment of GCS scoring are acknowledged in researches and clinical practice because each one of these possible factors can be modified. GCS scoring improved performance and enhanced the quality of GCS by using standardized approach. For correction of this situation by applying early and repeated GCS assessment in defined intervals, accurate reference, standardized reporting, GCS components and scores, and constant assessment schemes are suggested. A recognized board agreement articulation ought to stimulate quality advancement programs for more accurate and dependable GCS scoring.

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