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Clinical Article

A comparison of different grading scales for predicting outcome after subarachnoid haemorrhage

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Summary

Background. Most scales used to assess prognosis after subarachnoid haemorrhage (SAH) are based on the level of consciousness of the patient. Based on information from a logistic regression model, Ogilvy *et al.* developed a new grading scheme (Massachussetts General Hospital (MGH) Scale) which applied a simple scoring method to each prognostic factor considered relevant such as level of consciousness, age, quantity of blood in the first CT scan and size of the aneurysm. The purpose of this study is to introduce a modified version of the MGH scale, built up using factors applicable to every patient suffering SAH, and compare this new scale to the World Federation of Neurological Surgeons scale (WFNS), the Glasgow Coma Scale (GCS) scale for SAH and the MGH scale.

Method. A series of 442 patients consecutively admitted to Hospital 12 de Octubre between January 1990 and September 2001 with the diagnosis of spontaneous SAH were retrospectively reviewed. Outcome was assessed by means of the Glasgow Outcome Scale measured six months after hospital discharge. Differences between grades of the WFNS, the GCS scale for SAH, the MGH scale and the new scale were computed by χ^2 statistics. ROC curves were plotted for the different scales and their areas compared.

Findings. Both WFNS and GCS scales fail to present significant differences between most of their grades, while the proposed scale shows a constant inter-grade significant difference in predicting outcome. The proposed scale presents a significantly higher prognostic efficacy in the whole series of patients suffering spontaneous SAH, patients with idiopathic subarachnoid haemorrhage (ISAH) and patients with confirmed aneurysmal SAH. The MGH scale is not applicable to some groups of patients suffering SAH.

Interpretation. Grading scales including additional factors to the level of consciousness show higher prognostic efficacy. The proposed modification of the MGH scale makes it applicable to every patient suffering SAH without losing its prediction capability.

Keywords: Subarachnoid haemorrhage; grading system; outcome; prognosis; scale.

Introduction

A variety of scales have been used in order to assess prognosis after subarachnoid haemorrhage (SAH), most of which are mainly based on the level of consciousness of the patient. However, the use of different classifications, along with the inconsistent or vague definitions of the patient's level of consciousness, has hampered appropriate comparisons between series of patients and different management strategies. The most frequently used classification, i.e., the Hunt and Hess scale [17], has proved to present variability between observers and does not differentiate clearly between some of its grades. The World Federation of Neurological Surgeons proposed a new classification [7] based on the Glasgow Coma Scale (GCS) [35] in order to better define the level of consciousness of patients suffering aneurysmal SAH. However, this scale is still not widely accepted and different authors have questioned its validity, especially regarding its grouping composition [11, 15, 22, 27, 34, 36]. Thus, several corrections were proposed for this classification scheme and new scales such as the Glasgow Coma Scale for SAH appeared [27], using different cut-off points between clinical grades (Table 1).

Apart from the level of consciousness, other factors have also been related to the outcome of patients suffering aneurysmal SAH. For instance, different studies have shown that age is also a major prognostic factor [5, 6, 9, 10, 18, 24, 22, 26, 32]. Older patients present a

Table 1. *Summary of the World Federation of Neurological Surgeons Scale, the GCS grading scale for SAH as proposed by Oshiro et al., the Massachusetts General Hospital grading scale for surgical treatment of intracranial aneurysms and the proposed grading scale for SAH*

Grade	WFNS scale	GCS grading system		
I	GCS score of 15	GCS score of 15		
II	GCS score of 13 to 14 without focal deficit	GCS score of 12–14		
III	GCS score of 13 to 14 with focal deficit	GCS score of 9–11		
IV	GCS score of 7 to 12	GCS score of 6–8		
V	GCS score of 3 to 6	GCS score of 3–5		
Patient age	**Level of consciousness***	**Fisher Scale Score**	**Aneurysm size (mm)**	**Points†**
MGH Scale				
≤50	No coma	0–2	<10	0
>50	In coma	3 and 4	>10	1
Patient age	**WFNS grade**	**Fisher Scale Score**	**Points**	
Proposed scale				
≤50	I	0–2	0	
>50	II and III	3 and 4	1	
	IV and V		2	

* Defined by Hunt and Hess grade (I–III = no coma, IV and V = in coma).
† Add 1 additional point for giant (>25 mm) posterior circulation lesions.

dismal prognosis in many series, poor outcomes exceeding 60% in patients older than 60 years [5, 9, 10, 22, 24]. In addition, age is an independent factor in many studies using multivariate analysis [22, 32]. Thus, it is clear that age should be taken into consideration when assessing the individual prognosis of a given patient, and also when comparing different treatments and management strategies.

The quantity of blood present in the initial CT scan correlates to the severity of the bleeding and many times with the level of consciousness [22, 8, 14, 10, 26]. Although a high interobserver variability has been reported when grading the amount of blood from a CT, this variability dramatically diminishes if the classification used is simplified by comparing only large and small amounts of extravasated blood [8]. Such a classification could also help to improve the comparison between groups of patients from different centres.

Based on information extracted from a logistic regression model and selecting those factors independently related to outcome in their series, Ogilvy *et al.* developed a new grading scheme (Massachussetts General Hospital (MGH) Scale) [26] which applied a simple scoring method to each prognostic factor considered relevant such as the level of consciousness, the age, the quantity of blood in the first CT scan and the size of the aneurysm (Table 1). Although data regarding the validity of this new grading scheme have been already presented, both in retrospective and prospective fashion and in different subsets of their own series of patients [5, 16], the results of its applicability in total management series of patients with SAH or its application in other centres is still lacking. Another question regarding the validity of this scale is that it was designed for assessing prognosis of patients harbouring either ruptured or unruptured aneurysms. The importance of some prognostic factors for ruptured and unruptured aneurysms could be quite different, and thus assumptions made for the design of this grading scheme might prove valid only for the population of patients from which they were extracted.

The aim of this study is two fold: Firstly to introduce a modified version of the MGH scale, built up using the same methodology employed by Ogilvy *et al.* but using factors applicable to every patient suffering SAH, and secondly to compare this new scale to the World Federation of Neurological Surgeons (WFNS) scale, the GCS scale for SAH and the MGH scale.

Materials and methods

Patient selection and management

A series of 442 patients consecutively admitted to Hospital 12 de Octubre between January 1990 and September 2001 with the diagnosis of spontaneous SAH were retrospectively reviewed. The diagnosis of SAH was made by the presence of a typical clinical history of spontaneous SAH and the presence of blood in the basal cisterns observed on the admission CT scan. Sixty patients died before angiography could be performed, but were included because both the clinical history and the CT pattern of bleeding was typical of ruptured aneurysm. All the remaining 382 patients underwent four vessels cerebral angiography. The aneurysmal origin of SAH was confirmed in this first angiographic study in 252 patients. 130 more patients showed no vascular malformation and were classified into subgroups depending on the distribution of bleeding as seen on the admission CT scan (normal, perimesencephalic or aneurysmal like patterns). These last patients were subjected to control cerebral angiography if they exhibited an aneurysmal pattern of bleeding or showed vasospasm in the first angiogram; 17 of these patients presented an aneurysm in the second angiogram. Thus, a total of 269 patients had aneurysmal SAH in this series. The remaining 113 patients were classified as suffering idiopathic SAH. The long-term outcome of these last patients has been described in another study which showed that in the long term the probability of aneurysmal origin of the bleeding is very low in this subpopulation [23].

All patients were managed according to a previously published protocol designed by neurosurgeons, intensive care physicians, and neuroradiologists at our centre [29]. Of the 269 patients with confirmed aneurysmal SAH, 175 (65%) received surgical treatment, 62 (23%) received endovascular treatment and 32 (12%) did not receive any treatment due to poor clinical condition caused by initial bleeding or early rebleeding. Median interval between stroke and surgical or endovascular treatment was 12 days.

Data collection

Patients were prospectively evaluated in the Emergency Department by means of the GCS and classified into a clinical grade according to the World Federation of Neurological Surgeons (WFNS) scale for SAH. A CT scan was performed in all cases and the presence and amount of cisternal blood was evaluated by using the Fisher scale. All clinical records were retrospectively reviewed and the age, the GCS score and WFNS grading on admission and CT's Fisher grading were collected. In those cases of aneurysmal SAH, aneurysm size was measured in the angiographic study and classified into two groups, smaller than 10 mm or greater than 10 mm. The level of consciousness was also prospectively recorded at the time of aneurysm treatment in patients diagnosed with aneurysmal SAH, in order to retrospectively apply the MGH grading scale for aneurysmal treatment, as the level of consciousness considered in this scale is the one recorded at operation.

Outcome was evaluated six months after hospital discharge using the Glasgow Outcome Scale (GOS) [21]. Six patients were lost to follow up. Of these, three belonged to the group of confirmed aneurysmal SAH, and all three had received surgical treatment. The other three belonged to the group of ISAH. Only one of these six patients was in poor clinical grade on admission.

Scale design and statistical analysis

Using the methodology described by Ogilvy *et al.* [26] we assigned simple scores to factors related to the final outcome in our series which were applicable to every patient suffering SAH, such as age, level of consciousness and quantity of blood in the first CT scan. WFNS grading score groups were reassigned into three groups as described in a previous study [22]. With the addition of the scores assigned to each factor, patients were classified into a five tiered grading scale, ranging from 0 to 4 (Table 1).

For the purpose of statistical analysis patient outcome was dichotomised into the subgroups of favourable outcome (patients with GOS 1 and 2) and poor outcome (patients with GOS 3, 4 and 5). Differences between grades of the WFNS, the GCS scale for SAH and the new scale were computed by χ^2 statistics for the whole group of patients and included in the analysis the MGH scale for aneurysmal treatment in the group of patients with confirmed aneurysmal SAH.

The sensitivity, specificity, likelihood ratios (LR) and post-test probabilities for predicting poor outcome were calculated for the different cut-off values of the different scales used. The LR in this case is the ratio of the probability of a grade among patients with poor outcome to the probability of that same grade among patients with good outcome. The post-test probability is the proportion of patients with that particular grade or a higher grade who have a poor outcome. The statistical precision of the estimates of LR was calculated by their 95% confidence interval (CI), and post-test probabilities were calculated for the lower and upper limit of the CI.

Receiver operating characteristic (ROC) curves are used to describe and compare the performance of diagnostic tests [33]. ROC curves display the sensitivity and specificity along the range of values of a test or scale. For each value of the test the sensitivity and specificity are calculated and sensitivity is plotted against 1-specificity, with both axes ranging from 0 to 1. The area under the ROC curve (AUC) represents the probability of correctly classifying patients, and so therefore the discriminatory capacity of the test [12]. ROC curves and the AUC were calculated for the different scales when they were applicable in the following groups of patients: the whole group; patients with ISAH; patients with confirmed aneurysmal SAH; patients treated with endovascular procedures, and patients treated by surgery. The MGH scale could not be applied to the whole group of patients or patients with ISAH, as it scores size of the aneurysm as one of the grading factors and thus was not included in comparisons between grading schemes in these groups. The statistical uncertainty of the AUC was calculated in 95% confidence interval (CI). Areas under the ROC curve computed for each scale were compared using the methodology described by Hanley *et al.* for comparing the areas under the ROC curve derived from the same cases [13]. The level of statistical significance was set at a probability value of less than 0.05. All statistical analyses were performed using SPSS statistical software running on a personal computer.

Results

Characteristics of the patients

The characteristics of the 442 patients included in the study are shown in Table 2. Mean age was around 54 years both in the global series and in the different subgroups analysed. Female to male ratio was nearly 1.5:1 in the global series and the aneurysmal SAH group, but it was 1:1 in the ISAH group. Up to 83% of the patients were admitted within the first two days of the bleeding (median interval = 1 day; range = 1–30 days) and 92% had their initial CT scan performed (either at our centre or at regional hospitals) within the first three days after the bleeding (mean interval = 1.8 days). In the group of patients with confirmed aneurysmal SAH, 87% had their ruptured aneurysm in the anterior circulation and 13% in the posterior circulation. Embolised and "operated" patients had similar clinical grade and CT grading on admission. However, 92% of the surgically treated patients had their aneurysms in the anterior circulation, while this percentage decreased to 75% in the embolised patients.

The distribution of outcomes for the different scales and grades for patients suffering SAH, patients with confirmed aneurysmal SAH and ISAH is shown in Table 3.

Table 2. *Clinical characteristics of 442 patients with SAH*

	All SAH	ISAH	Confirmed aneurysmal SAH	Embolised patients	Operated patients
Male	186 (42%)	56 (50%)	109 (40%)	26 (42%)	67 (38%)
Female	256 (58%)	57 (50%)	160 (60%)	36 (58%)	108 (62%)
Age (SD*)	54 (14)	53 (13)	53 (13)	50 (12)	53 (13)
WFNS grade at admission					
I	211 (48%)	85 (75%)	125 (46%)	33 (53%)	84 (48%)
II	102 (23%)	22 (20%)	72 (27%)	12 (19%)	51 (29%)
III	28 (6%)	1 (1%)	22 (8%)	2 (3%)	16 (9%)
IV	33 (8%)	3 (3%)	23 (9%)	7 (11%)	12 (7%)
V	68 (15%)	2 (2%)	27 (10%)	8 (13%)	12 (7%)
Fisher Grade					
I	39 (9%)	22 (20%)	18 (7%)	6 (10%)	11 (6%)
II	73 (17%)	37 (32%)	36 (13%)	11 (18%)	23 (13%)
III	167 (38%)	22 (19%)	114 (42%)	19 (31%)	72 (41%)
IV	163 (37%)	32 (28%)	101 (38%)	26 (42%)	69 (40%)

* *SD* Standard deviation.

Table 3. *Distribution of outcome among the different grades of the different scales in patients admitted with SAH, patients with confirmed SAH and ISAH*

Grade	WFNS			GCS scale for SAH			Proposed scale		
	Good outcome	Poor outcome	Total n (%)	Good outcome	Poor outcome	Total n (%)	Good outcome	Poor outcome	Total n (%)
All SAH									
I-0	182	27	209 (48)	177	28	205 (47)	54	–	54 (12)
II-1	56	45	101 (23)	71	61	132 (31)	88	9	97 (22)
III-2	10	16	26 (6)	3	13	16 (3)	67	27	94 (22)
IV-3	7	26	33 (8)	7	23	30 (7)	48	86	134 (31)
V-4	7	60	67 (15)	4	49	53 (12)	5	52	57 (13)
Total n (%)	262 (60)	174 (40)		262 (60)	174 (40)		262 (60)	174 (40)	
Confirmed aneurysmal SAH									
I-0	101	23	124 (47)	101	24	125 (47)	26	–	26 (10)
II-1	41	31	72 (27)	51	44	95 (36)	50	7	57 (22)
III-2	9	11	20 (7)	3	8	11 (4)	46	24	70 (26)
IV-3	6	17	23 (9)	4	15	19 (7)	37	51	88 (33)
V-4	5	22	27 (10)	3	13	16 (6)	3	22	25 (9)
Total n (%)	162 (61)	104 (39)		162 (61)	104 (39)		162 (61)	104 (39)	
ISAH									
I-0	80	3	83 (75)	75	3	78 (71)	28	–	28 (25)
II-1	14	7	21 (19)	19	7	26 (23)	38	1	39 (35)
III-2	1	0	1 (1)	0	2	2 (2)	20	3	23 (21)
IV-3	1	2	3 (3)	3	0	3 (3)	10	6	16 (15)
V-4	2	0	2 (2)	1	0	1 (1)	2	2	4 (4)
Total n (%)	98 (89)	12 (11)		98 (89)	12 (11)		98 (89)	12 (11)	

Analysis of inter-grade differences

The analysis of the differences between clinical grades of the WFNS, GCS and the new proposed scale in relation to patient's outcome for the global series of patients is presented in Fig. 1. The MGH scale was not used in this analysis as it could not be applied to all patients. Both WFNS and GCS scales fail to present significant differences between most of their grades, while the proposed scale shows significant differences between all its grades. The same happens when applying all scales, including the MGH scale, to those patients

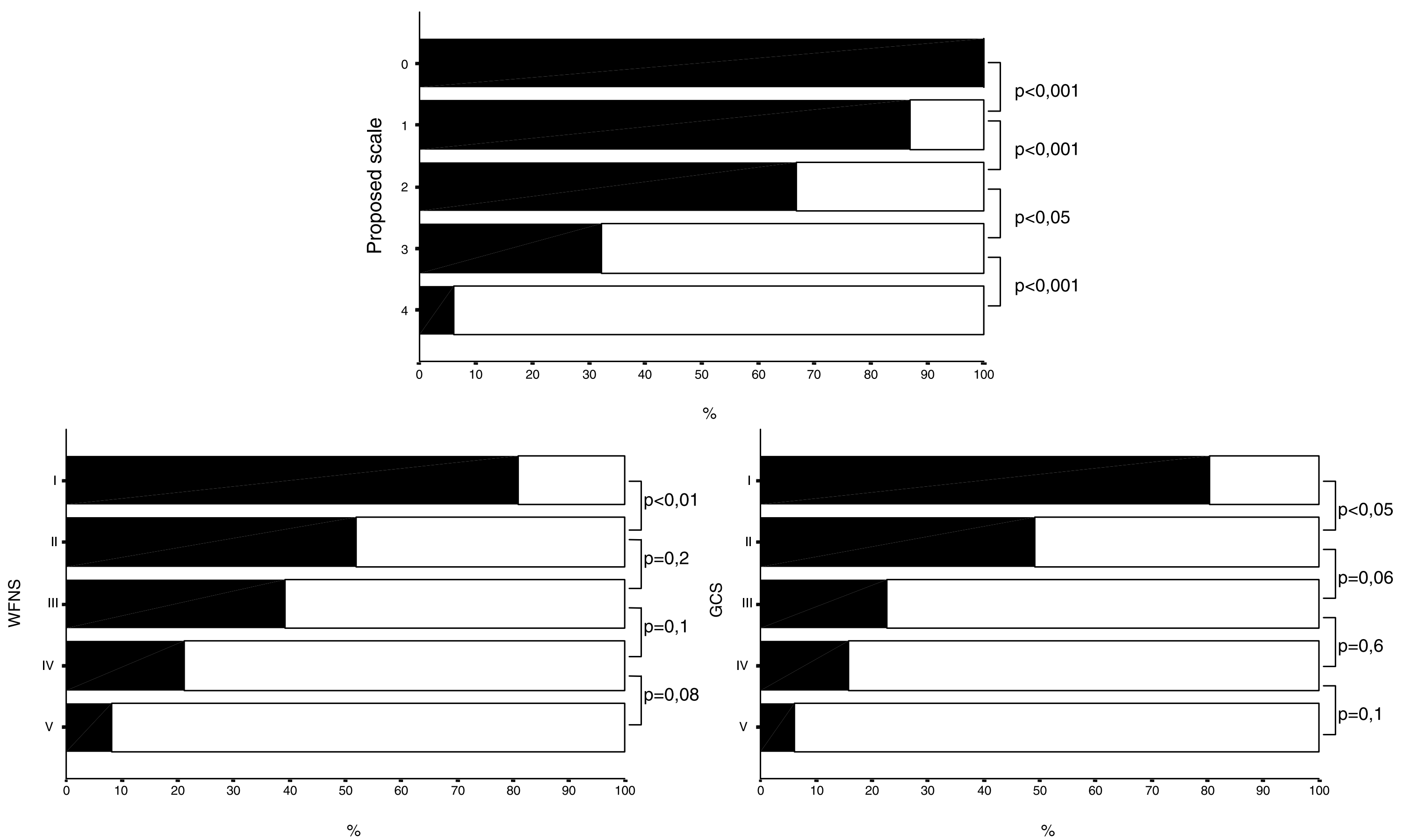

Fig. 1. Analysis of the differences between clinical grades in relation to patient's outcome using the proposed scale, WFNS scale and GCS scale for SAH in a series of 442 patients with spontaneous SAH (Black bar = good outcome; Empty bar = poor outcome)

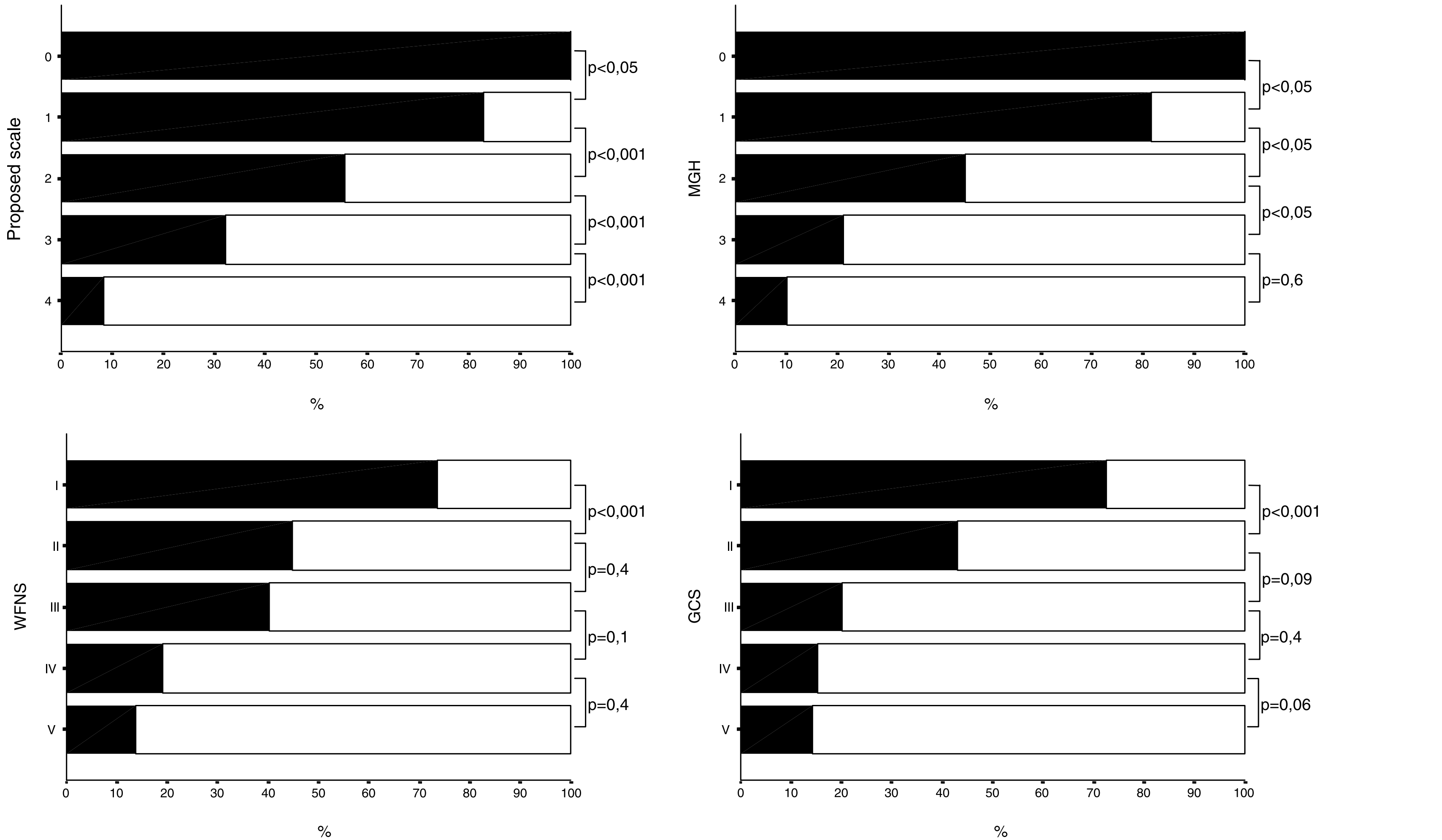

Fig. 2. Analysis of the differences between clinical grades in relation to patient's outcome using the proposed scale, MGH scale, WFNS scale and GCS scale for SAH in 269 patients with confirmed aneurysmal SAH (Black bar = good outcome; empty bar = poor outcome)

with confirmed aneurysmal SAH (Fig. 2). The only scale that shows a constant inter-grade significant difference in predicting outcome is the proposed scale. Although MGH scale seems to have a very progressive difference in outcome between grades, it fails to present significant differences between the last two grades. Patients with grades II and III, and grades IV and V of the WFNS show non-significant differences in prognosis. The GCS scale only distinguishes between grades I and II, and prognosis for grades II, III, IV and V is not significantly different.

When assessing the probability of poor outcome for patients with ISAH (Fig. 3), the only scale that seems to have a correlation with outcome is the proposed scale.

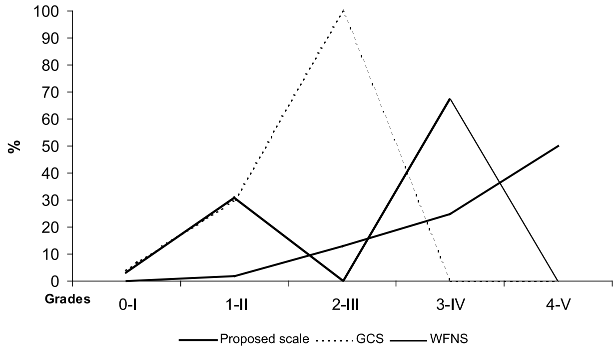

Fig. 3. Prediction of poor outcome in 113 patients suffering ISAH using the WFNS scale, GCS scale and the new proposed scale

Table 4. *Sensitivity, specificity, likelihood ratios and post-test probabilities of the several cut-offs of the different grades for all patients suffering SAH and patients suffering confirmed aneurysmal SAH. (Grade I-0 always show sensitivity = 1 and specificity = 0)*

All SAH	Grade	Sensitivity	Specificity	LR	95%CI*	Post test probability	95% CI*
WFNS							
	II	0.84	0.69	2.77	2.28–3.35	64%	58–70%
	III	0.59	0.91	6.40	4.28–9.55	80%	75–87%
	IV	0.49	0.95	9.25	5.43–15.7	86%	79–92%
	V	0.34	0.97	12.9	6.04–27.6	89%	82–97%
GCS							
	I						
	II	0.84	0.68	2.59	2.15–3.12	63%	38–47%
	III	0.49	0.95	9.14	5.37–15.6	85%	79–92%
	IV	0.41	0.96	9.86	5.38–18.1	86%	79–94%
	V	0.28	0.98	18.4	6.77–50.2	92%	85–99%
Proposed scale							
	1	1	0.21	1.26	1.18–1.33	45%	41–51%
	2	0.95	0.54	2.07	1.8–2.37	57%	52–63%
	3	0.79	0.80	3.92	3.04–5.04	72%	65–78%
	4	0.30	0.98	15.7	6.38–38.4	91%	83–98%
Confirmed aneurysmal SAH							
WFNS							
	II	0.78	0.62	2.06	1.66–2.59	57%	49–65%
	III	0.48	0.88	3.85	2.45–6.11	71%	60–82%
	IV	0.37	0.93	5.43	2.92–10.2	78%	67–89%
	V	0.21	0.97	6.85	2.67–17.5	81%	66–96%
GCS							
	II	0.77	0.62	2.04	1.63–2.5	56%	48–65%
	III	0.34	0.94	5.50	2.9–10.8	78%	66–90%
	IV	0.26	0.96	6.23	2.82–13.7	80%	66–93%
	V	0.12	0.98	6.75	1.97–23.1	81%	62–100%
MGH							
	1	1	0.15	1.17	1.10–1.25	43%	36–49%
	2	0.91	0.48	1.76	1.50–2.07	52%	66–90%
	3	0.47	0.90	4.44	2.7–7.3	74%	66–93%
	4	0.10	0.99	15.7	2–119	90%	73–107%
Proposed scale							
	1	1	0.16	1.2	1.11–1.27	43%	37–49%
	2	0.93	0.47	1.76	1.5–2.05	53%	45–60%
	3	0.70	0.75	2.83	2.1–3.81	64%	55–73%
	4	0.21	0.98	11.4	3.54–37	88%	75–100%

* *CI* Confidence interval.

Neither the WFNS, nor the GCS scale detect an increase in the probability of poor outcome as the clinical grade increases. By contrast, the proposed scale shows a linear increase in the probability of poor outcome as the clinical grade increases.

An analysis of the different cut-off values of the different scales, with their corresponding likelihood ratios for poor outcome and their post-test probabilities is presented in Table 4. WFNS scale and GCS scale show overlapping intervals for the likelihood ratios

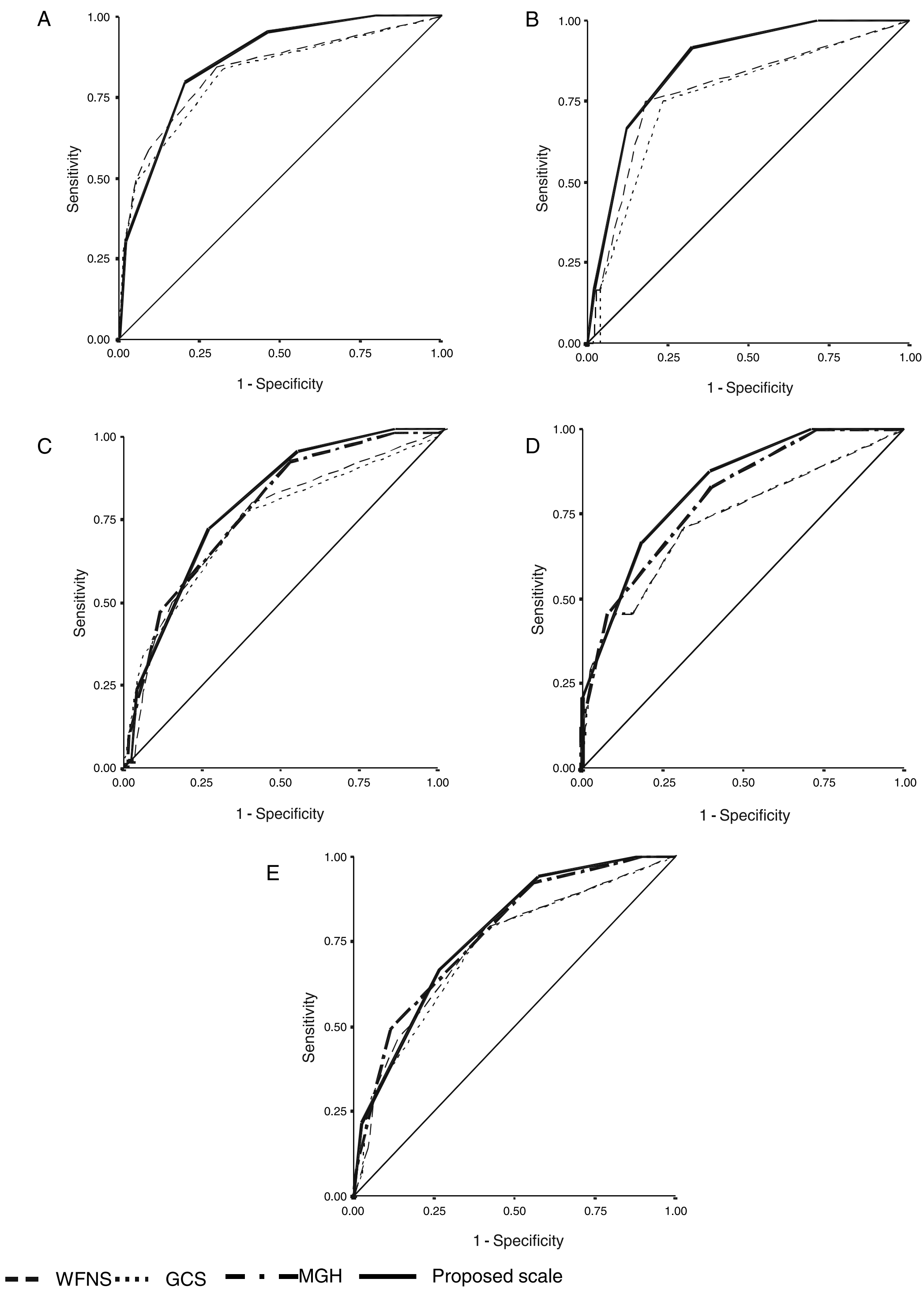

Fig. 4. ROC curve plots for the different scales where applicable: A) All patients suffering SAH; B) Patients suffering ISAH; C) Patients with confirmed aneurysmal SAH; D) Patients treated by embolization; E) Patients treated by surgery

Table 5. *Area under the ROC curve (AUC), standard error (SE), 95% confidence interval (CI) for the different subsets of patients and scales where applicable and comparison of the AUC*

	AUC	SE	95% CI	Comparison AUC (p values)	
				MGH	Proposed scale
All SAH					
WFNS	0.830	0.02	0.789–0.871	*	<0.001
GCS	0.824	0.02	0.782–0.865	*	<0.05
Proposed scale	0.859	0.01	0.825–0.893		
ISAH					
WFNS	0.781	0.07	0.632–0.930	*	<0.05
GCS	0.782	0.07	0.633–0.931	*	<0.05
Proposed scale	0.863	0.05	0.769–0.957		
Confirmed aneurysmal SAH					
WFNS	0.750	0.03	0.688–0.811	=0.19	<0.05
GCS	0.736	0.03	0.674–0.799	=0.12	<0.05
MGH	0.779	0.03	0.723–0.834	–	=0.12
Proposed scale	0.806	0.02	0.746–0.851		
Embolization treatment					
WFNS	0.733	0.07	0.601–0.868	=0.11	<0.05
GCS	0.710	0.07	0.580–0.855	=0.17	<0.05
MGH	0.800	0.06	0.691–0.911	–	=0.2
Proposed scale	0.824	0.05	0.728–0.929		
Surgical treatment					
WFNS	0.742	0.04	0.658–0.825	=0.2	=0.2
GCS	0.732	0.04	0.648–0.816	=0.2	=0.2
MGH	0.782	0.04	0.708–0.855		
Proposed scale	0.776	0.04	0.701–0.846		

and post-test probabilities between some of their grades. However, most intervals for the proposed scale and MGH scale do not overlap.

Area under ROC curve (AUC) analysis

The ROC curves for the different scales, when applicable on the different subgroups of patients and the whole series are presented in Fig. 4, and the values of the AUC and the analysis of their differences are presented in Table 5. The proposed scale presents a significantly higher diagnostic efficacy for assessing the probability of poor outcome in the whole series of patients suffering spontaneous SAH, in patients with ISAH and in patients with confirmed aneurysmal SAH. AUCs for MGH grading scale and the proposed scale are equal for patients treated surgically, and though larger are not significantly different from those obtained by the previously used scales. However, the proposed scale shows a significantly higher prognostic efficacy on patients treated by embolisation.

Discussion

Rationale for modifying the MGH scale

Several grading scales have been used for predicting the outcome of patients suffering SAH [1, 7, 11, 15, 17, 22, 27]. Among them, the first described were the Botterel [1] and the Hunt and Hess scales [17]. Both were based on describing the level of consciousness of the patients, but used ambiguous definitions to describe it, and included in their grading subjective and not easily quantifiable data such as headache and its intensity, and neck stiffness, leading to high inter-observer variability. These two scales share the problem of not detecting definite differences in prognosis between consecutive grades, a critical requirement for a classification to be useful in clinical practice. The introduction of the GCS [35], which defines the level of consciousness with clearer and more objective data, and shows high inter-observer reproducibility led the World Federation of Neurological Surgeons to use it for proposing in 1988 a more reliable grading system for aneurysmal SAH [7].

This scale uses the parameters of the GCS scale for assessing the level of consciousness, combined with the presence or absence of focal signs. For this purpose the GCS scale was divided into a five-tiered classification like the older grading scales. Although the WFNS recommended the general use of this scale in order to make the experience of different centres more comparable, a survey of how the clinical grades had been defined in studies published between 1985 and 1992 showed that an unequivocal grading system (WFNS or GCS scales) was only used in 19% of clinical series, a proportion which has not increased since 1988 [36].

In the 1990s several authors demonstrated that the WFNS scale did not detect differences in outcome between some of its grades [11, 15, 22, 27, 34], and this weakness led to a description of other combinatorial grades based on the GCS such as the GCS scale for SAH described by Oshiro *et al.* [27]. However, their use has not reached wide acceptance and their performance in other series has not been tested.

More recently, Ogilvy *et al.* used a different new approach for the design of a grading scale to be applied on patients undergoing surgical management of intracranial aneurysms [26]. They performed an analysis of the factors related to prognosis in their series of patients operated on for ruptured and unruptured aneurysms, and considered only those factors showing a significant relationship with outcome in the multivariate analysis (level of consciousness, age, Fisher scale rating of the first CT scan and size in mm of the aneurysm). One of the advantages of this scale is that it included age and the amount of extravasated blood, factors repeatedly related to prognosis in different studies [6, 9, 10, 18, 22, 24] which had not been considered in previous grading schemes. For the design of the scale they assigned a standard weight or score to factors having similar influence on outcome, and the grade for a given patient resulted from the addition of the score of the different factors. This scale achieved a high inter-observer reliability because prognostically related factors were sharply simplified; the level of consciousness was separated into the categories of coma or non-coma, the Fisher scale into two categories and aneurysm size into bigger or smaller than 10 mm in diameter. In this way the scale showed a good performance in different subsets of patients from the MGH series [5, 16], but it has not been tested by other authors.

On the other hand the use of this surgically designed scale becomes limited in a general population of patients with SAH. When analysing overall populations of patients suffering spontaneous SAH, it is realised that nearly 17 to 31% of patients in different global series do not undergo surgery because of poor clinical condition on admission or rebleeding [4, 19, 30–32]. Moreover, nearly 19% do not even reach angiography for the same reasons [22]. Furthermore, another subgroup of patients (those presenting ISAH) do not show any lesion responsible for the bleeding, a factor unknown by the clinician initially managing the case [23]. The MGH scale cannot be applied to all these patients, which in our series reach nearly 40% of all patients admitted suffering SAH. Another problem of this scale is that it uses the preoperative level of consciousness when the patient has deteriorated in respect to the level on admission. This strategy, though leading to a better prediction of the final outcome distort, in our opinion, the assessment of the global management received by patients suffering SAH, as it begins after they suffer the stroke or immediately after admission to the hospital. Finally, the population from which the scale was designed included cases without SAH, as 37% of the patients used for the multivariate analysis had unruptured aneurysms [26]. Despite the above mentioned limitations we resorted to the MGH scale which firstly included factors improving prognostic efficacy, such as the age of the patient and the quantity of subarachnoid blood seen in the first CT scan for developing our modified version, which is applicable to all SAH patients from the moment of hospital admission independently of whether or not they eventually undergo surgery.

Aneurysm size was not used in the proposed grading scale as the scale was meant to be used in all patients suffering SAH, not only patients suffering aneurysmal SAH. Furthermore, in our series, aneurysm size, classified as Ogilvy *et al.* described in their study, was not a significant prognostic factor in the whole group of aneurysmal SAH, the surgically treated patients or in the group of patients treated by embolisation.

Performance of the different scales

As shown in the different figures and tables, the ROC curve analysis included, our modified version of the MGH scale allows grading of all patients with SAH with high prognostic accuracy, and from the very moment the patient is diagnosed. This prognostic efficacy is higher than that obtained with classical scales using the level of consciousness as the only grading factor. However, differences in terms of efficacy are limited among the different scales as the 95% confidence limits of the AUC show considerable overlap. Nevertheless, the proposed scale also detects a significant prognostic difference between all its grades.

Although significance between grades in the different scales could be theoretically obtained if the number of patients in the different grades were increased, we were not able to find them in most of the scales using all patients admitted in the last ten years to our Department.

The MGH grading scale reaches a higher, but not significantly different efficacy than previous scales in the subgroups of patients in which it can be applied. Our modified version of this scale maintains a prognostic efficacy similar to the original MGH grading scheme including also patients surgically managed, but the prognostic information is obtained much earlier, as prognosis with the MGH scale is established with the worst level of consciousness presented by the patient just before surgery. Thus, although prognosis is done earlier, prognostic information is similar to the later applied scale. In fact, in our series, the level of consciousness on admission had a similar prognostic efficacy as that recorded at the pre-treatment level. The proposed scale also showed better prognostic efficacy when applied to patients treated by embolisation than the other scales.

It could be argued that the MGH scale was designed for surgical patients and thus the composition of this present series, which includes embolised patients could be different regarding location of the aneurysm and thus influence our results. However, the location of the aneurysms in this series (87% anterior circulation and 13% posterior circulation in the confirmed aneurysmal SAH group) is very similar to that of the original series of Ogilvy *et al.* (85% anterior circulation and 15% posterior circulation) [26].

Since the present study is retrospective, interobserver variability for the different scales could not be tested. However, previous experience with the MGH scale has shown low interobserver variability as all the variables possibly increasing this variability are simplified into two categories. Thus it can be assumed that our modified scale, which shares the simplified categorisation of prognostic variables should also have good inter-rater reproducibility. However, this assumption has to be proved by its prospective application, as well as by external validation in other centres.

Grading of patients with ISAH

There are no previous studies on the application of prognostic grading scales in patients with ISAH. Although it is widely accepted that prognosis in these patients is good, there have been several reports challenging this idea [2, 3, 25, 28]. It is true that the majority of patients suffering ISAH have a good level of consciousness on admission [23, 28], a factor that could seriously limit the prognostic efficacy of scales based only on the level of consciousness. Therefore, a scale for assessing prognosis in this group of patients should include more variables, such as the age of the patients and/or the quantity of blood in the CT scan. Moreover, the clinician in charge of the patient does not know until days or weeks after admission if the patient has or has not an aneurysm. Thus it is desirable to have a prognostic tool capable of determining prognosis with certain reliability in these patients just after admission, independently of the final diagnosis. Although the small number of patients in the subgroup of patients suffering ISAH could affect the validity of the analysis, it seems our proposed scale fulfils these requirements, as prognosis is made on admission with high reliability.

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Comment

A Lagares *et al.* have conducted a retrospective study on 442 subarachnoid haemorrhage patients in order to develop a new grading scale for predicting outcome after subarachnoid haemorrhage. They have based their proposed grading scale on the study carried out by Ogilvy and Carter reported in Neurosurgery 42: 959–970, 1998. The major differences are that they have substituted a modified WFNS grading scale and used it in place of the modified Hunt & Hess classification used by Ogilvy *et al.* that they refer to on the Massachusetts General Hospital scale and the WFNS was measured both at the time of admission and pre-treatment while the Hunt & Hess was measured before treatment. The major comparisons they make are with the WFNS and the GCS grades. There is some difficulty in comparing the new grading scale with that proposed by Ogilvy and Carter for the authors report that aneurysm size in their patients made no significant difference and that assessing the patients level of consciousness on admission allowed a better determination of prognosis, therefore, they excluded aneurysm size from their grading scale.

The authors have attempted to develop a scale, which is applicable in all patients suffering SAH with regard to prognosis. In doing that they have included patients who clearly have a poor prognosis, those who have died before angiography and those who are too ill for treatment, as well as patients who have a good prognosis namely those who are not shown to have an aneurysm. They have also included in the treatment group patients who have had surgery and those who have had endovascular coiling which is indicative of a selection process. This inclusion would seem to make it difficult to compare this new grading scale with other grading systems. The authors, however, argue that they have compared only scales that were applicable to all patients in each group so that like with like comparisons could be made. Their final statement "the proposed modification of the Massachusetts General Hospital scale makes it applicable to every patient suffering SAH without losing its prediction capability" can only be fully supported by using their new grading scale in a prospective study.

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