Clinimetric measurement in traumatic brain injuries

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Abstract
Traumatic brain injury is a leading cause of death and disability worldwide. Every year, about 1.5 million affected people die and several millions receive emergency treatment. Most of the burden (90%) is in low and middle-income countries. The costs of care depend on the level of disability. The burden of care after traumatic brain injury is caused by disability as well as by psychosocial and emotional sequelae of injury. The final consequence of brain injury is the reduction of quality of life.

It is very difficult to predict the outcome after traumatic brain injury. The basic clinical model included four predictors: age, score in Glasgow coma scale, pupil reactivity, and the presence of major extracranial injury. These are the neuroradiological markers of recovery after TBI (CT, MRI and PET) and biomarkers: genetic markers of ApoE Gene, ectoenzyme CD 38 (cluster of differentiation 38), serum S100B, myelin basic protein (MBP), neuron specific endolase (NSE), and glial fibrillary acidic protein (GFAP).

These are many clinimetric scales which are helpful in prognosis after head injury. In this review paper, the most commonly used scales evaluating the level of consciousness after traumatic brain injury have been presented.

Keywords: Traumatic Brain Injury, TBI, coma, consciousness

Introduction
Every year, about 1.5 million affected people die and several millions receive emergency treatment because of traumatic brain injury (TBI). The costs of care after TBI are also caused by disability as well as by psychosocial and emotional sequelae of injury. It is very difficult to predict the outcome after traumatic brain injury.

The basic model included four predictors: age, Glasgow coma scale, pupil reactivity, and the presence of major extracranial injury. In a CT model, additional indicators were the presence of petechial hemorrhages, obliteration of the third ventricle or basal cisterns, subarachnoid bleeding, mid-line shift, and non-evacuated hematoma [1]. The longer the period of post-traumatic amnesia, the worse the outcome. The latter is defined as the period of time from injury until resumption of day-to-day memory.

There is a crude correlation between the amount of brain damage (as determined by MRI) and long-term outlook. However, there are many exceptions to these general rules and it is always unwise to give any definite prognosis within the first few weeks of injury. Most physical recovery will occur in the first 12 months, but some physical improvement can certainly occur during the second year after injury. Neuropsychological recovery takes much longer and between 2 and 3 years is usually taken as reasonable length of time for natural recovery to continue [2]. Following Oxford Handbook of Rehabilitation Medicine these are five factors that reduce life expectancy after TBI: immobility, incontinence, inability to swallow (necessity of PEG), on-going and uncontrolled epilepsy, severe cognitive and intellectual damage [2].

These are many clinimetric scales that assess consciousness and disability after TBI, i.e. Glasgow Coma Scale (GCS), Grady Coma Scale, Comprehensive Level of Consciousness Scale (CLOCS), Full Outline of UnResponsiveness score (FOUR), JFK Coma Recovery Scale – Revised (CRS-R), Disorders of Consciousness Scale (DOCS), Disability Rating Scale (DRS), Coma/Near-Coma Scale (CNC), Sensory Modality Assessment Rehabilitation Technique (SMART), Rancho Los Amigos Cognitive Levels (RLA), Western Neuro Sensory Stimulation Profile (WNSSP), Sensory Stimulation Assessment Measure (SSAM), Wessex Head Injury Matrix (WHIM), Loewenstein Communication Scale (SCS), Swedish Reaction Level Scale (RLS 85), Innsbruck Coma Scale (INNS), Glasgow Liege Coma Scale (GLCS), Neurological Outcome Scale for TBI (NOS-TBI) [3-27]. In this review, the most popular and valid scales will be described.

Scales assessing disorders of consciousness

The Glasgow Coma Scale (GCS) has been the gold standard of neurologic assessment for trauma patients since its development by Jennett and Teasdale in
1974 [22-24]. The GCS was found to be a simple tool to use. It became the method of choice for trauma care practitioners to document neurologic findings over time and predict functional outcome. Although the scale has been shown to be effective, many authors have cited weaknesses in the scale including the inability to predict the outcome, variation in inter-rater reliability, and the inconsistent use by caregivers in the prehospital and hospital settings.

GCS is based on motor responsiveness, verbal performance, and eye opening to appropriate stimuli. Individual elements as well as the sum of the score are important. The final score, expressed in the form “GCS 9 = E2 V4 M3 at 07:35”, ranges from 1 to 15. Generally, brain injury is classified as severe (with GCS < 9), moderate (GCS 9–12) and minor (GCS ≥ 13).

According to Matis and Birbilis these are many conditions that affect the calculation of three components of GCS: ocular trauma, cranial nerve injuries, pain, intoxication (alcohol, drugs), medications (anesthetics, sedatives), dementia, psychiatric diseases, developmental impairments, no comprehension of spoken language, intubation, tracheostomy, laryngectomy, edema of tongue, facial trauma, mutism, hearing impairments, language, Intubation, tracheostomy, laryngectomy, edema sedatives), dementia, psychiatric diseases,
that the WHIM was largely superior to the GCS and Glasgow Liege Coma Scale for detecting subtle changes for patients emerging from the vegetative state and for patients being in a minimally conscious state. However, the study also showed that the sequence of recovery proposed by Shiel et al. (2000) is very probabilistic and lacks precision, as the proposed order of recovery could not be replicated for all items of the scale [12].

In 2002, Borer-Alafi et al. published the Loewenstein Communication Scale. LCS measures five hierarchical functions - mobility, respiration, visual responsiveness, auditory comprehension and linguistic skills (verbal or alternative) - which are divided into five parameters and rated in developmental order on a 5-point scale by level of difficulty [5]. In 1984, Stanczak et al. proposed an alternative method of coma assessment compared with the Glasgow Coma Scale called Comprehensive Level of Consciousness Scale. CLOCS is a simple scale consisting of seven items assessing eye responses, motor, posture, communication and general responsiveness [20].

In 1985, the Swedish Reaction Level Scale (RLS 85) was developed by Starmark et al. It is a single, eight grade lines scale where 1-3 means that the patient is conscious and 4-8 means that the patient is unconscious [21]. In 1991, Innsbruck Coma Scale (INNS) was created by Benzer et al. and modified by Diringer and Edwards in 1997. It assesses eight reactions in a four-level scoring system. The validation made in 1997 proved that both GCS and ICS are good at predicting independence (GCS and ICS, 71% correct) and mortality (GCS, 60% correct; ICS, 56% correct) and in predicting levels of outcome (help or independent) [4,7].

In 1982, Born et al. developed the Glasgow-Liège Coma Scale (GLCS). It combines the GCS with a quantified analysis of five brain stem reflexes: frontoorbicular, vertical oculocephalic, pupillary, horizontal oculocephalic and oculocardiac. The study done in 1987 showed the good agreement achieved by different examiners in the evaluation of brain stem reflexes. Brain stem reflexes offer a slightly higher agreement (kappa = 0.69) than that of the study of motor response (kappa = 0.65). In conclusion: the reliability of the evaluation of motor and brain stem parameters justifies the use of the GLCS as a means for evaluating disturbances of consciousness [6].

Neurological Outcome Scale for TBI (NOS-TBI) has been developed in 2010 by Wilde et al. This is an adaptation of the National Institutes of Health Stroke Scale (NIHSS), specifically for clinical and research use in patients with TBI, including the addition of items specific to TBI, adjustment to the scoring algorithm to allow quantification of deficits in patients who are comatose/vegetative or agitated, and the reassignment of items (i.e., limb ataxia) that are problematic in TBI as supplemental items. The total score for the NOS-TBI is the sum of the scores for items 1–13 (based on 3-, 4-, and 5-level ratings, where 0 represents no impairment or deficit. Items 14 and 15 are considered supplemental and do not factor into the total score; thus low scores reflect less severe neurological impairment. This scale is envisioned to serve as a tool for initial stratification of injury severity, and as an outcome measure in randomized clinical trials [26].

In 2010, Seel et al. published a report of the American Congress of Rehabilitation Medicine, Brain Injury-Interdisciplinary Special Interest Group, Disorders of Consciousness Task Force, Assessment scales for disorders of consciousness: evidence-based recommendations for clinical practice and research. According to it, the JFK Coma Recovery Scale – Revised (CRS-R) may be used to assess disorders of consciousness with minor reservations, and the SMART, Western Neuro Sensory Stimulation Profile (WNSSP), Sensory Stimulation Assessment Measure (SSAM), Wessex Head Injury Matrix (WHIM), and Disorders of Consciousness Scale (DOCS) may be used to assess disorders of consciousness with moderate reservations. The FOUR, Innsbruck Coma Scale (INNS), Glasgow-Liege Coma Scale, Swedish Reaction Level Scale-1985, Loewenstein Communication Scale (SCS), and Comprehensive Level of Consciousness Scale (CLOCS) are not recommended at this time, bedside behavioral assessment of disorders of consciousness because of a lack of content validity, lack of standardization, and/or unproven reliability [28].

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