



Subarachnoid Hemorrhage Grading Scales A Systematic Review

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Abstract

Numerous systems are reported for grading the clinical condition of patients following subarachnoid hemorrhage (SAH). The literature was reviewed for articles pertaining to the grading of such patients, including publications on the Hunt and Hess Scale, Fisher Scale, Glasgow Coma Score (GCS), and World Federation of Neurological Surgeons Scale. This article reviews the advantages and limitations of these scales as well as more recent proposals for other grading systems based on these scales with or without addition of other factors known to be prognostic for outcome after SAH. There remain substantial deficits in the literature regarding grading of patients with SAH. Most grading scales were derived retrospectively, and the intra- and interobserver variability has seldom been assessed. Inclusion of additional factors increases the complexity of the scale, possibly making it less likely to be adopted for routine usage and increasing (only marginally in some cases) the ability to predict prognosis. Until further data are available, it is recommended that publications on patients with SAH report at least the admission GCS as well as factors commonly known to influence prognosis, such as age, pre-existing hypertension, the amount of blood present on admission computed tomography, time of admission after SAH, aneurysm location and size, presence of intracerebral or intraventricular hemorrhage, and blood pressure at admission.

Key Words: Subarachnoid hemorrhage; grading system; cerebral aneurysm; Glasgow Coma Score.

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Introduction

Subarachnoid hemorrhage (SAH) caused by ruptured intracranial aneurysm is a heterogeneous disease with a wide spectrum of initial clinical presentations and eventual clinical outcomes. The outcome of patients with SAH is influenced by factors related to the patient, the pathology, and treatments rendered. It has long been recognized that clinical features observed near the time of presentation with SAH have significant prognostic implications. A large amount of work has been devoted to the development of scales to clinically grade patients with SAH or cerebral aneurysms to measure the severity of

initial neurological injury, to provide prognostic information regarding outcome, to guide treatment decisions, and to standardize patient assessment across medical centers for the purposes of scientific study.

Since 1933, when Bramwell proposed grading aneurysm patients as either apoplectic or paralytic, more than 40 grading systems for patients with cerebral aneurysm have been proposed (1-3). Historically, important systems include the Botterell (4), Nishioka (5), and Cooperative Aneurysm Study systems (6). Currently, the most commonly used SAH grading scales are the Hunt and Hess Scale (7) or a slightly modified version (8),



the Fisher Scale (9), the Glasgow Coma Score (GCS; ref. 10), and the World Federation of Neurological Surgeons (WFNS) Scale (11–13). Numerous other grading scales have been proposed recently, most of which are modifications of existing scales.

The sheer number of SAH grading scales prohibits a concise comprehensive review. Instead, we have conducted a systematic review of the medical literature for articles examining and comparing the most commonly used SAH grading scales. Recently proposed grading scales are given additional attention, because they may not have had time to gain widespread usage.

Methods

We conducted a systematic review of the medical literature for articles pertaining to the most commonly used SAH grading scales as well as recently proposed grading scales. A MEDLINE search was conducted of articles published between 1966 and March 2004. Publication language other than English was not an exclusion criterion. The search terms were “subarachnoid hemorrhage” or “aneurysm” and “grading” or “grade,” in different combinations. Titles were reviewed, and then the abstracts of articles pertaining to cerebral aneurysms were reviewed. The articles were included if the purpose of the article was to use or create a grading scale on which to predict outcome after SAH. Articles were excluded if they examined a single prognostic factor (such as age or a biochemical measurement) and related this factor to outcome or if factors were used to predict some other complication of SAH (such as vasospasm), rather than outcome. Articles studying selected groups of patients with SAH were excluded (such as attempts to improve outcome prediction in only poor-grade patients), as were some articles that simply used multivariate analysis to list prognostic factors for outcome following SAH. Otherwise, publications generally were included because very relevant older publications, which might not employ criteria presently considered scientifically rigorous, are still important to the field. The reference list of each reviewed article was examined to find additional relevant articles that met the inclusion and exclusion criteria. We independently reviewed articles specifically addressing SAH grading scale creation, validity, or comparison among scales. The data included in most publications did not permit independent calculation of validity and reliability for the published scales if it had not already been performed. If stated, relevant values are cited.

Results

The literature addressing SAH grading scales contains some deficiencies. It was observed that more attention has focused on the development of new grading scales than on the validation of existing scales. Most of the reported grading systems are based on the expert opinions of the authors and are applied to a relatively small set of patients, usually selected from a single institution. Some series included only patients undergoing surgery, which limited the use of the grading scale to determine whether or not the prognosis for outcome was so dismal that treatment could reasonably be withheld. Few publications included patients undergoing endovascular treatment of aneurysms. Outcome assessment was often retrospective or conducted by an individual not clearly blinded to the initial

patient condition. Furthermore, the outcome scales used are often poorly described, patients are lost to follow-up, and uniform follow-up times are not used. A paucity of validation studies exists, and only a small number of studies have been conducted to compare different grading systems. No prospective, controlled, comparison studies have been published.

There were a large number of recent references to the Hunt and Hess Scale, GCS, Fisher Scale, and WFNS Scale. Articles that focused on the role of grading as one of the prognostic factors for outcome following SAH were not included in this article, unless there was specific relevant information about the grading scale. A review of 184 articles regarding SAH published in nine neurological journals between 1985 and 1992 showed that 71% of authors used the Hunt and Hess and Hunt and Kosnik Scales, 19% used the WFNS Scale or GCS, and 10% used other scales (13). Numerous modifications to these grading systems have been suggested (3,14–26).

The Hunt and Hess and Hunt and Kosnik Scales

The Hunt and Hess scale was proposed in 1968 as a modification to an older system originally reported by Botterell and colleagues in 1956 (Table 1; refs. 4 and 7). The scale was intended to be a gauge of surgical risk and to aid neurosurgeons in deciding on the appropriate time after SAH at which the neurosurgeon should operate. It was based on the opinion of its authors, who judged that the most important clinical signs of SAH were: (a) the intensity of meningeal inflammatory reaction, (b) the severity of neurological deficit, (c) the level of arousal, and (d) the presence of associated disease. Therefore, a grading system based on the level of severity (or axis) of the first three signs was created. The Hunt and Hess scale has five grades incorporating all three axes, with differentiation between grades made by descriptive terminology. A modification was added for severe systemic disease, which places the patient in the next most severe grade. In 1974, Hunt and Kosnik proposed a modification of their SAH scale by adding a zero grade for unruptured aneurysms and 1a grade for a fixed neurological deficit in the absence of other signs of SAH (8).

The most important advantages of the Hunt and Hess Scale are that it is widely known in the neuroscientific community and that it is well-entrenched in the literature on SAH. It is also relatively easy to administer, because multiple steps are not required to derive a comprehensive grade. However, in the introduction to their article, Hunt and Hess acknowledged the most significant flaws of the scale, stating, “It is recognized that such classifications are arbitrary and that the margins between categories may be ill defined” (7).

Many of the terms used to define the grades (such as drowsy, stupor, and deep coma) are vague and subject to variable interpretation. Moreover, the Hunt and Hess Scale considers three axes of clinical signs in one scale. When patients present at different points on the axes, clinicians are forced to use their judgment in determining which axis is most important. For example, although uncommon, a patient might present with severe headache, intact level of consciousness, and hemiplegia. On the arousal axis, the patient is without deficit and could be assigned grade 2. However, the patient also has a severe neurological deficit and, therefore, could be assigned grade 4. In this case, the clinician must decide which axis should be

Table 1
Clinical Grading Scales for Aneurysmal SAH

Grade	Botterell et al. (4)	Hunt and Hess (7) ^a	WFNS (11)
1	Conscious with or without signs of blood in the subarachnoid space	Asymptomatic or minimal headache and slight nuchal rigidity	GCS 15, no motor deficit
2	Drowsy without significant neurological deficit	Moderate-to-severe headache nuchal rigidity, no neurological deficit other than cranialnerve palsy	GCS 13 to 14, no motor deficit
3	Drowsy with neurological deficit and probably intracerebral clot	Drowsy, confusion, or mild focal deficit	GCS 13 to 14 with motor deficit
4	Major neurological deficit, deteriorating because of large intracerebral clots or older patients with less severe neurological deficit but pre-existing cerebrovascular disease	Stupor, moderate-to-severe hemiparesis, possibly early decerebrate rigidity and vegetative disturbances	GCS 7 to 12, with or without motor deficit
5	Moribund or near moribund with failing vital centers and extensor rigidity	Deep coma, decerebrate rigidity, moribund appearance	GCS 3 to 6, with or without motor deficit

^aSerious systemic disease such as hypertension, diabetes, severe arteriosclerosis, chronic pulmonary disease, and vasospasm on angiography result in placement in next less favorable category.

SAH, subarachnoid hemorrhage.

considered more strongly to determine a final grade. This ambiguity blurs the lines between adjacent grades and reduces the inter-rater reliability of the scale. κ values are often reported to measure the inter-rater reliability of grading systems or of various diagnostic tests. A $\kappa=1$ corresponds to complete agreement between raters, and a $\kappa=0$ corresponds to no agreement between raters. The κ values for the components of the Hunt and Hess Scale range between 0.25 for headache (marginally greater than chance) and 0.52 for level of consciousness (27). The overall κ for the Hunt and Hess Scale is 0.42, which is significantly greater than that expected by chance. The κ values for the Nishioka Scale are not significantly different, nor are values for experienced evaluators compared to less experienced evaluators. Although no agreement exists regarding an acceptable κ level, these numbers were significantly below the κ for the GCS (0.69) in this article (28) and the κ value for another scale (0.69;19). Overall, the inter-rater variability of this scale is higher than for the GCS.

A feature of the Hunt and Hess Scale, which is applied inconsistently, is the requirement to increase a patient's grade one level in the presence of serious systemic disease or severe vasospasm on angiography (7). However, only some qualifying diseases are defined, and the level of severity necessary for upgrading is unclear. Some systemic diseases, such as hypertension, likely have a much stronger impact on the course of SAH than others, such as diabetes (3,29). The added ambiguity of this feature likely increases inter-rater disagreement and may undermine the prognostic strength of the system. Comparison of the Hunt and Hess Scale, GCS, and WFNS Scale in a series of 185 patients with SAH showed that the Hunt and Hess Scale has strongest predictive power for outcome at 6 months, as assessed by the Glasgow Outcome Scale (GOS; [29]). The authors noted that many poor-grade patients achieved good recoveries and, therefore, that current admission grading scales are not accurate enough to be the sole basis for treatment decisions. They also found that scores on the day of operation were of more prognostic value than values observed immediately after hospitalization.

Table 2

The Fisher Scale for Grading SAH on Admission CT Scan (9)

Grade	CT Scan
1	No blood visualized
2	A diffuse deposition or thin layer with all vertical layers of blood (interhemispheric fissure, insular cistern, ambient cistern) less than 1 mm thick
3	Localized clots and/or vertical layers of blood 1 mm or greater in thickness
4	Diffuse or no subarachnoid blood, but with intracerebral or intraventricular clots

Abbreviations: SAH, subarachnoid hemorrhage; CT, computed tomography.

Several studies compressed the Hunt and Hess grades to demonstrate that patients in grades 1 to 3 had better outcomes than patients in grades 4 and 5 (30,31). However, some researchers have questioned whether there are significant differences in outcome between the various Hunt and Hess grades (17,20,21). From a statistical perspective, significance can be achieved if one reduces the number of outcome categories and grades in the scale, but this comes at the expense of overall precision of the grading scale. In a series of 304 patients with SAH, outcome was only significantly different between patients in Hunt and Hess grades 2 and 3 and between those in grades 3 and 4 (17). In a separate analysis of 405 patients, no significant difference was observed between Hunt and Hess grades 0 to 2 (19). The lack of difference in outcome between Hunt and Hess grades 1 and 2 (which are differentiated mainly on the basis of headache severity that has no known effect on outcome) was termed an oversplitting error, which weakens the prognostic power of the scale (24).

New SAH grading scales based on the Hunt and Hess Scale have been proposed. Deruty et al. (32) proposed emphasizing the level of consciousness to compress the five grades of the Hunt and Hess Scale into three groups: 1 plus 2 (alert), 3 plus 4 (drowsy), and 5 (comatose). The new grading scale was

Table 3
Clinical Grading Scales for Aneurysmal SAH

Grade	Jagger et al. (18)	Ogilvy et al. (19)
0	–	Younger than 50 years, not in coma, Fisher score 0–2, or aneurysm <10 mm
1	–	Only 1 of age >50 years, coma, Fisher score 3–4, or aneurysm >10 mm
2	No eye opening + abnormal flexor or extensor posturing or no response	Two of age >50 years, coma, Fisher score 3–4, or aneurysm >10 mm
3	Eyes open to pain + abnormal flexor or extensor posturing or no response or no eye opening + severe focal deficit	Three of age >50 years, coma, Fisher score 3–4, or aneurysm >10 mm
4	Eyes open to verbal command + abnormal flexor or extensor posturing or no motor focal response or eyes open to pain + severe deficit or no eye opening + mild focal deficit	Four of age >50 years, coma, Fisher score 3–4, or aneurysm >10 mm
5	Eyes open spontaneously + abnormal flexor or extensor posturing or no response or eyes open to verbal command + severe focal deficit or eyes open to pain + mild focal deficit or no eye opening + normal motor response	Age >50, coma, Fisher score of 3–4, and aneurysm >10 mm
6	Eyes open spontaneously + severe focal deficit or eyes open to verbal command + mild focal deficit or eyes open to pain + normal motor response	
7	Eyes open spontaneously + mild focal deficit or eyes open to verbal command + normal motor response	
8	Eyes open spontaneously + normal motor response	

Abbreviations: SAH, subarachnoid hemorrhage.

applied to 74 patients and was found to correlate with outcome. Outcome was good in 71% of the alert group, 14% of drowsy group, and in none of the patients in the comatose group.

Grading Scales for Subarachnoid Hemorrhage Volume

In 1980, the Fisher Scale was proposed to predict cerebral vasospasm after SAH (Table 2; ref. 9). The scale assigns a grade based on the pattern of blood visualized on initial computed tomography (CT) scanning. It was validated prospectively in a small series of patients (33). However, there are several limitations of this scale. It was developed when imaging technology had roughly one-tenth of the resolution currently available. The measurements used were actual measurements on printed CT scan images and had no relationship to the real clot thickness. Subarachnoid clot less than 1 mm in true thickness is uncommon, as is the finding of no blood on admission CT scan; therefore, grades 1 and 2 were actually be quite uncommon. Classification of patients with thick SAH and intracerebral or intraventricular blood or those with intracerebral or intraventricular hemorrhage alone is unclear. In the original description by Fisher et al. (9), grade 4 included patients with intracerebral or intraventricular blood and only diffuse thin SAH. However, confusion has arisen because some patients can have thick SAH and intracerebral or intraventricular hemorrhage. The scale is subjective, but the inter-rater reliability has been reported to be high, with one series reporting a κ of 0.90 (19). Finally, additional factors such as clot density and clearance rate, which may be equally important, are not considered in the Fisher Scale (34–36).

Although the Fisher Scale was designed to predict cerebral vasospasm, correlation with clinical outcome has been reported (19). The Fisher Scale is not comprehensive enough to serve as a primary grading system for SAH, but it has been incorporated into proposed variations of other SAH grading systems. Saveland et al. (22) retrospectively classified 63 patients with SAH by the Fisher and Hunt and Hess Scales. Outcome was assessed as good, fair, or poor at a mean of 19 months after SAH. The Hunt and Hess Scale was modified by assigning only Hunt and Hess patients with grade 1, 2, or 3 to the next worst grade if they had Fisher grade 3 SAH. No statistical analysis was performed, but this system was suggests to lead to better prediction of outcome.

Ogilvy and Carter (19) combined the Hunt and Hess and Fisher Scales with patient age as well as aneurysm size and location to create a new grading system (see Table 3; ref. 19). The outcome measure was the GOS at a mean of 3.2 years after surgery. Unruptured aneurysms were included; the utility of this inclusion is unclear, because factors affecting the outcome of these patients are different than the factors that affect patients with SAH (25). The scale was derived based on retrospective review but was tested and found to predict outcome prospectively in 72 patients. There was no statistically significant difference in outcome between grades 0 and 1. Comments about the scale were that it treated each factor with equal weight, that only patients treated surgically were included (which limits the use of the scale and introduces potential bias), and that the initial Hunt and Hess grade was used, even if it improved before surgery (37).

Hijdra and colleagues (26) developed the second major scale that grades SAH on admission CT scan. They graded

each of 10 basal cisterns and fissures according to the amount of blood (0 = no blood; 1 = small amount of blood; 2 = moderately filled with blood; 3 = completely filled with blood). The scale had high interobserver reliability with κ -values between 0.35 and 0.75. The scale was not used to predict outcome but currently is used by some groups to grade SAH on admission CT scan (25).

The Glasgow Coma Score

The GCS is the most universally recognized and accepted system for grading level of consciousness (Table 4). In 1974, Teasdale and Jennett reported the GCS a bedside system for grading consciousness (10). Since then, it has been applied as a grading system for neurological conditions, including closed head trauma (38,39), gunshot wounds to the head (40–42), spontaneous intracerebral hemorrhage (43), nontraumatic coma (44), and SAH (11,16,20). The inter- and intrarater reliability of the GCS is strong and is superior to other methods of consciousness assessment (45,46). In SAH, the GCS had a κ of 0.46 (20), which increased to 0.69 if the GCS was compressed to three groups (6–15,27). Assessments of neurosurgical patients by inexperienced users were reported to vary significantly from those of experts (47).

The GCS measures neurological function on three axes: eye opening, verbal response, and motor response. However, unlike the Hunt and Hess Scale, each axis is graded separately. The grades from the three axes are totaled to produce a final comprehensive grade. This system requires four steps (three grading and one summation) to produce a comprehensive grade. The relative importance of the different components of the scale varies. Eye opening is commonly reduced after SAH, which could result in decreasing the clinical grade of the patient; however, the prognosis is better if the patient is otherwise normal (GCS = 14 as a result of eye opening only to speech) than it is for those who are confused with a GCS of 14 (17). Speech is commonly confounded by intubation (18).

Gotoh et al. (16) prospectively examined the prognostic strength of the GCS in a series of 765 patients with SAH who had undergone surgery. Outcome was measured at 6 months using the GOS. There was a strong correlation between higher GCS and better outcome ($r_2 = 0.62$; $p < 0.001$). However, there were only significant differences between GCS 14 and GCS 15, with no significant differences between the remaining adjacent GCS grades. Their breakpoints appeared to be 15 and 14, 11 and 10, and 7 and 6. There were significant differences between every group when the patients were classified by the WFNS Scale. The findings highlight the statistical problem of being able to differentiate patients on scales with increasing numbers of grades, especially when outcome is only assessed relatively crudely on a 5-point scale, such as the GOS.

Additional scales have been proposed based on the GCS. The WFNS Scale, which is considered separately later because of its popularity, is the GCS with the addition of a fourth axis for a focal neurological deficit. Hirai et al. (17) retrospectively examined the three axes of the GCS individually in a series of 304 patients with SAH who underwent surgery whose outcomes were recorded at 6 months using the GOS. They advocated reporting each axis of the GCS separately, because outcome was similar among patients with a GCS of 15 or a verbal score of 5, irrespective of the eye and motor scores. Outcome

Table 4
The Glasgow Coma Scale (10)

Parameter	Score
Eyes	
Open spontaneously	4
Open to verbal command	3
Open to pain	2
No eye opening	1
Best motor response	
Obeys to verbal command	6
Localizes to painful stimulus	5
Flexion withdrawal to pain	4
Abnormal flexion (decorticate rigidity) to pain	3
Abnormal extension (decerebrate rigidity) to pain	2
No response	1
Best verbal response	
Oriented and converses	5
Disoriented and converses	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1

was also similar among patients with GCS scores of 14 (verbal = 4, eye opening = 4, motor = 6) and 13 (verbal = 4, eye opening = 3, motor = 6 or verbal = 4, eye opening = 4, and motor = 5). In their examination of the summated GCS, significant differences in outcome were observed only between GCS 13 and GCS 14 and between GCS 7 and GCS 8.

Oshiro et al. (20) proposed compressing the 13 grades of the GCS into five grades: 1 (GCS: 15), 2 (GCS: 12–14), 3 (GCS: 9–11), 4 (GCS: 6–8) and 5 (GCS: 3–5). Their grading scale was an attempt to correct the lack of prognostic significance between adjacent GCS grades by compressing the grades into five groups that had a statistically significant difference in outcome. The scale increases the number of steps required to produce a comprehensive grade from a GCS 4 to a GCS 5 (three grading, one summation, and one compression). In 15 prospectively evaluated patients, two raters had κ scores of 0.46, 0.41, and 0.27 for the new GCS-based system, the Hunt and Hess Scale, and the WFNS Scale, respectively. The authors retrospectively applied the GCS-based scale to 291 patients and compared it to the WFNS and Hunt and Hess Scales. The GCS-based scale was the strongest predictor of discharge GOS, with an odds ratio of 2.6, compared to 2.3 for both the WFNS and Hunt and Hess Scales. On the other hand, the Hunt and Hess Scale was the strongest predictor of mortality, although this was believed to be less important because outcomes of patients with SAH are distributed from full recovery to death. The three scales had high agreement with each other, as judged by a κ statistic (0.63) indicating strong agreement. However, it should be noted that this analysis was based on discharge GOS, which may be an inadequate endpoint for final outcome after SAH. Additionally, the methods for determining the breakpoints for this system were not reported.

The creation of appropriate breakpoints is a key factor in the creation of a grading system that is based on compression of another system (24). Breakpoints are positions on a scale where two adjacent grades connote a significant difference in outcome. In grading systems that are the product of an author's

opinion, these breakpoints may be arbitrary. Takagi et al. (24) recommended a combinatorial approach to derive breakpoints. A mathematical approach was used to derive breakpoints that created maximal intergrade differences in outcome based on the GOS at 6 months. They applied their system retrospectively to a series of 1398 patients with SAH and found that the optimal GCS groups for compression into a five-grade system are: 1 (GCS: 15), 2 (GCS: 11–14), 3 (GCS: 8–10), 4 (GCS: 4–7), and 5 (GCS: 3). These categories differ from all other scales reviewed. The authors acknowledge that other breakpoints may apply to other populations.

Another problem with the GCS is that it heavily relies on a patient's verbal score. However, many patients with SAH are intubated early in their clinical course. Jagger et al. (18) proposed a SAH grading scale that eliminated the verbal axis of the GCS. Their SAH grading system may be the first to be statistically derived. Data from 3521 patients enrolled in the International Cooperative Aneurysm Study were analyzed to derive and validate the grading system, which summated two axes: eye opening response (graded identically to the GCS) and motor response (graded in four levels based on worst motor response; Table 3). Although the grading scale demonstrated prognostic strength, it has failed to gain widespread usage. The method of grading the worst motor response, which is contrary to the well-entrenched GCS methods of grading best motor response, may have contributed to clinicians' reluctance to adopt this system. Additionally, the use of seven categories and alteration in the motor responses from the standard GCS might be perceived to increase complexity in daily use. However, an advantage exists in not using the speech axis, and that the scale was derived statistically on the largest population studied to date.

The World Federation of Neurological Surgeons Scale

In 1988, an expert opinion committee chaired by Charles Drake proposed the WFNS Scale (11). It was based on the committee members' opinions that a SAH scale should (a) include five grades, (b) be based on the GCS, and (c) acknowledge the presence of a focal neurological deficit. The committee considered data from the International Cooperative Aneurysm Study that assessed the prognostic importance of headache, stiff neck, and major focal neurological deficits in terms of grading. The analysis showed that Hunt and Hess grades 1 and 2 were prognostically the same because, as long as consciousness was normal, headache and/or stiff neck had no significant effect on outcome. Second, the most important predictor of death and disability was level of consciousness, and the most important predictor of disability—but not mortality—was hemiparesis and/or aphasia. The WFNS Scale compresses the GCS into five grades, with the addition of a fourth axis (focal neurological deficit) to differentiate grades 2 and 3. The WFNS Scale requires six steps to determine a comprehensive grade (four grading, one summation, and one classification). Its primary advantages over the Hunt and Hess Scale are that it uses objective terminology and grades each of its axes separately. The WFNS Scale has two main advantages over the GCS alone. It compresses the GCS into five grades, which may create greater intergrade differences in outcome. It includes

the presence of a focal motor deficit axis. However, the amount of additional prognostic power derived from adding this axis is unknown. A limitation is that the method for determining the GCS breakpoints were not defined. Because the location of breakpoints may vary, a limitation of the scale is the broad range of GCS scores in some categories such as grade 4 (GCS: 7–12), among which patients may have widely different outcomes. The classification of patients in the same grade, despite widely varying outcomes, was called a co-existing error (24).

Conflicting data exist regarding the prognostic power of the WFNS grades. Several studies found a stepwise increase in the likelihood of an unfavorable outcome with increasing WFNS grade (3,20). In a series of approximately 3500 patients with SAH who were graded prospectively and assessed for outcome on the GOS 3 months after SAH, the likelihood ratio of a poor outcome was: WFNS grade 1 = 0.36, WFNS grade 2 = 0.61, WFNS grade 3 = 1.78, WFNS grade 4 = 2.47, and WFNS grade 5 = 5.22 (3). A total of 66% of patients were WFNS grades 1 and 2, with approximately 10% of patients in each of the remaining three grades. The bias toward good WFNS grades may result from the patients being studied in clinical trials. Almost all underwent surgery. Other series have found a paucity of WFNS grade 3 patients and a lack of significant differences in outcome between adjacent grades. Gotoh et al. (16) studied 765 patients and found no significant difference in outcome between WFNS grades 2 and 3 or between grades 3 and 4. In a series of 304 patients with SAH, only 6% of patients were classified as WFNS grade 3, and no significant difference in outcome was observed between grades 2 and 3, grades 3 and 4, or grades 4 and 5 (17). Among 294 patients, the WFNS Scale failed to predict significant differences in outcome between adjacent grades based on the GOS 1 month after discharge (48). Only 8% of patients were WFNS grade 3.

We reported a modification of the WFNS Scale (see Table 5; ref. 3). The 3567 patients who were enrolled in four prospective, randomized, double-blind, placebo-controlled, multicenter trials of the drug tirilazad were used to derive and validate a grading system. In addition to the four axes of the WFNS Scale, seven additional axes were added, including age, history of hypertension, admission systolic blood pressure, aneurysm size, aneurysm location, clot thickness, and presence of vasospasm on admission angiography. Although the modification added prognostic strength to the WFNS Scale, the 11 axes require 14 steps to produce a comprehensive grade. Advantages include derivation of the scale based on statistical analysis of a large number of patients. Disadvantages include the inclusion of factors, such as aneurysm characteristics, that may not be known; additionally, almost all patients were treated surgically. It was noted that adding more axes improved prognostic accuracy, but the gains achieved by the WFNS Scale were relatively modest, prognostic inaccuracies remained, and with all grading methods tested, occasional grade 5 patients achieved good outcomes. The scale is probably too complex and cumbersome for routine clinical usage. The data from which the scale is derived could be biased, because they were derived from randomized, clinical trials that may have preferentially included good-grade patients.

Table 5
Grading Scale Using Eight Clinical and Radiological Factors^a

Points	WFNS grade	Age (yr)	History of hypertension	Admission systolic blood pressure(mm Hg)	Aneurysm size(mm)	Aneurysm location	Clot Thickness	Admission vasospasm
0	–	<50	No	<190	≤12 mm	Anterior	None or thin	No
1	1	50–69	Yes	≥190	13–24 mm	Posterior	Thick	Yes
2	2	70–79			≥25 mm			
3	3	≥80						
4	4							
5	5							

^aWFNS, World Federation of Neurological Societies.

Table 6
Grading Scale Based on Gerber et al. (14)

Parameter	Score
CT scan	Score 2 points for each site for a maximum of 8 points
Interhemispheric, basal, ventricular blood and intracerebral hematoma	
Neurological grade	
Grades 1–3 (alert and oriented with or without cranial nerve palsy or neurological deficit)	Subtract 1 point from total scan score
Grade 4 (drowsy with or without disorientation)	Leave total scan score unchanged
Grade 5–6 (drowsy and major deficit or coma)	Add 5 points to total scan score

Abbreviations: CT, computed tomography.

Other Scales

Gerber et al. (14) prospectively studied three series of patients with SAH with data collected over different times (Table 5). Prognostic factors were identified in the earliest series and were used to develop a grading scale that was tested for accuracy on subsequent series of patients. Clinical grading was based on the Cooperative Aneurysm Study Neurological Scale (47). Subarachnoid clot on admission CT scan was graded by giving 2 points each for the presence of interhemispheric, basal, ventricular, and intracerebral hemorrhage, for a maximum score of 8. A grading scale was derived based on the clinical grade, and CT grade (Table 6), and patients who were divided into three risk categories (low risk: <1; medium risk: 0–2; high risk: >2), which were shown to significantly correlate with death and recovery based on outcome assessed at 3 months using a scale similar to the GOS. This study was meritorious because of its prospective derivation and because patients who were not selected for surgery were included, although the number of patients studied was relatively small (80–100 for each study) and they represented only about 61% of those admitted during the study.

Claassen et al. (25) prospectively studied a consecutive cohort of 413 patients with SAH. The goal was to determine the effect of physiological variables on outcome in these patients. A physiological derangement score was derived by assigning points for arterio-alveolar gradient greater than 125

mmHg, serum bicarbonate less than 20 mmol/L, serum glucose greater than 180 mg/dL, and mean arterial blood pressure less than 70 or greater than 130 mmHg. A multivariate model was constructed using clinical and radiological variables to predict poor outcome at 3 months on the modified Rankin scale. Hunt and Hess grade, loss of consciousness, aneurysm size, intra-ventricular hemorrhage, and rebleeding were significant predictors of outcome; however, including the physiological derangement score improved outcome prediction.

Discussion

A grading scale serves two primary functions. First, it is a system for classification of data. However, a grading scale is a more sophisticated instrument than a classification system, because the term “grading” implies that some type of directional axis is used as the basis for classification. In this way, a grading scale is a tool for measuring its primary axis. For most of the grading scales included in this article, the primary axis is the clinical severity of SAH, and the grading scale attempts to convert a qualitative impression of SAH severity into a quantitative measurement with the purpose of estimating prognosis early. The characteristics and requirements for an ideal SAH grading scale have been discussed (19,24):

1. Aid clinicians in making patient management decisions that are influenced by the severity of SAH.
2. Guide prognosis so that clinicians, patients, and family members can have appropriate expectations for outcome. In this role, it is also essential for clinicians to thoroughly understand the prognostic limitations of the grading scale.
3. Facilitate communication between physicians to describe individual patients and to compare similar groups of patients in multicenter studies that examine the impact of new treatment strategies.
4. Enable clinicians to track a patient’s status serially to detect and quantify changes in the severity of disease. This is a critical use, but most units probably use the GCS or a modification thereof (e.g., Japanese coma score).

To meet these criteria, the scale must (24): (a) have significant correlation with outcome and significant differences in outcome between grades; (b) be easy to use and have low intra- and inter-observer variability; (c) be able to be applied retrospectively.

It follows that a useful grading scale should emerge as a significant factor predictive of outcome in studies using multivariate analysis to determine prognostic factors for outcome

after SAH (3,30). Lindsay and colleagues proposed the approach that is used to develop grading scales by some authors (3,50), which is to identify prognostic factors for outcome (including clinical factors, patient age, blood pressure, aneurysm site, and size) and to develop an index based on these factors (25). Statistically, a grading scale with fewer grades has a higher chance of differentiating between outcomes, depending on where the breakpoint in the scale was placed. The predictive ability of the grading scale also depends on the outcome scale used. It is statistically easier to correlate grade with a dichotomous outcome measure than with a more complex outcome scale. In terms of each of these factors, although data are currently limited, the GCS best fulfills the intra- and interobserver variability criterion.

Because of the limitations of the current grading scale data, it is unreasonable to strongly advocate universal adoption of any of the available SAH grading scales. The final judgment of a grading scale's value is based on the clinical community's willingness to use it. No SAH grading scale has approached universal acceptance, which is likely emblematic of the clinical community's dissatisfaction with all of the available scales. The GCS has gained widespread acceptance in the evaluation of brain injury. If SAH is viewed as simply another form of brain injury, then one might question why the GCS is not an adequate SAH scale. Current data suggest that the relatively greater objectivity and precision of the GCS compared to other scales (demonstrated in part by the lower degree of intra- and interobserver variability) are a step forward from the Hunt and Hess Scale. However, in the 30 years since the GCS was proposed, the search for a SAH grading scale has continued. This may be because SAH is a unique form of brain injury, or it may simply reflect the inaccuracies inherent in the clinical assessment of patients with SAH who may be sedated or otherwise inaccessible because their clinical condition appears worse than it is as a result of reversible causes or because they deteriorate irreversibly for some reason after a clinical grade is determined. It remains to be determined whether or not a biochemical marker of brain injury will improve prognostic accuracy, although the additional predictive value of physiological variables reported by Claassen and colleagues supports further work in this area (25,51,52). Because of these inaccuracies, it should be emphasized that a grading scale is only one tool on which to gage the potential outcome, and the etiology of poor neurological condition, in addition to multiple other factors, needs to be considered before making decisions regarding treatment of the patient with SAH.

Undoubtedly, it will be necessary for new grading scales to be proposed. The increased use of endovascular treatment of ruptured aneurysms may alter factors prognostic for outcome. Other treatments may arise, and the epidemiology of SAH could change. Finally, the outcome measure used may be sensitive to different aspects of the condition of the patient immediately following the SAH.

For future scale development, it is suggested that grading scales be derived from statistical analysis of large patient series and not based simply on expert opinion. However, the creation of new grading scales should not overshadow work on the validation and comparison of existing grading scales. The validity, precision, and prognostic power of a grading scale should be prospectively evaluated and compared to existing

scales in large patient series. Consideration needs to be given to the assessment of patients who are sedated, whether the best or worst grade should be used, and whether grading scales apply to special populations—such as children. A retrospective study of 56 patients with SAH who were assessed for outcome at 6 months using the GOS found that the worst grade recorded on the WFNS Scale or GCS before surgery was most closely correlated with outcome (53). Another study noted that clinical grade immediately before surgery was more closely correlated with outcome than admission grade (29). Presently, SAH studies might best report the GCS in total and, possibly, the scores on each axis as well as information regarding all known prognostic factors for outcome after SAH (3,28,55). The ability to publish data online appears to allow and warrant the inclusion of as much detail as possible.

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