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Validation of the newly conceived Surgical Swedish ICH grading scale for surgically treated patients with intracerebral hemorrhage: patient series

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BACKGROUND The authors sought to externally validate a newly developed clinical grading scale, the Surgical Swedish ICH (SwICH) score. Patients surgically treated for spontaneous supratentorial intracerebral hemorrhage (ICH) from 2009 to 2019 in a single center in Denmark were identified. Data were retrospectively collected from patient records and neuroimaging. Surgical SwICH and ICH scores were calculated for each patient, and the validity of the Surgical SwICH was assessed and compared.

OBSERVATIONS The 126 patients included had an overall 30-day mortality rate of 23%. All patients with a Surgical SwICH score of 0 survived past one year. No patient scored the maximum Surgical SwICH score of 6. The 30-day mortality rates for Surgical SwICH scores 1, 2, 3, and 4 were 0%, 20%, 53%, and 25%, respectively ($p < 0.0001$ for trend). Mortality rates for ICH scores 1, 2, 3, and 4 were 0%, 11%, 33%, and 76%, respectively ($p < 0.001$ for trend). Receiver operator characteristics showed an area under curve of 0.78 for the Surgical SwICH score and 0.80 for the ICH score ($p = 0.21$ difference).

LESSONS The Surgical SwICH score was a good predictor of 30-day mortality in patients surgically treated for spontaneous supratentorial ICH. However, the Surgical SwICH score did not outperform the previously established ICH score in predicting 30-day mortality.

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KEYWORDS stroke; intracerebral hemorrhage; clinical grading scale; external validation; outcome

Intracerebral hemorrhage (ICH) is the cause of 10%–15% of strokes worldwide and is a major cause of mortality and morbidity. The mortality rate can be up to 40%, and more than 75% of patients develop long-term functional dependence.[1–5] Extensive retrospective studies and randomized controlled trials have been performed to optimize treatment strategies in ICH but have not established a clear consensus regarding the use of medical and surgical therapies to improve long-term outcomes.[6–8] This has led to great heterogenicity in the general treatment, management, and assessment of patients with ICH.

In an effort to achieve a more uniform understanding of prognostic factors and risk stratification, several grading scales for primary ICH have been developed.[9] The ICH score introduced by Hemphill et al. in 2001 has been extensively used as the primary grading scale for risk stratification of patients with ICH.[10] It has wide application to patients with supra- and infratentorial hemorrhages and was developed using cohorts of both conservatively and surgically treated patients.

The potential benefit of surgery over conservative treatment in ICH has long been a point of interest and debate.[6,8,11–14] Some evidence suggests a better outcome from surgical treatment versus conservative management in select patient groups.[12,13,15,16] Fahlström and colleagues sought in 2019 to introduce the first clinical grading scale specifically developed for surgically treated patients with ICH,[18] attempting to strengthen the hypothesis that purposefully selected surgical patients would have a better outcome than conservatively treated patients.[12] Their Surgical Swedish ICH (SwICH) score is calculated based on the Glasgow Coma Scale (GCS) score, the age and volume of the hematoma, previous diagnosis with diabetes mellitus type 2 (DM2), and previous acute myocardial infarction (AMI).[17] These characteristics were identified as independent risk factors for 30-day mortality, and points are awarded for each of the five factors based on their strength of association with this outcome. The sum of points forms the Surgical SwICH score for a given patient (Table 1).

ABBREVIATIONS AMI = acute myocardial infarction; AUC = area under the curve; CT = computerized tomography; DM2 = diabetes mellitus type 2; GCS = Glasgow Coma Scale; ICH = intracerebral hemorrhage; MI = myocardial infarction; ROC = receiver operator characteristic; SwICH = Swedish ICH.

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TABLE 1. Calculation of the grading scales

Surgical SwICH Score		ICH Score	
Feature	Points	Feature	Points
GCS Score		GCS Score	
13–15	0	13–15	0
5–12	1	5–12	1
3–4	2	3–4	2
Age (years)		Age (years)	
<75	0	<80	0
≥75	1	≥80	1
Intracerebral hemorrhage volume (mL)		Intracerebral hemorrhage volume (mL)	
<50	0	<30	0
≥50	1	≥30	1
Diabetes mellitus type 2		Intraventricular hemorrhage present	
No	0	No	0
Yes	1	Yes	1
Previous myocardial infarction		Infratentorial origin	
No	0	No	0
Yes	1	Yes	1
Total score range	0–6	Total score range	0–6

For the Surgical SwICH score to function as an international risk stratification scale, it needs to be applicable to a wider demographic than the Swedish catchment area where it was developed. The initial results of Fahlström et al.[17] have not yet been validated elsewhere.

The primary objective of the current study was to externally validate whether the Surgical SwICH score can be applied to a different set of patients and how well it is able to predict 30-day mortality for patients with ICH surgically treated at a Danish university hospital. The secondary objective was to compare the predictive accuracy of the Surgical SwICH score with the already established ICH score from 2001.

Study Description

The study was approved by the Danish Patient Safety Authority (3–3013–3241/1) and the Danish Data Protection Agency (19/42792). Data were collected through a comprehensive review of patient medical records and neuroimaging records from the years 2009 to 2019. A search for patients tagged with the *International Statistical Classification of Diseases and Related Health Problems*, 10th revision, code I61 (nontraumatic ICH) and the Danish Health Authority's procedural code KAAD0 (operation on cranial or intracranial lesion) and/or KAAB30 (removal of intracranial hemorrhage) yielded a total of 240. All patients had been surgically treated for spontaneous ICH in the region of Southern Denmark, an area of approximately 1.3 million inhabitants. Patients presenting with ICH originating from infratentorial hemorrhages, neoplasms, trauma, and vascular malformations were excluded. No patients under the age of 18 years were included in the cohort.

The patient data collected from medical records were as follows: age, sex, GCS score, DM2 status, previous ischemic stroke, myocardial infarction (MI), and treatment with antihypertensives, antiplatelets, vitamin K antagonists, and nonvitamin K antagonists. GCS score was defined as the last GCS score entry in the patient's records before surgery. In the absence of this score, the GCS score was assigned based on the clinical description of the patient (n = 7).

Head computerized tomography (CT) or cerebral magnetic resonance imaging at the time closest to surgery provided the basis for calculation of hematoma volume and information on the presence of intraventricular hemorrhage and/or hydrocephalus. Hematoma volume was measured with the Horos viewer (Horusproject.org), using volumetric calculations of hematoma size. We had considered using the ABC/2 method to measure volume, in which A is the largest diameter of the hematoma, B is the diameter perpendicular to A, and C is the number of CT slices containing hematoma multiplied by the thickness of the slices. We found, however, that the ABC/2 method overestimated the hematoma volume,[18] thus influencing the hematoma volume score. The Horos viewer provided a more accurate volume estimate. In the case of missing scans (n = 2), we used the size of the hematoma as reported in the patient's journal.

Primary outcome was mortality 30 days after surgery. Three patients who left the country after surgery were assumed to be alive after 30 days. One-year mortality rate was also recorded and analyzed for both the Surgical SwICH score and the ICH score, using the same assumptions for patients who had left the country.

Previous MI, DM2 status, and previous stroke were treated as categorical variables and are presented as numbers and/or percentages and compared using Pearson's chi-square test. Age and hematoma volume were treated as continuous variables and are presented as means (with standard deviation) or medians (with range) as appropriate. Continuous variables were compared using Student's *t* test if normally distributed and Mann-Whitney U-test if not normally distributed. Cuzick's nonparametric test of trend[19] was used to evaluate the statistical significance of the grading scale.

The predictive value of the Surgical SwICH score in the current cohort was compared with that in the original Swedish cohort by calculating the area under the curve (AUC) of the receiver operator characteristic (ROC) curves for both cohorts. The same method of comparison was used with the ICH score for the current cohort.

Statistical analysis was performed with Stata (StataCorp. 2019. *Stata Statistical Software: Release 16*. College Station, TX: StataCorp LLC.). Statistical significance was set at a p value of <0.05.

Discussion

Clinical grading scales have become important tools in outcome assessment, but they continue to be inaccurate in identifying patients who are at high risk for early death from ICH.[20] A shortcoming of existing prognostic tools is the large inconsistency of results when applied to different populations.[9,21,22] A reliable grading scale can improve interphysician communication and help improve the overall management of patients.[20] This is crucial not only for mortality rates but also because patients who survive an ICH often develop debilitating neurological deficits and loss of function.[1,4,22] Improved clinical grading scales could increase the accuracy of outcome prediction.

Observations

Of the 130 adult patients identified with spontaneous supratentorial ICH, four had missing initial CT scans and descriptions, making it impossible to calculate a Surgical SwICH score. These patients were excluded from the analysis, leaving 126 included patients. Mean age of the 126 patients was 61 years, 60% were males, and 40% were females. Half the patients were taking antihypertensives, and 25% were on antiplatelet medication. Diabetes mellitus was present in 10% of patients, and only three patients had a history of previous MI. The descriptive data are summarized in Table 2. Overall, 30-day mortality for the 126 patients was 23%.

TABLE 2. Preoperative patient characteristics

	Current Cohort (n = 126)	Original Surgical SwICH Cohort (n = 401)
Characteristics	Value	Value
Age (years)		
Mean (SD)	61 (11)	58 (12)
Median (range)	63 (34–82)	59 (20–85)
Sex, no. (%)		
Male	76 (60)	253 (63)
Female	50 (40)	148 (37)
Medication, no. (%)		
Antiplatelet	32 (25)	75 (19)
Warfarin	10 (8)	37 (9)
Non–vitamin K antagonist, no. (%)	8 (6)	5 (1)
Antihypertensive, no. (%)	63 (50)	N/A
Medical history, no. (%)		
Hypertension	69 (55)	183 (46)
DM2	13 (10)	40 (10)
Previous MI	3 (2)	33 (8)
Previous stroke	21 (17)	48 (12)
GCS score, no. (%)		
3–4	16 (13)	20 (5)
5–12	86 (68)	309 (77)
13–15	24 (19)	72 (18)
Hematoma volume (mL)		
Mean (SD)	80 (29)	79 (37)
Median (range)	79 (22–173)	72 (11–240)
Intraventricular hemorrhage, no. (%)		
Present	73 (58)	225 (56)
Not present	53 (42)	176 (44)
Hydrocephalus, no. (%)		
Yes	29 (23)	101 (25)
No	97 (77)	300 (75)
Hematoma location, no. (%)		
Right hemisphere	59 (47)	221 (55)
Left hemisphere	67 (53)	178 (44)
Lobar	102 (81)	215 (54)
Central	24 (19)	186 (46)

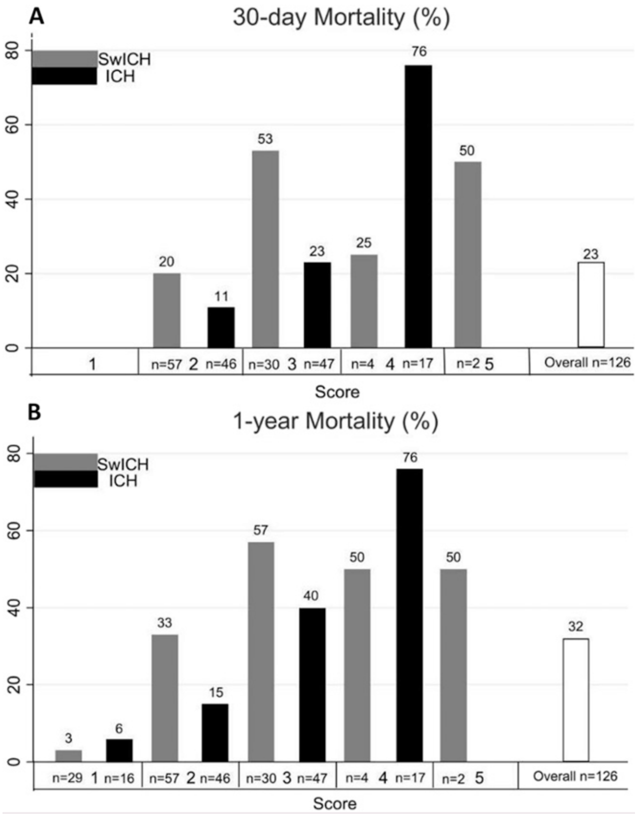

FIG. 1. 30-day mortality rate (**A**) and 1-year mortality rate (**B**) according to patients' Surgical SwICH score (Fahlström et al., 2019) and ICH score (Hemphill et al., 2001).

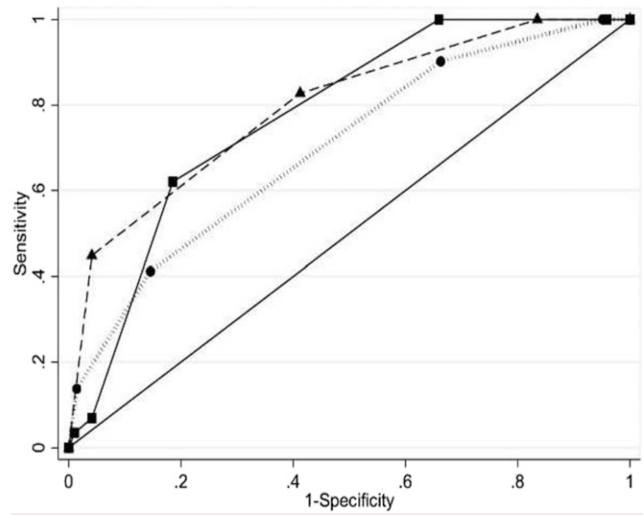

FIG. 2. ROC curves for the Surgical SwICH score (■) and ICH score (▲) in the current Danish cohort, and for the Surgical SwICH score in the original Swedish cohort (●) (Fahlström et al., 2019). For the current cohort, the AUC for the Surgical SwICH score was 0.78, compared to 0.80 for the ICH score (p = 0.21 difference). AUC for the Surgical SwICH score in the original Swedish cohort was 0.70.

The Surgical SwICH scores ranged from 0 to 5. All patients with a Surgical SwICH score of 0 survived past one year, and no patients with a Surgical SwICH score of 1 died within the 30-day period (Fig. 1A). Of the two patients with a Surgical SwICH score of 5, one survived and the other died within a month. No patient had a maximum Surgical SwICH score of 6. The 30-day mortality rates for Surgical SwICH scores 1, 2, 3, and 4 were 0%, 20%, 53%, and 25%, respectively ($p < 0.0001$ for trend). At one year, the mortality rates had changed to 3%, 33%, 57%, and 50% for Surgical SwICH scores of 1, 2, 3 and 4, respectively.

The calculated ICH scores ranged from 1 to 4, thus no patients scored 0 or 5 (the inclusion criteria meant that none of the patients could have an infratentorial hemorrhage for a maximum score of 6). Mortality rates for ICH scores 1, 2, 3, and 4 were 0%, 11%, 33%, and 76%, respectively, for 30 days ($p < 0.001$ for trend) and 6%, 15%, 40%, and 76%, respectively, after 1 year (Fig. 1B).

ROC curves for Surgical SwICH scores showed an AUC of 0.78 for patients in the current cohort, compared with an AUC of 0.70 for patients in the original Swedish cohort (Fig. 2). ROC curves for ICH scores for patients in the current cohort had an AUC of 0.80.

For a grading scale to be effective in a clinical setting, it must be applicable to a broad demographic, be reliable and easy to use,[23] and show validity in a variety of settings. Use of the Surgical SwICH score does not require previous statistical knowledge or training. The information needed to assign a patient to a specific score can be found within patient records and imaging reports. It is simple to use and applicable in a hospital setting.

The Surgical SwICH scores were skewed in the current study. Only four patients had a calculated score of 4, and two patients had a score of 5. This is a logical effect of patient selection for acute neurosurgical intervention under current clinical standards but, nevertheless, a limiting factor when validating a grading scale. When plotted as an ROC curve, the Surgical SwICH score could predict 30-day mortality for this specific cohort by its AUC. Comparison of the original and current cohorts suggested that the Surgical SwICH grading scale performed similarly in the two patient populations, with the original having an AUC of 0.70 and the current having an AUC of 0.78 (Fig. 2).

An AUC of 0.70 to 0.80 implies a good ability to positively discriminate patients with a poor outcome based on their Surgical SwICH score, whereas a score of 0.50 would mean no discrimination.[24] This shows that the Surgical SwICH score is able to predict 30-day mortality for two separate populations, which supports its external validity. Overall, the Surgical SwICH score fulfils the necessities of a clinical grading scale, but comparison with the existing ICH score must be considered to determine any benefits of a new surgical grading scale.

The ICH score from 2001 was based mostly on conservatively treated patients.[10] Fahlström et al. (2019) found the ICH score demonstrated considerable discrepancies between the predicted and actual 30-day mortality rates when applied to their surgically treated cohort.[17] Differences in the calculation of the two scores are shown in Table 1.

The authors of the Surgical SwICH score identified for the first time both DM2 and previous AMI as independent predictors of 30-day mortality in patients with spontaneous supratentorial ICH.[17] There is evidence to suggest that there is a modest association between DM2 and ICH in terms of both incidence and outcome,[25] although this could not be confirmed in the current cohort. Given that only three patients in the current cohort had previous MI, the ability to examine this association with 30-day mortality was further limited.

In contrast to the ICH score, the Surgical SwICH score does not include the presence of intraventricular hemorrhage, and 58% of patients in the current cohort had intraventricular hemorrhage. Such differences in calculating the two scores could explain the disparities in the 30-day mortality rate between the two grading scales.

Outcomes for the calculated ICH score in the current cohort perform comparably with previous studies.[9,21,26] The ICH score was more evenly distributed, as 17 patients had a score of 4 (Fig. 1). Given that only 24% of patients with an ICH score of 4 survived, it is reasonable to presume that a score of 5 or higher would predict an even poorer outcome. The ROC curves for both the Surgical SwICH and ICH scores showed comparable AUCs (0.78 and 0.80, $p = 0.21$) (Fig. 2). This suggests that the ICH score could be an accurate grading scale for patients treated exclusively by surgical intervention.

Because the Surgical SwICH score incorporates DM2 and previous MI into the calculation of the total score, it arguably relies on patient history more than the ICH score does. In an emergency operation, in which the patient's identity or illness history are sometimes unknown, it may be impossible to accurately calculate the Surgical SwICH score. In contrast, the ICH score can be mostly estimated using neuroimaging, which is routinely performed on hospital admission. The Surgical SwICH score was developed based on patients with surgically treated supratentorial ICH and excluded infratentorial hemorrhages, which account for 10%–20% of all spontaneous ICH.[27,28] Although several studies show that the differing treatment approaches for these two entities may be important,[29,30] the ICH score performed similarly to the Surgical SwICH score in the current cohort (shown by the ROC curves), implying a narrower application of the Surgical SwICH grading scale than of the ICH score. In the current study, 13% of the patients identified with primary nontraumatic ICH had an infratentorial origin, and they were excluded from the analysis.

The current study collected data retrospectively from patient records, and the data may thus be subject to human error. We observed occasional discrepancies between the records of the admitting physician and subsequent records in relation to reporting comorbidities and medicinal status. The GCS score sometimes had to be extrapolated based on the preoperative clinical description. Any potential differences between the estimated and actual scores are presumably minor, but they could have affected our results. This could especially occur when a surgical patient had a GCS score below 5, in which motor function was unknown or difficult to classify. Given that a GCS score of 3 to 4 gives a 1-point difference in the Surgical SwICH score compared with a GCS score of 5 (Table 1), this may have led to over- or underestimation of the total Surgical SwICH score. Additionally, all patients were treated at a single center with substantial surgeon overlap.

Similar to the original Swedish study,[17] we did not include data on other comorbidities or risk factors, nor on functional and neurological deficits at follow-up. Also, as with the original study, we did not estimate 3- and 6-month mortality rates. Finally, this is a relatively small cohort with a population of 126, and there is a low incidence of previous MI and DM2, which can be considered a further limiting factor.

A strength of the current study is that it is the first application of the newly developed Surgical SwICH score outside its original setting. Furthermore, it uses the same inclusion criteria but also contains two patients with a score of 5, which was not attained in the original cohort.

Lessons

The Surgical SwICH score was a good predictor of 30-day mortality in a cohort of patients who had been surgically treated for spontaneous supratentorial ICH. However, the Surgical SwICH score did not outperform the relatively well-established ICH score in predicting 30-day mortality. Although the current cohort was not powered for subgroup analysis of single risk factors, we saw no tendency for DM2 or previous MI to be significant predictors of 30-day mortality. Further validation of the Surgical SwICH score is needed to determine its usefulness as a clinical grading scale for surgically treated patients with ICH and the effects of single risk factors such as diabetes and previous MI.

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Disclosures

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

Author Contributions

Conception and design: Forsse. Acquisition of data: Haga. Analysis and interpretation of data: Haga, Forsse. Drafting the article: Haga, Poulsen. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Haga. Statistical analysis: Haga. Administrative/technical/material support: Forsse. Study supervision: Poulsen, Forsse.

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