Instruments for evalutation of altered states of consciousness

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Abstract

In recent years an increase of interest concerning the altered states of consciousness was observed. In particular literature provided a wide amount of contribution about the scales for measurement of level of responsivity. Our aim is to describe the principale scales used in diagnosis of Disorder of Consciousness (DOC) trying to illustrate administation procedures, specifically assessed aspects, modality of stimulation, reliability, and validity. We divided them in four main different groups: the first one in which descriptive scales are included, that is those scales basically used after a clinical observation; the second group which concerns scales requiring defined stimulation sets; in the third group we considered the scale which refer to diagnostic criteria stated by the Aspen Work Group (Giacino et al., 2002); whilst in the fourth group we describe a battery aimed to assess patients with severe cognitive deficits which are not yet evaluable with neuropsychological tests.

Keywords: DOCs; Coma; Vegetative state; Minimally conscious state; Assessment

1. Introduction

Awareness can be affected following a severe brain injury, for variable periods. There is a wide agreement between authors in identifying three clinical levels corresponding to different ways in which consciousness can be damaged. The first category is Coma intended as the clinical condition characterized by

absence of eye opening, no comprehensible speech output, lack of response to command (Jennett & Teasdale, 1981); another state of severe deficit following acquired brain injury is Vegetative State (VS) which corresponds to the clinical condition of recovery of consciousness (characterized by eye opening) without the ability to interact with the environment (The Multy-Society Task Force on the Vegetative State, 1994); at least, Minimally Conscious State (MCS) that is the condition in which severe impairments of consciousness are documented but, although inconsistently, behaviors that express awareness of self and surrounding environment are present (Giacino et al., 2002).

The transition between coma and VS is easily identifiable by eye opening; but on the other hand it is much more difficult to judge if the patient moves from VS condition to MCS, actually in this case reliable and repeatable signals, indicative of the presence of conscious should be detected at the bed-side examination. Consciousness, thought as understanding the sense of self, others and the surrounding environment (Cohadon, 2003), can not be directly observed and the clinician can only draw inferences about the state of consciousness from patient's overt behavior (Laureys et al., 2005; Giacinto et al., 2007). For a detailed clinical description of the three clinical categories of disorder of consciousness see Inzaghi and Sozzi (in press, same issue).

One of the most studied subject in disorder of consciousness is the modality of assessment, and in particular the detection of signals that indicates the presence of consciousness. Detection of patient's reactions seems to be dependent to many variables including significant differences between examiners, extreme variability of the patient's behaviors and unpredictable fluctuations in arousal during the day, which may often influenced by drugs too. The literature shows considerable percentage of errors (varying from 30% to 40%) in the evaluation of patients. Some author show how they can be classified as VS when they are in MCS at a matter of fact, and this has surely dramatic consequences on their management (Childs et al., 1993; Andrews et al., 1996; Schnakers et al., 2009). A proper assessment of the level of responsiveness in the early stages, in fact, allows capturing the subtle changes that are indicative of possible changes and all of these observations are found to be relevant in rehabilitation projects to obtain the best recovery. In more steady conditions, the evaluation aims to identify level of responses, and monitor them over time in order to find a possible delayed recovery of consciousness.

If not caught, early signs of the presence of consciousness could determine a decrease or even a premature interruption of finding ways of communication, and, further, the interruption of rehabilitative treatment programs. On the other hand, overestimate the random answers or interpret behavior as deliberate reflections, can lead to false optimistic hypotheses, realizing excessively long treatments no longer eligible. The Multy-Society Task Force on

persistent VS (1994) claims that in order to determine whether a patient is conscious or not and whether or not feels pain, careful repeated neurological examinations are the best evaluation modality, so the assessment of the condition of VS and MCS should be defined on the basis of clinical criteria (Jennett, 2002). To evaluate the presence of responsiveness, the patient should be able to process and comprehend the request, and, on the other hand, he or she should have a reliable way to communicate, even in a basically code, such as a yes/no code. Several factors can hinder one of the two processes and can therefore become confounding factors in assessing the state of consciousness. All of these possible factors must be considered at the time of diagnosis: first of all, motor deficits: hemiplegia, cerebellar or extrapyramidal syndromes, spinal injury, injury of the peripheral nervous system, serious damage to the musculo-skeletal system, etc. These may hinder the performance of the motion required; then sensory deficits: impairment of cranial nerves, injuries of visual, auditory and olfactive systems, cortical blindness, lack of sensitivity and so on, actually the patient can prevent the detection of stimuli offered. Cognitive deficits such as aphasia, apraxia, agnosia, neglect, disexecutive syndrome, attention deficits, etc. may determine an impairment in the stimulus detection and in giving response. Moreover, medications: several authors argue that correct drug cares could promote the recovery contact with the environment (Haig & Ruess, 1990; Wroblewski et al., 1993; Wroblewski et al., 1996; Plenger et al., 1996; Reinhard et al., 1996; Matsuda et al., 1999; Passler & Riggs, 2001; Meythaler et al., 2002) however, some drugs can produce an inhibitory effect (Feeney et al., 1993; Goldstein, 1999). This view has had a widespread interest in the literature and clinical practice but no significant evidences of these effects were provided (Forsyth & Jayamoni, 2003): the evidence level is "expert opinion". At least, hydrocephalus: this condition may follow to hemorrhagic or traumatic lesions and could determine a further involvement of white matter which prevents the recovery of consciousness. The diagnosis of vegetative state must therefore exclude the presence of this condition (Pickard et al., 2005), as also claimed by the Royal College of Physicians in their detailed guidelines (2003).

In addition, other factors may hinder the detection of intentional responses. First, the examiner must have adequate experience and specific training and he or she should do any effort to be impartial and should not get involved in the interpretation of signals dictated from his or her expectations. The general health of the patient can then delayed his or her possibility of conscious interaction: the presence of pain, the increase in body temperature, infections, lack of adequate sleep, activities that can reduce the few attentional resources available. Finally, the environment where the patient spends his or her days can cause discomfort because too full of noise in along the day

and with an excessive intense stimulation; actually there are no studies at the moment that can exclude a distressing effect for the patient.

Distinguish between Coma, VS and MCS requires rigorous evaluation, and the use of appropriate tools. The use of structured scales for neurobehavioral assessment of patients with severe acquired brain deficit is justified by the need to seek a result concerning the quantification of the damage; this result should be the most objective and reproducible as possible, either for clinical evaluation or medical-legal value (Zasler, 2004). In a recent review (Inzaghi et al., in press) we analyzed the literature about instruments for the assessment of the altered state of consciousness as a result of severe brain injury, which should lead to a correct diagnostic classification. This research was conducted analyzing works published between 1981 (year of publication of the work of Jennett & Teasdale, 1981 on the definition of coma) and 2010.

From the wide number of works we found, we then excluded those one in which main subject concerned electrophysiological investigations (EEG, EP, EMG), fMRI and other functional neuroimaging techniques, work on animals, pediatric patients, medication or cyto-biological data, medical-legal, neurosurgical or ethical-moral aspects, and those containing only recommendations for the management of patients without describing in detail an assessment procedure. Based upon these limits, 20 works concerning behavioral evaluation were considered. All of them were characterized by detailed description of scales that can be used in assessment at a bedside examination; analyzing each one of them, we found that these scales could be divided into 4 main groups.

2. Group 1

The first group includes the "descriptive" scales, that is those one characterized by taxonomic criteria to be applied to patients after a clinical observation; these tools are found to be advantageous for the easy and speed way of administration, however, they show a reduced sensitivity to minor changes in level of consciousness, and in highlighting subtle changes in the framework of the transition between various altered states of consciousness.

2.1. Rancho Los Amigos Levels of Cognitive Functioning Scale (LCFS) (Hagen et al., 1972; Hagen, 1997)

The LCF consists of a nominal scale of eight categories; it allows the categorization of the cognitive level of a patient based on reactivity to environmental stimuli, the level of confusion, the level of agitation and the presence of

cognitive deficits. Since it is a scale of observation of behavior in response to external stimuli, the LCF does not require direct cooperation by the patient. The organization describes the levels of cognitive and behavioral steps that may occur as a result of brain damage, from the low responsiveness to the complete autonomy. Moreover it allows to identify the highest level of participation. Not all patients necessarily run through the whole sequence of levels, they can present only some of the characteristics of a level or show at the same time aspects described in more than a level. This classification is used to describe and monitor trends over time, but it does not give a prediction nor about speed of transition from one level to another, nor about the fact that a level corresponds to a temporary or permanent stay. The inter-evaluator reliability (from .87 to .94) and the test-retest reliability (.82) are high. The LCF is suitable for use at the bedside of patients with any level of severity and is widely used in the rehabilitation fields. It can be administered by most healthcare personnel. There is also a modified version in 1997 (LCF-R); compared to the original (LCF) it provides more clearly and articulated definitions, and in particular concerning cognitive and behavioral characteristics; moreover more advanced stages of recovery are considered in a more detailed form.

2.2. Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974; Jennett &Teasdale, 1981)

The GCS is the most widely used objective scale for measuring the level of coma. This test is brief and easy to administer and provides a numerical score indicating the level of vigilance based on the observation of eye opening, motor response and verbal behavior. It was shown to have a moderate internal consistency (Crombach alpha = . 69), high inter-evaluator reliability (.95) and test-retest reliability (.85) in a large neurosurgery patient sample. In this same sample, the evaluation through the GCS moderately correlated (.56) with independent assessments of the level found by nurses. The GCS is suitable for use at the bedside of comatose patients and can be administered in a series. It requires a simple training, and can be administered by most healthcare personnel, including physicians, nurses, psychologists and speech therapists.

2.3. Disability Rating Scale (DRS) (Rappaport et al., 1982)

The scale has the objective to provide an instrument which gives a quantitatively measure of the disability outcomes for patients with severe head injury, so it can document their evolution throughout the rehabilitation process, from initial coma, passing through various stages of impaired level

of consciousness and coming at the time of hospital discharge and reintegration into communities. The DRS is a test with 8 items divided into four categories: (1) vigilance and responsiveness (includes the voices eye opening, communication skills, and best motor response), (2) cognitive skills for self-care (includes ability to feeding, sphincter control, ability to wash), (3) dependence on others (corresponds to the entry level of functional autonomy), (4) social participation (including possible employability). The score ranges from 0 (no disability) to 29 (severe vegetative state). The items are related to arousal changes recorded in the GCS; the numerical values are in reversed scale so that high scores correspond to more deterioration, while low scores correspond to less deterioration. The patient's behavior is evaluated through observation and by analysis of the responses to various stimuli. The inter-rater reliability for the full DRS is high (from .97 to .98). DRS allows better monitoring of patient progress and is more predictive about the long-term outcomes, but it can not provide a fully, sensitive evaluation of disorder of consciousness by itself; it represents a suitable and good-level instrument when used in association to other scales such as Coma Near Coma or Coma Recovery Scale. It has been documented also a high correlation between DRS and some measures of brain function (e.g. evoked potentials). As for LCF, it may be administered by all member of health care group. The correlation between different examiners (inter-rater reliability) is very high (0.97/0.98).

2.4. Sensory Stimulation Assessment Measure (SSAM) (Rader & Ellis, 1994)

The SSAM records three categories of responses (eye opening, response of the eyes, vocalization-verbalization) by the administration of structured stimuli concerning the following modalities: visual, gustatory, tactile and olfactory. Each category is divided into scores from 1 to 6, hierarchically organized in order to be compatible with the behavior commonly observed in brain-injured population. Lower values are assigned to responses that reflect no changes in behavior, while higher values represent the better demonstration of the patient's ability to use a reliable and consistent behaviors of eye opening, movement and verbalization. The evaluation procedure for each sensory modality consists on a gradual stimulation whose last level consist of formulation of questions in order to study the accuracy of patient response. The limit of this scale is the need that the patient can understand increasingly complex verbal commands presented in written form, and he or she is able to overcome the tendency to provide perseverative answers, so disexecutive syndrome and aphasia could be a limitation. The latter aspect my consequently influence the application of the scale because even non-verbal yes/no codes,

useful in the presence of a locked-in syndrome, could be ineffective in case of lack of communicative competence.

2.5. Coma Exit Chart (CEC) (Freeman, 1996)

This scale was developed using the parameters of the GCS. The assessment procedure involves collecting information from family, friends and staff, clinical examination and discussion of post-examination. The criterion "eye opening" and "verbal reaction" are the same as the GCS, and they are examined in addition to auditory, visual and tactile feedback. Motor skills involve the analysis to the ability in controlling the movement of the head, arm, hand and leg. Another criterion considered in this scale is the emotional expression, that is evaluating by asking family members and staff if the emotional reactions manifested by the patient, are congruent with the contextual situations. No statistical analysis were provided by the Authors with the proposed score system.

2.6. Wessex Head Injury Matrix (WHIM) (Shiel et al., 2000)

The authors propose an assessment based on the behavioral observation made by the entire multidisciplinary team. The aim of these authors is to develop an assessment technique in which data can be collected by observation through the application of tasks used in everyday life. The operational basis for the development of WHIM derive form the clinical approach that describes the more frequently behaviors detected in traumatic-brain injury rehabilitations. The observed behaviors were then recorded and categorized by authors into spontaneous behaviors, behaviors as reactions to stimuli incidentally presented, and behaviors related to specific answers to test stimuli. The scale consists of 58 items. The internal validity is 0.86 and test-retest reliability is 0.74.

2.7. Full Outline of Unresponsiveness (FOUR) (Wijdicks et al., 2005; Wolf et al., 2007)

FOUR is designed as an alternative scale to the GCS in the assessment of the state of disorder of consciousness in seriously ill patients; it evaluates 4 main components: eye response, motor, and breathing reflexes of the trunk; each subscale has a maximum score of 4. The component based on observation of breath and trunk reflexes lead to a differentiation only between severely different ill patients. But, on the other hand, the FOUR scale seems useful in identifying patients in locked-in syndrome because of the possibility to test,

on command, the open and closing movements of the eyes. However, even though it is a good scale to differentiate between severe injured patients, and moreover to individuate closing-in syndrome patients, it could show some lack in differentiate between VS and MCS.

3. Group 2

The second group is characterized by those scales which require the administration of specific and defined stimulation and a subsequent analysis of the responses. This second group includes the scales published before the theoretical contribution and definitions provided by the Aspen Work Group (Giacino et al., 2002), so they do not allow to diagnose the transition from VS to MCS and from MCS state to full consciousness. However, the overall scores obtained from these assessment can provide information about the state of consciousness in terms of improvements or regressions, nevertheless they show limitation concerning not taking into total account the presence of sensory and cognitive deficits frequently present in severe acquired brain damaged patients. From this point of view the analysis of the overall score could be affected by the presence of a cognitive or sensory deficits and that would result in an underestimation of consciousness and thus lead to a misdiagnosis.

3.1. Coma Near Coma Scale (CNC) (Rappaport et al., 1992)

The CNC was developed to evaluate the responsiveness of patients with severe brain lesion. The scale examines the patient's response on stimulation with different sensory modalities (verbal, auditory, visual, tactile, nociceptive, olfactory). Compared to the DRS, the CNC has a higher sensitivity in detecting small changes that may characterize the degree of responsiveness of the patient. Numerous studies have shown that the CNC score correlates positively with physical and mental condition of the patient and with the results of neurophysiological investigations. The score at the CNC is also a reliable indicator of the progress made by the patient or, otherwise, the absence of improvements. The CNC is finally a useful instrument to predict the outcome, even when the evaluation is made after a long period from brain injury. The CNC can be used for patients with scores greater than or equal to 21 at the DRS; it is a simple administration tool, which requires a limited time to be applied (about 20 minutes). For every item you can give a score range from a minimum of 0 (if the subject provides the expected response) to a maximum of 4 (if the subject does not give the expected answer or gives an answer that

is unrelated to the stimulus). The total score is the average obtained dividing the sum by the number of items administered (in some cases, it is not possible to administer all the stimuli: for example if the patient has a tracheostomy cannot be given the olfactory item). The final score can be attributed to class level and each level has its own definition in the term of variation of "coma" (e.g. extreme coma, moderate coma, no coma, near coma). Even if it represents a sensitive tool to assess variation of responsivity, it provides an obsolete terminology as it reflects a basic theoretical construct, which does not take in consideration the evolution of the concept of coma and the acquisition of consciousness, even thought Rappaport, provided a wide description of the behavioral repertoire attributed to each category. To increase the reliability of the test and considering the well-know behavioral variability of these patients, Rappaport recommended to administer the CNC twice a day for the first two days, then weekly for three weeks and finally every 15 days until the DRS remains below 21. The CNC has high validity and reliability rates.

3.2. Western Neuro-Sensory Stimulation Profile (WNSSP) (Ansell & Keenan, 1989)

This scale is oriented to provide a more objective and precise measurement of the patient described as stages II to V at LCF (i.e. Level of Cognitive Function, see above) and monitor changes in patients who are stable for a long time to levels II and III of LCF. According to authors, a further aim is to predict improvement of patients. It consists of 32 items that assess activation and attention, expressive communication, response to visual, tactile, auditory, and olfactory stimulation. In the section of attention/activation the examiner observes if the patient is awake, if he or she has eye contact and pays attention to the tasks. In the expressive communication section, the examiner evaluates the presence of a yes/no code to simple questions and the ability to vocalize and articulate words. The section of responses to auditory stimulation involves the assessment of voice perception and nonverbal sounds, and of ability to respond to commands; while the visual stimulation section is assessed by means of gaze tracking behavior and responding to commands presented with written procedures; furthermore the tactile stimulation section assesses the ability to perceive and use of common objects while in the olfactory section the perception of some odors is evaluated. The scale can be administered in 20-40 minutes. It uses a scoring system for all items with variable-range from 0-1 to 0-5. The higher is the score, the higher is the level of cognitive behavior. The total score is the sum of all 32 performance items. The subscale scores at 6, arousal, attention, auditory comprehension, visual

comprehension, visual tracking, object manipulation olfactory and tactile feedback, allows to evaluate the pattern of specific behavior for each patient. In their work, the authors show the scores of a large sample of patients and the internal validity coefficient (a. Crombach) is .95.

3.3. Lowenstein Communication Scale for the Minimally Responsive Patient (LCS) (Borer-Alafi et al., 2002)

The authors' aim is to create a tool to discriminate between patients in VS and MCS. The scale assesses 5 functions: mobility (motor skills to communicate in the environment), breathing (basic skills for breathing and vocalization), visual response (the use of visual channels of communication to understand the basic contact and react to the environment), verbal comprehension (patient's response to noise and human voice, and the presence of simple or complex verbal productions), and finally communication skills (verbal communication: language and ability to articulate words, quality of the message; alternative communication: ability to communicate through specific movements or instruments). Each function is divided into 5 parameters, the score ranges from 0 (no response) to 4 (totally appropriate response). The scores for each function (maximum 20) are added together to obtain a global profile with a total score from 0 to 100. The theoretical construct of this scale is oriented towards the evaluation of communication ability as only sign of the presence of consciousness; for this reason, it does not take into account other signs that can reliably classify the patient as responsive. Moreover the only analysis of communication skills could be an important limitation for all aphasic patients. Consequently, its detailed and well-organized structure in collecting response, allow the its use only in those cases in which aphasia could be clearly excluded.

3.4. Disorders of Consciousness Scale (DOCS) (Pape et al., 2005)

The first version was developed between 1991 and 1992, reviewed in 1999. Even if validated in 2005 it does not take into account the theoretical definitions of the group of Aspen. The authors investigated the following aspects: social knowledge and responses to various stimulation: auditory, visual, taste and swallowing, olfactory, proprioceptive vestibular, and tactile. The order of item administration is realized on the basis of the reflex functioning indicating the integrity of neurophysiological hierarchical structures. The administration of the scale is interrupted if the patient shows the presence of consciousness. In this scale, a larger importance is given to reflex responses with respect to the components of social interaction and communication skills which are not

even considered; we claim that the presence of reflex responses can only be indicative of the possibility that the patient can use a specific sensory modality but does not provide some indication of the state of responsiveness, this scale shows however a very detailed statistical analysis with a study of the calibration item and this latter point allow a reliable use in case of reflex analysis.

3.5. Sensory Modality Assessment and Rehabilitation Technique (SMART) (Gill-Thwaites, 1997; Gill-Thwaites et al., 2004)

The scale was developed in 1988 and further refined based on the experience of the authors in subsequent years. There are 2 main components: formal and informal. The latter section relies on informal observations conducted by teams, friends and relatives in recording answers pertaining to activities of daily living and environmental stimuli. The formal sections are conducted by trained examiner and include assessments and observations of the patient behavior in response to the administration of structured stimuli. The scale evaluates the responses to eight components: level of wakefulness, visual, tactile, auditory, olfactory and taste, sensory motor and communication skills. For each item the score range is 1 to 5. The evaluation protocol requires collaboration between the evaluator, team, family and friends, for the observation of responses to sensory and environmental stimulation. The changes in total scores can be used as indicators of changes in the responsiveness of patients, but the authors found more informative the analysis of the level of frequency and consistency of the responses obtained in 10 sessions for each of the individual sensory modalities. When the patient gives consistent answers to 5 consecutive administrations of the scale, it is possible to define the presence of a minimal level of consciousness or a level of emergence from vegetative state. This represents an advantage in terms of possibility provided be the scale to overcome the problem of unreliable scores in cases of severe sensory or specific cognitive deficits.

4. Group 3

This group includes the only scale that takes into account the recommendations of the Aspen Workgroups that is the JFK Coma Recovery Scale-R (Giacino et al., 2004).

It was initially proposed by Giacino in 1991 to describe patients who were from level 1 to 4 at the LCF. It was later revised to achieve an agreement with the recommendations of Aspen Workgroup and in particular the changes

in the diagnostic parameters related to disorders of consciousness. The original scale did not include all the necessary criteria to diagnose MCS, but the revised scale, published in 2004 (Giacino et al.), includes the criteria to differentiate between Coma, VS and MCS and allows each patient to be assigned to the most appropriate diagnostic category. In 2007 Lombardi and coworkers published an Italian version of JFK-CRS; this scale represents a faithful translation of original items. The measurement was reliable if trained staff performs the administration procedures. The scale includes 29 items hierarchically organized, and includes 6 subscales: processing of auditory, visual, motor, oro-motor, and communication stimuli, besides arousal level. The rating is based on the presence/absence of response to stimulation administered in a standardized way. The lowest item of each subscale corresponds to the reflex activity; the highest is corresponds to an item in which cognitive processing is request. Total score in include in a range between 0 and 23 and an increase in the total score means an improvement towards "state of consciousness". The weekly evaluation, or otherwise periodic, with CRS-R allows to detect fluctuation signals of consciousness in terms of stability, recovery, progression, improving or worsening. By means of this scale a differential diagnosis is possible, either with total and partial scores, consequently it represents a very useful assessment tool because it also allows to overcome to those subscales in which patients are unable to provide answers. This aspect is actually crucial in the attempt to individuate the presence of consciousness even in those patients who show some difficulty in providing response. A critical element remains the low reliability levels for patients with significant cognitive syndromes such as aphasia or neglect, or with severe motor deficit because most of the items significantly rely on patient's ability to understand verbal messages, sometimes presented in written form, the ability to scan the visual space or to execute complex motor patterns. However this scale could be a considered a sufficient flexible instrument to assess the presence of consciousness.

5. Group 4

In analogy to Group 3, also this group is characterized by one scale, administered to patients which emerged from MCS even though they are not yet evaluable with structured psychometric tests: the Preliminary Neuropsychological Battery (PNB) (Cossa et al., 1999).

This battery has as main objective the cognitive assessment of all those patients which are accessible to a structured observation but are unable to provide verbal or complex motor responses. The PNB is a task battery that

requires yes/no responses; in particular patients are required to express a parity judgment between two items presented together. It consists of two parts divided into 5 sections each; in every section 6 items are included: the first part uses "non-symbolic" tools (geometric shapes, points, etc.); the second part is composed by "symbolic" items (numbers and letters). In total, the battery is composed by 60 stimuli. Based on the data obtained, the authors claim that a score less than 37/60 could be determined, due to the severity of the patient, to an insufficient number of responses or random responses. A score greater than or equal to 37/60 corresponds to responses not depending by chance but provided by the patient by means of an information processing. Statistical analysis shows a significant correlation between scores on the neuropsychological test and PNB. There were no differences between the performance at symbolic and non-symbolic sections and there were not significant correlations between each of these two parts and specific tests for both right and left hemispheric functions. Based on these results, the battery can be considered useful for the assessment of cognitive skills in those patients who do not yet have access to formal psychometric assessment.

6. Conclusions

We analyzed the scales generally used to assess disorder of consciousness and we then divided all them in four main groups. The first one considered the most used scale with a clinical taxonomic judgment. They provide an immediate level of clinical profile of the patient after a brief clinical examination. Unfortunately they show low sensitivity in detecting minor changes of levels of consciousness. Table 1 summarizes the characteristics of the scales. For each of them it is possible to see the aspects evaluated, the number of items, time of administration, the commitment to the patient, the number of patients on which has been validated, the reliability, the validity, and the presence of an overall score, and the possible sensory, motor and cognitive impairments that may affect the diagnosis. At a general view of this work we can see that CNC and LCS show the advantage to require less effort from the patient: first one due to a reduced number of items; the second one because it is based on collection of anamnestic data; both of them require a reduce time in administration and provide reliable information about the patient. Although these aspects were both validated on a very small sample of subjects and, as the DOC scale, only an overall score is possible, and therefore it does not provide a correct diagnosis in those cases in which administration of part the item sample is not possible.

Table 1. Scale characteristics

Scale	Aspects evalutated	N. items	Duration of administration	N. of Pts for validation	Reliability	Validity
CNC	Auditory, visual, olfactory, tactile, verbal, and nociception.	8	20'	20	0,98	Correlation with DRS = .69 internal validity =.95
WNSSP	Auditory and visual comprehension object manipulation tactile, olfactory, attention, alert.	32	20-40'	57	Inter rater 0.64 -0.99	Correlation with LCF = .73
LCS	Motility, breath, visual, auditory comprehension, communication ability.	25	observational	42	0,9	Not reported
DOCs	Social skills, auditory, swallowing and tasting ability, olfactory, proprioceptive, vestibular, tactile.	23	45-60'	95	Not reported	Not found
SMART	Visual, tactile, auditory, taste, olfactory, awakeness, motor funcioning, communication skills.	34	20-30'	60	.97 (test retest .95)	Correlation with LCF = .47
CRS-R	Auditory, visual, motor, oromotor, communication, and arousal.	29	20-45'	80	Inter rater = .84	Correlation with DRS = -.90

CNC: Coma Near Coma (Rappaport et al., 1992); WNSSP: Western Neuro-Sensory Stimulation Profile (Ansell & Keenan, 1989); LCS: Lowenstein Communication Scale for the Minimally Responsive Patient (Borer-Alafi et al., 2002); DOCs: Disorders of Consciousness Scale (DOCS) (Pape et al., 2005); SMART: Sensory Modality Assessment and Rehabilitation Technique (Gill-Thwaites, 1997); CRS-R: Coma Recovery Scale Revised (Lombardi et al., 2007).

Moreover none of them takes into account the presence of significant motor deficits, sensory or cognitive impairments that may affect the assessment of difficulties for patients to receive stimuli or organize responses. The scales described in the second group were realized before definition of disorder of consciousness given by the Aspen Workgroups and, for this reason, they can not diagnose the transition from the VS to MCS. JFK-CRS-r represents at present the only instrument that allows reliably detection of changes in the patient in phase of recovery of consciousness; besides it also has the possibility to correctly classify the patient on the basis of the individual subscale performances, and this can overcome the limit given by use of overall score.

A specific group was created for PNB (Preliminary Neuropsychological Battery); this is an important instrument that can be used when the patient is responsive, but definitely has important anartria and/or cognitive or motor deficits, and could not be accessible to a structured psychometric assessment.

The general analysis of the characteristics of the tools presented here shows that many of them contain clinical indicators that may have prognostic utility specifically in the acute phase (i.e. the corneal reflex, pupillary reactivity, ocular motor responses, the spontaneous opening of the eyes), while other scales do not allow a properly classification of patients; others again are useful only in assessing patients previously unresponsive but still not evaluable with structured psychometric tests. Every instrument examined here may show specific advantages in assessing the disorder of consciousness but none of them could be entirely appropriate to this aim.

We conclude that future research should lead to the realization of assessment tools that can contain useful indicators for the acute phase but also more sensitive sections for examination of the evolution over time; moreover that should provide the possibility of using multiple independent channels for stimulation by the examiners. Further aspects are the possibility to distinguish between the intentional answer form reflected or stereotyped ones; and allow the diagnosis even in presence of potential motor deficits, sensory and cognitive impairments such as aphasia, neglect, etc. Besides they should give the opportunity to provide a ever better and reliable description of altered consciousness, and control the accuracy and reliability of data recording.

As a matter of fact, according to the authors (Seel et al., 2010), evaluation of disorder of consciousness remains, at the moment, as a main clinical examination and, for this reason, it is essential that the neuropsychologist perform periodic observations and evaluations, using the most useful scales available, taking into account the recommendations of the Aspen Work Group and the elements that may hinder the detection or comprehension of the questions and the organization and execution of responses, in order to capture the significant changes of the level of consciousness.

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