Predictive values of CSS and NIHSS in the prognosis of patients with acute cerebral infarction

A comparative analysis

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Abstract

This study aims to investigate the predictive values of the Chinese Stroke Scale (CSS) and National Institutes of Health Stroke Scale (NIHSS) in the prognosis of patients with acute cerebral infarction.

A total of 399 patients with acute cerebral infarction were assessed using CSS and NIHSS within 1 day after admission. Then, the receiver operating characteristic (ROC) curves were established, and the area under the curves of these 2 scoring systems was compared.

The area under the curve of CSS and NIHSS was 0.796 and 0.794, respectively.

CSS and NIHSS have good predictive values for the prognosis of patients with acute cerebral infarction.

Abbreviations: ACI = acute cerebral infarction, AUC = area under the curve, CSS = Chinese Stroke Scale, CT = computed tomography, MESSS = modified Edinburgh–Scandinavian Stroke Scale, MRI = magnetic resonance imaging, NIHSS = National Institutes of Health Stroke Scale, ROC = receiver operating characteristic, SSS = Scandinavian Neural Stroke Scale, TOAST = Trial of ORG 10172 in Acute Stroke Treatment.

Keywords: acute cerebral hemorrhage, assessing severity, CSS, NIHSS, outcome

1. Introduction

Acute cerebral infarction (ACI) is a common cerebrovascular disease that seriously endangers human health, and is characterized by high morbidity, high mortality, high disability rate, and high recurrence rate.[1] With the development of society and the improvement of living standards, its prevalence rate has shown a marked upward trend. It is of great significance to determine the prognosis, in order to objectively and accurately assess the severity of the disease in patients with cerebral infarction.

Many researchers have considered that it is very important to carry out disease assessment to rescue patients who may suffer from preventable death.[2] However, in clinical practice, the method used for assessing disease severity based on 3 levels (mild, moderate, and severe) is too crude, and cannot accurately reflect the severity of the disease and its rapid changes. Furthermore, even for the same patient, different doctors or nurses may draw significantly different judgments. Determining the severity of the disease and predicting the probability of death can easily be influenced by both iatrogenic factors and the patient's subjective factors.[3] At present, many neurological deficit scoring methods have been proposed abroad. China has also established its own stroke scoring system in 1995, namely, the Chinese Stroke Scale (CSS); which is also called the modified Edinburgh-Scandinavian Stroke Scale (MESSS).[4] The National Institutes of Health Stroke Scale (NIHSS)[5] is one of the scales for assessing neurological function in stroke patients, which can effectively reflect the patient's neurological deficits and accurately determine the prognosis. Hence, it has been extensively used.[6] However, few comparative studies have been conducted on scoring systems that assess the severity and prognosis of stroke damage.

In the present study, CSS and NIHSS were used to comprehensively evaluate the same patient with cerebral infarction, and the evaluation values of these 2 scoring methods for the clinical severity, prognosis and outcomes of ACI patients were compared, providing a reference for the correct selection of cerebral infarction scoring methods, and its value in determining the critical severity and prognosis of ACI.

2. Data and methods

2.1. Patient selection

A total of 399 ACI patients, who were diagnosed in the Neurology Department of our hospital in the past 2 years, were included into this study. All patients were admitted within 3 days

after onset. These patients comprised of 221 males and 178 females, and all patients met the diagnostic criteria of various cerebrovascular diseases established at the Fourth Academic Conference of National Cerebral Vascular Disease in 1995. The diagnosis was confirmed by cranial computed tomography (CT) or magnetic resonance imaging (MRI). Among the patients with cerebral infarction, patients with only sensory symptoms or had a muscle strength of ≥grade IV, patients who had a transient ischemic attack, patients with serious dysfunction of the heart, liver, kidney and other organs, patients who could not take care of themselves before the illness, patients who had a history of stroke and were unable to take care of themselves, and patients who failed to complete the test or did not have compliance were excluded from the study. This study was conducted with approval from the Ethics Committee of the Affiliated Hospital of North China University of Science and Technology. This study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

2.2. Evaluation method

All assessments were completed by investigators who received a unified training. Assessments were strictly performed according to the CSS and NIHSS scoring criteria.

2.3. Statistical methods

All data were processed using the SPSS 16.0 statistical software. Count data were evaluated using Chi-square test. Measurement data were compared using t-test. The ROC curves of these 2 scores for distinguishing the prognosis of ACI were respectively drawn, and the area under the curve (AUC) was calculated. The predictive abilities of these 2 scoring systems were compared using the AUC of the ROC. The Youden's indexes (cut-off values) corresponding to the points on the ROC curve were calculated to determine the sensitivity and specificity of the prognosis. The cut-off value corresponding to the maximum Youden's index was used as the best cut-off value for evaluating the prognosis. For each scale, the judgment of a patient's prognosis was drawn according to the ROC curve. $P < .05$ was considered statistically significant. The predictive abilities of these 2 scoring systems were compared based on the method proposed by Hanley et al.

3. Results

3.1. Comparison of the 2 scales between the survival and death groups

The differences in CSS and NIHSS scores in ACI patients at the first day after admission between the survival group and death group were statistically significant. The CSS and NIHSS scores were significantly higher in the death group, compared to the survival group (Table 1).

3.2. The dose–response relationship between these 2 scales and in-hospital mortality in ACI patients

The strength of association between these 2 scales (CSS and NIHSS) and in-hospital fatality rates in patients with ACI were analyzed, and these were evaluated using X^2-test for linear trend. Results revealed that as CSS and NIHSS scores increased, the risk of in-hospital mortality revealed an upward trend and mortality risk increased (Tables 2 and 3).

Table 1

Comparison of 2 scoring systems between survival group and death group in hospitalized patients with acute cerebral infarction.

Classification	Survival group (n = 278)	Death group (n = 121)	t	P
CSS	13.75 ± 10.62	27.64 ± 12.49	−11.373	.000
NIHSS	6.69 ± 5.53	15.33 ± 8.78	−9.920	.000

CSS = Chinese Stroke Scale, NIHSS = National Institutes of Health Stroke Scale.

3.3. Comparison of the validity of these 2 scoring methods in predicting the fatality rate of inpatients with ACI

The present study states that death or survival at 1 month after admission in ACI patients is the gold standard for judging the prognosis of the patients. The sensitivity and specificity of these 2 scoring systems at each point were calculated, the ROC curves of these 2 scoring systems were drawn (Fig. 1), and the AUC was calculated. The differences between the AUCs of these 2 scoring systems and the baseline area (0.5) were evaluated to determine whether the differences were statistically significant. Results revealed that the AUC of CSS and NIHSS was 0.796 and 0.794, respectively; and the difference between these 2 was not statistically significant (Fig. 1, Table 4).

3.4. The best cut-off values of the 2 scoring systems in predicting the prognosis of patients with cerebral infarction

The present study revealed that these 2 scoring systems have good validity in predicting the prognosis of patients with cerebral infarction. In combining the sensitivity, specificity, and predicted values (Table 5), the optimal cut-off values of these 2 scoring systems in predicting cerebral infarction are as follows: 25 points for CSS and 10 points for NIHSS.

4. Discussion

At present, with the shift of the medical model and disease spectrum, and the development of medical science and technology, the quantitative assessment of disease severity of patients with stroke can provide an objective basis for the scientific evaluation of a patient's condition, prediction of prognosis, and medical decisions made by doctors, families and the society.[7] CSS is the scoring criteria system for clinical neurological deficits in Chinese stroke patients. This was issued during the second Chinese Academic Conference on Cerebrovascular Disease in 1988, based on the Scandinavian Neural Stroke Scale (SSS) authored by Professor Jiamei Meng,[8] and was revised by the *Fourth Academic Conference on Cerebrovascular*

Table 2

Risk of death in subgroups of CSS scores in hospitalized patients with acute cerebral infarction.

	CSS Each subgroup was scored				
	0~	10~	20~	30~	40~
Death toll from cerebral infarction	16	17	23	45	20
Death toll from cerebral infarction	129	71	46	28	4
OR		1.930	4.031	12.958	40.313

$\chi^2 = 96.683$, $P < .001$.
CSS = Chinese Stroke Scale.

Table 3

Risk of death in subgroups of NIHSS scores in hospitalized patients with acute cerebral infarction.

	NIHSS Each subgroup was scored					
	0~	5~	10~	15~	20~	25~
Death toll from cerebral infarction	16	16	33	13	12	31
Death toll from cerebral infarction	122	96	37	12	6	5
OR		1.271	6.801	8.260	15.250	47.275

Cerebral infarction $\chi^2 = 115.755$, $P < .001$.
NIHSS = National Institutes of Health Stroke Scale.

Disease in 1996. The criteria include 8 items: level of consciousness, horizontal gaze, facial paralysis, speech, walking ability, and shoulder, hand and lower limb motor function. The scoring range is 0 to 9 points or 0 to 6 points, and the highest total score is 45 points. NIHSS is a commonly used scale for assessing the severity of neurological deficits. The clinical manifestations of infarct in the corresponding brain functional areas were scored from the point of view of clinical functional impairment. This scale is suitable for patients with cerebral infarction at various stages, which has high reliability, validity and responsiveness.[9–11] NIHSS was designed in 1989, which includes 15 items. It is a neurological examination scale for the evaluation of consciousness, eyeball movements, visual field, limb motor and sensations, limb coordination, speech, cognition and attention in the form of grade. The total score is 0 to 42 points. In a study on the evaluation of stroke patients using NIHSS, Kwiatkowski et al[12] verified that NIHSS had good reliability and validity. Furthermore, Trial of ORG 10172 in Acute Stroke Treatment (TOAST) Investigators[13] verified in a prospective clinical trial that NIHSS had good predictive value for the long-term prognosis of stroke.

In a study on the predictive value of early NIHSS assessment on the prognosis of ischemic stroke, Kwakkel et al[14] revealed that the assessment using NIHSS at different time points within a few days after the onset of acute stroke could strongly predict the prognosis at 3 and 6 months after stroke. Young et al[15] also revealed that the baseline NIHSS score was the best early predictor of functional outcome in patients with ACI.

NIHSS is an important scale of stroke, which provides a comprehensive evaluation of the activities of consciousness, movement, sensation, response and advanced neurological function in stroke patients. It has high reliability for the diagnosis of stroke severity,[16] and can comprehensively evaluate the level of consciousness, vision, movement, sensation and cerebellar functional impairment in ischemic stroke patients. However, most studies at home and abroad suggest that[17–19] NIHSS has relatively poor sensitivity in the disease assessment of patients with posterior circulation stroke. A study revealed that[20] NIHSS scores can effectively predict the risk of bleeding in patients with cerebral infarction after emergency thrombolysis.

Both CSS and NIHSS scores have been applied for evaluating the extent of neurological deficits in stroke patients. Studies have revealed that NIHSS could effectively reflect the degree of neurological deficits in stroke patients and accurately predict the prognosis of patients. Hence, it has been widely used in clinic.[21–23] However, there are few reports on the validity of these 2 scoring methods for patients with ACI. This study revealed that CSS and NIHSS scores were significantly higher in the death group than in the survival group, and the differences in scores of these 2 scales between the survival group and death group were statistically significant ($P < .001$). These results indicate that both scales can predict the prognosis of ACI patients. The higher the CSS and NIHSS scores, the severer the condition is. The receiver operating characteristic or relative operating characteristic (abbreviated as ROC) has been widely used in the evaluation
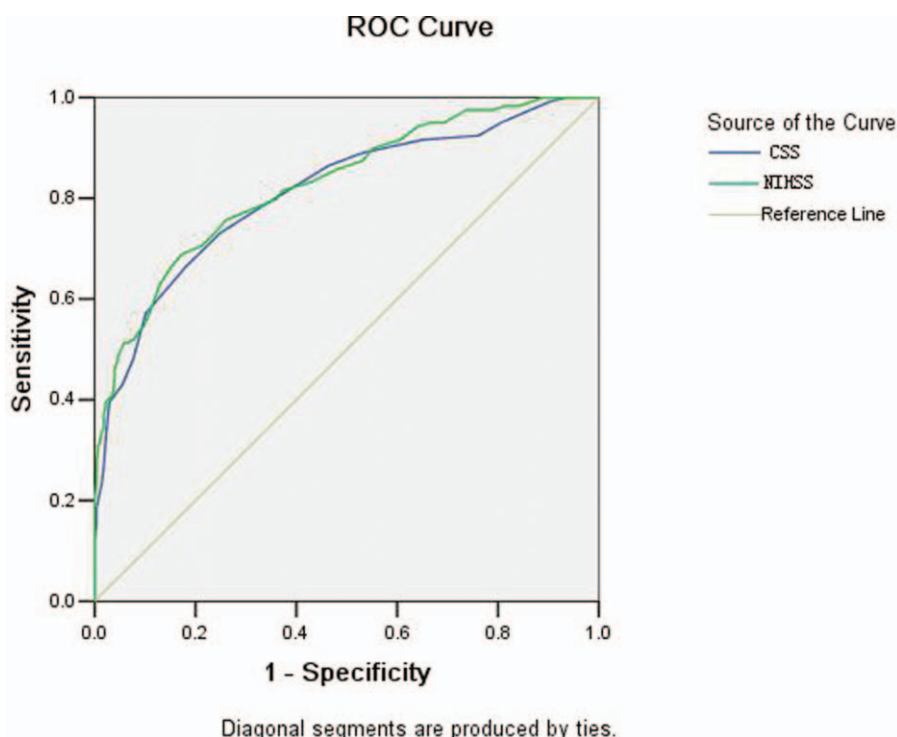

Figure 1. ROC curves of the 2 scoring systems in ACI patients. ACI = acute cerebral infarction, ROC = receiver operating characteristic.

Table 4

Table of area under ROC curve of 2 grades of admission in patients with acute cerebral infarction.

Classification	Area under the curve	Standard error	P	95%CI	
				Low limit	High limit
CSS	0.796	0.027	.000	0.743	0.848
NIHSS	0.794	0.027	.000	0.740	0.848

CSS = Chinese Stroke Scale, NIHSS = National Institutes of Health Stroke Scale, ROC = receiver operating characteristic.

Table 5

Sensitivity and specificity of 2 scoring systems in predicting prognosis of patients with cerebral infarction.

Classification	Score	Sensitivity	Specificity
CSS		0.710	0.776
	23	0.710	0.799
	24	0.701	0.811
	25	0.692	0.826
	26	0.682	0.838
	27		
NIHSS	8	0.804	0.680
	9	0.766	0.734
	10	0.738	0.792
	11	0.626	0.822
	12	0.607	0.849

CSS = Chinese Stroke Scale, NIHSS = National Institutes of Health Stroke Scale.

of medical diagnosis.[24] The present study revealed that the AUC of CSS and NIHSS was 0.796 and 0.794, respectively, which was consistent with that reported in a literature.[25] These results revealed that both CSS and NIHSS have good validity in evaluating the prognosis of ACI patients. It has been generally considered that the greater the AUC is, the higher the validity for the prediction of the prognosis of the patient becomes. In the present study, the predictive power of these 2 scoring systems was compared by comparing the AUC of the ROC curves between these 2 scoring systems. Results revealed that the difference in the AUC of the ROC curve between CSS and NIHSS was not statistically significant. Therefore, we considered that the difference in the capacity of distinguishing the survival rate of patients with cerebral infarction (namely discrimination ability) between these 2 scoring methods was not statistically significant.

Very few studies have been conducted on the cut-off value of CSS and NIHSS scores for the determination of death. Yaghi et al[26] revealed that NIHSS has an ideal specificity, sensitivity and accuracy in predicting the prognosis, and 13 points could be used as the cut-off value of prognosis for stroke patients. Muir et al[27] considered that NIHSS has an ideal specificity, sensitivity and accuracy in predicting prognosis. They pointed out that 13 points of NIHSS could be used as the cut-off value of prognosis for stroke patients. Adams revealed that[28] less than 20% of patients with >15 points of NIHSS score had a relatively satisfactory prognosis. Furthermore, Zhang et al considered that the cut-off values of death of CSS and NIHSS for patients with cerebral infarction were 26 and 15 points. In addition, Schlegel et al[29] revealed that NIHSS could predict the outcome of a patient; that is, patients with a score of ≥5 points of NIHSS score has a great possibility to discharge, patients with a score of 6 to 13

points of NIHSS score need to be treated in a rehabilitation hospital, and patients with a score of ≥13 points of NIHSS score has a large possibility of receiving long-term care in the hospital. Since these NIHSS evaluation items do not cover all neurological deficits, dizziness, headache, nausea, vomiting, double vision and unstable walking are the main manifestations; and the main signs are nystagmus, diplopia, eyeball movement disorder and decreased hearing. Although the presence of ACI can be identified on MRI-DWI images, these symptoms and signs are difficult to evaluate by NIHSS.[30] These different results may be correlated to differences in inclusion criteria, follow-up duration, medical conditions, treatment methods, and even regional differences. The present study is a retrospective study, and the scale evaluation is influenced by subjective factors to a great extent. Therefore, there may be some biases. Taking into account the instability of patients at the acute phase of cerebral infarction, most scholars have a tendency to evaluate patients for several days or more.

Our preliminary study suggests that these 2 scoring systems (CSS and NIHSS) have good predictive values for ACI patients. However, the present study is a retrospective study, and the scale evaluation is influenced by subjective factors to a great extent. Therefore, our study needs to be validated through a prospective study with a large sample size.

Author contributions

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