ORIGINAL ARTICLE

https://doi.org/10.1590/1806-9282.20211339

Braden scale for predicting pneumonia after spontaneous intracerebral hemorrhage

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SUMMARY

OBJECTIVE: Stroke-associated pneumonia is an infection that commonly occurs in patients with spontaneous intracerebral hemorrhage and causes serious burdens. In this study, we evaluated the validity of the Braden scale for predicting stroke-associated pneumonia after spontaneous intracerebral hemorrhage.

METHODS: Patients with spontaneous intracerebral hemorrhage were retrospectively included and divided into pneumonia and no pneumonia groups. The admission clinical characteristics and Braden scale scores at 24 h after admission were collected and compared between the two groups. Receiver operating characteristic curve analysis was performed to assess the predictive validity of the Braden scale. Multivariable analysis was conducted to identify the independent risk factors associated with pneumonia after intracerebral hemorrhage.

RESULTS: A total of 629 intracerebral hemorrhage patients were included, 150 (23.8%) of whom developed stroke-associated pneumonia. Significant differences were found in age and fasting blood glucose levels between the two groups. The mean score on the Braden scale in the pneumonia group was 14.1±2.4, which was significantly lower than that in the no pneumonia group (16.5±2.6), p<0.001. The area under the curve for the Braden scale for the prediction of pneumonia after intracerebral hemorrhage was 0.760 (95%CI 0.717–0.804). When the cutoff point was 15 points, the sensitivity was 74.3%, the specificity was 64.7%, the accuracy was 72.0%, and the Youden's index was 39.0%. Multivariable analysis showed that a lower Braden scale score (OR 0.696; 95%CI 0.631–0.768; p<0.001) was an independent risk factor associated with stroke-associated pneumonia after intracerebral hemorrhage.

CONCLUSION: The Braden scale, with a cutoff point of 15 points, is moderately valid for predicting stroke-associated pneumonia after spontaneous intracerebral hemorrhage.

KEYWORDS: Intracerebral hemorrhage. Pneumonia. Risk factors.

INTRODUCTION

Nosocomial infections are complications that frequently occur in patients with spontaneous intracerebral hemorrhage (ICH)[1,2]. Stroke-associated pneumonia (SAP) accounts for 18% of all nosocomial infections and is the most common infection in patients with ICH, especially for the elderly[3]. SAP not only increases the length of hospital stay and hospital costs[4,5] but is also an important risk factor for poor outcomes after acute stroke[6,7]. Therefore, it is important to find a scale that is effective in predicting SAP and can help clinicians take early preventative measures to reduce the incidence of SAP[8,9]. The Braden scale is used to assess the risk of pressure ulcers[10,11], and our prior study indicates that the Braden scale is useful for predicting pneumonia after acute ischemic stroke (AIS)[12]. In the clinical use of this scale, we found that the Braden scale might be related to pneumonia after spontaneous ICH. In this study, we aimed to evaluate the validity of the Braden scale in predicting pneumonia after spontaneous ICH.

METHODS

Study participants

We retrospectively included consecutive patients with spontaneous ICH who were admitted to Jingjiang People's Hospital and Zhoukou Central Hospital between January 2015 and August 2018. These two hospitals are the largest tertiary hospitals in the region and are responsible for the treatment of critical illnesses in the area. This study retrospectively

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Conflicts of interest: the authors declare there is no conflicts of interest. Funding: This work was funded by the Fifth "311 Project" in Taizhou (RCPY202004) and Taizhou Municipal Science and Technology Bureau (CN) (SSF20200086).
Received on April 10, 2022. Accepted on April 28, 2022.

included ICH patients admitted to the neurology department who did not undergo surgery. The inclusion criteria were patients who

(1) were diagnosed with spontaneous ICH according to the World Health Organization criteria[13];
(2) were confirmed to have ICH by head computed tomography;
(3) did not undergo any surgical procedures to treat or reduce the hematoma, including, but not limited, to minimally invasive hematoma aspiration and craniotomy hematoma removal; and
(4) aged ≥18 years. The exclusion criteria were patients who acquired pneumonia before admission and patients with primary intraventricular hemorrhage.

This study was approved by the Medical Ethics Committee of Jingjiang People's Hospital (ethical application ref: 2019-01-44) and Zhoukou Central Hospital. Because it was a retrospective study and did not include any personal information related to the participants, the need to obtain written informed consent was waived. The treatment of each participant during hospitalization was approved by the patient or their family member, and a written informed consent form was obtained before treatment.

Data collection and variable definitions

Each center selected two senior neurologic physicians to collect information on the included cases. Cases with discrepancies in the data were evaluated by a third senior physician until an agreement was reached. We collected the patients' demographic and clinical characteristics upon admission, including demographic data, risk factors, and laboratory examination results.

Nurses administered the Braden scale at 24 h after admission, which is composed of six subscales: sensory perception, skin moisture, activity, mobility, nutrition, friction, and shear forces. The score for friction and shear forces ranges from 1 (worst) to 3 (best), and the other scores range from 1–4. The sum of the scores ranges from 6–23[14].

Pneumonia after ICH was diagnosed according to the Centers for Disease Control and Prevention criteria[15] for hospital-acquired pneumonia.

Statistical analysis

Statistical analysis was performed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). Student's *t*-test was used for normally distributed variables (described as the mean±SD), the Mann-Whitney U test was used for non-normally distributed continuous variables, and Fisher's exact test or the χ^2 test was used for dichotomous variables. A $p<0.05$ was considered statistically significant. Then, receiver operating characteristic (ROC) curve analysis was performed to investigate the predictive validity of the Braden scale for pneumonia after ICH, and the Youden's index was used to determine the diagnostic threshold. An area under the curve (AUC) of 0.97–1.00 indicates excellent accuracy, 0.93–0.96 indicates very good accuracy, 0.75–0.92 indicates good accuracy, <0.75 indicates obvious deficiencies, and an AUC of <0.5 indicates that the test has no predictive ability[16]. Factors with $p<0.10$ and variables of risk factors in the univariate analysis were entered into the multivariate analysis to identify the independent risk factors associated with pneumonia after spontaneous ICH.

RESULTS

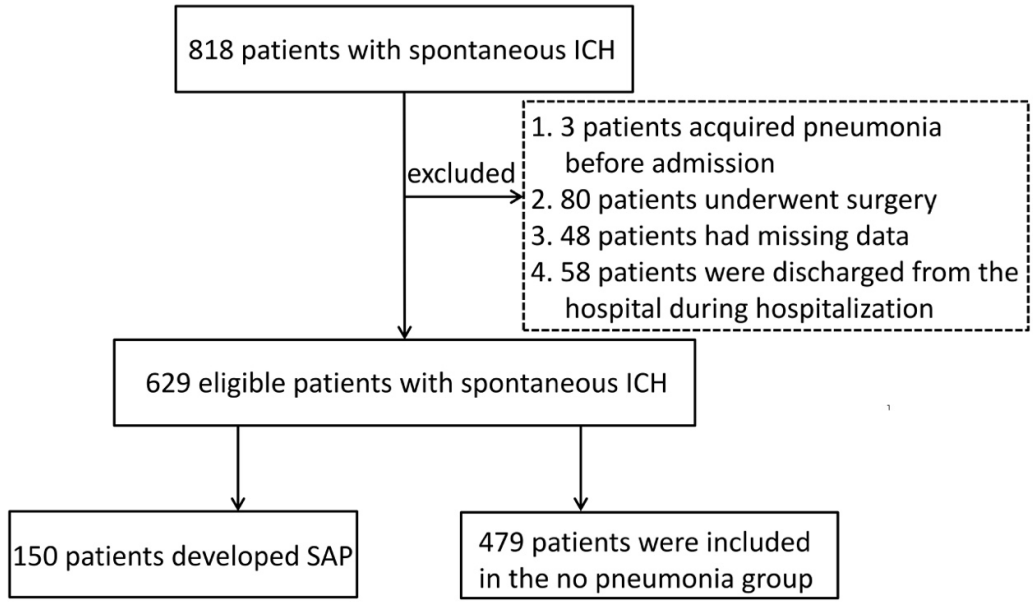
A total of 818 patients with spontaneous ICH were admitted to Jingjiang People's Hospital and Zhoukou Central Hospital between January 2015 and August 2018. Among them, 3 patients acquired pneumonia before admission, 80 patients underwent surgery, 48 patients had missing data, and 58 patients were discharged from the hospital during hospitalization. Ultimately, 629 patients with spontaneous ICH were retrospectively included in this study, of which 150 (23.8%) patients were included in the pneumonia group and 479 (76.2%) patients were included in the no pneumonia group (Figure 1). There were 380 (60.4%) males and 249 (39.6%) females, and their mean age was 66.1±13.4 years.

Demographic and clinical characteristics

There were significant differences in age, history of diabetes, and fasting blood glucose level between the two groups. The other demographic data, risk factors, and laboratory examination results showed no significant differences between the pneumonia and no pneumonia groups. The mean score on the Braden scale in the pneumonia group was 14.1±2.4, which was significantly lower than that in the no pneumonia group (16.5±2.6, $p<0.001$) (Table 1). All six subscale scores on the Braden scale significantly differed between the two groups (Table 2).

Braden scale score and pneumonia after spontaneous ICH

The AUC for the Braden scale for the prediction of pneumonia after spontaneous ICH was 0.760 (95%CI 0.717–0.804). When the cutoff point was 15 points, the sensitivity was 74.3%, the specificity was 64.7%, the accuracy was 72.0%, and the Youden's index was 39.0% (Figure 2).



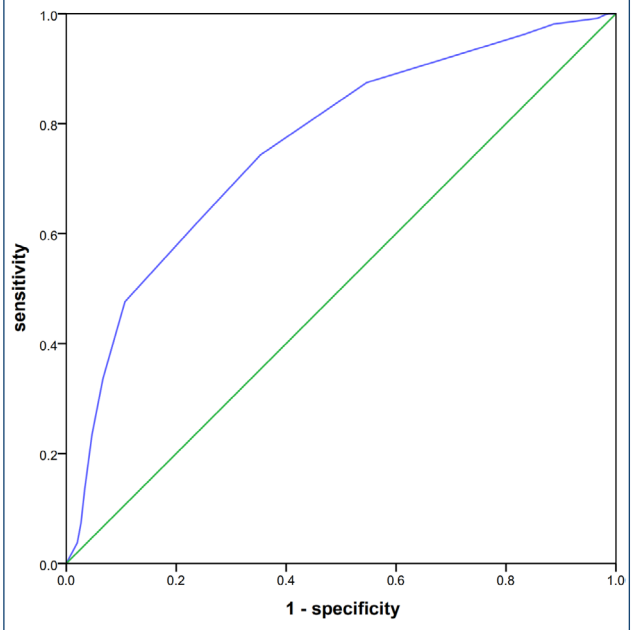
ICH: intracerebral hemorrhage; SAP: stroke-associated pneumonia.

Figure 1. Patient selection flowchart.

Table 1. Demographic and clinical characteristics of the patients in the two groups.

	No pneumonia (n=479)	Pneumonia (n=150)	p-value
Demographic			
Age (years)	64.2±13.0	72.1±12.9	<0.001
Male (case %)	292 (61.0)	88 (58.7)	0.633
Risk factors			
Smoking status (case %)	152 (31.7)	44 (29.3)	0.614
Drinking status (case %)	93 (19.4)	28 (18.7)	0.906
COPD (case %)	6 (1.3)	2 (1.3)	1.000
Hypertension (case %)	333 (69.5)	107 (71.3)	0.760
Diabetes (case %)	142 (29.6)	61 (40.7)	0.009
Hyperlipidemia (case %)	20 (4.2)	6 (4.0)	1.000
Coronary heart disease (case %)	48 (10.0)	19 (12.7)	0.365
AF (case %)	50 (10.4)	12 (8.0)	0.435
Laboratory examination			
INR	1.0±0.3	1.1±0.9	0.154
Serum creatinine (μmol/L)	81.8±58.2	88.7±32.1	0.167
Fasting blood glucose (mmol/L)	6.0±2.2	7.3±3.2	<0.001
TC (mmol/L)	4.3±1.1	4.4±1.6	0.305
TG (mmol/L)	1.5±0.9	1.6±2.5	0.398
HDL (mmol/L)	1.1±0.5	1.2±0.3	0.180
LDL (mmol/L)	2.7±1.0	2.7±1.1	0.834
Scores			
Braden scale	16.5±2.6	14.1±2.4	<0.001

COPD: chronic obstructive pulmonary disease; AF: atrial fibrillation; INR: international normalized ratio; TC: total cholesterol; TG: triacylglycerol; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein cholesterol.



Braden scale for predicting pneumonia after spontaneous intracerebral hemorrhage (Source: Authors.)

Figure 2. Receiver operating characteristic curve for the Braden scale. The area under the curve for the Braden scale for the prediction of pneumonia after spontaneous intracerebral hemorrhage was 0.760 (95%CI 0.717–0.804). When the cutoff point was 15 points, the sensitivity was 74.3%, the specificity was 64.7%, the accuracy was 72.0%, and the Youden's index was 39.0%.

Factors associated with pneumonia after spontaneous ICH

Older age, diabetes, higher fasting blood glucose, and a lower Braden scale score at baseline were associated with pneumonia after spontaneous ICH on univariate analysis. The results of the multivariable analysis are presented in Table 3. After adjusting for confounders, an older age (OR 1.039; 95%CI 1.020–1.058, p<0.001), a higher fasting blood glucose (OR 1.193; 95%CI 1.087–1.309, p<0.001), and a lower Braden scale score (OR 0.696; 95%CI 0.631–0.768, p<0.001) were independent risk factors associated with SAP after ICH (Table 3).

Table 2. Braden scale scores for the two groups (mean±SD).

Braden scale	No pneumonia (n=479)	Pneumonia (n=150)	p-value
Sensory perception	3.4±0.7	2.8±0.7	<0.01
Skin moisture	3.7±0.5	3.5±0.6	<0.01
Activity	1.3±0.8	1.1±0.6	0.001
Mobility	3.0±0.8	2.4±0.8	<0.01
Nutrition	2.9±0.4	2.7±0.6	<0.01
Friction and shear	2.1±0.7	1.7±0.6	<0.01
Sum score	16.5±2.6	14.1±2.4	<0.01

Table 3. Risk factors associated with stroke-associated pneumonia after spontaneous intracerebral hemorrhage.

	B	S.E.	Wals	OR	95%CI	p
Age (years)	0.038	0.009	16.323	1.039	1.020–1.058	<0.001
Female (case %)	-0.356	0.249	2.043	0.701	0.430–1.141	0.153
Smoking status (case %)	0.125	0.260	0.231	1.133	0.681–1.886	0.631
COPD (case %)	0.000	0.939	0.000	1.000	0.159–6.300	1.000
Hypertension (case %)	-0.025	0.239	0.011	0.976	0.611–1.558	0.918
Diabetes (case %)	-0.124	0.266	0.219	0.883	0.524–1.486	0.639
Hyperlipidemia (case %)	-0.214	0.528	0.165	0.807	0.287–2.271	0.685
Coronary heart disease (case %)	-0.202	0.336	0.361	0.817	0.423–1.578	0.548
AF (case %)	-0.659	0.378	3.033	0.518	0.247–1.086	0.082
Serum creatinine (μmol/L)	0.001	0.002	0.416	1.001	0.998–1.005	0.519
Fasting blood glucose	0.176	0.047	13.809	1.193	1.087–1.309	<0.001
Braden Scale	-0.363	0.050	52.272	0.696	0.631–0.768	<0.001

COPD: chronic obstructive pulmonary disease; AF: atrial fibrillation; B: Beta coefficient; S.E.: Standard Error; Wals: Wald χ^2.

DISCUSSION

In this study, we evaluated the correlation between the Braden scale and SAP after ICH. We found that patients with ICH who had a lower Braden scale score were more likely to develop SAP. The AUC for the Braden scale for the prediction of pneumonia after spontaneous ICH was 0.760 (95%CI 0.717–0.804). When the cutoff point was 15 points, the sensitivity was 74.3%, the specificity was 64.7%, the accuracy was 72.0%, and the Youden's index was 39.0%.

SAP is a frequent and often preventable complication of stroke and is one of the major modifiable risk factors for stroke-related in-hospital mortality[17]. In addition, SAP also significantly increases length of stay and hospitalization costs, underscoring the need for screening and preventing poststroke infections[18]. Therefore, knowledge of predictors of SAP is a crucial prerequisite for identifying high-risk patients and taking preventive measures[19]. According to our findings, aggressive measures should be taken to prevent SAP in patients with ICH within 15 points of the Braden scale. This will effectively guide clinical practice and provide a reference for the prevention of ICH complications.

Our previous study verified the correlation between the Braden scale and SAP after AIS. The AUC for the Braden scale for the prediction of pneumonia after AIS was 0.883 (95%CI 0.828–0.937). When the cutoff point was 18 points, the sensitivity was 83.2% and the specificity was 84.2%[12]. This result suggests that the efficacy of the Braden scale in predicting pneumonia after ICH is lower than that in predicting pneumonia after AIS. After we compared the data, we found that the average Braden scale score of all the ICH patients in this study was 15.91±2.77, which was lower than that reported in a previous study of AIS patients (18.96±2.71) and suggests that compared with AIS patients, ICH patients may have poorer mobility and a poorer nutritional status at admission. Therefore, we speculate that ICH patients may have more severe nerve functional impairment at admission, decreasing the sensitivity of the Braden scale in predicting pneumonia after ICH. However, the sensitivity was 74.3% with a cutoff point of 15 points, which still suggests that it is feasible for predicting SAP after ICH.

Risk factors for SAP after stroke include the following[20-22]: age, sex, NIH Stroke Scale (NIHSS) score, dysphagia, current smoking status, Glasgow Coma Scale (GCS) score, and dysphagia. Although the Braden scale does not include these risk factors, the indexes in the Braden scale are associated with some risk factors for SAP. The nutritional indicators are related to the patient's age and dysphagia. Sensory perception and mobility are related to the NIHSS score. Skin moisture and activity are related to the patient's GCS score. This may be the reason why the Braden scale is related to SAP.

Most studies of SAP are based on ischemic stroke, and many scales have been developed to predict SAP after AIS[23-25]. However, the applicability of these scales to ICH needs further exploration. There are studies looking for risk factors for SAP after ICH. Divani et al found that early hospital admission, in-hospital aspiration, intubation, and tracheostomy are risk factors for SAP after ICH[26], which is somewhat different from the SAP risk factors for AIS. Marini et al found that male sex, which is also a risk factor for SAP after AIS, independently increases pneumonia risk and subsequently increases 90-day mortality[27,28]. However, there are few studies on the SAP assessment scale after ICH. Ji et al developed the ICH-APSs scale to predict SAP after ICH[29]. A 23-point ICH-APS-A was developed based on a set of predictors and showed good discrimination in the overall derivation (AUC 0.75; 95%CI 0.72–0.77) and validation (AUC 0.76; 95%CI 0.71–0.79) cohorts. Our study showed that the Braden scale has the same predictive ability, and research can be conducted to evaluate the strengths of different scales in the future.

Unlike AIS patients, we did not observe an association of atrial fibrillation (AF) with SAP after ICH in our multivariate analysis[30]. We speculate that this may be due to the association of AF with the severity of AIS patients. Zhao et al observed a correlation between infarct volume and SAP after AIS[31], whereas patients with cardioembolism tended to have a larger infarct volume[32] and more severe clinical symptoms, which leads to the correlation of AF with SAP. However, in patients with ICH, the severity of symptoms was related to the site and volume of bleeding, which was not directly related to AF, so AF was not an important risk factor when assessing SAP in patients with ICH. In addition, we did not find that chronic obstructive pulmonary disease (COPD) and smoking history affected SAP after ICH, which suggests that factors such as disturbance of consciousness and dysphagia after ICH have a greater impact on SAP than pulmonary adverse factors before admission. The Braden score, which is related to these factors, is indeed an independent risk factor for SAP.

Diabetic patients are more prone to pulmonary infection[33], but we did not observe an association of diabetes with SAP after ICH in the multivariable analysis. However, we found that there is a correlation between fasting blood glucose and SAP, which may suggest that it is the blood sugar control at the onset of ICH rather than the history of diabetes that affects SAP. Therefore, effective blood sugar control for diabetic patients is an important measure to reduce SAP. Another reason for this phenomenon may be stress hyperglycaemia[34]. A previous study

showed that stress hyperglycemia was associated with a high risk of mortality and recurrence after stroke[35] and the excessive release of pro-inflammatory cytokines[35]. These elevated cytokines reduce insulin production in peripheral tissues and further increase blood glucose, resulting in a vicious cycle[36]. Furthermore, the aforementioned pro-inflammatory molecules are significant contributors to SAP[37], and stroke-induced immunosuppression and infection promote and accelerate the occurrence and development of SAP[38]. Thus, stroke patients with a stress hyperglycemia-induced high inflammatory state may be associated with a high risk of SAP. Therefore, for patients with ICH, the history of diabetes should not only be considered, and the blood glucose status at the onset of the disease has a stronger correlation with SAP.

Patients with ICH experience different neurological deficits and levels of consciousness at different times. Therefore, the Braden score, NIHSS score, and GCS score assessed at different time points also differ. We administered the Braden scale at 24 h after admission to evaluate the incidence of SAP after AIS, and we confirmed that the 24-h Braden score can effectively predict poststroke pneumonia. In this study, we also administered the Braden scale to patients at 24 h after admission because cerebral hemorrhage is more likely to progress within 24 h after onset, most patients' conditions tend to stabilize after 24 h of onset, and the possibility of increased bleeding is relatively low. Therefore, the assessments of neurological deficits performed at 24 h are more indicative of the progression of patients' conditions.

Our study did not include patients with ICH who underwent surgery because the purpose of this study was to evaluate the sensitivity of the Braden scale in predicting poststroke pneumonia; the eventual goal was to screen high-risk patients and take effective preventive measures, thereby improving their prognosis. ICH patients undergoing surgery are already at high risk of lung infection due to anesthesia and tracheal intubation[39-41]. These patients need medical staff to take necessary measures to prevent pneumonia after stroke. In addition, there was no correlation between the risk factors for the need for these operations and the Braden scale, but the presence of correlations may increase the incidence of pneumonia and affect the sensitivity of the study. Therefore, we excluded all patients who underwent surgical treatment.

Our study has some limitations. First, our study did not include outpatient clinic patients. Second, there is a possibility that unmeasured confounders might have some impact on the risk of SAP after ICH.

CONCLUSION

The Braden scale, with a cutoff point of 15 points, is a moderately valid clinical grading scale for predicting SAP after spontaneous ICH.

ACKNOWLEDGMENT

We thank all relevant clinicians, nurses, and laboratory technicians.

AUTHORS' CONTRIBUTIONS

YLD: Conceptualization, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing. **ZYJ:** Data curation, Writing - original draft, Writing - review & editing. **YL:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **JLN:** Conceptualization, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing.

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