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Development and Validation of Scoring Indication of Surgical Clipping and Endovascular Coiling for Aneurysmal Subarachnoid Hemorrhage from the Post Hoc Analysis of Japan Stroke Data Bank

Michitsura YOSHIYAMA,[1] Fusao IKAWA,[1,2] Toshikazu HIDAKA,[1] Shingo MATSUDA,[1] Iori OZONO,[1] Kazunori TOYODA,[3] Shotai KOBAYASHI,[4] Shuhei YAMAGUCHI,[5] and Kaoru KURISU[2]

[1]*Department of Neurosurgery, Shimane Prefectural Central Hospital, Izumo, Shimane, Japan*
[2]*Department of Neurosurgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Hiroshima, Japan*
[3]*Department of Cerebrovascular Medicine, National Cerebral and Cardiovascular Center, Suita, Osaka, Japan*
[4]*Shimane University School of Medicine, Izumo, Shimane, Japan*
[5]*Hospital Bureau of Shimane Prefecture, Izumo, Shimane, Japan*

Abstract

There are no scoring methods for optimal treatment of patients with aneurysmal subarachnoid hemorrhage (aSAH). We developed a scoring model to predict clinical outcomes according to aSAH risk factors using data from the Japan Stroke Data Bank (JSDB). Of 5344 patients initially registered in the JSDB, 3547 met the inclusion criteria. Patients had been diagnosed with aSAH and treated with surgical clipping or endovascular coiling between 1998 and 2013. We performed multivariate logistic regression for poor outcomes at discharge, indicated by a modified Rankin Scale (mRS) score >2, and in-hospital mortality for both treatment methods. Based on each risk factor, we developed a scoring model assessing its validity using another dataset of our institution. In the surgical clipping group, scoring criteria for aSAH were age >72 years, history of more than once stroke, World Federation of Neurological Societies (WFNS) grades II–V, aneurysmal size >15 mm, and vertebrobasilar artery (VBA) aneurysm location. In the endovascular coiling group, scoring criteria were age >80 years, history of stroke, WFNS grades III–V, computed tomography (CT) Fisher group 4, and aneurysmal location in the middle cerebral artery (MCA) and anterior cerebral artery (ACA). The rates of poor outcome of mRS score >2 in an isolated dataset using these scoring criteria were significantly correlated with our model's scores, so this scoring model was validated. This scoring model can help in the more objective treatment selection in patients with aSAH.

Keywords: aneurysmal subarachnoid hemorrhage, endovascular coiling, outcome, scoring model, surgical clipping

Introduction

In patients with aneurysmal subarachnoid hemorrhage (aSAH), endovascular coiling has been reported by one meta-analysis to achieve better clinical outcomes than surgical clipping.[1)] The guidelines of the American Heart Association/American Stroke Association state that endovascular coiling should be considered for patients with ruptured aneurysms that are judged to be technically amenable to both treatments (Class I; Level of Evidence B).[2)] These guidelines are based on findings of the randomized controlled International Subarachnoid Aneurysm Trial, which also demonstrated better outcomes for endovascular coiling compared to surgical clipping.[3)] However, there is no reliable evidence that can be

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used directly to guide treatment in patients with aSAH who have a poor clinical condition.[4] Indeed, a recent meta-analysis found that endovascular coiling did not result in superior outcomes to surgical clipping in patients with high-grade aneurysmal SAH and that endovascular coiling carried a greater risk of mortality.[5] Our previous analysis of data taken from the Japan Stroke Data Bank (JSDB) revealed no significant difference in clinical outcomes at discharge between surgical clipping and endovascular coiling in patients with a modified Rankin Scale (mRS) score >2.[6] Additionally, in 2012, a nationwide study in Japan reported that surgical clipping was associated with lower in-hospital mortality compared with endovascular coiling.[7] A recent meta-analysis that used propensity score matching analysis of data from a nationwide database found no significant difference between surgical clipping and endovascular coiling, not only in poor outcomes at discharge but also in in-hospital mortality.[8] However, it is essential to determine a method to select the best therapy for patients with aSAH according to their individual condition.

In reality, the indication of treatment method tends to depend on institutional guidelines or the physician's judgment because there is not currently any standard scoring method that can be used to guide decisions on optimal treatment methods. Therefore, the present study developed a scoring system that can be used to indicate use of surgical clipping or endovascular coiling of aSAH, which we validated using a different dataset.

Methods

Ethics statement

This study was approved by the Ethics Committee of Shimane Medical University (approval no. 34). Details on data collection and management have been published elsewhere.[6,9–11] Given the anonymous nature of the data, the requirement for informed consent was waived.

Data source and patient and aneurysm selection

The JSDB has accumulated data from 101165 patients with acute stroke treated in 163 institutions across Japan between 1998 and 2013. The Japanese stroke management protocol was standardized according to findings from this nationwide stroke database.

A total of 5344 patients from 68 institutes were registered as having suffered an aSAH. Among these, we excluded 46 patients who had received both treatments and included the 3547 patients who had been diagnosed with ruptured saccular cerebral aneurysm that was treated only by surgical clipping or endovascular coiling.[6]

Predictor candidate variables of a poor clinical outcome consisted of patient and aneurysm characteristics. We selected these potential predictor variables from the available cohort data obtained from the database, as well as by referring to the current knowledge on risk factors for aneurysm rupture.[12,13] Patient characteristics included the following variables: age (years), sex (male/female), hypertension (none/receiving treatment), diabetes mellitus (none/receiving treatment), history of stroke (none/once/more than once), the World Federation of Neurological Societies (WFNS) grade (I/II/III/IV/V), CT Fisher group (1/2/3/4), and mRS score at discharge. The aneurysmal characteristics were size (mm) and location (anterior cerebral artery/anterior communicating artery [ACOA]/internal carotid-posterior communicating artery [IC-PC]/MCA]/other internal carotid artery [ICA]/VBA).

Validation data

To assess validity, we applied the scoring system developed using data from the JSDB to an isolated dataset of our hospital. A total of 651 patients were registered in our hospital database as having experienced aSAH between 2000 and 2018. Of these, 609 patients were diagnosed with ruptured saccular cerebral aneurysm that was treated by surgical clipping and/or endovascular coiling. Data from a final total of 269 patients were used for validation after exclusion of the 340 patients who had also been registered in the JSDB. To validate the efficacy of the developed scoring method, scores were calculated for each case within both treatment groups, and the median mRS score and interquartile range (IQR) in each point from 1 to 7 score were assessed by linear regression analysis.

Statistical analysis

All missing variables were treated as deficit data that did not change the other variables. We performed multivariate logistic regression for poor outcomes at discharge, indicated by a mRS score >2, and for in-hospital mortality in both surgical clipping and endovascular coiling treatments. Independent variables were selected based on the existing literature, and no variable selection method was applied.[12,13] Dependent variables were age, sex, hypertension, diabetes mellitus, history of stroke, WFNS grade, CT Fisher group, aneurysm size, and aneurysm location. The odds ratio (OR) and 95% confidence intervals (CIs) were calculated. P values <0.05 were considered statistically significant.

We assigned scores for the variables in the regression coefficient (related strength of a result and the factor in the outcome) in the logistic regression model, using the OR found using the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD) statement defined by the formula below.[14)]

$$\text{Probability} = \exp(\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k) / (1 + \exp(\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)) = 1/(1 + \exp(-(\beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)))$$

(β_n: regression coefficient; Xn: Explanation variable; $\exp(\beta)$ = OR)

All statistical analyses were performed using JMP Pro15 (SAS Institute Inc., Cary, NC, USA).

Results

Participants and aneurysms

The 3547 cases of ruptured cerebral aneurysms were divided into two groups according to the treatment method (surgical clipping group: n = 2666; endovascular coiling group: n = 881). The multivariate logistic regression analyses allowed us to identify patient and aneurysm characteristics within the surgical clipping and endovascular coiling groups. Table 1 presents the ORs, 95% CIs, and P values for poor outcome and in-hospital mortality in the surgical clipping group. The significant risk factors for poor outcome in the surgical clipping group were age (OR: 1.06, 95% CI: 1.05–1.07), receiving treatment for hypertension (OR: 1.38, 95% CI: 1.08–1.77), more than one previous stroke (OR: 4.57, 95% CI: 1.10–18.98); WFNS grade II (OR: 2.16, 95% CI: 1.64–2.87), III (OR: 2.52, 95% CI: 1.74–3.66), IV (OR: 9.20, 95% CI: 6.66–12.71), V (OR: 20.81, 95% CI: 14.05–30.82); CT Fisher group 4 (OR: 2.25, 95% CI: 1.07–4.76), and an aneurysm size of 15–24 mm (OR: 1.97, 95% CI: 1.09–3.56). The significant risk factors for in-hospital mortality in the surgical clipping group were age (OR: 1.03, 95% CI: 1.01–1.04), receiving treatment for hypertension (OR: 1.47, 95% CI: 1.03–2.11), WFNS grade II (OR: 1.75 95% CI: 1.05–2.91), III (OR: 1.95, 95% CI: 1.00–3.78), IV (OR: 5.10, 95% CI: 3.13–8.32), V (OR: 8.44, 95% CI: 5.09–14.00); and an aneurysm size of 15–24 mm (OR: 2.73, 95% CI: 1.46–5.11), and over 24 mm (OR: 4.19, 95% CI: 1.09–16.18).

Table 2 presents the results of multivariate analysis for poor outcome and in-hospital mortality in the endovascular coiling group. Risk factors for poor outcome in the endovascular coiling group included age (OR: 1.07, 95% CI: 1.05–1.09), more than one previous stroke (OR: 3.03, 95% CI: 1.61–5.72); WFNS grade III (OR: 4.59, 95% CI: 2.32–9.11), IV (OR: 7.67, 95% CI: 4.30–13.68), V (OR: 24.38, 95% CI: 12.52–47.49); CT Fisher group 3 (OR: 4.26, 95% CI: 1.12–16.19), group 4 (OR: 7.35, 95% CI: 1.74–31.00); and aneurysmal location in the ACA (OR: 3.88, 95% CI: 1.31–11.48) and VBA (OR: 1.91, 95% CI: 1.14–3.23). The significant risk factors for in-hospital mortality in the endovascular coiling group were as follows: age (OR: 1.03, 95% CI: 1.01–1.05), more than one previous stroke (OR: 2.17, 95% CI: 1.25–3.77), WFNS grade III (OR: 3.87, 95% CI: 1.60–9.34), IV (OR: 3.64, 95% CI: 1.73–7.66), V (OR: 9.63, 95% CI: 4.69–19.80); and the aneurysm location: the MCA (OR: 2.52, 95% CI: 1.15–5.51), the other ICA (OR: 8.81, 95% CI: 1.92–40.50), and VB (OR: 1.83, 95% CI: 1.06–3.15).

Scoring model of surgical clipping and endovascular coiling

Concerning age, we previously reported that the cutoff age calculated using Youden's index for a poor outcome was 61 years in the surgical clipping group and 70 years in the endovascular coiling group.[9)] The unit OR when a continuous variable changed only by 1 unit (year) was 1.06 in the surgical clipping group. Therefore, we calculated whether we surpassed 2 units of OR if we repeated this unit of OR for how many years; $1.06^x > 2$, $X > 11.13$, using the formula of OR = exp (regression coefficient). We rounded this result down to 11 years. Thus, we added 11 years to the previously defined cutoff age of 61 years in the surgical clipping group such that 1 point was allocated to participants older than 72 (61 plus 11) years. Similarly, the unit OR was 1.07 in the endovascular coiling group; after performing a similar calculation, it was 10.10. We rounded this down to 10, and thus added 10 years to the previously defined cutoff age of 70 years in the endovascular coiling group; a score of 1 point was allocated to participants older than 80 (70 plus 10) years.

To identify other risk factors, we applied a risk score as an OR of 2 or more (Tables 1 and 2) and the value of score was determined by the value of ORs.[14)] Scoring within the surgical clipping group was applied as follows: more than one previous stroke = 1 point; WFNS grade II and III = 1 point, grade IV = 2 points, grade V = 3 points; an aneurysm size more than 15 mm = 1 point; and aneurysmal location in the VBA = 1 point. Scoring within the endovascular coiling group was applied as follows: one previous stroke = 1 point; WFNS grade III = 1 point, grade IV = 2 points, grade V = 3 points; CT Fisher group 4 = 1 points; and aneurysmal location in the ACA and MCA = 1 point (Table 3). By removing the hematoma directly in surgical clipping, only one point was assigned on the CT Fisher group 4 in the endovascular coiling. For anatomical and low incidence reasons, we assigned

Table 1 Multivariate analysis for poor outcome and in-hospital mortality in surgical clipping group (n = 2666)

Variable	For poor outcome		For in-hospital mortality	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Age	1.06 (1.05–1.07)	<0.001*	1.03 (1.01–1.04)	<0.001*
Sex				
Female	0.85 (0.67–1.08)	0.180	0.72 (0.51–1.01)	0.057
Hypertension				
None	Reference			
Receiving treatment	1.38 (1.08–1.77)	0.010*	1.47 (1.03–2.11)	0.034*
Diabetes mellitus				
None	Reference			
Receiving treatment	1.43 (0.77–2.64)	0.251	1.48 (0.66–3.33)	0.346
History of stroke				
None	Reference			
Once	1.00 (0.65–1.55)	0.988	1.47 (0.87–2.50)	0.154
More than once	4.57 (1.10–18.98)	0.041*	1.40 (0.27–7.17)	0.685
WFNS Grade				
I	Reference			
II	2.16 (1.64–2.87)	<0.001*	1.75 (1.05–2.91)	0.032*
III	2.52 (1.74–3.66)	<0.001*	1.95 (1.00–3.78)	0.049*
IV	9.20 (6.66–12.71)	<0.001*	5.10 (3.13–8.32)	<0.001*
V	20.81 (14.05–30.82)	<0.001*	8.44 (5.09–14.00)	<0.001*
CT Fisher group				
1	Reference			
2	0.79 (0.38–1.66)	0.538	0.37 (0.13–1.06)	0.063
3	1.25 (0.62–2.54)	0.533	0.68 (0.27–1.69)	0.409
4	2.25 (1.07–4.76)	0.033*	0.79 (0.30–2.06)	0.630
Aneurysm size (mm)				
<6	Reference			
6–14	1.10 (0.89–1.37)	0.396	1.30 (0.95–1.78)	0.099
15–24	1.97 (1.09–3.56)	0.02*	2.73 (1.46–5.11)	0.002*
>24	5.92 (0.70–50.02)	0.102	4.19 (1.09–16.18)	0.038*
Aneurysm location				
IC-PC	Reference			
ACA	1.39 (0.91–2.16)	0.128	0.56 (0.27–1.18)	0.130
A.comA	0.92 (0.70–1.24)	0.617	1.06 (0.70–1.61)	0.787
MCA	0.89 (0.68–1..19)	0.453	0.93 (0.63–1.37)	0.717
Other ICA	0.24 (0.02–2.64)	0.240	N/A	
VBA	1.30 (0.71–2.43)	0.394	1.27 (0.58–2.78)	0.550

*P <0.05. ACA: anterior cerebral artery, CI: confidence interval, IC-PC: internal carotid-posterior communicating artery, MCA: middle cerebral artery, N/A: not applicable, Other ICA: other internal carotid artery, VBA: vertebrobasilar artery, WFNS: World Federation of Neurological Societies.

Table 2 Multivariate analysis for poor outcome and in-hospital mortality in endovascular coiling group (n = 881)

Variable	For poor outcome		For in-hospital mortality	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Age	1.07 (1.05–1.09)	<0.001*	1.03 (1.01–1.05)	<0.001*
Sex				
Female	0.91 (0.57–1.47)	0.710	1.26 (0.75–2.11)	0.389
Hypertension				
None	Reference			
Receiving treatment	1.06 (0.68–1.66)	0.795	1.53 (0.95–2.46)	0.078
Diabetes mellitus				
None	Reference			
Receiving treatment	1.11 (0.42–2.97)	0.830	0.75 (0.25–2.26)	0.614
History of stroke				
None	Reference		Reference	
Once	3.03 (1.61–5.72)	<0.001*	2.17 (1.25–3.77)	0.006*
More than once	3.44 (0.53–22.64)	0.197	N/A	
WFNS grade				
I	Reference			
II	1.23 (0.72–2.11)	0.440	1.52 (0.69–3.35)	0.296
III	4.59 (2.32–9.11)	<0.001*	3.87 (1.60–9.34)	0.003*
IV	7.67 (4.30–13.68)	<0.001*	3.64 (1.73–7.66)	0.001*
V	24.38 (12.52–47.49)	<0.001*	9.63 (4.69–19.80)	<0.001*
CT Fisher group				
1	Reference			
2	3.18 (0.79–12.83)	0.103	N/A	
3	4.26 (1.12–16.19)	0.033*	N/A	
4	7.35 (1.74–31.00)	0.007*	N/A	
Aneurysm size(mm)				
<6	Reference			
6–14	1.08 (0.72–1.62)	0.719	1.12 (0.73–1.73)	0.596
15–24	1.77 (0.62–5.05)	0.282	1.32 (0.54–3.22)	0.548
>24	N/A		N/A	
Aneurysm location				
IC-PC	Reference			
ACA	3.88 (1.31–11.48)	0.011*	0.97 (0.33–2.90)	0.960
ACOA	1.31 (0.80–2.16)	0.272	1.16 (0.67–2.01)	0.602
MCA	0.94 (0.43–2.08)	0.896	2.52 (1.15–5.51)	0.021*
Other ICA	1.17 (0.22–6.18)	0.580	8.81 (1.92–40.50)	0.005*
VBA	1.91 (1.14–3.23)	0.012*	1.83 (1.06–3.15)	0.030*

*P <0.05. ACA: anterior cerebral artery, ACOA: anterior communicating artery, CI: confidence interval, IC-PC: internal carotid-posterior communicating artery, MCA: middle cerebral artery, N/A: not applicable, Other ICA: other internal carotid artery, VBA: vertebrobasilar artery, WFNS: World Federation of Neurological Societies.

Table 3 Scoring model for surgical clipping and endovascular coiling groups

Surgical clipping group		Endovascular coiling group	
Factor	Scoring	Factor	Scoring
Age, years		Age, years	
≥ 72	1	≥80	1
History of stroke		History of stroke	
More than once	1	Once	1
WFNS grade		WFNS grade	
II, III	1	III	1
IV	2	IV	2
V	3	V	3
CT Fisher group		CT Fisher group	
N/A		4	1
Aneurysm size		Aneurysm size	
>15 mm	1	N/A	
Aneurysm location		Aneurysm location	
VBA	1	MCA	1
		ACA	1

ACA: anterior cerebral artery, MCA: middle cerebral artery, N/A: not applicable, VBA: vertebrobasilar artery, WFNS: World Federation of Neurological Societies.

one point to VBA aneurysms in surgical clipping, and no score to VBA aneurysms in endovascular coiling despite the significant risk.

Validation using the isolated database

We assessed the efficacy of this scoring system using an isolated dataset of 269 cases. Scores were calculated for each case within both treatment groups to assess the median mRS score and IQR, whereby we assessed the rate of poor outcome of mRS score >2 for each score. The results of the surgical clipping group, the median and IQR of mRS score and the rate of poor mRS score >2 according to each scoring points in surgical clipping group are shown in Fig. 1, in which the rates of poor mRS score >2 were significantly correlated with the present scoring points. A similar tendency was seen in the endovascular coiling group (Fig. 2). The linear regression analysis revealed that rates of poor outcome of mRS score >2 were significantly correlated with the scoring points in both the surgical clipping group and endovascular coiling group (P <0.001).

Discussion

Some previous reports have proposed scoring methods to predict the outcome of aSAH.[13,15] To our knowledge, this is the first report to develop and validate a scoring system to compare surgical clipping and endovascular coiling treatments. The aim of this study was to identify independent risk factors for aSAH and to develop a scoring model that can predict clinical outcomes using data from the JSDB. We found that age, history of stroke, WFNS grade, CT Fisher group, aneurysm size, and aneurysm location were associated with poor outcomes and in-hospital mortality for aSAH.

We compared each risk factor between both treatments. In our previous work, we reported cutoff ages for poor outcomes of 61 years following surgical clipping and 70 years following endovascular coiling.[9] In the present study, we assigned a score of 1 to patients older than 72 years in the surgical clipping group and older than 80 years in the endovascular coiling group. This scoring involving age could be reasonable as the risks of death and unfavorable outcomes regardless of the clinical management increased by 6% and 11% per year of age, respectively, in patients older than 75 or 80 years with poor-grade aSAH.[16,17]

Generally, the ability to perform daily activities decreased after stroke. Although this study excluded patients with premorbid mRS score >2, the decreased ability to perform daily activities, especially of the

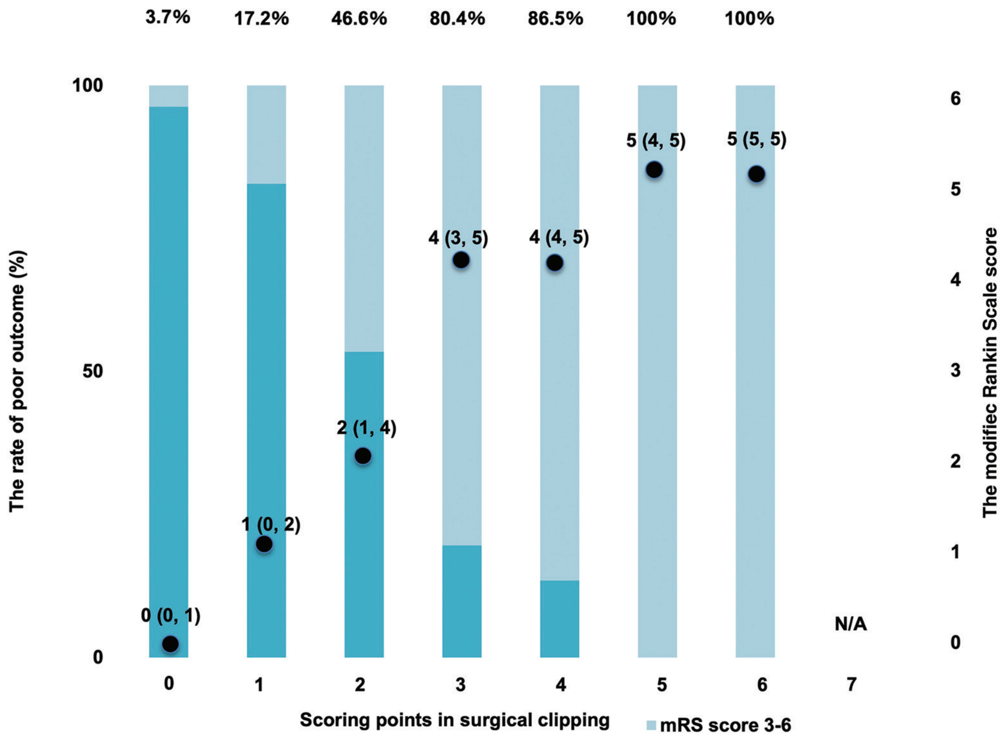

Fig. 1 Validation using isolated database in surgical clipping. The median (IQR) mRS score and the rate of poor mRS score >2 from the cases of an isolated database and according to each score in the surgical clipping group. The median (IQR) mRS score significantly increased alongside an increase in the scoring system (P <0.001). IQR: interquartile range, mRS: modified Rankin scale.

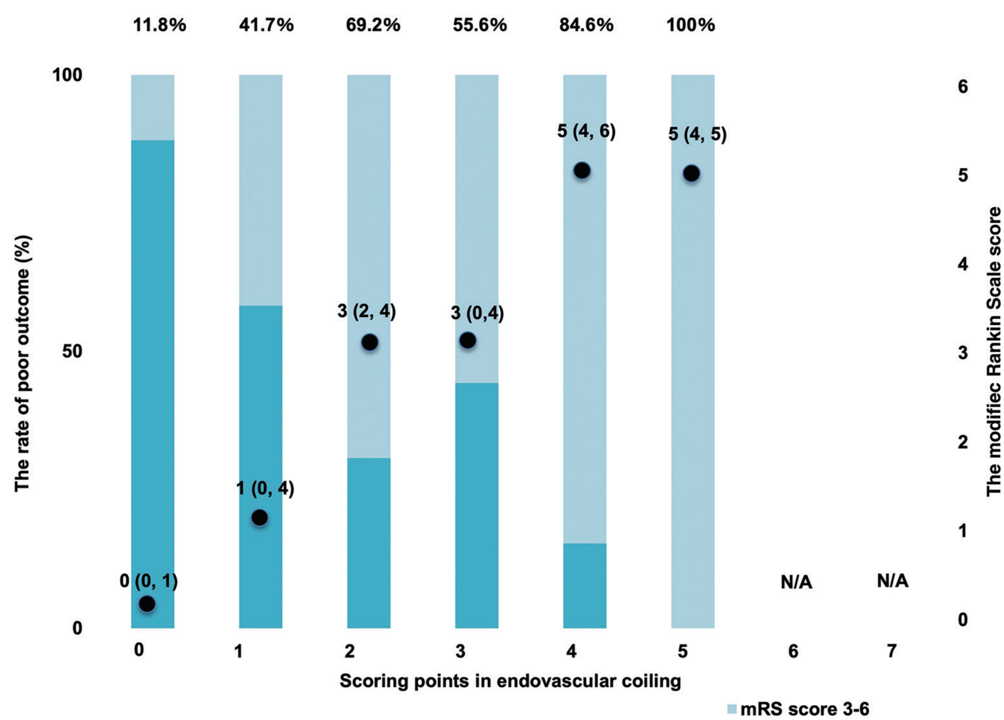

Fig. 2 Validation using isolated database in endovascular coiling. The median (IQR) mRS score and the rate of poor mRS score >2 from the cases of an isolated database and according to each score in the endovascular coiling group. There was a significantly proportional increase in our scoring system and the median (IQR) mRS score (P <0.001), as also in the surgical clipping group. IQR: interquartile range, mRS: modified Rankin scale.

older patients was speculated to be a risk factor for their poor outcomes. The history of stroke should be regarded as a risk of poor outcome, especially when using endovascular coiling, due to the severe atherosclerotic change of the large vessels.

The initial neurological grade is also a well-known risk factor.[18–20] We could reconfirm the risk of each WFNS grade for poor outcome and in-hospital mortality in both surgical clipping and endovascular coiling. The WFNS grade II was a risk factor for poor outcome and in-hospital mortality only in the surgical clipping group. This fact could be explained by the international subarachnoid aneurysm trial.[3] The subarachnoid hematoma volume at hospitalization, classified by Fisher grading scale as group 3, has been associated with a subsequent cerebral vasospasm contraction.[12,21] A CT Fisher group 3 was only identified as a risk factor in the endovascular coiling group, which could be because surgical clipping is associated with better intraoperative irrigation of the hematoma and washing out.[22] In this scoring, we assigned one point to CT Fisher group 4 in the endovascular coiling method because the hematoma is removed directly in surgical clipping. However, another superior CT classification may be better for aSAH.[23]

The aneurysm size has been reported to be directly associated with functional outcomes.[24] Surgical neck clipping becomes more difficult as aneurysms increase in size, and special treatment methods are often necessary. Conversely, aneurysms are treatable by endovascular coiling regardless of their size. This could explain why aneurysm size was only identified to be a risk factor in the surgical clipping group. Concerning aneurysm location, generally, surgical clipping is superior for aneurysms located in the MCA and ACA because of shallow aneurysms, and endovascular coiling is most effective for aneurysms located in the posterior circulation due to the deep position.[25] Aneurysmal locations on VBA in surgical clipping were identified as a risk score 1 for anatomical and low incidence reasons, considering only low number of cases (3.3%) in VBA location in surgical clipping for statistical analysis. The ACA is located in the peripheral artery and an aneurysm located in ACA has wide neck-dome ratio, signifying that there is greater catheter distance, which may have reduced its operability, thus increasing complications.

This surgical clipping and endovascular coiling scoring model can help in more objective treatment selection because the total score in each patient with aSAH can be compared between both treatments. This is essential, as clinicians are less likely to rely only on the intuition in making treatment selection.[26] Reliably predicting the outcome of aSAH can control patient mobility between expensive intensive care units and inexpensive wards, and allow more effective allocation of limited resources.[27] The results of the present study could aid clinical decision-making and serve as a guide for inexperienced practitioners. We believe this newly developed scoring model could be beneficial not only for the older patients but also to the young adults who could expect a long recovery process. The utility value of this scoring model will vary depending on each facility, operator, and country in a different situation. Therefore, selection of the suitable treatment method would be more appropriate depending on the situation of each facility and an operator regarding the judgment in each case, although this scoring models are used as reference.

Limitations

The present study has several limitations that should be noted. First, this study was conducted in Japan, and so the results should be applied with caution to other populations. Indeed, this scoring system may only be applicable to Japanese patients where there is a dominant use of surgical clipping and less use of endovascular coiling for treating aSAH.[28] Nonetheless, given the lack of evidence for risk factors and treatment indications in patients with poor grade aSAH, neurosurgeons could still refer to the present findings. Second, information regarding the neck-dome ratio of cerebral aneurysm, smoking habits, direct comparison between surgical clipping and endovascular coiling, possibility of selection bias, and outcome at 6 months after onset were absent in this study, considering this is a limited cases registry-based study instead of a designed randomized control study. Third, a convalescence result prediction of SAH could be facilitated based on this scoring system in the future. We used data from the JSDB that were collected between 1998 and 2013. Given that endovascular coiling is now a common treatment for cerebral aneurysm both worldwide and in Japan, these data should be updated appropriately to improve the accuracy of the proposed scoring system. However, we believe that this scoring can contribute to the decision-making for patients with aSAH globally because the latest endovascular coiling devices are not available in developing countries. Fourth, these data included only a limited dataset of all SAH cases in Japan, especially in VBA location in surgical clipping, collected at the participating institutes.

Conclusions

We performed a multivariate analysis using data from the JSDB and developed a scoring model to determine the risk of poor outcome and in-hospital mortality associated with surgical clipping and endovascular coiling. This scoring model can be easily utilized in clinical practice to assist decision-making regarding the best treatment for patients with aSAH.

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Conflicts of Interest Disclosure

All authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Corresponding author: Fusao Ikawa, MD, PhD
Department of Neurosurgery, Shimane Prefectural Central Hospital, 4-1-1 Himebara, Izumo, Shimane 693-8555, Japan.
e-mail: fikawa-nsu@umin.ac.jp