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Prediction Values of the Simplified Motor Score and the Glasgow Coma Scale Motor Component for the Clinical Outcomes of Intracranial Hemorrhage

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ABSTRACT

Objective: To assess the prognostic values of simplified motor score (SMS) and Glasgow Coma Scale motor component (GCS-M) in predicting the clinical outcomes of intracranial hemorrhage (ICH).

Methods: A total of 205 patients with ICH were enrolled. The clinical outcomes were evaluated using the Glasgow Outcome Scale (GOS) at day 30. SMS and GCS-M were evaluated by comparing areas under the receiver operating characteristic curve (AUC) in predicting 30-day mortality, respectively. The linear correlations were evaluated to determine the relationship between different parameters. Comparison of AUC was performed using the *Z*-test.

Results: No significant difference of AUC was found between GCS-M and GCS in predicting 30-day mortality (0.864 vs. 0.871, $P = 0.552$), but there was significant difference of AUC between SMS and GCS (0.779 vs. 0.871, $P<0.001$). The levels of SMS, GCS-M and GCS were significantly higher in good outcomes group (GOS: 4-5) compared with the poor outcomes group (GOS:1-3), while APACHE II was significantly lower. Moreover, there were significant differences on SMS, GCS-M, GCS and APACHE II among different groups based on SMS (Group One: SMS=0, Group Two: SMS =1, and Group Three: SMS=2). Finally, SMS, GCS-M and GCS were positively correlated with GOS. Whereas SMS, GCS-M, GCS and GOS were negatively correlated with APACHE II.

Conclusion: Compared with SMS, GCS-M demonstrates test performance similar to GCS for predicting 30-day mortality of ICH. Both SMS and GCS-M could be accurately and reliably as GCS for predicting poor outcomes of ICH.

Keywords Intracranial Hemorrhage; Glasgow Coma Scale; Simplified Motor Score; Glasgow Outcome Scale; Prognosis

1. Introduction

The 15-point Glasgow Coma Scale (GCS), first introduced in 1974 by Teasdale and Jennett, is a neurological scale to give a reliable and objective way of recording the conscious state of a patient for initial as well as subsequent assessment [1]. Nowdays, GCS, accomplished easily by all healthcare providers with high repeatability, can be widely used to assess coma and impaired consciousness in traumatic brain injury (TBI) [2-3], stroke [4] and so on [5]. However, in recent years, GCS was regarded as complexity and limitations, especially in accurately assessing pediatric, intubated or aphasic patients. Therefore, some researchers were enthusiastic about resorting to simplified GCS, which could exclude the eye-moving and verbal evaluation. In 2012, Caterino *et al.* [6] showed that the emergency medical services -obtained simplified motor score (SMS) performed as well as GCS in a state trauma registry including both trauma and non-trauma centres. In addition, one meta-analysis displayed that SMS predicted different outcomes with similar accuracy as GCS except mortality in TBI patients [2]. Recently, Wang *et al.* [7] found that Glasgow Coma Scale motor component (GCS-M) approached the same test performance as GCS in assessing the prognosis of intubated patients with acute severe cerebral

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vascular disease. Furthermore, another study [8] showed that GCS-M and SMS not only accurately predicted the clinical outcomes of TBI patients, but also could be used safely as a triage tool in cases where the full GCS was difficult to assess. To our knowledge, the prediction values of SMS and GCS-M in ICH outcomes have not yet been discussed. In the present study, we will focus on the relationship between SMS and GCS-M and ICH outcomes. This study may provide novel evidences for whether the application of SMS and GCS-M are as performance similar to GCS for the prediction of clinical outcomes of ICH.

2. Materials and Methods

2.1. Study Design

The study was conducted in accordance with the *Declaration of Helsinki* and approved by the Ethics Committee of the Fourth Affiliated Hospital Zhejiang University School of Medicine. As a retrospective study, this study was exempt from the informed consent from patients.

2.2. Study population

205 ICH patients who have been admitted to Intensive Care Unit (ICU) or Department of Neurosurgery of the Fourth Affiliated Hospital Zhejiang University School of Medicine, were consecutively enrolled from January 2016 to September 2018. Inclusion criteria were ≥18 years old; spontaneous subarachnoid hemorrhage (SAH) or intracerebral hemorrhage confirmed by brain computerized tomography; symptoms onset within 24 hours. Exclusion criteria were mental illness or psychotic disorder; patients who had previous cerebrovascular events with obvious sequela of dysphasia or dyskinesia; TBI; acute cerebral infarction ;dementia; eyelid edema; patients with awareness disorders caused by other diseases; patients whose medical records were incomplete; patients who had received anesthetics, sedatives, or neuromuscular blocking agents within the past 24 h excluding the use of sedatives during the process of emergency tracheal intubation; patients who refused to cooperate with treatments or follow-up; and patients whose clinical data were incomplete.

2.3. Baseline data

Baseline data were recorded when patients were admitted to ICU or Department of Neurosurgery, including age, gender, type of ICH (intracerebral hemorrhage or SAH), emergency tracheal intubation, SMS, GCS-M, GCS and APACHE II.

2.4. Coma scoring

We recorded GCS-M, SMS, and GCS of ICH patients on admission. GCS includes three components (Eye, Verbal and Motor) with a resulting score ranging from 3 (worst) to 15 (best). GCS-M includes six resulting score ranging from 1 (worst) to 6 (best). SMS is classified into 3-point scores according to the patients' motor response (defined as obeys commands = 2; localizes to pain = 1; and withdrawal to pain or worse= 0). The rater recorded the best motor response from any upper limb.

2.5. Study outcomes

Glasgow Outcome Scale (GOS) was recorded based on follow-up at day 30 after symptoms onset. Poor outcomes were defined as GOS of 1-3, while good outcomes were GOS of 4-5. Outcomes at day 30 after symptoms onset, classified as either death or survival, were also recorded.

2.6. Statistical analysis

Statistical analysis was performed using SPSS software (version 19.0 for Windows, SPSS Inc., Chicago, IL USA). Descriptive analyses for continuous variables were used to calculate mean values and standard deviations. The *t*-test of independent samples was adopted for the comparison between the mean of two groups. One–way analysis of variance (ANOVA) was used to compare the mean among multiple groups. Prognostic performance was tested by calculation of the receiver operating characteristic (ROC) curve and displayed in the area under the curve (AUC). Spearman correlation analyses were performed to investigate the correlation between two variables. Comparison of AUC was performed using the *Z*-test of the software MedCalc ®version 18.2.1 (Frank Schoonjans, Mariakerke, Belgium). From ROC coordinates, the cutoff values for the aforementioned scores using the score value with the best Youden index (sensitivity + specificity − 1) were identified. $P<0.05$ was considered statistically significant.

3. Results

3.1. Characteristics of total population

A total of 205 ICH patients were available for final analysis. The mean age of the study sample was 55.58 ± 15.59 years. 121 (59.0%) were males and 84 (41.0%) were females. A total of 148 (72.2%) were SAH, and the rest 57 (27.8%) were brain parenchyma or ventricular system hemorrhage. Of all ICH patients, a total of 38 (18.5%) underwent emergency tracheal intubation. A total of 33

(16.1%) were dead, and the rest 172 (83.9%) were alive at day 30 after symptoms onset.

3.2. Predictive performance of different coma scales in predicting 30-day mortality of ICH

AUC in predicting 30-day mortality of ICH was 0.779 (95% confidence interval (CI), 0.716 to 0.834, *P*<0.001) for SMS, 0.864 (95%CI, 0.809 to 0.908, *P*<0.001) for GCS-M and 0.871(95%CI, 0.817 to 0.913, *P*<0.001) for GCS. No significant difference of AUC was found between GCS-M and GCS in predicting 30-day mortality (0.864 vs. 0.871, *Z* = 0.595, *P* = 0.552), but there was significant statistical difference of AUC between SMS and GCS (0.779 vs. 0.871, *Z* = 4.504, *P*<0.001) (Figure 1). The cutoff values were 0 in predicting 30-day mortality (specificity 64.53% and sensitivity 84.85%) for SMS, 3 (specificity 76.74% and sensitivity 84.85%) for GCS-M and 5 (specificity 80.81% and sensitivity 78.79%) for GCS.

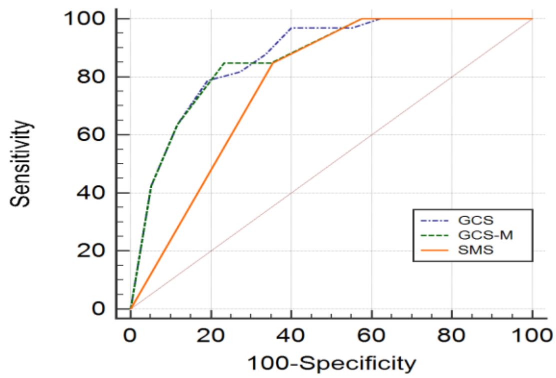

Figure 1. **Predictive performance of different coma scales in predicting 30-day mortality of ICH**

3.3. Comparison of the levels of different parameters between two outcomes groups of ICH

There were significant statistical differences on SMS, GCS-M, GCS and APACHE II except age between good outcomes group and poor outcomes group of ICH based on GOS (all *P*<0.001) (Table 1).

Table 1. **Comparison of the levels of different parameters between two outcomes groups of ICH**

Parameters	Good Outcomes (n=82)	Poor Outcomes (n=123)	*P* value
Age (years)	56.01 ± 13.69	55.28 ± 16.78	0.734
GCS (point)	12.71 ±3.04	6.66 ± 3.19	0.000
GCS-M (point)	5.51 ± 0.97	3.46 ± 1.68	0.000
SMS (point)	1.61 ± 0.72	0.46 ± 0.67	0.000
APACHE II (point)	8.48 ± 1.93	15.41 ± 6.61	0.000

Data were present as mean ± standard deviations; GCS: Glasgow coma scale; GCS-M: GCS motor component; SMS: Simplified motor score; APACHE II: Acute Physiology and Chronic Health Evaluation II; *Student's t*-test.

3.4. Comparison of the levels of different parameters among three subgroups of ICH

There were significant statistical differences on GCS, GCS-M, APACHE II and GOS except age among three subgroups of ICH based on SMS (Group One: SMS=0, Group Two: SMS =1, and Group Three: SMS=2) (all *P*<0.001) (Table 2).

Table 2. **Comparison of the levels of different parameters among three subgroups of ICH**

Parameters	Group One (n=89, SMS=0)	Group Two (n=43, SMS=1)	Group Three (n=73, SMS=2)	*P* value
Age (years)	54.64 ± 15.59	59.44 ± 16.79	54.44 ± 14.70	0.188
GCS (point)	5.00 ± 1.85	9.23 ± 1.95	13.96 ± 1.23	0.000
GCS-M (point)	2.53 ± 1.14	5.00 ± 0.00	6.00 ± 0.00	0.000
APACHE II (point)	17.38 ± 4.49	12.23 ± 4.61	7.10 ± 4.18	0.000
GOS (point)	2.25 ± 1.12	3.09± 1.09	4.45 ± 0.80	0.000

Data were present as mean ± standard deviations; GCS: Glasgow coma scale; GCS-M: GCS motor component; APACHE II: Acute Physiology and Chronic Health Evaluation II; GOS: Glasgow outcome scale; One-way ANOVA.

3.5. Spearman correlation analysis between different parameters of ICH

The levels of SMS, GCS-M and GCS were positively correlated with GOS of ICH patients (r_s =0.698, P =0.000; rs =0.740, P =0.000; r_s =0.770, P =0.000).In addition, the levels of SMS and GCS-M were positively correlated with GCS (r_s =0.901, P =0.000; r_s =0.948, P=0.000). Whereas, the levels of SMS, GCS-M, GCS and GOS were negatively correlated with APACHE II (r_s = -0.756, P =0.000; r_s = -0.787, P =0.000; r_s = -0.804, P =0.000; r_s = -0.656, P =0.000) (Table 3).

Table 3. **Spearman correlation analysis between different parameters of ICH**

Parameters	GCS (point)	APACHEII (point)	GOS (point)
SMS (point)	r_s =0.901 P =0.000	r_s = -0.756 P =0.000	r_s =0.698 P =0.000
GCS-M (point)	r_s =0.948 P =0.000	r_s = -0.787 P =0.000	r_s =0.740 P =0.000
GCS (point)	/	r_s = -0.804 P =0.000	r_s =0.770 P =0.000
APACHE II (point)	/	/	r_s = -0.656 P =0.000

GCS: Glasgow coma scale; GCS-M: GCS motor component; APACHE II: Acute Physiology and Chronic Health Evaluation II; GOS: Glasgow outcome scale; Spearman correlation.

4. Discussion

In 1988, Tuhrim, *et al.* [9] had already drawn a conclusion that GCS could be used to categorize correctly 92% of the patients as alive or dead at 30 days after onset of ICH. FU, *et al.* [10] performed a retrospective analysis of 1268 primary ICH patients, then found that GCS was independently associated with severity on admission and in-hospital mortality after ICH. In addition, another study also confirmed that APACHE II could be used to predict the severity and outcome of acute ICH [11]. In the present study, we found that AUC of GCS was 0.871(95% CI, 0.817 to 0.913, P<0.001) in predicting 30-day mortality of ICH and there was positive correlation between GCS and GOS of ICH patients (r_s =0.770, P =0.000), suggesting that GCS might be used to assess the prognosis of ICH. In fact, our study results were also consistent with Jamil [12] and his colleagues' conclusion, as they found that GCS of ICH was significant independent predictor of 30-day mortality in both univariate analysis and multivariable analysis. Moreover, our research also displayed that both GCS and APACHE II were closely related to poor outcomes of ICH (r_s = 0.770, P=0.000; r_s = -0.656, P=0.000). This was consistent with the Cho *et al*. [13] study (200 patients), in which both APACHE II and GCS could predict hospital mortality and there was no significant statistical difference between APACHE II (AUC 0.84) and GCS (AUC 0.86). Grmec and Gašparovic [14] also drew similar conclusions. From the above, we were more certain about the accuracy of our conclusions.

At present, GCS was widely used in the diagnosis and prognosis of various coma patients, including TBI, which has been gradually accepted by clinical physicians. However, it still had some limitations. For example, tester experience with GCS could affect the accuracy and reliability of scoring [15]. Holdgate and his_colleagues [16] found that there was variability in agreement between physicians and nurses when measuring GCS in the emergency department. Although the levels of agreement for GCS scores was generally high, a significant proportion of patients had GCS scores which differed by two or more points. In addition, Buechler, *et al.* [17] revealed that the variability in application of GCS in the intubated and sedated population reduced the ability of the scale and, in turn, could affect its validity as a predictor of trauma outcome. Moreover, there was more radical suggestion that it was time to abandon GCS [18]. Obviously, this view was not accepted by the vast majority of clinical physicians. Therefore, many researchers have proposed whether SMS or GCS-M could be for the diagnosis and prognosis of TBI. In recent years, increasing evidence indicated that both SMS and GCS-M could approach the same test performance as GCS in assessing the prognosis of TBI or severe stroke patients [2,7,8,19]. Furthermore, Ting, *et al.* [20] performed a research on good mortality prediction by GCS for 154 neurosurgical patients, finally the result showed that both GCS ≤ 5 and GCS-M ≤ 3 were good indicators of mortality in these patients. It is interesting that both SMS and GCS-M were as accurate as GCS for the prediction of poor outcomes in ICH. At the same time, we also found that SMS ≤ 0, GCS-M ≤ 3 and GCS ≤ 5 were good indicators of 30-day mortality in ICH patients. As the results showed that no significant difference of AUC was found between GCS-M and GCS (0.864

vs. 0.871, *Z* = 0.595, *P* = 0.552), which further verified that the accuracy and reliability of GCS-M as GCS in predicting 30-day mortality of ICH. While there was significant statistical difference of AUC between SMS and GCS (0.779 vs. 0.871, *Z* = 4.504, *P*<0.001), according to which, SMS did not demonstrate better test performance than GCS in predicting 30-day mortality of ICH.

As our study showed that there were positive correlations between SMS and GCS-M and GOS of ICH, respectively (r_s=0.698, *P*=0.000; r_s=0.740, *P*= 0.000). Furthermore, for the first time we performed correlation analysis between the coma scales and APACHE II. The results demonstrated that SMS, GCS-M and GCS were negatively correlated with APACHE II (r_s = -0.756, *P* =0.000; r_s = -0.787, *P* =0.000; r_s =-0.804, *P*=0.000), which further verified that the accuracy and reliability of SMS and GCS-M as GCS in predicting poor clinical outcomes of ICH.

In addition, the present study also showed that GCS-M, GCS, GOS and APACHE II varied with different classifications of SMS and there were significant statistical differences among three groups (all *P*<0.001). To some extent, all this seemed to account for that the higher the SMS, the better the outcomes of ICH. Because of GCS-M ≤4 (defined as withdraws to pain or worse= SMS 0), GCS-M =5(defined as localizes to pain= SMS 1), and GCS-M =6(defined as obeys commands= SMS 2), we could also draw the similar conclusion that the higher the GCS-M, the better the clinical outcomes. Therefore, once GCS is difficult to obtain under exceptional circumstances, we might resort to select the above-mentioned SMS or GCS-M. As it would be easier and more practical to operate in clinical practice, whereas its prognostic power was equivalent to GCS in predicting poor outcomes of ICH.

There are several limitations in our study. First, it was a retrospective analysis and thus did not perform a more rigorous design. Second, from a single-center, the sample size was small. Third, there was heterogeneity of the sample (such as percent of emergency tracheal intubation and SAH). A larger and more homogeneous sample from multicenter study is needed, and our results should only be used as a reference for clinicians.

In conclusion, compared with SMS, GCS-M demonstrates test performance similar to GCS for predicting 30-day mortality of ICH. Both SMS and GCS-M could be accurately and reliably as GCS applied in predicting poor outcomes of ICH. However, due to heterogeneity and limited sample numbers, further prospective studies are required.

Conflict of Interests

None.

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