Modified World Federation of Neurosurgical Societies Subarachnoid Hemorrhage Grading System

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Key words
- Glasgow Coma Scale
- Modified Rankin Scale
- Outcomes
- Subarachnoid hemorrhage
- World Federation of Neurosurgical Societies

Abbreviations and Acronyms
AUC: Area under the curve
GCS: Glasgow Coma Scale
GOS: Glasgow Outcome Scale
mRS: Modified Rankin Scale
m-WFNS: modified World Federation of Neurosurgical Societies
ROC: Receiver operating characteristic
SAH: Subarachnoid hemorrhage
WFNS: World Federation of Neurosurgical Societies

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OBJECT: **A modified World Federation of Neurosurgical Societies scale (m-WFNS scale) for aneurysmal subarachnoid hemorrhage (SAH) recently has been proposed, in which patients with Glasgow Coma Scale (GCS) scores of 14 are assigned to grade II and those with GCS scores of 13 are assigned to grade III regardless of the presence of neurologic deficits. The study objective was to evaluate outcome predictability of the m-WFNS scale in a large cohort.**

METHODS: **This was a multicenter prospective observational study conducted in Japan. A total of 1656 patients with SAH were registered during the 2.5-year study period, and the outcome predictability, using the Glasgow Outcome Scale (GOS) and modified Rankin Scale (mRS) scores at discharge and at 90 days after onset, was evaluated by comparing the m-WFNS with the original WFNS scale. We focused on whether significant differences in these scores were present between the neighboring grades.**

RESULTS: **In the m-WFNS scale, significant difference between any neighboring grades was observed both in the mean GOS and mRS scores at 90 days except between grades III/IV. However, differences were not significant between grades II/III and between grades III/IV in the original WFNS scale.**

CONCLUSIONS: **SAH-induced brain injury may be substantially severer in patients with GCS 13 than those with GCS 14, which may explain why grade III patients faired significantly worse than grade II patients by the modified WFNS scale. Although further validation is necessary, the m-WFNS scale has a potential of providing neurosurgeons with simpler and more reliable prognostication of patients with SAH.**

INTRODUCTION

A grading scale for aneurysmal subarachnoid hemorrhage (SAH) was first introduced by Botterell et al. in 1956 (2), followed by the Hunt and Hess (8)/Hunt-Kosnik (9) and the World Federation of Neurosurgical Societies (WFNS) scales (5), which have gained widespread acceptance in the last 2–3 decades (1, 4). Despite moderate differences, all these scales use the patient's level of consciousness as the major predictor of outcomes. Earlier grading scales, however, such as Hunt and Hess, used less clearly defined scales of consciousness (8). The WFNS scale attempted to overcome this issue by using the Glasgow Coma Scale (GCS) as its major input. The decision to use the GCS as the major predictor of outcomes was reached by consensus of the WFNS Committee (5) and was refined further to include the presence of focal neurologic deficits.

The lack of formal validation of the original WFNS scale, however, has led to occasional overlap between grades (particularly between grade II and grade III), where the outcomes predicted by the assigned grade may not differ substantially (6, 7). Therefore, it may be worthwhile to review the current WFNS scale and modify it according to outcomes necessary. The WFNS Cerebrovascular Disease & Treatment Committee and the Japan Neurosurgical Society have jointly proposed a modified World Federation of Neurosurgical Societies (m-WFNS) scale, in which SAH patients with a total GCS score of 14 are assigned to grade II and those with a total GCS score of 13 are assigned to grade III, regardless of the presence of neurologic deficits.

An SAH scale that relies only on initial GCS scores already has been proposed by van Heuven et al. (12), whose main objective was to make a better prognostication tool for patients with poor-grade SAH. The objective of this study, by contrast, was to evaluate whether the proposed m-WFNS scale was superior to the original WFNS scale in prediction of outcomes for patients with mild-grade SAH: we focused on whether grade III on the m-WFNS scale had better outcome predictability compared with the original WFNS scale.

METHODS

Patients

This was a multicenter, prospective observational study conducted between October 2010 and March 2013, and a total of 38 neurosurgical institutions across Japan participated in the study. The exclusion criteria for the study were patients <20 years of age and interval between symptom onset and admission >72 hours. Pertinent clinical data collected prospectively included age, sex, location of ruptured aneurysm, each component of the GCS score (on admission and after initial stabilization), presence/type of concomitant neurologic deficits (weakness and/or aphasia), premorbid modified Rankin Scale (mRS) scores, medical comorbidities, type of treatment for aneurysm obliteration, type of perioperative complications, Glasgow Outcome Scale (GOS) scores at discharge and 90 days after onset, and mRS scores at discharge and 90 days after onset.

The clinical data such as GCS scores were assessed by board-certified neurosurgeons in each institution. The GCS scores obtained after initial stabilization of the patient were used for grading. Treatment methods for aneurysm obliteration were not randomized and were at the discretion of each participating institution. Data were stored in a secured, electronic database after anonymization. Patients and their surrogates were informed of concept and design of this study, and only data of those who provided consent to us were used.

Evaluation of Outcomes and Statistical Analysis

The clinical outcomes were assessed using both GOS and mRS scores. In both WFNS scales (i.e., m-WFNS scale and original WFNS scale), mean GOS and mRS scores at discharge and at 90 days after onset of symptoms were calculated (for conversion from descriptive GOS scores to numerical GOS scores, see Table 1). In both WFNS scales, the mean (numerical) GOS and mRS scores between the neighboring grades were compared to evaluate the outcome predictability via the Mann-Whitney U test and nonparametric test by Dunn's multiple comparisons. In both WFNS scales, distributions of the descriptive GOS scores in relation to grades (assessed at discharge) were compared with the Wilcoxon rank-sum test with no adjustment for multiple comparisons, with the aim to evaluate intergrade difference in the ranking/ordered profile of these descriptive GOS scores.

Table 1. Numerical/Descriptive Glasgow Outcome Scale (GOS)

1	Low disability (LD)
2	Moderate disability (MD)
3	Severe disability (SD)
4	Persistent vegetative state (PVS)
5	Death (D)

Furthermore, receiver operating characteristic (ROC) curve analysis was conducted to determine whether the m-WFNS scale was superior to the original WFNS scale in predicting those with favorable outcomes: patients either with mRS $\leq$ 1 or GOS = 1 at the time of evaluations (i.e., at discharge and at 90 days) were defined as those having favorable outcomes, and for each outcome scale, area under the curve (AUC) values were compared between the 2 groups at the 2 time points. Statistical significance was set at a P-value < 0.05. Statistical analysis was performed using the JMP version 10 (SAS Institute, Cary, North Carolina, USA).

RESULTS

Patients

During the 2.5-year study period, a total of 1863 patients with SAH from 38 institutions were registered. Two-hundred seven patients (11.1%) were excluded, either because the interval between symptom onset and admission was >72 hours or because the timing of symptom onset was unidentifiable. The data of the remaining 1656 patients were analyzed. The mean age was 63.7 $\pm$ 14.1 years, and male/female ratio was 1:2. Sixteen-hundred forty-two patients (99.2%) were followed till hospital discharge, whereas 1552 patients (93.2%) were followed till 90 days after symptom onset (Table 1). Thirteen-hundred twenty-nine patients underwent treatment for the obliteration of ruptured aneurysm, and the other 327 patients were managed conservatively. Of those treated, 839 (63.1%) were treated by open surgery, 473 (35.6%) were treated by endovascular surgery, and 17 (1.3%) were treated by both (Figure 1). By the original WFNS scale, classification of the 1642 patients into the 5 grades was: 478 in grade I, 345 in grade II, 41 in grade III, 306 in grade IV, and 472 in grade V. By the m-WFNS scale, 249 patients were assigned to grade II and 137 patients were assigned to grade III.

Evaluation of Outcomes

The results of mean GOS scores at discharge are shown in Figure 2A and B. In the m-WFNS scale, there was a significant difference between all neighboring grades (Figure 2A). In contrast, in the original WFNS scale, significant difference was observed only between grade I and grade II and between grade IV and grade V patients (Figure 2B). The results of mean mRS scores at discharge are shown in Figure 2C and D. In the m-WFNS scale, there was a significant difference between all neighboring grades (Figure 2D). In contrast, in the original WFNS scale, a significant difference was observed only between grade I and grade II and between grade IV and grade V patients (Figure 2D).

The results of mean GOS scores at 90 days after symptom onset are shown in Figure 3A and B. In the m-WFNS scale, there was a significant difference between all neighboring grades except between grade III and grade IV (Figure 3A). Similarly, in the original WFNS scale, a significant difference was observed between all neighboring grades except between grade III and grade IV patients (Figure 3B). The results of mean mRS scores at 90 days after symptom onset are shown in Figure 3C and D. In the m-WFNS scale, there was a significant difference between all neighboring grades except between grade III and IV patients (Figure 3C). In the original WFNS scale, a significant difference was observed only between grade II and grade III and between grade IV and grade V patients (Figure 3D).

The distribution of the descriptive GOS scores in relation to progressing SAH grades (assessed at discharge) is shown in Figure 4A and B. On the m-WFNS scale, there was a significant difference between all neighboring groups, indicating that progressing SAH grades might be predictive of poorer outcomes (Figure 4A). In contrast, there were no significant differences between grade II and grade III and between grade III and grade IV patients on the