



# A new tool to assess responsiveness in disorders of consciousness (DoC): a preliminary study on the Brief Post-Coma Scale (BPCS)

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## Abstract

**Introduction** The Brief Post-Coma Scale (BPCS) is an easy diagnostic tool for individuals with disorders of consciousness (DoC), in a reduced version from a previously Post-Coma Scale, that could distinguish patients in the minimally conscious state (MCS) from those in unresponsive wakefulness syndrome (UWS), formerly defined as vegetative state (VS).

**Objective** Aim of the study was to assess the diagnostic validity of the BPCS in comparison with the Coma Recovery Scale-Revised (CRS-R), in its Italian validated version, the Disability Rating Scale (DRS), the Level of Cognitive Functioning (LCF), and the Glasgow Outcome Scale (GOS).

**Methods** In an Italian multicenter study on 545 patients with DoC, 36 post-acute rehabilitation wards, 32 long-term care centers, and 2 family associations participated to data collection.

**Results** Statistically significant correlations were found between the BPCS and the other clinical scales:  $R = 0.586$  ( $p < 0.001$ ) with LCF,  $R = -0.566$  ( $p < 0.001$ ) with DRS,  $R = 0.622$  ( $p < 0.001$ ) with CRS-R. The BPCS scores resulted significantly correlated with the time from acute event ( $R = 0.117$ ,  $p = 0.006$ ). Patients with GOS score 2 had mean BPCS of  $1.84 \pm 1.19$ , whereas those with GOS 3 had significantly higher scores  $3.88 \pm 1.71$  ( $p < 0.001$ ). Similarly, in patients with vegetative state/UWS (VS/UWS), the mean BPCS score was  $1.71 \pm 1.09$ , significantly lower ( $p < 0.001$ ) than that of patients with minimally conscious state (BPCS =  $3.83 \pm 1.29$ ). Finally, the agreement of the BPCS and clinical diagnosis was of 84.4%, with an odds ratio OR = 3.781 (95% CI = 3.026–4.725,  $p < 0.001$ ).

**Conclusions** The BPCS has demonstrated statistically significant correlations with the most commonly used scales in persons with DoC.

**Keywords** Brief Post-Coma Scale · Disorders of consciousness · Outcome evaluation scales · Coma Recovery Scale-Revised

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## Introduction

The most successful scales to assess coma and outcome are respectively the Glasgow Coma Scale (GCS) [1] and Glasgow Outcome Scale (GOS) [2] for their easiness and rapidity of administration.

The Brief Post-Coma Scale (BPCS) is an easy diagnostic tool for individuals with disorders of consciousness (DoC), in a reduced version from a previously Post-Coma Scale [3], that could distinguish patients in the minimally conscious state (MCS) from those in unresponsive wakefulness syndrome (UWS) [4], formerly defined as vegetative state (VS). The BPCS consists of

seven items assessing eye tracking, command following, spontaneous motility, decerebrated and decorticated posturing, psychomotor agitation, the ability of safe oral feeding, and the presence of recurrent infections and/or hyperthermia, with three option answers: yes, sometimes/partially, no ([Appendix](#)). Indeed, the presence of tracheostomy, the severity of the disability, and the medical complications, commonly related to recurrent infections after fever, have recently demonstrated a significant correlation with the efficacy of early rehabilitation and the need of transferring back from rehabilitation units to acute care wards. [5, 6].

Aim of the study was to assess the diagnostic validity of the BPCS in comparison with the Coma Recovery Scale-Revised (CRS-R), in its Italian validated version [7–9], the Disability Rating Scale (DRS) [10], the Level of Cognitive Functioning (LCF) [11], and the GOS.

## Methods

In an Italian multicenter study on 545 patients with DoC, 36 post-acute rehabilitation wards, 32 long-term care centers, and 2 family associations participated to data collection. Five hundred forty-five patients with DoC were enrolled in this multicenter study (age  $56.06 \pm 17.26$ ; 59% M; 41% F). The 54% of these patients were traumatic brain injury (TBI). According to the Coma Recovery Scale-Revised (CRS-R) [7], the diagnosis was VS/UWS in 70% of the cases and MCS in the remaining 30%. The BPCS was administered at an average of time interval from acute event of 27 months (interquartile range = 42).

The majority of the patients enrolled were in the post-acute rehabilitation wards and long-term care centers, since only the trained and experienced examiners to the use of BPCS and the other clinical scales were asked to administer them.

The diagnosis of VS/UWS or MCS was performed by the professionals involved in this study, according to CRS-R. The examiners of the different scales were specifically trained on the mixed modality of administration of BPCS based on both direct neurological examination and caregiver reports, and all the examiners were neurologists or psychologists with expertise on the administration of the other scales since at least 2 years. The BPCS has been administered by the same examiner of the other clinical scales, and the questions regarding

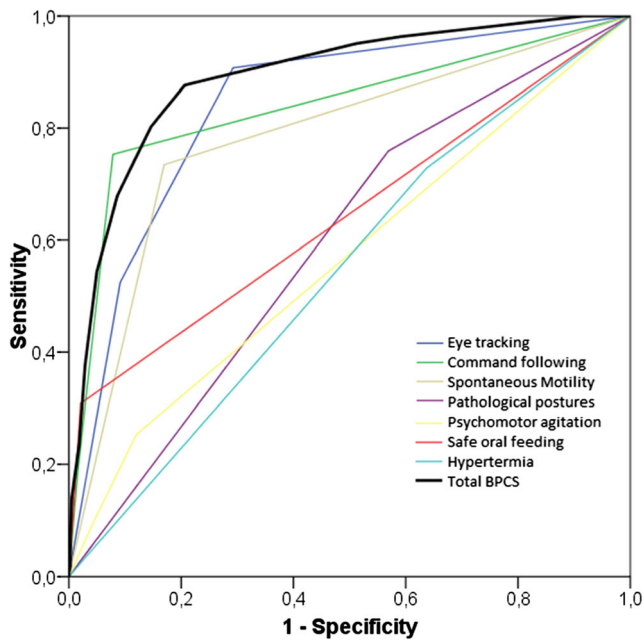
the visual fixation or eye tracking were asked to the main caregivers, including nurses, physiotherapists, speech therapists (rehabilitation team), and relatives of the individuals enrolled, in reference to the last week, as well as for the presence of spontaneous motility at the level of head and upper and lower limbs, during resting condition.

As for the presence of decorticate/decerebrate pathological postures or psychomotor agitation, a complete neurological examination was performed in all patients as well as detailed information was collected by the caregivers, investigating the occurrence of pathological postures, such as flexion and intra-rotation of the upper limbs or extension and intra-rotation of the upper and lower limbs. As for as psychomotor agitation [12] is concerned, restlessness and/or self-directed aggression, such as gastric tube or tracheal cannula removal, as well as aggressive behaviors against others were accurately evaluated, also by means of caregiver reports. The same investigation was carried out for safe oral feeding and fever/infection recurrence. To each item, it could be assigned a score of 1 for the presence of a positive sign and 0 for negative ones, whereas for some items, it is possible to give a score of 0.5 if the sign is present just sometimes or partially (see [Appendix](#)).

Spearman correlation coefficient was used to assess correlations between variables. Odds ratio (OR) was computed for analyzing the relationship between the BPCS score and diagnosis together with 95% confidence interval (IC95%). ROC curve allowed analyzing the sensitivity and specificity of BPCS total score as well as of the single items, to assess their discriminative power with respect to the diagnosis. Item consistency was assessed with a reliability analysis performed for computing the Cronbach's alpha: levels  $< 0.6$  are considered poor, between 0.6 and 0.7 questionable,  $> 0.7$  acceptable. Alpha-level was set for all the analyses at 0.05.

## Results

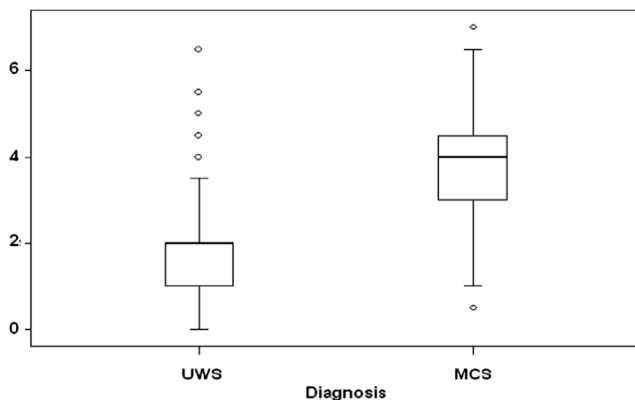
Statistically significant correlations were found between the BPCS and the other clinical scales:  $R = 0.586$  ( $p < 0.001$ ) with LCF,  $R = -0.566$  ( $p < 0.001$ ) with DRS,  $R = 0.622$  ( $p < 0.001$ ) with CRS-R. The BPCS scores resulted significantly correlated also with the time from acute event ( $R = 0.117$ ,  $p = 0.006$ ).



**Fig. 1** Curve of receiver operating characteristic (ROC curve) for the BPCS scores (total and single items) with respect to diagnosis

For patients with a GOS score = 2, the mean BPCS was  $1.84 \pm 1.19$ , and for GOS score = 3, it was significantly higher  $3.88 \pm 1.71$  ( $p < 0.001$ ). Similarly, for patients in VS/ UWS, the mean BPCS score was  $1.71 \pm 1.09$ , which was significantly lower ( $p < 0.001$ ) than that of patients with MCS (BPCS =  $3.83 \pm 1.29$ ).

Finally, the agreement of the BPCS and clinical diagnosis was of 84.4% (variance explained), with an



**Fig. 2** Total score of the BPCS. Box-whisker plots of total score of the BPCS for VS/UWS and MCS. Boxes represent the first and third quartile, whereas the wide line is the median. The whiskers represent the minimum and fourth quartile, and circles can be considered outliers

odds ratio  $OR = 3.781$  (95%  $CI = 3.026-4.725$ ,  $p < 0.001$ ). The item consistency was evaluated by means of reliability analysis that highlighted a Cronbach's alpha value of 0.721. Figure 1 shows the ROC curve for BPCS score as well as for the single items. The widest area under the curve (0.891) was for the total BPCS score, followed by eye tracking (0.843), command following (0.839), spontaneous motility (0.782), safe oral feeding (0.644), pathological postures (0.595), psychomotor agitation (0.567), and hyperthermia or infections (0.546). The best cutoff value for BPCS total score resulted of 2.25. Hence, given that the score of BPCS has a step of 0.5, the closest threshold for BPCS was of 2.5. This threshold resulted to have a sensitivity of 87.7% and specificity of 79.4% with respect to diagnosis (Fig. 2).

## Conclusions

The BPCS has demonstrated statistically significant correlations with the most commonly used scales in a large population of persons with DoC. Item consistency was acceptable, and the single-item discriminative power was good, with the highest power found, as expected, for the total score of BPCS. The well-recognized role of the caregivers' emotional mediation in the evaluation of responsiveness [13–15] and the statistically significant correlation of BPCS with the CRS-R and other clinical scales leads to propose BPCS for possible phone interview to the caregivers.

Moreover, the impact of cognitive rehabilitation in patients with DoC, the role of psychological condition, and coping strategies of their caregivers have been recently emphasized [16–18].

Since the same examiner administered BPCS and the other clinical scales, this choice might have artificially inflated the agreement among scales and the agreement with clinical diagnosis; thus, it could be considered one of the limitations of the study.

Indeed, limitations of the present scale include the mixture of items directly observed by the examiner and collected by interview, as well as a limitation of the present preliminary study may be considered the administration of BPCS and the other scales by the same examiner.

Further work is suggested on inter-rater and intra-rater agreement and possible adaptation to phone interview that will need specific validation studies.

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## Appendix

### Brief Post-Coma Scale (BPCS)

*R. Formisano, M. Aloisi, M. Iosa, M. Contrada, F. Rizza, D. Sattin, M. Leonardi, M. D'Ippolito*

	Yes	Sometimes / Partially	No
1) Visual fixation and eye tracking	<input type="checkbox"/> 1	<input type="checkbox"/> 0.5	<input type="checkbox"/> 0
2) Commands following	<input type="checkbox"/> 1	<input type="checkbox"/> 0.5	<input type="checkbox"/> 0
3) Spontaneous movements at upper and/or lower limbs	<input type="checkbox"/> 1		<input type="checkbox"/> 0
4) Decortication and/or decerebration pathological postures	<input type="checkbox"/> 0		<input type="checkbox"/> 1
5) Psychomotor agitation	<input type="checkbox"/> 1	<input type="checkbox"/> 0.5	<input type="checkbox"/> 0
6) Safe oral feeding	<input type="checkbox"/> 1	<input type="checkbox"/> 0.5	<input type="checkbox"/> 0
7) Recurrent infections and/or hyperthermia/fever	<input type="checkbox"/> 0		<input type="checkbox"/> 1
<b>TOTAL</b>	.....		

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