The Glasgow Coma Scale at 40 years: standing the test of time

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Since 1974, the Glasgow Coma Scale has provided a practical method for bedside assessment of impairment of conscious level, the clinical hallmark of acute brain injury. The scale was designed to be easy to use in clinical practice in general and specialist units and to replace previous ill-defined and inconsistent methods. 40 years later, the Glasgow Coma Scale has become an integral part of clinical practice and research worldwide. Findings using the scale have shown strong associations with those obtained by use of other early indices of severity and outcome. However, predictive statements should only be made in combination with other variables in a multivariate model. Individual patients are best described by the three components of the coma scale; whereas the derived total coma score should be used to characterise groups. Adherence to this principle and enhancement of the reliable practical use of the scale through continuing education of health professionals, standardisation across different settings, and consensus on methods to address confounders will maintain its role in clinical practice and research in the future.

Introduction

It is now difficult to envisage the chaos that characterised the assessment of patients with a head injury or other acute brain insult before the mid-1970s. Repeated observation of, what was termed at that time, conscious level was regarded as essential, but collection and exchange of data were undermined by ill-defined and inconsistent methods. Most investigators sought to divide the spectrum of altered consciousness into different constellations of discrete levels on the basis of terms such as comatose, sub-comatose, obtundation, stupor, semi-purposeful, and posturing. These terms now seem perplexingly vague and obscure. As a result, there were delays in detection of clinical changes,[1] avoidable morbidity and mortality,[2] and barriers to drawing reliable conclusions from research findings.

40 years ago, the description in *The Lancet*[3] of what was later termed the Glasgow Coma Scale aimed to address the confusion resulting from these vague terms by proposing a practical approach, likely to be widely acceptable, through structured assessment of defined responses to stimuli. In this Personal View, we will examine the extent to which the original aspirations of the authors have been fulfilled, address some myths and misapprehensions, examine criticisms, and give our view of the continuing role of the scale in research and clinical practice. Although the scale has found wide application, our main focus is on its use in adults with traumatic brain injury, for whom most data are available.

Development and adoption of the scale

The rumour that the Glasgow Coma Scale was conceived in a bar in Glasgow is, sadly, not true.[4] Its development began in 1971, as an instrument to improve the clinical care of people with acute brain injury and to increase understanding of the prognosis of those with severe brain damage.

The research that produced the scale took place in the Neurosurgical Unit at the Institute of Neurological Sciences in Glasgow, UK, a multidisciplinary clinical unit that provided specialist services in the west of Scotland. This regional unit was responsible for all specialist services in an area with population over 3 million. About 50 000 people per year attended the local general hospitals, where those patients that had to be transferred to the Neurosurgical Unit were assessed and identified. This process was applied not only to head injuries but also to other acute brain disorders, such as stroke, and especially subarachnoid haemorrhage. The need for clear, consistent clinical communication between local hospitals and specialist units was a major stimulus to develop the scale. A second incentive was the need to link information about a patient's state at initial admission with their outcome.

A critical review of clinical practice and the literature at that time underlined the notion that there was no general agreement on how to assess and monitor level of consciousness.[3] Approaches that depended on the concept of focal pathoanatomical substrates for impaired consciousness, such as decorticate and decerebrate posturing, were rejected as inconsistent as the importance of diffuse brain damage in head injury,[5] as well as in coma caused by hypoxia, metabolic disorders, or poisoning, was better understood.

Systematic assessments of different methods in patients in the Neurosurgical Unit showed the fallacy of the then common presumption of discrete one-dimensional levels of conciousness. Built upon earlier multidimensional approaches,[6,7] the scale was based on three different aspects of response (figure 1, panel 1). Verbal and motor responses had appeared in various forms in previous assessment instruments; opening of the eyes was included to avoid the need for judgments about arousal and awareness. A shortlist of terms that could be clearly defined and graded was refined through pioneering studies of interobserver agreement, then in their infancy in neurology.[8] The implementation of the scale received much input from junior doctors and nurses, and also from colleagues elsewhere (especially Reinder Braakman [Erasmus University, Rotterdam, Netherlands], David Shaw [University of Newcastle, Newcastle upon Tyne, UK], and Fred Plum [Cornell University New York, NY, USA]).

The Glasgow Coma Scale was aimed to complement, not to replace, other assessments of neurological

function.[3] Its simplicity and ease of communication were attractive to health professionals caring for patients with acute brain injury. Presentation of trends in the findings on a specially designed chart allowed detection of clinical changes (figure 1), and nurses rapidly welcomed the clarity of such visual display.[9]

The description of the Glasgow Coma Scale and, 1 year later, of its sister the Glasgow Outcome Scale (which included the categories death, vegetative state, severe and moderate disability, and good recovery[10]) along with their use in international comparisons,[11] coincided with an upsurge of research interest in head injuries. This interest was spurred by new knowledge on traumatic brain injury, especially of its pathophysiology and the importance of secondary damage. CT was introduced in many centres, and there was rapid expansion in the number of intensive care units. Interdisciplinary communication and research needed standardised methods to report initial severity and outcome. 4 years after the original Article in *The Lancet*, an editorial in the *Journal of Neurosurgery*[12] called for neurosurgical units worldwide to adopt the Glasgow Coma Scale and standardised outcome measures to assess head injuries. Thereafter, the scale was increasingly used in clinical practice internationally and became an expected component of research articles.[13]

The role of the scale in clinical practice was influentially endorsed by the first edition of the Advanced Trauma Life Support Course, which recommended its use for the assessment of level of consciousness.[14] In 1988, the World Federation of Neurosurgical Societies (WFNS) used it as the basis for their recommendations about grading of patients with subarachnoid haemorrhage.[15] It became a fundamental component of clinical guidelines and an integral part of trauma or critical illness management.[16] The Glasgow Coma Scale is now used by neurosurgeons and other health-care professionals in more than 80 countries, is the only method in use for assessment of head injuries in 80% of these countries, and has been translated into the national language in 74% of countries (appendix). The recommendation of the Neurotrauma Committee of the WFNS for the incorporation of data from the Glasgow Coma Scale into the injury and neurology sections of the 11th edition of the International Classification of Disease (ICD-11) has been accepted by WHO.

Scaling, scoring, and classifying with the Glasgow Coma Scale

Soon after the description of the scale, each level of response was assigned a number—the worse the response, the lower the number. The steps in the eye opening, verbal response, and motor response subscales could then be communicated as three numbers (eg, E1, V2, M3, etc), allowing entry of clinical findings into a computer-based databank.[11] The convenience of summing the separate scores into a single total score was soon recognised.[17] This total score provided a useful overview for clinicians to summarise research findings, but also had other consequences, which were not foreseen at the time and were not always desirable.[18] These consequences included its attraction to clinicians as a shorthand but less informative replacement for the full description of the three responses, the potential for confusion about the number of points in the total score, and the uncertainty about how best to deal with missing or untestable components when adding separate subscales into a total score.

When numbers were allocated to each component, a score of 1 was used to indicate an absence of response.

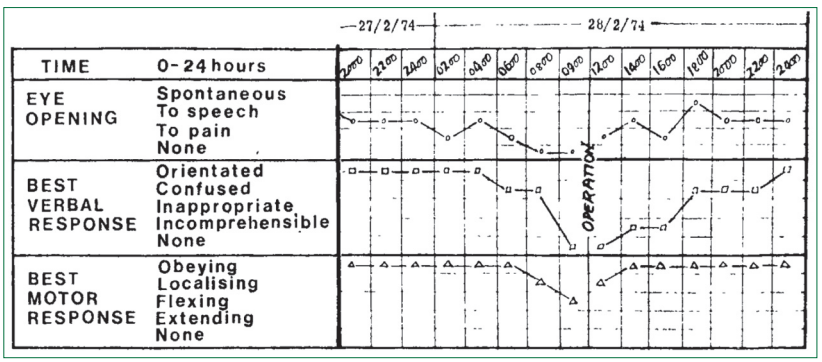

Figure 1: **Chart to record assessment of consciousness with the Glasgow Coma Scale**
The separate components of the scale were incorporated into a chart to record and display the repeated observations of nurses. Changes over time in the steps in each component clearly conveyed trends in the patient's condition: an initial deterioration despite conservative medical actions, leading to a decision to remove an intracranial lesion, which was followed by recovery. The motor subscale used at that time was later expanded to include subdivision of flexion responses. Reproduced from Teasdale and Jennett.[3]

Panel 1: **Glasgow Coma Scale**

Eye opening (E)
1 None
2 To pressure
3 To speech
4 Spontaneous

Verbal response (V)
1 None
2 Sounds
3 Words
4 Confused
5 Orientated

Best motor response (M)
1 None
2 Extension
3 Abnormal flexion
4 Normal flexion (withdrawal)
5 Localising
6 Obeying commands

Each component is assessed by a standardised approach that permits objective evaluation and documentation of information about the level of consciousness. Changes in terminology from the original 1974 version (figure 1) are incorporated.

See **Online** for appendix

This system resulted in the lowest total score being 3, even though a range starting at zero might have been more logical. Confusion about the maximum possible score was caused by the introduction of the distinction between normal and abnormal flexion in the motor response componant. In the original description (targeted towards clinical monitoring by nurses and junior doctors) this distinction had not been made because studies of observer variability showed that this assessment was difficult for less experienced staff.[8] However, the distinction proved useful for prognosis. When the revised score was described in 1979,[17] the motor component of the scale contained six categories, resulting in an upper total of 15 (panel 1), compared with a total of 14 with the earlier system.

The acronym GCS can refer to either the Glasgow Coma Scale (individual components) or the Glasgow Coma Score (total sum of components) and their roles can become confused. The scale is most applicable to the management of the individual patient, whereas the score is best suited to summarise information about groups of patients.

	Date	Total cases (% that died)	Proportion that were severe (% that died)	Proportion that were moderate (% that died)	Proportion that were mild (% that died)
Thornhill and colleagues, 2000*	1995–1996	2903 (9%)	3% (38%)	5% (16%)	90% (8%)
Trauma Audit Research Network†	2003–2013	34 977 (18%)	22% (46%)	12% (20%)	71% (8%)

Severe denotes Glasgow Coma Score of 3–8, moderate is a score of 9–12 , and mild a score of 13–15. Most cases in each series were mild, but more so in the study by Thornhill and colleagues[21] because patients admitted for less than 72 h were not included in the Trauma Audit Research Network database.The table shows the results of the more restricted policy for inclusion in the Trauma Audit Research Network. Mortality is similar in the groups with equivalent severity in each series. Higher overall mortality in the Trauma Audit Research Network database was associated with higher proportion of severe injuries. *All adults admitted to a hospital in Glasgow; outcome 1 year later. Data from Thornhill and colleagues.[21] †Patients of all ages, either those that died or were admitted for 3 days; outcome at discharge or 30 days after admission. Data provided from the Trauma Audit Research Network database (Lecky F, Jenks T; personal communication).

Table 1: **Mortality in studies that used Glasgow Coma Score to categorise patients with different head injuries into subgroups of severe, moderate, and mild injuries**

	Measure	Findings
Metabolism	$CMRO_2$; CMRglc	Decreased levels of $CMRO_2$ as Glasgow Coma Scale score gets lower;[26,27] cortical grey matter CMRglc correlated with score on Glasgow Coma Scale[28]
Intracranial volume or pressure dynamics	Intracranial pressure	Raised intracranial pressure more common in patients with Glasgow Coma Scale score 8 or lower[29]
Structural damage	CT and MRI	More CT abnormalities and lower values for apparent diffusion coefficient and fractional anisotropy in patients with lower scores on the Glasgow Coma Scale[30]
Electrophysiology	Evoked potentials	More abnormalities in patients with lower score on the Glasgow Coma Scale[31]
Blood biomarkers	S-100B, NSE, GFAP, UCHL-1	Increased serum concentrations in patients with lower score on the Glasgow Coma Scale[32,33]

$CMRO_2$=cerebral metabolic rate of oxygen. CMRglc=cerebral metabolic rate for glucose. NSE=neuron-specific enolase. GFAP=glial fibrillary acidic protein.

Table 2: **Relation of the Glasgow Coma Scale to early indices of severity of brain injury**

The use of the Glasgow Coma Score to subdivide the continuum of head injury severity has become common practice in neurotrauma research. The practice started when a score of 8 was used to signify a severe head injury in the Traumatic Coma Data Bank;[19] this score corresponded broadly to the characteristics that were the criteria for inclusion into the original data bank (E1, V≤2, and M≤5).[11] The growing research interest in the effects of mild head injuries led to investigators then classifying patients with mild head injury by scores of 13–15.[20] The designation of those with scores of 9–12 as patients with moderate injuries then occured (table 1).[22]

Despite this ad hoc rather than scientifically grounded classification, it has been useful to provide a summary overview of injury severity within and between series of patients (table 1). Nevertheless, the validity of the cutoff points could be challenged. The grouping together of patients with a score of 13–15 as those with mild injuries might be useful epidemiologically, but might group together patients with differing levels of risk of an early complication or of likelihood of an adverse late outcome.[23] To capture the complexity and severity of a traumatic brain injury, the multidimensional approach of prognostic research[24,25] needs to be applied to clinical classification.

Validity: relation to other indices and measures of severity

Without a gold standard for the evaluation of consciousness, the validity of the Glasgow Coma Scale as an indicator of severity is commonly obtained through the assessment of the relation between its score and other early clinical, functional metabolic, or structural features, and outcome (table 2,[26–33] figure 2, figure 3). Clinically, the duration of post-traumatic amnesia[34] is a classic index for the severity of brain dysfunction after an injury, and lower values in the Glasgow Coma Score are associated with increases in duration of post-traumatic amnesia.[35] Measurements of metabolism provide quantitative biological indices of brain activity—eg, overall cerebral metabolic rate of oxygen ($CMRO_2$) decreases as the Glasgow Coma Score decreases (figure 2).[26,27] PET findings are more complex—the overall cerebral metabolic rate of glucose does not clearly relate to the level of consciousness,[36] but there is a correlation between the Glasgow Coma Score and reductions in metabolic rate in cortical grey matter,[28] thalamus, brainstem, and cerebellum at different times after injury.[37]

The ability of cross-sectional CT to detect focal structural lesions rapidly cemented its status as key to clinical care. However, CT imaging is not sensitive to the diffuse microscopic injury in the white matter thought to be the main cause of traumatic unconsciousness. Now this damage can be investigated with quantitative magnetic resonance diffusion-tensor imaging. Measures of apparent diffusion coefficient and other indices, either from several

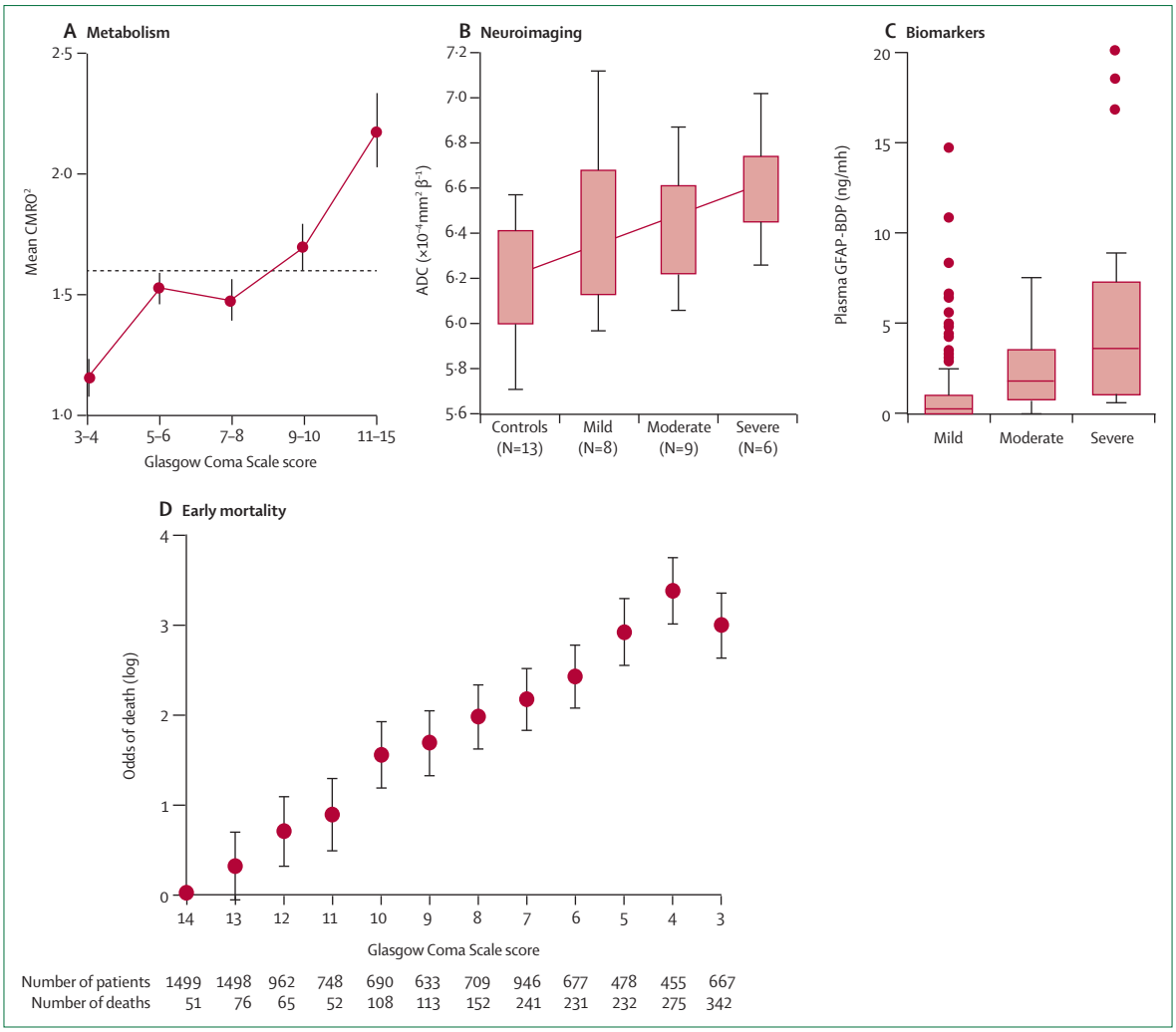

Figure 2: **Associations between Glasgow Coma Score and other indices of severity of brain injury**
The sum score of the Glasgow Coma Scale is related to indices of initial severity and to early mortality. Relation of score to metabolism (A); relation to values on neuroimaging (B), ADC values are higher in more severely injured patients; relation to biomarkers (C), with higher levels of glial fibrillary acidic protein breakdown products in patients with more severe injuries; and relation to prediction of mortality (D), with increasing risk of death within 14 days of injury as the score on the Glasgow Coma Score decreases. $CMRO_2$=cerebral metabolic rate of oxygen. ADC=apparent diffusion coefficient. GFAP-BDP=glial fibrillary acidic protein breakdown products. Part A is reproduced from Obrist and colleagues,[26] part B is reproduced from Goetz and colleagues,[30] part C is reproduced from Okonkwo and colleagues;[33] and part D is reproduced from MRC CRASH Trial Collaborators.[24]

regions of interest (figure 2)[30] or from whole-brain white matter,[38] correlate with reductions in the Glasgow Coma Score. Associations also exist between the Glasgow Coma Score and concentrations of blood biomarkers in patients with traumatic brain injury (figure 2).[32,33] Nevertheless, discrepancies between clinical responsiveness and findings from imaging[39] and biochemical investigations, especially in mild injuries with focal lesions, point to these investigations having complementary roles to characterise patients with traumatic brain injury.

Components of the Glasgow Coma Scale and the overall score are strongly related to outcome after acute brain damage.[29] Gennarelli and colleagues[40] reported a relation across the full range of the score and mortality. A decade later, analysis of data from the CRASH trial,[24] a study on a contemporary cohort of adults with head injuries admitted to hospitals, showed a smooth increase in early mortality as the Glasgow Coma Score at admission decreased from 14 to 4 (figure 2). This pattern was maintained 6 months after injury (figure 3). Also at 6 months, a relation was noted in survivors in whom the likelihood of recovery without disability was correlated with a higher early Glasgow Coma Score. The relation has also been seen in other disorders—eg, data from more than 1 million injured people in the USA National Trauma Data Bank (table 3) shows that the initial Glasgow Coma Score correlated with outcome across the full range of trauma severity, with

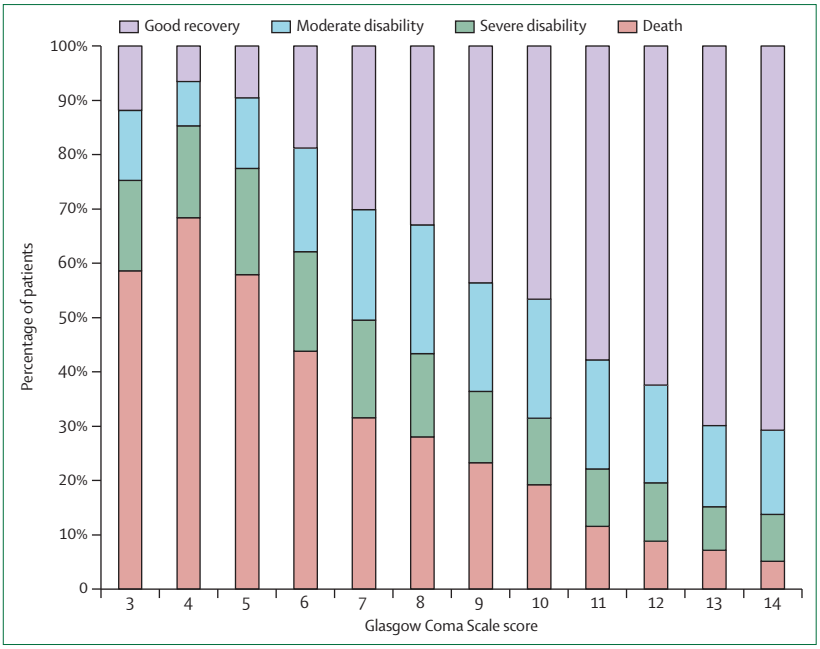

Figure 3: **Mortality and outcome 6 months after injury in relation to Glasgow Coma Score recorded at the time of recruitment onto the MRC CRASH trial[24]**

The reduced mortality for a total score of 3 probably shows pseudo-unresponsiveness due to confounding factors. Note that for scores of 8 or lower, most surviving patients were disabled, whereas for scores of 9 and higher, most had a good recovery.

	Patients	Deaths (N)	Proportion that died (95% CI)
3	53 246	13 823	26·1% (25·7–26·4)
4	3076	818	26·8% (25·2–28·3)
5	3093	717	23·2% (21·7–24·7)
6	5948	1019	17·2% (16·2–18·2)
7	5787	669	11·6% (10·8–12·4)
8	5367	547	10·2% (9·4–11·0)
9	5613	536	10·0% (8·8–10·4)
10	7127	567	8·0% (7·4–8·6)
11	8233	551	6·7% (6·2–7·3)
12	11 312	557	5·0% (4·5–5·3)
13	21 517	872	4·0% (3·8–4·3)
14	86 791	2381	2·8% (2·6–2·7)
15	801 025	8280	1·04% (1·01–1·06)

Data for 1 018 135 individuals in the National Trauma Data Bank and a known score on Glasgow Coma Scale and outcome.

Table 3: **Relation of Glasgow Coma Score to mortality in injured people with or without traumatic brain injury**

mortality rising from 1% at a Glasgow Coma Score of 15 to 27% at a score of 4 (Osler and Cook, personal communication, 2014).

The precise relation between Glasgow Coma Score and outcome is affected by the time of assessment after injury, becoming stronger if the assessment is done after initial stabilisation than if done before.[41,42] In patients with severe injuries, low scores are driven by the status of the motor component.[43] This relation is shown in studies of mortality prediction after severe traumatic brain injury, in which the motor component score is almost as informative as the overall score.[44] By contrast, in cohorts of patients with milder injuries, and when considering outcome in survivors, the verbal and eye components substantially add prognostic value. Findings from a meta-analysis[45] have confirmed the better prognostic performance of the Glasgow Coma Score compared with a shortened motor response scale.[46]

Despite the robust correlation between a lower Glasgow Coma Score and poorer outcomes, the scale was never intended to be used alone as a guide to outcome.[47] Instead, prognosis should be estimated by use of a combination of different features in multivariate models.[48] Many models have been developed, but only two have been comprehensively validated.[24,25] Murray and colleagues[49] reported the Nagelkerke partial R^2 values for the motor response score using the Glasgow Coma Scale as a measure of the added proportion of the explained variability, relative to the contribution of other predictors. In the International Mission for Prognosis and Analysis of Clinical trials in TBI (IMPACT) core model,[25] three main features—age, pupil reactivity, and motor response—had very similar predictive power, with a partial R^2 value of 6–7%. However, even such a well validated model does not explain all variations in outcome, leaving an inevitable uncertainty that limits the role of statistical predictions in clinical decision making.

Reliability and confounders

After 40 years of use, and with the evolution of its applications, some investigators have had reservations and made critical comments about the Glasgow Coma Scale.[50–52] When the Glasgow Coma Scale was devised the discipline of clinimetrics had not yet been developed.[53] Subsequent systematic analyses[54–56] yielded largely supportive conclusions about its composition and effectiveness, including its validation by acceptance.[55] However, a consistent criticism has been variation in reliability. After the studies that guided the development of the Glasgow Coma Scale,[8] the consistency between assessments by different observers has varied in different reports. Thus, observer agreement has been reported to range from high[57] to low,[50] with kappa indices ranging from 0·85 to 0·32.[58] When studied separately, the motor response usually shows higher interobserver reliability than do the verbal or eye responses. Overall, reliability has been summarised as "good if no untestable feature present and if user is experienced".[54] Reliability is affected by training and by consistency in assessment technique.[58] The original description of the composition of the scale[3] did not set out rigid detailed specifications for the technique of assessment, in part to respect the skill of experienced clinicians. This feature might have contributed to an increasing variability over time in techniques used for examination and assignment of findings. For example, a 2014 survey of trainee

neurosurgeons reported seven different body locations used for painful stimulation compared with the two that were initially recommended.[59] Clinicians should address variations in reliability through new actions. These actions may include renewed guidance on good practice, standardisation in stimulation, interpretation and dealing with confounding factors, reporting of the three components and not only the total sum score, and continuing education for health-care providers.[60,61]

Reservations about the Glasgow Coma Scale[43,50–52] mainly relate to the sum score and to its calculation. These include the appropriate number of steps in each component scale and the weighting that should be attached to each step. We therefore re-emphasise the distinction between use of the scale to assess impaired consciousness in individual patients and the use of the score for classification and research. Moreover, the score is not an interval scale and the common practice of reporting an average Glasgow Coma Score is not appropriate.[62] Several confounding factors can render a component of the scale untestable,[63] precluding derivation of a score (panel 2). The problems caused by untestable components have increased compared with those present in 1974, because severely injured patients are now often sedated and intubated at the scene of an incident.[63] Approaches to manage missing components (panel 3) depend on the reason for absence of information and the purpose of assessment. Missingness (mechanisms for missing data) is typically not completely random and therefore, in clinical management, the reason why a component is untestable should be recorded. Although often done, a score of 1 should not be assigned, because differentiation between a true 1 and an untestable component is relevant. Designation of sedated and paralysed patients as pseudo 3 distorts the relation of the motor response and of the overall score to outcome.[43]

The absence of information about a component of the Glasgow Coma Scale interferes with use of the score to compile information about patient cohorts for audit and research. Incorporation of the Glasgow Coma Scale into scoring systems such as the APACHE (Acute Physiology and Chronic Health Evaluation) score[66] for patients in intensive care units or the Revised Trauma Score[67] in those receiving trauma care is still possible using modelling—eg, to input the verbal component based on the eye and motor components.[64,65] This technique is impractical in bedside practice, but is also unnecessary because clinical decisions can be based on the findings in the remaining components.

Use of the Glasgow Coma Scale in clinical practice

Modern management of a patient with an acute brain injury is based on an anticipatory approach, aiming to identify and deal with sources of potential worsening rather than to react to adverse developments. For example, space-occupying haematomas should preferably be operated on before brainstem herniation

Panel 2: Confounding factors rendering one or more components of the Glasgow Coma Scale untestable

- Drugs (anaesthetics, sedatives, neuromuscular blockade, etc)
- Cranial nerve injuries
- Intoxication (alcohol or drugs)
- Hearing impairment
- Intubation or tracheostomy
- Limb or spinal-cord injuries
- Dysphasia
- Pre-existing disorders (dementia or psychiatric disorders)
- Ocular trauma
- Language and culture
- Orbital swelling

Adapted from Zuercher and colleagues[60] and Middleton.[61]

Panel 3: Prevention and management of missing components

Avoid missing values
- Temporary stop sedation (wake-up test)

Simple imputation (same value for each patient)
- Record the verbal scale in patients intubated or with tracheostomy as $V_{T(ube)}$
- We advise against assigning a score of 1 to eye and verbal components in sedated or untestable patients

Statistical imputation (single or multiple imputation) based on data
- Imputation of verbal score from eye and motor components[64,65]
- Imputation based on other patient characteristics

	Patients (N)	Results of CT scan		
		Proportion with any abnormality	Proportion with midline shift	Proportion with intracranial haematoma needing evacuation
3	652	78%	23%	9%
4	453	86%	34%	19%
5	467	86%	31%	17%
6	667	81%	21%	16%
7	940	82%	16%	14%
8	700	76%	12%	13%
9	629	68%	12%	14%
10	685	69%	10%	11%
11	746	52%	6%	7%
12	959	45%	5%	7%
13	1484	37%	4%	5%
14	1489	29%	2%	4%

Data from the MRC CRASH trial.[68] Recruitment criteria excluded patients with a score of 15.

Table 4: Relation of Glasgow Coma Scale score to findings of CT imaging

occurs. Assessment of conscious level has a key role in clinical monitoring and in risk assessment for the presence of structural abnormalities. This is shown by the increasing yield of clinically important findings from CT scanning in relation to the extent of depression of responsiveness (table 4). The application of such knowledge to clinical practice has minimised mortality and morbidity in patients with intracranial haematoma.[69]

The Glasgow Coma Scale is now a core part of many clinical guidelines (table 5, appendix). In addition to being a guide for initial decision making, trends in responsiveness shown by changes in the Glasgow Coma Scale remain important. In a study in which 11 of 340 patients admitted to hospital with a minor head injury urgently needed neurosurgical intervention, this decision was made in response to a decrease in the Glasgow Coma Scale in nine of those patients.[70] Despite intensive-care management, episodes of neurological worsening leading to a poor outcome occur in about a third of cases with severe head injuries.[71] Robust assessments of consciousness are important across the provision of clinical care from pre-hospital settings, through emergency care, to intensive care and post-acute care.

In emergency care, the importance of the Glasgow Coma Scale is shown by the standard practice of calculating the score right after the evaluation of airways, breathing, and circulation. A baseline score should be established as soon as possible, but findings after management of any hypoxia, hypovolaemia, or hypoglycaemia provide a more valid index of brain injury severity than the score obtained at admission. Reservations about the use of the full scale in emergency triage usually relate to perceptions of overcomplexity—ie, "the Glasgow Coma Scale is not consistently remembered".[51] Simplifications of the coma scale[46,52,72] or the older AVPU (alert, voice, pain, unresponsive) systems developed originally for people after poisoning,[73] might guide elementary triage decisions but are of minimal value to establish a baseline to detect subsequent changes in responsiveness or to establish detailed prognosis. The description of patients using the scale and its summarised score remain an integral part of the language of emergency care and a core component of guidelines[14,74] that have improved patients' outcomes.[75,76]

In intensive care, despite the implementation of brain function monitoring by measurement of intracranial pressure, cerebral oxygenation, and electrical activity, clinical assessment remains crucial. Indeed, by contrast with emergency triage, there have been proposals to add information (eg brainstem-related features) to the elements of the Glasgow Coma Scale to create more complex scoring systems[77,78] for patients with severely impaired responsiveness. The principle of multidimensional assessment is well founded, but such assessment does not imply that different variables should be compressed into a single scale. Uncertainties about weighting apply to the components, and one or more of these may be affected by the confounding effects from sedation, neuromuscular blockade, and endotracheal intubation. Comparisons of predictive value should not consider the Glasgow Coma Scale in isolation, but rather input its use as a core part of readily available, multivariate models.[24,25] Important advantages of the Glasgow Coma Scale are that it supports continuity of information in clinical care across different settings, and that it is applicable across the broad severity range of traumatic brain injuries.

In paediatric practice, as in adults, the Glasgow Coma Scale has a central role in assessment of brain injury and is a key part of guidelines[75] and risk scores.[79] However, the scale cannot be applied directly to children of all ages because, for example, the best verbal response of "oriented" and the best motor response of "obeys commands" are not possible in children younger than 5 years. Several changes have been proposed (table 5).[80–84] A review in 2008[85] and an overview of clinical practice in more than 40 sites in the Approaches and Decisions in

	Simpson and Reilly, 1982[80]	James and Trauner, 1985[81]	Gordon and colleagues, 1983[82]	Tatman and colleagues, 1997[83]	Hahn and colleagues, 1988[84]
5	Talks normally	Alert, babbles words, or uses sentences normal for age	Fixes on, follows, and recognises objects and persons; laughs	Spontaneous normal facio-oro motor activity	Smiles, oriented to sound, follows objects, and interacts
4	Words	Less than usual ability, irritable cry	Fixes on and follows objects inconsistently, recognition of people is uncertain	Less than usual spontaneous activity	Crying that is consolable, interacts inappropriately
3	Cries to pain	Arousable at times, does not drink	Cries to pain	Vigorous grimace to pain	Inconsistently moaning, consolable
2	Moans	Motor restlessness, unarousable	Moans	Mild grimace to pain	Inconsolable, irritable, restless
1	None	Complete unresponsiveness	None	No response to pain	No response

Modified from Kirkham and colleagues.[85]

Table 5: **Paediatric versions of the Glasgow Coma Scale**

Acute Pediatric TBI (ADAPT) network showed that none of these modified versions has gained universal acceptance (M Bell, personal communication, 2014).

In post-acute care, the Glasgow Coma Scale provides an index of recovery rate, but cannot be interpreted as an outcome measure. Cessation of improvement or new deterioration might indicate the development of complications such as hydrocephalus or a chronic subdural haematoma.

Recommendations for use

The Glasgow Coma Scale assesses the level of consciousness in patients and should be distinguished from the overall coma score (numerical sum of the three components of the scale), which can be used for comparisons of groups. The scale is an effective instrument to monitor trends in level of consciousness. Ratings of the three individual components should be monitored, reported, and communicated separately (preferably in words but, with care, as a number). The displacement of graphical representation by the display only of scores after the introduction of electronic recordings in many setting is concerning, because changes in consciousness might be detected less rapidly—"Graphics is intelligence made visible".[86] For consistency, we recommend use of the extended motor scale because it is now the most widely used instrument. In response to calls for continuous quality improvement,[60] an interactive internet-based training method and a structured approach to assignment of responses will be available. Although there is clearly a general relation between the severity of acute brain injury and responsiveness, this notion should be applied with caution. Thus, it is necessary to be aware that the precise details of the relations vary according to clinical circumstances (eg, in relation to type of patient and time of assessment). The score for an individual patient may indicate which broad severity group they fall into, but the scale can convey crucial information about current status and affords the most sensitive baseline to detect change in conciousness. Panel 4 shows proposed measures to consolidate and enhance the use of the Glasgow Coma Scale in clinical practice.

Conclusions and future research

The Glasgow Coma Scale has evolved into a clinical instrument with several applications, including risk assessment, trend monitoring, classification, and prognosis. After 40 years, wide use of the scale supports its validation by acceptance[55] and indicates that its creators have achieved many of their original aims. *The Lancet* article of 1974 was identified as a leading 'citation classic' in 2010.[87,88] An update in January, 2014, again using the Web of Science (appendix), showed a continuing increase in citations, now about 300 every year and at a total count of 5468 (figure 4, appendix) and it remains the most cited clinical neurosurgical paper. Citations of descriptions of alternative systems to grade the level of consciousness are quote low compared with those of the 1974 paper.

The Glasgow Coma Scale has played a sustained, highly influential role in improving patient care and in increasing knowledge on head injury (especially traumatic brain injury) and other acute brain insults. The improvements in outcome associated with developments in management over the past 40 years are a foundation for future advances. The extensive data available already provide opportunities to increase understanding of the interplay of the components of the scale, their total score, and how these measures can be best used in clinical practice and clinical investigations.

In research, the Glasgow Coma Scale has become an essential instrument to characterise populations of patients with acute brain damage of many causes. The data obtained by the use of this instrument are a portal to

***Panel 4:* Strategies to improve use of the Glasgow Coma Scale**

- Describe the responses of each of the components in individual patients
- Use the extended six-point motor subscale and 15-point score
- Do not assign 1 for imputation of missing values
- Chart and display changes over time
- Limit the use of the score to classification and research
- Improve standardisation in assessment of patients
- Develop training instruments and implement quality improvement programmes
- Use the scale for prognosis only in combination with other prognostic factors (eg, age, pupil reactivity, and imaging)

For the **Glasgow Coma Scale after 40 years website** see http://www.glasgowcomascale.org

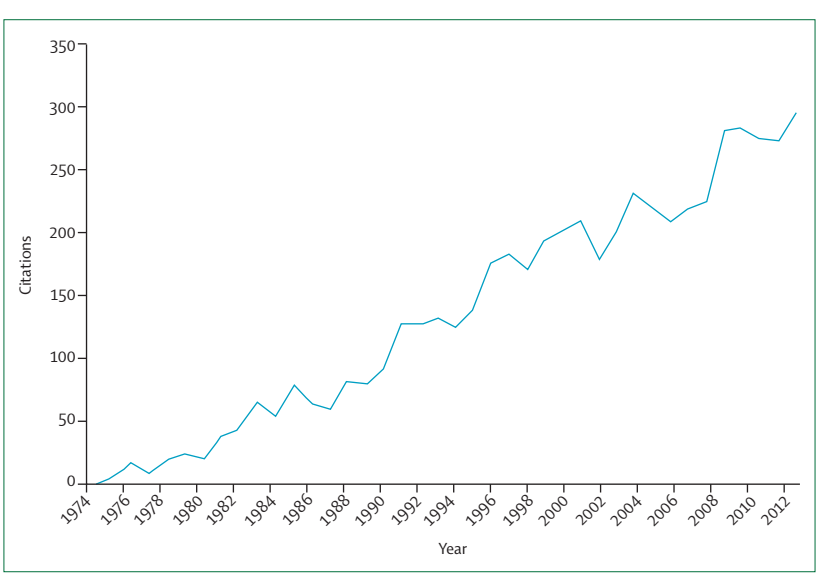

Figure 4: **Citations for the initial publication of the Glasgow Coma Scale[3] as shown by Web of Science**
Search done on Jan 17, 2014, by Andrew McAinsh, Information Officer at the Royal College of Physicians and Surgeons of Glasgow (data from citations listed in the appendix).

Search strategy and selection criteria

We identified articles through searches of PubMed, Science Direct, Ovid Medline, Embase, OVID, and CINAHL, with use of the search terms "Glasgow Coma Scale" or "Glasgow Coma Score" separately, and in combination with "review articles". We included articles published up to Nov 1, 2013. We also identified papers from the authors' own files and from references cited in relevant articles. We generated the final reference list on the basis of articles' relevance to the topic of this Personal View.

a large amount of information about epidemiology, natural history, management, and prognosis, and can be used in comparative effectiveness studies of current methods and new interventions.[89] Nevertheless, findings that arise from the use of the Glasgow Coma Scale should not stand in isolation. Indeed, a major goal in research is to use interactions with data from other indices to build new multidimensional classifications, combining clinical, patho-anatomical, and molecular features,[90] potentially linked to more specific and more effective treatments. Two new major international studies, CENTER-TBI and TRACK-TBI,[91] have these goals, with the use of the Glasgow Coma Scale at their core 40 years after its first description.

For more on **CENTER-TBI** see https://www.center-tbi.eu/

Contributors

AM initiated the concept of this Personal View. GT designed its scope. All authors contributed to the review of the relevant literature and to the writing of the Personal View. All authors reviewed and approved the final version.

Declaration of interests

After the description of the Glasgow Scale in 1974, GT lectured widely on its use in the assessment and management of patients with acute brain damage. Between 2011 and 2014, he received travel to one international symposium and an honorarium for one lecture from Barnabas Health New Jersey and American Association of Neurological Surgeons. AM, FL, GMa, NS, and GMu declare no competing interests. The Glasgow Coma Scale and associated chart have always been available, without charge, to clinical and scientific users.

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