

Multum in parvo

DAN CRISTIAN VOINESCU¹⁾, AUREL GEORGE MOHAN²⁾, ANDREI ALEXANDRU MARINESCU³⁾,
 ALEXANDRU VLAD CIUREA^{3,4)}

¹⁾Department of Neurosurgery, "Elias" Emergency University Hospital, Bucharest, Romania

²⁾Department of Neurosurgery, Faculty of Medicine and Pharmacy, University of Oradea, Romania;
 Department of Neurosurgery, Emergency County Hospital, Oradea, Romania

³⁾Department of Neurosurgery, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania

⁴⁾Department of Neurosurgery, "Sanador" Medical Hospital, Bucharest, Romania

Abstract

The authors begin from the Latin expression *Multum in parvo*, which is used to summarize the essential aspects of something. This phrase is used in this case to define the Glasgow Coma Scale (GCS) – the posttraumatic conscious state evaluation scale. The authors gather the entire information regarding the creation of a uniform evaluation scale for the patients that have the state of consciousness altered or are even in a posttraumatic coma. This subject has been thoroughly debated for over 40 years. Teasdale & Jennett represented a huge step in the evaluation of patient's state of consciousness. They created a universal scale usable by all the medical fields involved in neurotraumatology. This scale with a maximum of 15 points and a minimum of 3 proved its efficiency and usefulness with all its existing imperfections. The scale is based upon three simple answers: ocular response 1–4 points, verbal response 1–5 points, motor response 1–6 points. The authors have taken in consideration the pediatric coma scale which derived from the original GCS and other known scales such as FOUR (Full Outline UnResponsiveness). This scale is focused on appreciating the state of consciousness of intubated patients who have altered cerebral functions. The prognosis scale, Glasgow Outcome Scale (GOS), which later has been modified into Glasgow Outcome Scale Extended is also presented. In over 40 years since their first use, the GCS and GOS have proved their efficiency and universality in evaluating the consciousness state of traumatized patients.

Keywords: posttraumatic, GCS, GOS, FOUR Scale, Children Coma Scale.

Introduction

The Latin expression *Multum in parvo* is used, generally speaking, to express the summarizing capacity of something, respectively the quality of meaning more while saying less. This syntagma was used in various contexts. It was associated even with Albert Einstein's famous equation „ $E=mc^2$ ” (Figure 1) and with the Tablets on which Moses wrote the Laws of God.

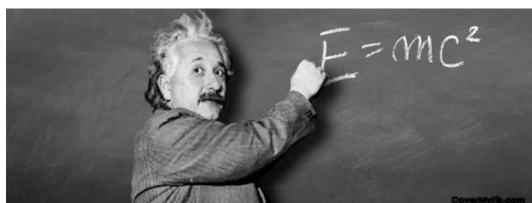


Figure 1 – Albert Einstein (1879–1955) (<https://s-media-cache-ak0.pinimg.com/originals/5d/e5/7f/5de57f7c9eb82e300aed388f7cf68c16.jpg>).

In the medical field, this expression was used initially to characterize the signification of the pathological reflex described in 1896 by Joseph Babinski (Figure 2). This reflex carries his name and represents the alteration of cortico-spinal nerve conduction, a peripheral sign of a neurological lesion of the central nervous system.

Even from the beginnings, the medical community, regardless of the specialty, but especially from the field of neurology, neurosurgery and other related fields such as internal medicine, emergency medicine, cardiology,

intensive care, was preoccupied with finding a method of quantifying the level of patient's conscious state degradation.



Figure 2 – Joseph Babinski (1857–1932) (https://upload.wikimedia.org/wikipedia/commons/thumb/0/0e/Jozef_Babinski.jpg/220px-Jozef_Babinski.jpg).

This method had to be on one hand a facile and practical way of evaluation and on the other hand, it had to have an adequate level of correlation with the extension of the involved anatomical lesions and with the evolutive potential of the patients.

It must be mentioned the fact that in the evaluation of the conscious state, the aspects regarding the patient's degree of vigilance, respectively the stimulation necessary to wake the patient up and the complexity of the activities the patient can perform must be taken in consideration. These evaluations must be done in comparison with the standards defined as nominal for the age and the patient's

level of education, as well as correlating the results with previous ones obtained prior to the investigated episode.

The alteration of the conscious state can be a consequence of some modifications and anatomical lesions, which occurred spontaneously or posttraumatic, pertaining to intracerebral space-replacing tumoral or non-tumoral processes or to some biochemical modification such as in the case of intoxication or some endogenous metabolic dysfunctions [1].

Aim

The scientific progress is in a constant, exponential growth. The sheer number of constant new medical information cannot be thoroughly analyzed by all medical personnel. In order to have a universal solution for communication, understanding and objective evaluation in the medical practice, it is necessary to use simple terms and methods which can be easily concentrated in international scales. This article pleads for the use of universal trauma scales for an easier communication and objective evaluation of cranio-cerebral traumatism.

☐ Studies to assess anatomic and clinical correlates in brain injuries

During 1960–1970, in many publications are used evaluations based on more or less subjective criteria, which depend on the conscious state, like example: somnolence, dizziness, stupor, torpor, semicomatose, superficial or deep coma [2].

The distinction between these levels of depth of conscious state alteration was most of the time arbitrary depending on the examiner's preference. This situation made interpersonal evaluations and international communication extremely difficult.

In 1970, at the order of *National Institutes of Health, Public Health Service, U.S. Department of Health and Human Services*, two large studies are being funded to collect data from patients with altered state of consciousness in USA, England and Holland. One of the studies was addressed to traumatic patients and was coordinated by Prof. Dr. Bryan Jennett, Chief of Neurosurgical Department at the Neurological Sciences Institute of Glasgow University. The second study responsible for evaluating the prognostic of comatose patients with non-traumatic, medical etiology was led by Prof. Dr. Fred Plum from Cornell University, New York [3, 4]. Both studies confronted with the lack of criteria and methods of conscious state evaluation uniformization both at the initial moment of assessment and following the evolution.

Table 1 – Glasgow Coma Scale (N/A: Not applicable)

Investigated function	1	2	3	4	5	6
Eye opening response	Do not open	Open at nociception	Open at verbal command	Open spontaneously	N/A	N/A
Verbal response	No response to nociception	Incomprehensible sounds	Non-sense words	Confuse, disoriented	Oriented	N/A
Motor response	No response to nociception	Extension to nociception (decerebration)	Flexion superior limbs, extension inferior limbs (decortication)	Flexion/retraction of the members at nociception	Localization of nociceptive stimuli	Executes correct commands

☐ The value and importance of the Glasgow Scale

Since the alteration of the conscious state is a result

In 1974, July, Graham Teasdale, who was later ennobled (Figure 3) and Bryan Jennett (Figure 4) published in "The Lancet", following the research done at the Neurosurgery Department of the Neurological Sciences Institute of Glasgow University, a clinical scale designed to evaluate and assess the level of state of consciousness alteration and coma state [5]. The scale was conceived initially to be used by the personnel from the Intensive Care Unit wards in order to evaluate the patients' motor reactivity, speaking capabilities, the ability to open the eyes. These abilities were quantified and numerical numbers were assigned to each of the evaluated capabilities accordingly. The obtained values were obtained at predetermined intervals (at one hour) and were used to create graphs, thus becoming a very useful medical monitoring instrument.



Figure 3 – Sir Graham Teasdale (born 1940) (http://www.universitystory.gla.ac.uk/images/UGSP01055_m.jpg).



Figure 4 – Bryan Jennett (1926–2008) (<http://middleeast.thelancet.com/cms/attachment/2000990825/2003653115/fx1.jpg>).

The two Scottish researchers named this evaluation scale "Coma Index" and it was a way to evaluate and follow the evolution of the patient's depth and length of state of consciousness alteration, with the help of objective criteria.

Considering the origins of the two researchers and the place where they realized the studies preceding the determination of the criteria which compose the scale, it was later renamed Glasgow Coma Scale (GCS).

Initially, the scale was conceived with 5-grade of motor response. Later, in 1977, a change was made by the authors by adding the retraction of the members to avoid nociceptive stimuli, which was noted with 4 points made the motor criteria to have possible values between 1 and 6 [6].

The elaborate scale had numerical values for each category of response. The final score is represented by the sum of the obtained values from the three types of evaluable responses. The result has possible values between 3 (the patient is completely unresponsive) and 15 (the patient is conscious) (Table 1).

of a general cerebral affection, the scale was conceived based on global evaluation criteria, necessary to assess the complex functions responsible for environment perception.

The method of quantifying the obtained results was elaborated with statistical purposes. Maybe this simplification of the criteria used to assess the response to stimuli determined its large use of the scale. A proof of its primary purpose of statistical evaluation instrument is the fact that the lowest obtainable value is 3 (by adding the individual values), not 1 or 0 as seen in most evaluation scales, regardless of the medical field it is addressed to.

The merit of the two remarkable Scottish researchers is not only the one to conceive this state of consciousness quantification model, but the one of picking the correct evaluation criteria, which had to be as concise as possible and to be able to evaluate the essential functions that had to be assessed.

A proof of its extremely high popularity is that the Glasgow Scale is a constitutive part of other evaluation scales addressed to traumatic and non-traumatic cranio-cerebral events. The evaluation of the conscious state according to the Glasgow Scale is present in the quantification of the subarachnoidian hemorrhage severity done by the scale proposed by the WFNS (*World Federation of Neurosurgical Societies*) [7].

The Glasgow Scale proved its efficiency by demon-

strating the correlation between the obtained score and the evaluation of diverse parameters related to the metabolic modification occurred posttraumatic at the level of the noble cerebral tissue. Thus, it was observed the decrease of the cerebral use of oxygen and glucose of the grey matter conjunctively with the decrease of the GCS values, which correlate with the increase of intracranial pressure [8].

There, though, some limitation in the Glasgow Scale. One of them is its use in evaluating the conscious state in the first few hours posttraumatic, more exactly at the moment of the first-aid teams' arrival at the traumatic event in order to stabilize the patient with neuro-muscular relaxants and sedatives to ease the patients' transportation, especially for those with psychomotor restlessness [1]. The action of these substances will interfere with establishing the correct level of conscious state. Another limitation is regarding the intubated patients who will not be able to have a correct verbal response.

Another important limitation of the scale is its use in pediatrics, especially for those who did not developed yet the verbal function (0–3 years old). In these cases, derivate scales of the Glasgow Scale are being used in order to adapt to this category of patients [9–11] (Table 2).

Table 2 – Children Coma Scale (after Reilly et al., 1988 [11]) (N/A: Not applicable)

Investigated function	1	2	3	4	5	6
Eye opening response	Do not open	Open at nociception	Open at verbal command	Open spontaneously	N/A	N/A
Verbal response	No response to nociception	Inconsolable, agitated; moaning at nociception	Inconsistent crying, inconsolable, moaning; crying at nociception	Crying consolable, inadequate reactions	Interacts, smiles, follows objects, sounds	N/A
Motor response	No response to nociception	Extension at nociception (decerebration)	Abnormal flexion at nociception (decortication)	Retraction of the members at nociception	Retraction of the members at tactile stimuli	Spontaneous motility or adequate orientation

Even though the scale is so propagated in the medical practice, or maybe because of this, the GCS was criticized multiple times for its relative lack of evaluation of the functions of the brainstem. Following these criticisms, several modifications have been done. One of the most known modifications is the one proposed in 1982, by Born *et al.* [12], who added the fronto-orbicular reflex (5 points), vertical oculo-cephalic reflex (4 points), pupillary reflex (3 points), horizontal oculo-cephalic reflex (2 points) and oculo-cardiac reflex (1 point) to the Glasgow Scale evaluation. The lack of an oculo-cardiac reflex is noted

with 0. This scale is known as the Glasgow–Liege Scale and its values are ranging between 3 and 20 points.

One of the last modifications to the Glasgow Scale who was designed to include the intubated patients is FOUR (Full Outline UnResponsiveness), published in 2005 by Wijdicks *et al.* [13]. This score, almost as facile as the Glasgow Scale, uses mostly the same evaluation criteria (motor, eyes) and proves its usefulness in the case of the patients admitted in the Intensive Care Unit. The FOUR Scale offers more details than its predecessor in terms of neurological status evaluation (Table 3).

Table 3 – FOUR (Full Outline UnResponsiveness) Score

Investigated function	0	1	2	3	4
Eye opening response	Do not open	Open at nociception	Open at verbal command	Open spontaneously, do not follow objects	Follows objects, blinks at command
Motor response	No response at nociception	Extension at nociception	Flexion at nociception	Localizes the nociceptive stimuli	Mobilizes at command (clenches fist, raises fingers)
Brainstem reflexes	No pupillary, corneal or cough reflexes	Pupillary and corneal reflexes absent	Pupillary or corneal reflexes absent	Fixed unilateral mydriasis	Pupillary and corneal reflexes present
Respiration	Apnea respiration completely maintained by ventilator	Respiration partially maintained by ventilator	Irregular respiration, not intubated	Cheyne–Stokes respiration, patient not intubated	Constant respiration, not intubated

The Glasgow Scale for the state of consciousness evaluation is utilized, most of the times, together with the prognosis evaluation scale GOS (Glasgow Outcome Scale) (Table 4). This scale, published by Jennett & Bond in 1975 [14], quantifies the capacity to do activities which

were considered normal before the traumatic event. This prognosis scale assigns values between 1 and 5 to the patients accordingly to the functional status at the moment of the evaluation, where 1 represents death and 5 best recovery.

Table 4 – Glasgow Outcome Scale

Score	Description
1 (Dead)	Severe lesion or death without regaining the state of consciousness.
2 (Persistent vegetative state)	Severe lesion with prolonged state of non-responsiveness and cortical function deficit.
3 (Severe disability)	Severe lesion with the permanent need for help in everyday activities.
4 (Moderate disability)	Does not require help in daily activities, can resume previous activities, but requires special work conditions (equipment, limited time, etc.).
5 (Good recovery)	Minor neurological and psychological deficits.

Soon, with the passing of time, it was revealed that it was difficult to classify some patients in all the five grades of the GOS; in 1998, Teasdale *et al.* [15] published a revised version of this prognostic score, maintaining the first two categories identical to the original, but adding a more detailed evaluation of the residual deficits. They named this revised version Glasgow Outcome Scale Extended (Table 5).

Table 5 – Glasgow Outcome Scale Extended (GOS-E)

GOS-E 1	Death
GOS-E 2	Vegetative state
GOS-E 3	Lower severe disability
GOS-E 4	Upper severe disability
GOS-E 5	Lower moderate disability
GOS-E 6	Upper moderate disability
GOS-E 7	Lower good recovery
GOS-E 8	Upper good recovery

☒ Conclusions

Over the years, the utilization of the GOS, despite all the criticism, extended more and more in the entire medical community. Its simplicity and functionality made it an extremely useful instrument in appreciating the patients' state of consciousness, especially for traumatic events victims. It can be easily said that at this moment, anywhere in the world a victim of a traumatic event is evaluated using the Glasgow Scale in order to establish the first stage diagnosis in conjunction with assessing the type of traumatism, posttraumatic lesions and the state of consciousness. We can say that the scale, which has been around over 40 years since its publishing, became an international language which must be known and mastered by all the medical personnel involved in evaluating the patient's state of consciousness, especially those with neurological lesions occurred post-traumatically. We can safely say that the two Scottish scientists through their activity made

possible an uniformization and globalization of the cranio-cerebral traumatism evaluation, which is extremely useful and necessary in the present development of the human society in which more and more people tend to be involved in high energy traumatic events. Therefore, we can state that the Glasgow Coma Scale can be defined in medicine, alongside the Babinski sign, as a true rendition of the saying *Multum in parvo*.

Conflict of interests

The authors declare that they have no conflict of interests.

References

- [1] Bordini AL, Luiz TF, Fernandes M, Arruda WO, Teive HA. Coma scales: a historical review. *Arq Neuropsiquiatr*, 2010, 68(6):930–937.
- [2] Arseni C, Oprescu I. *Neuro-traumatologie*. Ed. Didactică și Pedagogică, București, 1983, 17–28.
- [3] Rush C. The history of the Glasgow Coma Scale: an interview with Professor Bryan Jennett. Interview by Carole Rush. *Int J Trauma Nurs*, 1997, 3(4):114–118.
- [4] Matis G, Birbilis T. The Glasgow Coma Scale – a brief review. Past, present, future. *Acta Neurol Belg*, 2008, 108(3):75–89.
- [5] Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet*, 1974, 2(7872):81–84.
- [6] Jennett B, Teasdale G. Aspects of coma after severe head injury. *Lancet*, 1977, 1(8017):878–881.
- [7] Teasdale GM, Drake CG, Hunt W, Kassell N, Sano K, Pertuiset B, De Villiers JC. A universal subarachnoid hemorrhage scale: report of a Committee of the World Federation of Neurosurgical Societies. *J Neurol Neurosurg Psychiatry*, 1988, 51(11):1457.
- [8] Teasdale G, Maas A, Lecky F, Manley G, Stocchetti N, Murray G. The Glasgow Coma Scale at 40 years: standing the test of time. *Lancet Neurol*, 2014, 13(8):844–854.
- [9] Holmes JF, Palchak MJ, MacFarlane T, Kuppermann N. Performance of the pediatric Glasgow Coma Scale in children with blunt head trauma. *Acad Emerg Med*, 2005, 12(9):814–819.
- [10] Patel N, West M, Wurster J, Tillman C. Pediatric traumatic brain injuries treated with decompressive craniectomy. *Surg Neurol Int*, 2013, 4:128.
- [11] Reilly PL, Simpson DA, Sprod R, Thomas L. Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. *Childs Nerv Syst*, 1988, 4(1):30–33.
- [12] Born JD, Hans P, Dexters G, Kalangu K, Lenelle J, Milbouw G, Stevenaert A. [Practical assessment of brain dysfunction in severe head trauma]. *Neurochirurgie*, 1982, 28(1):1–7.
- [13] Wijidicks EF, Bamlet WR, Maramatton BV, Manno EM, McClelland RL. Validation of a new coma scale: the FOUR Score. *Ann Neurol*, 2005, 58(4):585–593.
- [14] Jennett B, Bond M. Assessment of outcome after severe brain damage. *Lancet*, 1975, 1(7905):480–484.
- [15] Teasdale GM, Pettigrew LE, Wilson JT, Murray G, Jennett B. Analyzing outcome of treatment of severe head injury: a review and update on advancing the use of the Glasgow Outcome Scale. *J Neurotrauma*, 1998, 15(8):587–597.

Corresponding authors

Aurel George Mohan, Associate Professor, MD, PhD, Department of Neurosurgery, Faculty of Medicine and Pharmacy, University of Oradea, 10 1 December Square, 410073 Oradea, Bihor County, Romania; Department of Neurosurgery, Emergency County Hospital, 65 Gheorghe Doja Street, 410163 Oradea, Bihor County, Romania; Phone +40740–514 636, e-mail: mohanaurel@yahoo.com

Alexandru Vlad Ciurea, Professor, MD, PhD, MSc, Department of Neurosurgery, “Carol Davila” University of Medicine and Pharmacy, 37 Dionisie Lupu Street, Sector 2, 020021 Bucharest, Romania; Department of Neurosurgery, “Sanador” Hospital, 9 Sevastopol Street, Sector 1, 010991 Bucharest, Romania; Phone +40744–649 678, e-mail: prof.avciurea@gmail.com