In Search of a Better Measuring Scale of Consciousness

Coma is a robust predictor of death and poor outcome of any disease. Consciousness has two components: wakefulness and awareness. Wakefulness depends on the degree of consciousness and anatomical substrates of wakefulness are tegmentum of pons and mesencephalon with their projection ascending reticular fibers to the diencephalon and cortex. Awareness is a qualitative function of cortex after being wakeful.[1,2] The contents of consciousness depend on the functions of various cortical structures and subcortical connections. Consciousness may range from alert to obtundation, delirium, torpor, stupor, and coma. Impaired consciousness may be due to diffuse cortical or pontomesencephalic dysfunction, which may be anatomical or physiological. The function of these anatomical structures may be evaluated by assessing consciousness, respiration pattern, papillary changes, eye movement, motor response, and cranial nerve functions. Coma scales are developed since 1969 to standardize these responses with an aim to predict severity, disease course, and outcome. The scale should easy and quick to apply and interpret in an emergency setting.

In the last five decades, five validated scales are available:

1. Jouvet Coma Scale
2. Moscow Coma Scale
3. Glasgow Coma Scale (GCS)
4. Bozza-Marrubini Scale
5. Full Outline of UnResponsiveness (FOUR) Scale.

There are other coma scales such as Japanese Coma Scale and Innsbruck Coma Scale, which are not used internationally.

Jouvet Coma Scale has been reported in 1969 and is based on two parameters as follows: (1) perception to written and verbal command and orientation to time. (2) Reactivity to specific, nonspecific and autonomic stimuli. The overall score ranges between 4 and 14, and higher score suggests more severe coma.[3] This scale gives good clinicoanatomical correlation but is complex, difficult to use and time-consuming, hence not suitable for emergency setting.

Moscow Coma Scale has been reported in 1991 and is based on 15 clinical parameters with a total score of 15–75. Patients with a score of 15 often die.[4] This scale has excellent predictive value but not used outside Russia probably because of political and language isolation.

Bozza-Marrubini Coma Scale has been developed in 1983 and is based on reactivity to voice and pain, and brain stem reflexes (pupillary and the vestibulo-ocular reflex). The Bozza-Marrubini Coma Scale ranges between 3 and 37, lower the better.[5]

GCS was developed in 1974 by Teasdale and Jennett as a practical guide for assessing the level of consciousness in traumatic brain injury by the emergency doctor and health professionals. The GCS score ranges between 3 and 15 based on the eye (4), verbal (5) and motor (6) response. Lower the score, worse is the outcome; a cutoff of ≤8 is considered serious condition.[6] Since then, the GCS score has been enjoying its dominance throughout the world. Its use has been extended beyond the traumatic brain injury to stroke, encephalopathy, central nervous system infection, septicemia, or any disease with altered sensorium. The widespread use of GCS in the last four decades is because of its ability to predict death, functional outcomes, ease and quick to perform, and ability to show day-to-day variation.[7-9] The GCS, however, has been criticized for the following reasons: (a) eye-opening present in vegetative state, (b) verbal response is not possible to assess in the patients with aphasia, endotracheal tube, and orofacial trauma, (c) does not assess all the anatomical correlates of consciousness, and (d) high inter-rater and intra-rater variability. The accuracy of GCS score and its component has been reported by assessing 10 video vignettes, 2084 observations made by 217 emergency providers. Overall GCS scoring accuracy was only 33.1%. Verbal response had higher accuracy (69.2%) followed by eye-opening (61.2%) and motor response (59.8%).[10] Similar results have also been reported by other studies as well.[11-13]

To overcome these limitations of the GCS score, FOUR score was developed in 2005 by Wijdicks *et al*.[14] Instead of verbal response, FOUR score includes brainstem reflexes and respiration. Each of four domains (eye response, motor response, brain stem reflexes, and respiration) is given equal weight 0–4 marks, 0 being for the worst, and four being the best. The total score range between 0 and 16. It has an advantage of being easy to perform, assesses more detail neurological status than GCS, can predict herniation due to the inclusion of pupillary and vestibulo-ocular reflex and has a higher predictive value in intensive care unit (ICU) patients.[15] These advantages, however, were not found valid in a recent study. Kasprowick *et al*. compared utility of FOUR score and GCS score in predicting the outcome of the patients with traumatic brain injury. The FOUR score along with age, systolic arterial blood presence, the computed tomography (CT) Rotterdam score and need of mechanical ventilation on day 1 predicted ICU mortality. The GCS score also had similar predictive values for ICU mortality with the same set of predictors in addition to pupillary reflex. This highlights the advantage of the inclusion of pupillary reflex in the FOUR score. The CT Rotterdam score, age and either the FOUR or GCS score equally predicted unfavorable outcome at 3 months. The FOUR or GCS score at discharge rather than

at admission had higher predictive value for the unfavorable outcome at 3 months. This study highlight equal predictive value of GCS score and FOUR score in multivariate analysis.[13] The verbal response in GCS and respiration in FOUR were found to be insignificant for mortality prediction in traumatic brain injury.[15] Wijdicks *et al*., however, found the good predictive value of FOUR score in different etiologies of ICU patients, and suggested that this may be due to the inclusion of brainstem reflex and respiration component.[16] It may be prudent to replace verbal response in GCS with pupillary reflex and to evaluate predictive model; or using permutation and combination of various coma scale parameters to derive a robust, short, and easy to apply scale if it is better than the most commonly used GCS for coma assessment.

The outcome of any critically ill patient, however, depends on reversibility, treatable etiology and extent of structural brain damage. The patients with malaria and scrub typhus in spite of being deeply comatose, on a mechanical ventilator have lower death and better outcome compared to tuberculous meningitis, as tuberculous meningitis is associated with infarction, hydrocephalous, and granuloma.[17,18] Reversible metabolic coma such as hyponatremia and hyperosmolar coma has a better outcome than the patients with end-stage renal or hepatic failure.[19] Therefore, a single scale may assess severity and to some extent prognosis, but cannot give everything. Same cork may not be fitted to every bottle. Therefore, there is the role of human skill and intuition which help in knowing the deterioration before the scale scores the deterioration. Intuition is knowing without knowing how we know.

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