**Glasgow Coma Scale**

Teasdale and Jennett published the Glasgow Coma Scale (GCS) in the *Lancet* in 1974 as an aid in the clinical assessment of post-traumatic unconsciousness. It was devised as a formal scheme to overcome the ambiguities that arose when information about comatose patients was presented and groups of patients compared. The GCS has three components: eye (E), verbal (V) and motor (M) response to external stimuli. The best or highest responses are recorded. The scale consisted of 14 points, but was later adapted to 15, with the division of the motor category 'flexion to pain' into two further categories (Figure 1).

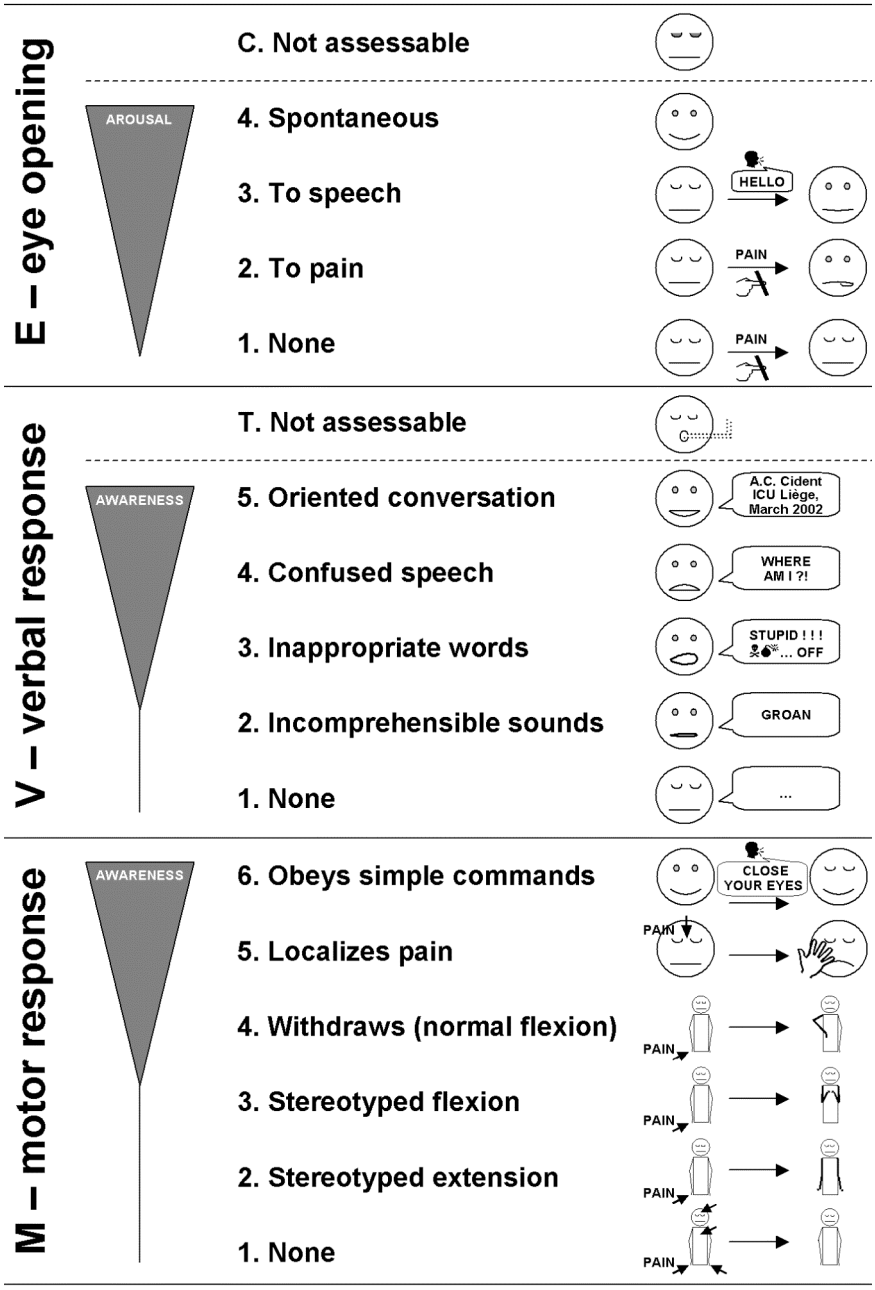


Figure 1: *Glasgow Coma Scale (GCS, Teasdale and Jennett 1974) (illustration taken from Laureys et al. 2002)*

So far, more than 4500 publications have appeared to its use (MEDLINE search performed in October 2005) (Figure 2). It is a component of the Acute Physiology and Chronic Health Evaluation (APACHE) II score, the (Revised) Trauma Score, the Trauma

and Injury Severity Score (TRISS) and the Circulation, Respiration, Abdomen, Motor, Speech (CRAMS) Scale, demonstrating the widespread adoption of the scale.

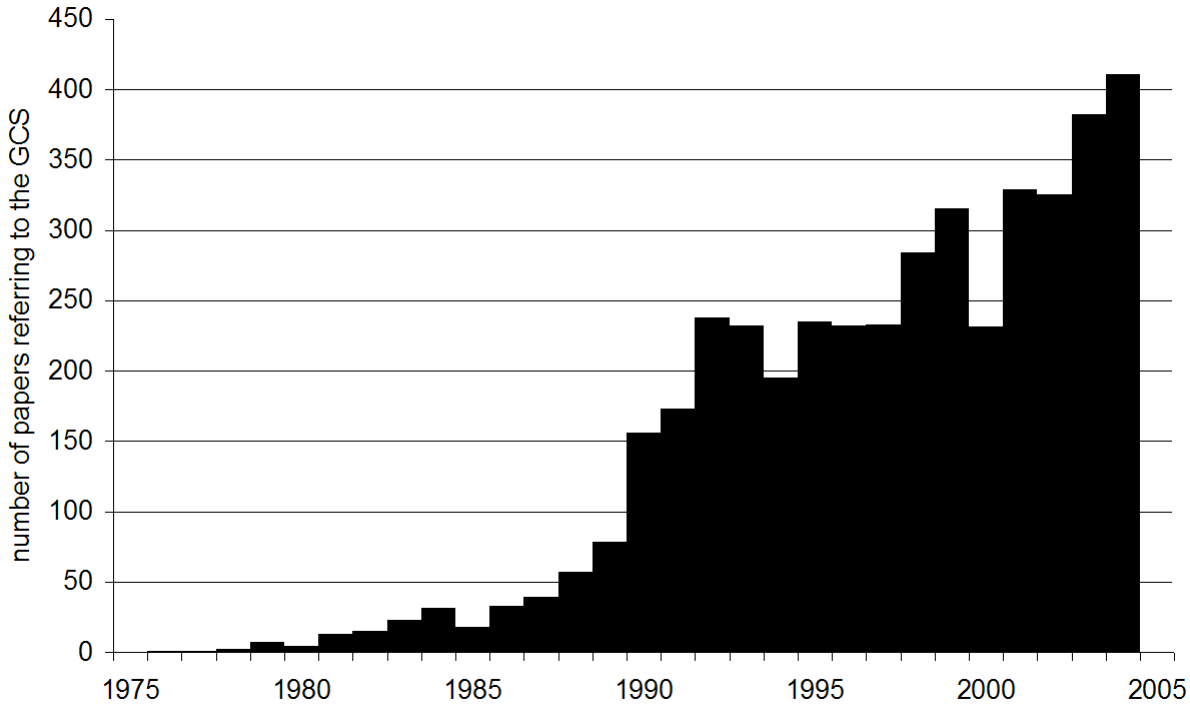


Figure 2: Number of scientific papers making reference to the Glasgow Coma Scale (from Laureys et al. 2005).

The presence of spontaneous eye opening "indicates that the arousal mechanisms of the brainstem are active" (Teasdale and Jennett 1974). Preserved arousal does not imply the presence of awareness. Patients in a vegetative state have awakened from their coma but remain completely unaware of their environment and self. Most comatose patients who survive will eventually open their eyes, regardless of the severity of their cerebral injuries (Jennett 1972). Indeed, less than 4% of head-injured patients never open their eyes before they die (Bricolo et al. 1980). The eye opening in response to speech tests the reaction "to any verbal approach, whether spoken or shouted, not necessarily the command to open the eyes" (Teasdale and Jennett 1974). Again, this response is observed in vegetative patients who can be awakened by non-specific auditory stimulation. In these patients it is recommended to differentiate between a reproducible response to command and to non-sense speech. Eye opening in response to pain should be tested by a stimulus in the limbs, because the grimacing associated with supraorbital or jaw-angle pressure may cause eye closure.
After arousing the patient the presence of verbal responses indicates the restoration of a high degree of interaction with the environment (i.e. awareness). An oriented conversation implies awareness of the self (e.g., the patient can answer the question: "What is your name?") and environment (e.g., the patient correctly answers the questions: "Where are we?" and "What year/month is it?"). Confused speech is recorded when the patient is capable of producing language, for instance phrases and sentences, but is unable to answer the questions about orientation. When the patient presents intelligible articulation but exclaims only isolated words in a random way (often swear words, obtained by physical stimulation rather than by a verbal approach) this is scored as "inappropriate speech". Incomprehensible sounds refer to moaning and groaning without any recognizable words. This rudimentary vocalization does not necessitate awareness and is thought to depend upon subcortical functioning as it can be observed in anencephalic children and vegetative patients.

The motor response first assesses whether the patient obeys to simple commands, given in verbal, gestural or written form. A non-specific sound stimulus may induce a reflex contraction of the patient's fingers or alternatively such a reflex response can result from the physical presence of the examiner's fingers against the palm of the patient (i.e., grasping reflex). Before accepting that the patient is truly obeying commands, it is advised to test that the patient will also release and squeeze again to repeated commands. If there is no response a painful stimulus is applied. First, pressure is applied to the fingernail bed with a pencil. If flexion is observed stimulation is then applied to other sites (applying pressure to the supraorbital ridge, pinching the trapezium or rubbing the sternum) to differentiate between localization (i.e., a stimulus at more than one site causes a limb to move so as to attempt to remove it by crossing the midline), withdrawal flexion (i.e., a rapid flexion of the elbow associated with abduction of the shoulder) or 'abnormal' flexion (i.e., a slower stereotyped flexion of the elbow with adduction of the shoulder that can be achieved when stimulated at other sites). Stereotyped flexion responses are the most common of the motor reactions observed in severely brain-injured patients; they are also the most enduring (Born 1988). Extensor posturing is more easily distinguished and is usually associated with adduction, internal rotation of the shoulder and pronation of the forearm. The term 'decerebrate rigidity' should be avoided because it implies a specific physioanatomical correlation. Abnormal flexion and extension motor responses often co-exist (Bricolo et al. 1977). It is important to appreciate that it is the best response that should be scored and that abduction movements reflect some residual awareness while stereotyped postures do not. The presence of asymmetrical responses are significant in indicating that there is a focal as well as a diffuse disturbance of brain function, and this should be noted separately. The side showing the impaired response locates the site of the focal brain damage and the level of the best response of the better side reflects the extent of general depression in brain function. The scale of responses to pain is applicable to the movements of the arms. The movements of the legs are not only more limited in range, but may take place on the basis of a spinal withdrawal reflex (e.g., in brain death, a spinal reflex may still cause the legs to flex briskly in response to pain applied locally (Ivan 1973)).

It is very tempting to sum the three components of the GCS (E-V-M) into a total score, ranging from 3 to 15. However, given the increased use of intubation, ventilation and sedation of patients with impaired consciousness before arrival at specialists units, and even before arrival at hospital (Marion and Carlier 1994), patients might wrongly being scored as GCS 3/15 rather than being more appropriately reported as impossible to assess or score. In a recent study of 1005 patients with head injuries in European centers, assessment of each of the three components of the GCS was possible only in 61% of patients before hospital, in 77% on arrival at the first hospital, in 56% on arrival in the neurosurgical unit, and in 49% of 'post-resuscitation (Murray et al. 1993). The inappropriate scoring of absent responsiveness as 3 has led to some data indicating that the mortality of patients with a score of 3 is apparently lower than that of those with a score of 4. Summing GCS components has also been criticized on a purely mathematical basis. Because there are only four units assigned to the eye responses, versus five to the verbal and six to the motor responses, the scale incorporates a numerical skew toward motor response. This problem can be tackled by weighting individual scores for eye, verbal and motor responses in such a way that each has a minimum contribution of one and a maximum of five (Bhatty and Kapoor 1993). This approach, however, is too complicated for practical use. Moreover, this effort to provide mathematical parity for the three components has abutted against studies that have stressed the particular importance of the motor portion of the GCS. Indeed, the motor score is more important than either of the other two components in predicting the magnitude of neurologic injury for patients with severe head injury (Jagger et al. 1983). While verbal and eye scores are more pertinent in patients who are not, in fact, comatose. It is a widespread but erroneous usage to define mild brain injury as a summed score ranging from 13-15, moderate injury, 9-12, and severe injury, 3-8. Indeed, in the persistent vegetative state, patients open their eyes spontaneously (E4) and may make moaning sounds (V2) or flex abnormally to pain (M3), while their condition hardly reflects "moderate" brain injury. For

clinical purposes, summation of the GCS is too imprecise (Bozza Marrubini 1984). To achieve a total score of 6 to 12 there are more than 10 simple combinations of variables, each with very different clinical profiles. In Glasgow, patients are always described by the three separate responses and never by the total (Teasdale et al. 1983). It is, therefore, good practice to communicate the GCS in terms such as "patient scored E2, VT, M4" and only sum its three components for research applications.

**Pitfalls**

Untrained or inexperienced observers produce unreliable scoring of consciousness (Rowley and Fielding 1991). In one study, one out of five ICU workers were mistaken when asked to make judgments as to whether patients were 'conscious' or 'unconscious', (Teasdale and Jennett 1976). Consciousness needs considerable skill to evaluate and the observer should be aware of the pitfalls encountered at ICU settings. It is also well known that the preceding score of the patient frequently influences the examinator when rating the patient's present state of consciousness. It therefore is recommended to score in a "blinded" manner.

Obviously, problems arise when the eyes are swollen shut, either following periorbital edema, direct ocular trauma, facial injury, craniotomy, cranial nerve VII injury or neuromuscular blockade. In these circumstances the enforced closure of the patient's eyes should be recorded on his chart by marking "C" (= eyes closed) (Teasdale 1975). In deep coma, flaccid eye muscles will show no response to stimulation yet the eyes remain open if the lids are drawn back. Such opening should be recorded as unresponsive. It is important to stress that although opening of the eyes implies arousal, it does not necessarily mean that the patient is aware.

Continued speechlessness may be due to causes other than unawareness (e.g., neuromuscular blockade, intubation via the oropharynx or through a tracheostomy, fractured mandible or maxillae, edematous tongue, deafness, foreign language, dysphasia, confusion or delirium). The evaluation of verbal responses is also biased when patients are sedated, alcohol or drug intoxicated or too young to speak. The use of early intubation and administration of neuromuscular paralyzing agents in the pre-hospital phase of care has rendered verbal and motor responses unmeasurable in these cases. Early treatment was uncommon when the GCS was first described, but has since gained greater acceptance. The FOUR (Wijdicks et al. 2005) and RLS85 (Starmark et al. 1988) which do not include a verbal response criterion, are the most notable alternative for scoring intubated patients. Several other techniques have been proposed to designate the verbal score in intubated patients. Some have proposed to assign an arbitrary score of one point to all intubated patients (Marshall et al. 1983). Others have created a pseudo-score by averaging the testable scores and adding this calculated score to the sum in lieu of the verbal score (Grahm et al. 1990). Linear regression predication of the verbal scores based on the other two scores has also been utilized (Meredith et al. 1998). The best alternative is to report separate responses, using a non-numerical designation of "T" (= intubated) when the verbal score cannot be assessed and not to sum the responses (Marion and Carlier 1994). The patient's verbal response may also be impaired as a result of a single focal lesion of the speech areas in the dominant hemisphere, that is, aphasia. The assessment of such a patient's language ability requires a specialized evaluation (e.g., written instructions and written replies in the case of motor dysphasia). The level of verbal response should still be indicated but an appropriate note may be made that the impairment is considered to be due to dysphasia ("D"= dysphasia) (Teasdale 1975). Motor responses cannot be reliably monitored in cases of spinal cord, plexus or peripheral nerve injury or in the presence of splint or immobilization devices. As previously stated, one must take care not to interpret a grasp reflex or postural adjustment as a response to command.

In most scoring systems, awareness is assessed as the level of obeying to commands. This approach cannot be applied to cases where the patient is clinically or pharmacologically paralyzed yet alert (e.g., locked-in syndrome, severe polyneuropathy or use of neuromuscular blocking agents) or those with psychogenic unresponsiveness. It is important to stress that special effort should be made to identify and exclude these

rare causes of pseudo-coma. The GCS has also been critiqued for lacking reliability in monitoring levels of consciousness in patients with moderate brain injury (Segatore and Way 1992). More detailed scales are recommended for the assessment of awareness in these patients (Malkmus et al. 1980; Majerus and Van der Linden 2000). Finally, as consciousness is a subjective first person experience, we remain with the theoretical limitation to the certainty of our clinical assessment of consciousness (since it is in another person that the clinician has to infer the presence or absence of conscious experience) (Bernat 1992).

Even if the GCS is the most widely used and validated tool to evaluate the state of consciousness, it also is the most frequently misused. One study showed that 51% of patients were incorrectly assessed (Crossman et al. 1998). It is important to stress that for clinical use, patients should be communicated by the three separate scores (E, V, M and R) and never by the total sum. If eye or verbal responses cannot be evaluated, this should be indicated by marking a "C" (eyes closed) or "T" (intubated), respectively.

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