Development of a prediction model for 1-year poor prognosis in patients with acute ischemic stroke

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ABSTRACT

The goals of this study were to develop a new prediction model to predict 1-year poor prognosis (death or modified Rankin scale score of ≥3) in patients with acute ischemic stroke (AIS) and to compare the performance of the new prediction model with other prediction scales. Baseline data of 772 patients with AIS were collected, and univariate and multivariate logistic regression analyses were performed to identify independent risk factors for 1-year poor prognosis in patients with AIS. The area under the receiver operating characteristics curve (AUC) value of the new prediction model and the THRIVE, iScore and ASTRAL scores was compared. The Hosmer-Lemeshow test was used to assess the goodness of fit of the model. We identified 196 (25.4%) patients with poor prognosis at 1-year follow-up, and of these 68 (68/196, 34.7%) had died. Multivariate logistic regression and receiver operating characteristic curve analyses showed that age ≥70 years, consciousness (lethargy or coma), history of stroke or transient ischemic attack, cancer, abnormal fasting blood glucose levels ≥7.0 mmol/L, and National Institutes of Health Stroke Scale score were independent risk factors for 1-year poor prognosis in patients with AIS. Scores were assigned for each variable by rounding off β coefficient to the integer score, and a new prediction model with a maximum total score of 9 points was developed. The AUC value of the new prediction model was higher than the THRIVE score ($p<0.05$). The χ^2 value for the Hosmer-Lemeshow test was 7.337 ($p>0.05$), suggesting that the prediction model had a good fit. The new prediction model can accurately predict 1-year poor prognosis in Chinese patients with AIS.

Significance of this study

What is already known about this subject?

- Acute ischemic stroke (AIS) is a common cause of disability and mortality worldwide.
- The poor prognosis in patients with AIS is a result of a combination of multiple risk factors.
- It is important to identify independent risk factors for poor prognosis and develop a prediction model for predicting poor prognosis in Chinese patients with AIS based on patients' clinical characteristics.

What are the new findings?

- A prospective cohort study with 1-year follow-up was conducted and aimed to develop a new prediction model to predict 1-year poor prognosis in patients with AIS.
- The new prediction model contained six variables (ie, age ≥70 years, National Institutes of Health Stroke Scale score, level of consciousness, history of stroke or transient ischemic attack, cancer, and fasting blood glucose ≥7.0 mmol/L) with a maximum total score of 9 points.
- The area under the receiver operating characteristic curve of the new prediction model for 1-year poor prognosis prediction in patients with AIS was higher than the THRIVE score.
- The new prediction model can accurately predict 1-year poor prognosis in Chinese patients with AIS.

How might these results change the focus of research or clinical practice?

- All variables in the new prediction model are simple and easily obtained.
- The prediction model has a lower total score, which is easy for clinicians to memorize.
- The new prediction model has important value for predicting 1-year poor prognosis in Chinese patients with AIS and developing individualized treatment plans.

INTRODUCTION

Stroke is currently the second most common cause of death in the world, accounting for 9% of all deaths globally, and it is also one of the leading causes of disability in adults. Acute ischemic stroke (AIS) accounts for about 85% of all strokes, and is associated with high rates of morbidity, mortality, and disability. The incidence of AIS has increased year to year. About 40% of patients cannot live independently after the onset of AIS. The mortality rate during the acute phase

of a first-ever acute stroke was 16.5% in a multiethnic population in South London,[1] and the disability rate during the acute phase of a first-episode AIS in Brazil and India was 33.3% and 27.0%, respectively.[2 3] In China, the 1-year mortality rate of AIS was 11.4%–15.4%, and the death/disability rate was 33.4%–44.6%, and has become the leading cause of death.[4]

Poor prognosis in patients with AIS is the result of a combination of multiple risk factors. Clinicians often need to make decisions about patient outcomes based on the assessment of associated risk factors and their specific knowledge and clinical experience. So it is of great significance to identify the independent risk factors for predicting poor prognosis in patients with AIS in China and develop a prediction model based on the clinical characteristics of Chinese patients with AIS. It could help clinicians evaluate long-term (1-year) prognosis of patients in the early phase of AIS, determine the most appropriate medical treatment, and communicate effectively with patients and their family, which may prevent the development of unnecessary complications and thereby reducing suffering and improving the quality of life of patients. Given this background, we conducted a prospective cohort study with 1-year follow-up. Clinical data of patients with AIS were collected, and logistic regression analysis was performed to identify independent risk factors and develop a prediction model for poor prognosis in Chinese patients with AIS. We then compared the performance of the new prediction model with other prediction scales.

SUBJECTS AND METHODS

Subjects

We enrolled consecutive patients with a first episode of AIS who were admitted to the Department of Neurology, Aerospace Center Hospital, Peking University Aerospace School of Clinical Medicine from December 1, 2012 to September 30, 2016. All of the patients met the following inclusion criteria: (1) age ≥18 years; (2) patients with an initial diagnosis of AIS in accordance with the criteria of the WHO[5]; (3) AIS was confirmed with CT or MRI; (4) infarct lesions were consistent with new symptoms; and (5) time from onset to admission <14 days. The exclusion criteria were as follows: (1) patients with transient ischemic attack (TIA) and hemorrhagic stroke; (2) patients with primary tumors, brain metastases, subdural hemorrhage, postictal Todd's paralysis, and brain injury; (3) patients who did not sign the consent form; (4) time from onset to admission >14 days; and (5) patients with incomplete baseline information and were lost to follow-up.

Data collection

The clinical data of patients with AIS were collected on a paper-based case report form, including age, gender, personal history of smoking and drinking, preadmission dependency (modified Rankin scale [mRS] score of ≥3), level of consciousness, hypertension (systolic blood pressure of ≥140 mm Hg or diastolic blood pressure >90 mm Hg, or use of antihypertensive drugs), year of developing hypertension, diabetes (on the second day after admission, fasting blood glucose [FBG) ≥7.0 mmol/L [at least 8 hours of no caloric intake] or 2-hour blood glucose ≥11.1 mmol/L during a 75 g oral glucose tolerance test, or glycated hemoglobin ≥6.5%[6] [according to the American Diabetes Association criteria], or use of antidiabetic drugs), coronary heart disease, myocardial infarction (history of myocardial infarction, presentation of symptoms characteristic of myocardial infarction, abnormalities in clinical laboratory parameters [such as Creatine Kinase (CK),Creatine Kinase isoenzyme MB (CK-MB), troponin], typical ECG abnormalities of myocardial infarction, and/or imaging-confirmed findings of myocardial infarction), atrial fibrillation (history of atrial fibrillation, typical ECG abnormalities of atrial fibrillation), chronic heart failure (history of chronic heart failure, long-term persistence of heart failure, accompanying pulmonary and/or systemic venous congestion and edema), peripheral arterial disease, cerebral infarction, cerebral hemorrhage, TIA, history of stroke or TIA, cancer (history of cancer, diagnosis of cancer was confirmed, or history of surgery or radiotherapy and chemotherapy), renal dialysis (history of renal dialysis), dementia, hyperlipidemia, Trial of Org 10,172 in Acute Stroke Treatment (TOAST) classification, and National Institutes of Health Stroke Scale (NIHSS) score. An electronic database was created using the EpiData V.3.1 software.

Outcome measures and follow-up

The primary outcome was defined as 1-year poor prognosis in patients with AIS. Poor prognosis was defined as follows: (1) death—AIS was the direct or indirect cause of death; and (2) moderate/severe disabilities—patients were unable to live independently with an mRS score of ≥3. According to the mRS score at 1-year follow-up, patients were divided into good and poor prognosis groups. Patients were followed up for 1 year after enrollment, and the time error was ≤7 days. Prognostic evaluation of patients was done by investigators through telephone or face-to-face interviews.

Statistical analysis

Statistical analysis was performed with SPSS V.22.0 statistics software package. All quantitative data were expressed as mean±SD and median (Q1–Q3) and were compared using independent sample t-test. Cut-off value was calculated using the MedCalc software. Enumeration data are expressed as percentages (%) and were compared using the χ^2 test, and data were analyzed using Yates's continuity correction or Fisher's exact probability test as necessary. Univariate and multivariate regression analyses were performed using the logistic regression model to identify independent risk factors. The area under the receiver operating characteristic (ROC) curve (AUC) was calculated by MedCalc and used to compare the performance of the new prediction model and the Totaled Health Risks in Vascular Events (THRIVE) score, the iScore score and the Acute Stroke Registry and Analysis of Lausanne (ASTRAL) score. An AUC value >0.5 indicated better predictive values; the closer the AUC to 1, the better the model performance. Hosmer-Lemeshow goodness-of-fit test was used to assess the fit of the prediction model. The significance level of the

Table 1 Clinical characteristics of patients with acute ischemic stroke

Clinical characteristics	All patients n=772	Patients in good prognosis n=576	Patients in poor prognosis n=196	P value
Age	66.1±12.8	64.0±12.5	72.5±11.3	<0.001
≥70	341 (44.2%)	210 (36.5%)	131 (66.8%)	<0.001
Male	536 (69.4%)	413 (71.7%)	123 (62.8%)	0.019
Preadmission dependency	48 (6.2%)	15 (2.6%)	33 (16.8%)	<0.001
History of smoking	362 (46.9%)	286 (49.7%)	76 (38.8%)	0.008
History of drinking	243 (31.5%)	201 (34.9%)	42 (21.4%)	<0.001
NIHSS score				<0.001
<9	628 (81.3%)	529 (91.8%)	99 (50.5%)	<0.001
9–13	93 (12.0%)	40 (6.9%)	53 (27.0%)	<0.001
14–22	34 (4.4%)	4 (0.7%)	30 (15.3%)	<0.001
>22	17 (2.2%)	3 (0.5%)	14 (7.1%)	<0.001
Median score	3 (1.25, 6)	2 (1, 5)	8 (4, 13)	<0.001
TOAST classification				
Large-artery atherosclerosis	396 (51.3%)	301 (52.3%)	95 (48.5%)	0.359
Cardioembolism	44 (5.7%)	17 (3.0%)	27 (13.8%)	<0.001
Small-vessel occlusion	127 (16.5%)	116 (20.1%)	11 (5.6%)	<0.001
Stroke of other determined or undetermined etiology	205 (26.6%)	142 (2.1%)	63 (32.1%)	0.04
Level of consciousness				
Drowsiness or lethargy or coma	74 (9.6%)	15 (2.6%)	59 (30.1%)	<0.001
Risk factors				
History of stroke or TIA	259 (33.5%)	158 (27.4%)	101 (51.5%)	<0.001
Cerebral infarction	225 (29.1%)	139 (24.1%)	86 (43.9%)	<0.001
Cerebral hemorrhage	27 (3.5%)	12 (2.1%)	15 (7.7%)	0.001
TIA	14 (1.8%)	7 (1.2%)	7 (3.6%)	0.056
Hypertension	509 (65.9%)	371 (64.4%)	138 (70.4%)	0.126
History of hypertension >7 years	337 (43.7%)	229 (39.8%)	108 (55.1%)	<0.001
Diabetes	261 (33.8%)	187 (32.5%)	74 (37.8%)	0.176
Hyperlipidemia	128 (16.6%)	99 (17.2%)	29 (14.8%)	0.437
Coronary heart disease	141 (18.3%)	93 (16.1%)	48 (24.5%)	0.009
Myocardial infarction	30 (3.9%)	18 (3.1%)	12 (6.1%)	0.061
Atrial fibrillation	76 (9.8%)	39 (6.8%)	37 (18.9%)	<0.001
Chronic heart failure	12 (1.6%)	6 (1.0%)	6 (3.1%)	0.048
Peripheral arterial disease	5 (0.6%)	2 (0.3%)	3 (1.5%)	0.074
Dementia	10 (1.3%)	3 (0.5%)	7 (3.6%)	0.004
Cancer	28 (3.6%)	11 (1.9%)	17 (8.7%)	<0.001
Renal dialysis	3 (0.4%)	1 (0.2%)	2 (1.0%)	0.100
Fasting blood glucose (mmol/L)				
≥7.0	342 (44.3%)	235 (40.8%)	107 (54.6%)	0.001
Glycated hemoglobin				
≥6.5%	532 (68.9%)	409 (71.0%)	123 (77.2%)	0.031

NIHSS, National Institutes of Health Stroke Scale; TIA, transient ischemic attack.

two-sided test was set at $\alpha=0.05$, and a p value of less than 0.05 indicates a statistically significant difference.

RESULTS

Baseline data of patients

A total of 807 patients with AIS were included in the study. Among them, 4 (0.5%) patients were excluded because of incomplete data, 29 (3.6%) patients were lost to follow-up, and 2 (0.2%) patients were excluded due to voluntary withdrawal. As such, 772 patients were enrolled in this study, including 536 (69.4%) men and 236 (30.6%) women, with an average age of 66.14±12.76 years (range, 27–93 years). One hundred and ninety-six (25.4%) patients had poor prognosis at 1-year follow-up, and of these 68 (68/196, 34.7%) had died and 576 (74.6%) had good prognosis. The baseline information of all patients and patients in good and poor prognosis groups is shown in table 1. The univariate logistic regression analysis of the risk factors for poor prognosis in patients with AIS is shown in table 2.

Multivariate logistic regression analysis and prediction model development

The independent risk factors identified by the univariate logistic regression analysis were entered into a multiple

Table 2 Univariate logistic regression analysis of risk factors associated with 1-year poor prognosis in patients with acute ischemic stroke

Risk factors	β	SE	Wald	Significance	Exp(B)	Exp(B) (95% CI) Lower limit	Exp(B) (95% CI) Upper limit
Age							
≥70	1.256	0.175	51.729	0.000	3.513	2.494	4.947
Male	−0.408	0.174	5.478	0.019	0.665	0.473	0.936
Preadmission dependency	2.024	0.324	39.073	0.000	7.572	4.014	14.285
History of smoking	−0.443	0.169	6.897	0.009	0.642	0.461	0.894
History of drinking	−0.676	0.195	12.031	0.001	0.509	0.347	0.745
NIHSS score							
<9			122.617	0.000			
9–13	1.957	0.236	68.582	0.000	7.080	4.455	11.252
14–22	3.691	0.543	46.125	0.000	40.076	13.814	116.267
>22	3.216	0.646	24.822	0.000	24.936	7.036	88.376
TOAST classification							
Large-artery atherosclerosis	−0.325	0.192	2.845	0.092	0.723	0.496	1.054
Cardioembolism	1.291	0.345	14.009	0.000	3.683	1.850	7.153
Small-vessel occlusion	−1.527	0.350	19.003	0.000	2.863	1.907	4.298
Stroke of other determined or undetermined etiology			43.714	0.000			
Level of consciousness	2.779	0.304	83.326	0.000	16.107	8.868	29.252
Risk factors							
History of stroke or TIA	1.034	0.171	36.689	0.000	2.813	2.813	3.930
Cerebral infarction	0.898	0.174	26.780	0.000	2.458	1.748	3.455
Cerebral hemorrhage	1.360	0.397	11.753	0.001	3.895	1.790	8.474
TIA	1.102	0.541	4.149	0.042	3.011	1.043	8.694
Hypertension	0.274	0.179	2.335	0.126	1.315	0.926	1.867
History of hypertension >7 years	0.615	0.167	13.540	0.000	1.851	1.333	2.568
Diabetes	0.233	0.172	1.825	0.177	1.262	0.900	1.768
Hyperlipidemia	−0.178	0.229	0.604	0.437	0.837	0.534	1.312
Coronary heart disease	0.521	0.201	6.727	0.009	1.684	1.136	2.498
Myocardial infarction	0.704	0.382	3.392	0.066	2.022	0.956	4.277
Atrial fibrillation	1.177	0.257	20.983	0.000	3.244	1.961	5.368
Chronic heart failure	1.099	0.583	3.546	0.060	3.000	0.956	9.413
Peripheral arterial disease	1.495	0.917	2.661	0.103	4.461	0.740	26.897
Dementia	1.956	0.695	7.921	0.005	7.074	1.811	27.630
Cancer	1.585	0.396	15.987	0.000	4.878	2.243	10.608
Renal dialysis	1.780	1.228	2.102	0.147	5.928	0.535	65.735
Fasting blood glucose (mmol/L)							
≥7.0	0.556	0.167	11.152	0.001	1.745	1.258	2.418
Glycated hemoglobin							
≥6.5%	−0.374	0.174	4.622	0.032	0.688	0.489	0.967

NIHSS, National Institutes of Health Stroke Scale; TIA, transient ischemic attack.

logistic regression model. Using the forward Wald selection method, the following independent risk factors for 1-year poor prognosis in patients with AIS were finally identified: age ≥70 years (OR=3.303, 95% CI 2.136 to 5.108), NIHSS score of 9–13 (OR=6.913, 95% CI 3.964 to 12.055), NIHSS score of 14–22 (OR=14.730, 95% CI 4.307 to 50.374), NIHSS score of >22 (OR=5.782, 95% CI 1.191 to 28.075), level of consciousness (OR=5.204, 95% CI 2.200 to 12.308), history of stroke or TIA (OR=2.953, 95% CI 1.942 to 4.490), cancer (OR=4.442, 95% CI 1.794 to 10.996), and fasting blood glucose ≥7.0 mmol/L (OR=1.862, 95% CI 1.231 to 2.815). Scores were assigned for each variable by rounding off their β coefficient to the integer score, and 1 point was assigned for each of age ≥70 years, history of stroke or TIA, cancer, and abnormal fasting blood glucose levels ≥7.0 mmol/L, 2 points were assigned for consciousness (lethargy or coma), and 2, 3, and 2 points were assigned for NIHSS scores 9–13, 14–22, and >22, and a new prediction model with a total score of 9 points was developed (table 3).

Performance of the new prediction model

The ROC curves of the new prediction model and the THRIVE, iScore, and ASTRAL scores in predicting 1-year poor prognosis in patients with AIS are shown in figure 1. The AUC values of the models were 0.841 ($p<0.05$, 95% CI 0.814 to 0.866), 0.777 ($p<0.05$, 95% CI 0.738 to 0.815),

Table 3 Multivariate logistic regression analysis and prediction model development

	Assigned scores	β	SE	Wald	Significance	Exp(B)	Exp(B) (95% CI) Lower limit	Exp(B) (95% CI) Upper limit
Age								
≥70	1	1.195	0.222	28.840	0.000	3.303	2.136	5.108
NIHSS score								
<9	0			58.660	0.000			
9–13	2	1.933	0.284	46.429	0.000	6.913	3.964	12.055
14–22	3	2.690	0.627	18.384	0.000	14.730	4.307	50.374
>22	2	1.755	0.806	4.737	0.030	5.782	1.191	28.075
Level of consciousness								
Lethargy or coma	2	1.649	0.439	14.099	0.000	5.204	2.200	12.308
History of stroke or TIA	1	1.083	0.214	25.632	0.000	2.953	1.942	4.490
Cancer	1	1.491	0.462	10.394	0.001	4.442	1.794	10.996
Abnormal fasting blood glucose levels								
≥7.0 mmol/L	1	0.621	0.211	8.6730	0.003	1.862	1.231	2.815

NIHSS, National Institutes of Health Stroke Scale; TIA, transient ischemic attack.

0.831 (p<0.05, 95% CI 0.796 to 0.865), and 0.860 (p<0.05, 95% CI 0.830 to 0.890), respectively. The χ^2 values for the Hosmer-Lemeshow for the new prediction model and the THRIVE, iScore, and ASTRAL scores were 7.337, 2.114, 4.877, and 5.838, respectively (all p>0.05) (table 4).

Comparison of the ROC curves of the new prediction model and the THRIVE, iScore, ASTRAL scores showed that there was a significant difference between the new prediction model and the THRIVE score in the prediction of 1-year poor prognosis in patients with AIS (table 5). Sensitivity, specificity, Youden Index, positive likelihood ratio, and negative likelihood ratio of the models are shown in table 6.

DISCUSSION

Stroke is the second leading cause of disability and the first leading cause of death in adults. AIS accounts for approximately 85% of strokes. Due to its high incidence, prevalence, mortality, and disability rates, AIS poses a heavy burden on patients, families, and the society. Therefore, early prediction of long-term poor outcomes in patients with AIS based on risk factors can help guide early intervention and achieve the best possible outcomes and quality of life for patients with AIS.

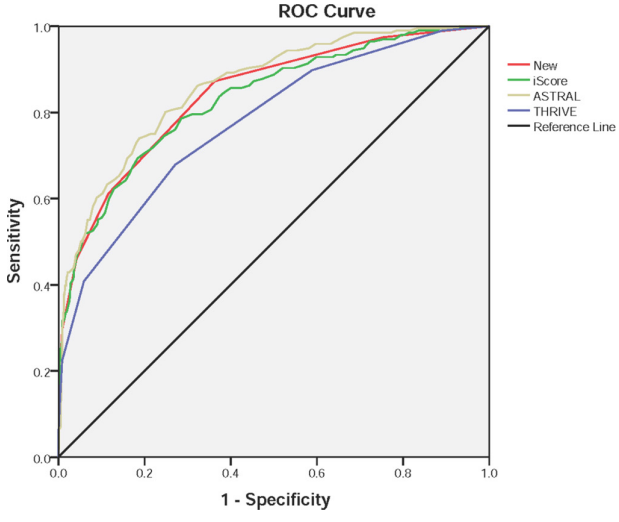

Figure 1 Receiver operating characteristics (ROC) curve of models for prediction of 1-year poor prognosis in patients with acute ischemic stroke.

Poor prognosis after AIS is associated with a combination of multiple risk factors. In the present study, univariate logistic regression analysis showed that there were many statistically significant risk factors for poor prognosis in patients AIS, including age ≥70 years, male, dependency prior to admission, personal history (smoking and drinking history), NIHSS score, TOAST classification, consciousness level, history of stroke or TIA, cerebral infarction, cerebral hemorrhage, TIA, history of hypertension >7 years, coronary heart disease, atrial fibrillation, dementia, cancer, abnormal fasting blood glucose levels ≥7.0 mmol/L, and glycosylated hemoglobin ≥6.5%. Multivariate logistic regression analysis showed that age ≥70 years, NIHSS score, level of consciousness, history of stroke or TIA, cancer, and abnormal fasting blood glucose ≥7.0 mmol/L were independent risk factors for predicting poor prognosis in patients with AIS and were entered into the prediction model.

With the increase in the aging population in China, the prevalence of AIS, which is known to increase with age, will also increase. The highest prevalence of AIS has been found in people over the age of 75, which was 30 times than that in those aged 35–44.[7] Age is considered as a risk factor for poor prognosis after stroke. Shrestha *et al*[8] found that the rates of death and disability in patients with AIS increased by 1.113 times for each 1-year increase in age. Many studies[9–11] have confirmed that age is an independent risk factor for predicting poor prognosis in patients with AIS. In the present study, we found that the risk of poor prognosis in patients aged ≥70 years was three times higher than those aged <70 years, indicating that age is an independent risk factor for poor prognosis in patients with AIS. The overall physical function was lower in older patients than that in younger patients. Older patients present more often with intracranial atherosclerosis, poor collateral

Table 4 Performance of models predicting 1-year poor prognosis in patients with acute ischemic stroke

1-year poor prognosis	New prediction model	THRIVE	iScore	ASTRAL
AUC (95% CI)	0.841 (0.814 to 0.866)	0.777 (0.738 to 0.815)	0.831 (0.796 to 0.865)	0.860 (0.830 to 0.890)
H-L test (p value)	7.337 (p=0.501)	2.114 (p=0.549)	4.877 (p=0.771)	5.838 (p=0.665)

AUC, area under the receiver operating characteristics curve; H-L, Hosmer-Lemeshow.

circulation, and many other complications, so older patients are more likely to have serious poor outcomes after AIS.

The NIHSS is the most widely used scale to assess the severity of neurologic functional deficits after stroke. In general, patients with high NIHSS scores have more severe symptoms during the acute phase of AIS, such as large-area cerebral infarction associated with cerebral edema and elevated intracranial pressure. Brain hypoxia or ischemia can aggravate central nervous system damage, resulting in serious poor prognosis. Many studies[12–14] have found that NIHSS score is an independent risk factor for poor prognosis in patients with AIS. Shrestha *et al*[8] found that one-unit increase in NIHSS score increased the odds of death and disability at 3 months after AIS by 1.55 times, which is an independent risk factor for predicting poor prognosis at 3 months in patients with AIS. Jain *et al*[15] showed that for every one-point increase in NIHSS score, there was a 2.3 times increased likelihood of mortality and 3 times increased likelihood of disability in patients with AIS. The results from Lima *et al*[16] showed that high NIHSS score at admission is an independent risk factor for poor prognosis at 3 months in patients with AIS (OR: 1.19, 95% CI 1.11 to 1.28). In the present study, the new prediction model included NIHSS scores, which indicated that the severity of stroke can affect the overall poor prognosis in patients with AIS.

The large-area cerebral infarction can cause poor prognosis in patients with AIS, such as extensive damage to brain tissue and impaired consciousness. Li *et al*[17] found that the rates of mortality/disability at 3 months were 12.7 times higher in patients with AIS with impaired consciousness prior to admission than that of patients with AIS without impaired consciousness (95% CI 8.3 to 19.5). Hénon *et al*[18] found that patients with AIS with acute impaired consciousness (evaluated at 3 hours after admission) had a 1.23 times higher 6-month mortality rate than patients with AIS without acute impaired consciousness (95% CI 0.64 to 2.36). But Chandra *et al*[19] reported that there was no correlation between impaired consciousness and poor prognosis in patients with AIS. In this study, we found that patients with AIS with impaired consciousness were at high risk for poor prognosis, indicating that impaired consciousness is an independent risk factor for poor prognosis in patients with AIS.

Stroke history is also a risk factor for poor prognosis after AIS. A study from Liang *et* al[20] showed that among 2557 patients with AIS, those with a history of stroke had an increased risk of poor prognosis at 14 days after discharge (OR: 1.27, 95% CI 1.03 to 1.58). The occurrence of TIA before stroke is beneficial to improve the ability of cerebral vessels to adapt to ischemia, and establish collateral circulation which is a protective factor for patients. In the present study, we found that history of stroke or TIA is an independent risk factor for poor prognosis in patients with AIS.

The results from studies assessing the association between cancer and poor prognosis in patients with AIS are inconsistent. Navi *et al*[21] found that cancer is associated with a short-term increased risk of stroke, especially lung cancer, pancreatic cancer, and colorectal cancer. De Bruin *et al*[22] found that Hodgkin's lymphoma was associated with a long-term increased risk of stroke. Tsai *et al*[23] found that the 5-year risk of developing AIS was 2.73 in patients with cervical cancer aged <51 years and was 1.37 in patients with cervical cancer aged ≥51 years. In the present study, our results showed that cancer is an independent risk factor for poor prognosis after AIS, which is consistent with the above results. But Cutting *et al*[24] found that cancer is not an independent risk factor for 3-month poor prognosis after AIS.

A number of studies have demonstrated that diabetes is an independent risk factor for poor prognosis after AIS.[25 26] Pan *et al*[27] found that diabetes was significantly associated with 1-year poor prognosis of AIS (OR: 1.51, 95% CI 1.28 to 1.77). Our results showed that patients with AIS with FBG ≥7.0 mmol/L at admission were at higher risk for poor prognosis.

According to multivariate regression analysis, the β coefficients of each independent risk factor (age ≥70 years, NIHSS score, consciousness level, history of stroke or TIA, cancer, abnormal FGB ≥7.0 mmol/L) were rounded to the nearest integer value, and thus a new prediction model with a maximum score of 9 was developed. The results of Hosmer-Lemeshow test (p>0.05) indicated that the model had a good fit, and the new prediction model was better able to predict 1-year poor prognosis in patients with AIS compared with one scale (THRIVE) only.

ROC curve analysis was used to compare the performance of the new prediction model with the THRIVE, iScore, and ASTRAL scores, and the results showed that the AUC value of the new prediction model was significantly higher than the THRIVE score. However, no significant difference was found between the new prediction model and iScore and ASTRAL scores (p>0.05). The THRIVE score is mainly based on prehospital stroke severity (NIHSS score) and associated risk

Table 5 Comparison of the ROC curves of the new prediction model versus THRIVE, iScore and ASTRAL in predicting 1-year poor prognosis in patients with acute ischemic stroke

1-year poor prognosis	New prediction model vs THRIVE	New prediction model vs iScore	New prediction model vs ASTRAL
Z value	3.639	0.697	1.224
P value	<0.001	0.4857	0.2210

ROC, receiver operating characteristics curve.

Table 6 Cut-off value, sensitivity, specificity, YI, LR+ and LR− of models

Poor prognosis	Cut-off value	Sensitivity	Specificity	YI	LR+	LR−
New prediction model	1	87.2	63.7	50.96	2.40	0.20
THRIVE	2	67.86	72.92	40.77	2.51	0.44
iScore	104	69.39	81.60	50.98	3.77	0.38
ASTRAL	21	75.00	78.65	53.65	3.51	0.32

LR+, positive likelihood ratio; LR−, negative likelihood ratio; YI, Youden Index.

factors for stroke (hypertension, diabetes, atrial fibrillation) to predict poor outcome in patients, but it lacks indicators that reflect the severity and extent of cerebral infarction and comorbid conditions before admission.

The new prediction model can assess the severity of stroke (NIHSS score) at admission and the level of consciousness that reflects the severity of cerebral infarction, as well as atherosclerosis risk factors (including history of diabetes, stroke history, or TIA), history of cancer, and comorbid medical conditions. Therefore, the new prediction model can accurately predict 1-year poor prognosis of patients with AIS in China. All variables in the model are simple and easily obtained, and the prediction model has a lower total score, which is easy for clinicians to memorize, and has obvious advantages in the early detection of long-term poor prognosis in patients with AIS.

This study has some limitations which have to be pointed out. Most of the patients included in this study are residents living near the hospital, and a few patients came from different areas of China, which is a limitation in terms of representativeness. Further studies need to be done with a larger, more diverse sample size in order to confirm the findings of the current study.

In summary, the new prediction model can accurately predict 1-year poor prognosis in patients with AIS in China, but the performance of the prediction model should be further assessed in external and internal validation studies.

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