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Study on the risk prediction for cerebral infarction after transient ischemic attack

A STROBE compliant study

Chenhao Zhang, MD[a], Yanjing Zang, MD[b], Lei Hu, MD[a], Qin Song, MD[c], Weidong Zhao, MD[c], Chunliang Zhang, MD[a], Hongshun Liu, MD[a], Fang Gu, MD[d,*]

Abstract

Transient ischemic attack (TIA) is often recurrent, and about one-third of patients will progress to cerebral infarction. Rapidly identifying high-risk patients is pivotal to prevent the development of cerebral infarction. Therefore, this study aimed to evaluate the value of $ABCD^2$ score, $ABCD^2$ score combined with magnetic resonance diffusion weighted imaging (DWI) and intracranial arterial magnetic resonance angiography (MRA) in predicting cerebral infarction after 2 to 30 days of transient ischemic attack (TIA).

182 patients with TIA from August 2011 to August 2014 were enrolled as study subjects, and their clinical data, test results of DWI and MRA were collected. The incidence of cerebral infarction was observed at 2 days, 7 days and 30 days after TIA in patients with TIA, through scoring according to the 7-point $ABCD^2$ score method proposed by Johnston. The relationship between $ABCD^2$ score, performances of DWI and MRA and the early incidence of cerebral infarction after TIA was analyzed. The accuracy rating of $ABCD^2$ score and $ABCD^2$ + DWI + MRA score used for predicting the early incidence of cerebral infarction after TIA were compared with each other.

The incidence of cerebral infarction after TIA was 19 cases (10.4%) in 2 days, 42 cases (23.1%) in 7 days, 56 cases (30.8%) in 30 days respectively. For the $ABCD^2$ score of incidence of cerebral infarction 2 to 30 days after TIA, that of those with high risk was higher than that with medium risk, and that with the medium risk was higher than that with low risk ($P < .05$). The area under the curve of $ABCD^2$ + DWI + MRA score and $ABCD^2$ score predicting the incidence of cerebral infarction was: in 2 days: 0.782 and 0.748, in 7 days: 0.839 and 0.801, in 30 days: 0.780 and 0.757, $P < .05$.

Compared with $ABCD^2$ score, $ABCD^2$ score combined with DWI and MRA can further improve the accuracy of prediction for cerebral infarction after TIA.

Abbreviations: DWI = diffusion weighted imaging, MRA = intracranial arterial magnetic resonance angiography, TIA = transient ischemic attack.

Keywords: $ABCD^2$ score, cerebral infarction, magnetic resonance angiography, magnetic resonance diffusion weighted imaging, transient ischemic attack

1. Introduction

Transient ischemic attack (TIA)'s clinical symptoms can be fully restored, but some patients will develop cerebral infarction in early days following the TIA. Therefore, for patients with TIA, a comprehensive etiology check should be conducted as early as possible to assess the relevant risk factors, to predict the risk of early cerebral infarction after TIA, so as to take measures as soon as possible to prevent cerebral infarction. In 2007, Johnston et al[1] proposed the simple scale "$ABCD^2$" score method based on clinical features to predict the occurrence of short-term cerebral infarction after TIA, but the assessment did not include imaging studies, A number of studies[2,3] had shown that positive diffusion weighted imaging (DWI) on MRI is associated with increased recurrent stroke risk in TIA patients, acute MRI aids in TIA risk stratification and diagnosis; large-artery disease, lesions detected on DWI were found to be independent predictors of subsequent stroke after TIA, and incorporating DWI positivity and etiology (large-artery atherosclerosis, cardioembolism, small-artery occlusion and so on) of TIA into the $ABCD^2$ score can improve the ability to predict stroke and death within 6 months after TIA. Therefore, we evaluated the value of $ABCD^2$ score as well as the $ABCD^2$ score combined with DWI and intracranial arterial magnetic resonance angiography (MRA) for predicting the risk of cerebral infarction in 2 days, 7 days, and 30 days after TIA with the hospitalized TIA patients as the subjects, to explore the risk factors of cerebral infarction in TIA patients, so as to evaluate and treat TIA patients and reduce the occurrence of cerebral infarction.

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[a] Department of Neurology, [b] Department of Geriatric, [c] Second Department of Neurology, the Second Hospital of Baoding city, [d] Fifth Department of Internal Medicine, Baoding Children's Hospital, Baoding, Hebei, China.

[*] Correspondence: Fang Gu, Fifth Department of Internal Medicine, Baoding Children's Hospital, Baoding 071051, Hebei, China (e-mail: drfanggu@sina.com).

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2. Subjects and methods

2.1. Subjects

The TIA patients hospitalized in the No. 2 Hospital of Baoding from August 2011 to August 2014 were continuously selected as the objects of the study. This study had been approved by the Clinical Research Ethics Committee of the No. 2 Hospital of Baoding.

TIA diagnostic criteria[4–6]: TIA was defined based on symptom duration lasting less than 24 hours. Transient focal neurologic system defect symptoms and signs consistent with a known vascular territory sustaining for several minutes or hours, generally lasting for 10 to 15 minutes, mostly recovered within 1 hour, a duration of less than 24 hours, then recovering completely.

TIA patient inclusion criteria:

(1) Meet the TIA diagnostic criteria;
(2) Patient consent and sign informed consent;
(3) Clear consciousness, the spirit of normal, no double ears deafness, is checked cooperatively.

TIA patient exclusion criteria:

(1) Partial epilepsy, migraine, multiple sclerosis;
(2) Inner ear vertigo such as Meniere's disease, benign paroxysmal positional vertigo, syncope, hypoglycemia, hypotension, anemia, Adams-Strokes syndrome;
(3) Cerebral hemorrhage, brain tumors, brain trauma, chronic subdural hematoma;
(4) Patients had no dementia, hematologic diseases, and no history of gastrointestinal bleeding.
(5) MRI examination contraindication;
(6) cannot be followed up.

2.2. Observation method

The patients were inquired in detail and examined by designated neurological physician of the TIA clinical symptoms and signs, TIA duration, times of TIA episodes and so on. For patients with repeated episodes of TIA, the $ABCD^2$ score was taken depending on the longest TIA episode. The specialist from medical imaging department is responsible for imaging and blind method to read for TIA patients, and recording the results of the examination as well. In this study, all patients experienced first DWI and MRA examination within 24 hours after hospitalization, the clinical signs of all the patients developed cerebral infarction were in consistence with head CT / MRI, and all are the new onset cerebral infarction lesions (A second MRI showed a new lesion to diagnose cerebral infarction); the 2nd day, 7th day and 30th day of course of disease were seen as the end points for outcome events observation.

2.3. "$ABCD^2$" score method

The scoring system proposed by Johnston et al[1] was used to predict the incidence of cerebral infarction in patients with TIA, specifically including:

1) where age (age) ≥ 60 years old, 1 point;
2) blood pressure: where systolic blood pressure ≥ 140mmHg and / or diastolic blood pressure ≥ 90 mmHg, 1 point;
3) clinical features: where unilateral limb weakness, 2 points; language barrier without limb weakness, 1 point; other symptoms, 0 points;
4) duration of symptoms: that ≥ 60 minutes, 2 points; 10 to 59 minutes, 1 point; < 10 minutes, 0 point;
5) diabetes, 1 point. According to $ABCD^2$ score results, the patients were divided into low risk (≤3 points), moderate risk (4–5 points) and high risk (≥6 points).

The risk of cerebral infarction was evaluated according to the $ABCD^2$ score of each patient. The 2nd day, 7th day, and 30th day of course of disease were seen as the end points for outcome events observation.

2.4. "$ABCD^2$ + DWI + MRA" score method

"ABCD2 + DWI + MRA" scoring criteria are that on the basis of ABCD2 score method. Head MRI scan was conducted with 1.5-T MRI equipment (Signa HDE; GE company) at 2 days of the disease onset, and at 30-day follow-up to visualize new lesions. The imaging sequences included sagittal T1-FLAIR, axial TI-FLAIR, T2-FLAIR, T2-FSE and diffusion weighted spin echo plane imaging (DWI). High signal on DWI was confirmed by ADC maps to represent true restricted diffusion, and not T2 shine-through. The abnormal (positive) DWI was defined as an area of focal hyperintense signal on the DWI, and the high signal intensity was located in the blood supply area of the blood vessels associated with the clinical symptoms,[7–12] and was assigned a score of 3 points, normal, 0 points.[13–15]

Magnetic resonance angiography (MRA) uses 3 dimension time of flight (3D-TOF) technique to detect the intracranial vessels. The degree of stenosis on MRA was measured according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria: mild stenosis (<50%), moderate stenosis (50% to 70%), severe stenosis to occlusion (> 70% or complete loss of signal), stenosis rate (%) = (1 − narrowest diameter / diameter of narrow distal artery) × 100%.[16,17] The lesions of intracranial vessels on MRA were graded: 0 point (stenosis <50%) and 2 point (stenosis ≥ 50%).[15] The assessment of the intracranial blood vessels location included the internal carotid artery, middle cerebral artery, anterior cerebral artery, vertebral artery, basilar artery and brain posterior artery.

The images were read in blind method by the physicians from the magnetic resonance room of our hospital medical imaging department. For those that vascular examination indicated severe lesions, further digital subtraction angiography (DSA) examination should be conducted.

2.5. Treatment and follow-up methods

After TIA patients hospitalized, the underlying diseases (hypertension, diabetes, coronary heart disease, etc.) were treated symptomatically, non-cardiac TIA were treated with oral enteric-coated aspirin 100 mg, atorvastatin 20 mg, once a day; for cardiogenic patients, with oral administration of warfarin 2.5 to 5 mg, and the dosage was adjusted according to the international standardized ratio (INR), so that INR was in the range of 2.0 to 3.0; flunarizine hydrochloride 5 mg was given orally once a day before going to bed; intravenous transfusion of Ginkgo biloba preparation 20 ml + 0.9% saline 250 ml once a day for 7 days; intravenous transfusion of Ozagrel sodium 80 mg + 0.9% saline 250 ml twice a day for 7 days. For those that needed intravenous thrombolysis, alteplase 0.6 mg / kg was given for treatment. Post-discharge routine oral administration of enteric-coated aspirin

100 mg/d or clopidogrel 75 mg/d, atorvastatin 20 mg for once a day. The patients were followed up at 2 days, 7 days, and 30 days after the onset of the disease. The presence of cerebral infarction, cerebral hemorrhage and death due to various causes were recorded.

2.6. Statistical methods

SPSS13.0 statistical software was used for data processing, and mean ± standard deviation represents the measurement data; adopt χ^2 test to analysis count data; employ the ROC curves to assess the degree of accuracy of $ABCD^2$ score and "$ABCD^2$ + DWI + MRA" score for predicting the risk of cerebral infarction of TIA patients respectively, and the difference was statistically significant, $P < .05$.

3. Results

3.1. General information

From August 2011 to August 2014, in patients hospitalized there were total of 194 patients meeting TIA diagnostic criteria, of which 2 patients failed follow-up, 10 patients did not complete the magnetic resonance examination according to requirements. According to the inclusion and exclusion criteria, 182 patients with TIA were enrolled and all experienced DWI and MRA examination within 24 hours after hospitalization, including 114 males and 68 females, aged 21 to 89 years, with mean age (56.02 ± 12.05) years.

There were 182 cases of intracranial artery stenosis, more than 2 different vascular stenosis were found in 50 cases at the same time. One hundred four cases were in internal carotid artery system, 49 cases were in vertebrobasilar artery system; 29 cases were in internal carotid - vertebrobasilar artery system. The stenosis of the internal carotid artery caused amaurosis, limb weakness, aphasia, dizziness, and the stenosis of the anterior cerebral artery caused weakness, aphasia and dizziness. The stenosis of the posterior cerebral artery caused blurred visual substance, unilateral limb weakness, dizziness, sensory disturbance, dysarthria, consciousness disorder, diplopia, vertebrobasilar stenosis caused blurred visual substance, limb weakness, dizziness, sensory disturbance, dysarthria, disturbance of consciousness, diplopia.

The patients were treated with drugs controlling the basic diseases, anti-platelet aggregation, statins, anticoagulant drugs; hospitalization duration was 7 to 31 days, with an average of 13.04 ± 5.12 days. All patients underwent cervical vascular ultrasonography. The characteristics of the patients were shown in Table 1.

Table 1

Characteristics of the patients.

	Patients with transient ischemic attack
Gender (n)	
Male	114
Female	68
Age (year)	56.02 ± 12.05
Hospitalization duration	13.04 ± 5.12 d
Main clinical manifestations	
Unilateral limb weakness	89
Dysarthria or aphasi	38
Dizziness	73
Hemisensory disturbance	22
Blurred vision and amaurosis	7
Disturbance of consciousness	8
Diplopia	3
Medical history	
Stroke	11
Hypertension	84
Diabetes	39
Ischemic heart disease	11
Atrial fibrillation	11
DWI abnormalities	
Abnormality in the basal ganglia	47
Abnormality in the corona radiata	29
Abnormality in the cerebral lobe	17
Abnormality in the brain stem	10
Abnormality in the cerebellum	5
Abnormality in the two different parts at the same time	29
Normal DWI	103
Intracranial artery stenosis ≥ 50%	
Left internal carotid artery stenosis	15
Right internal carotid artery stenosis	17
Left middle cerebral artery	10
Right middle cerebral artery	13
Left anterior cerebral artery	1
Right anterior cerebral artery	2
Left vertebral artery	2
Right vertebral artery	3
Left posterior cerebral artery	14
Right posterior cerebral artery	16
Basilar artery	5
Intracranial artery stenosis <50%	
Left internal carotid artery stenosis	21
Right internal carotid artery stenosis	21
Left middle cerebral artery	14
Right middle cerebral artery	13
Left anterior cerebral artery	8
Right anterior cerebral artery	5
Left vertebral artery	3
Right vertebral artery	4
Left posterior cerebral artery	14
Right posterior cerebral artery	15
Basilar artery	16

3.2. The incidence of cerebral infarction

In 182 cases, the incidence of cerebral infarction after TIA was of 19 cases (10.4%) in 2 days (≤ 2 days), 42 cases (23.1%) in 7 days (≤ 7 days), 56 cases (30.8%) in 30 days (7–30 days). No cerebral hemorrhage occurred. There was one case of acute myocardial infarction and one case of death (recurrent cerebral infarction).

3.3. The incidence of cerebral infarction of $ABCD^2$ score, DWI performance and intracranial artery stenosis

According to $ABCD^2$ score, the comparison of the incidence of cerebral infarction between TIA patients with low risk (≤ 3 points), and medium risk (4–5 points) and high risk (≥ 6 points), the incidence of cerebral infarction for patients with high risk was higher than that with medium risk, and that with medium risk was higher than that with low risk, and the difference was statistically significant ($P < .001$). The incidence of cerebral infarction was significantly higher in abnormal DWI patients than that in normal subjects ($P < .001$). The incidence of cerebral infarction in 30 days was significantly higher in patients with ≥ 50% artery stenosis than that in patients with < 50% artery

Table 2

Comparison of the incidence of cerebral infarction of different ABCD^2 score, DWI performance, and artery stenosis in TIA patients.

Group	TIA (cases)	2 days (cases/%)	7 days (cases/%)	30 days /cases (%)
ABCD2 score				
Low risk	111	3 (2.7)	8 (7.2)	12 (10.8)
Medium risk	61	9 (14.8)*	26 (42.6)*	36 (59.0)*
High risk	10	7 (70.0)*	8 (80.0)*	8 (80.0)*
DWI performance				
Normal	103	2 (1.9)	7 (6.8)	9 (8.7)
Abnormal	79	17 (21.5)†	35 (44.3)†	47 (59.5)†
Artery stenosis				
<50%	84	7 (8.3)	17 (20.2)	17 (20.2)
≥50%	98	12 (12.3)‡	25 (25.5)‡	39 (39.8)‡

* $P<.001$, comparison between ABCD^2 score >3 points and ABCD^2 score ≤ 3 points.
† $P<.001$, comparison between patients with DWI abnormalities and the normal DWI patients.
‡ $P=.013$, comparison between artery stenosis $\geq 50\%$ and artery stenosis $<50\%$.

Table 3

TIA patients with different ABCD^2 score, DWI performance 2d, 7d and 30d cerebral infarction incidence [Cases (%)] comparison.

DWI performance	TIA (cases)	2 days (cases/%)	7 days (cases/%)	30 days (cases/%)
Normal				
ABCD^2 score ≤ 3 points	71	0 (0)	1 (1.4)	3 (4.2)
ABCD^2 score >3 points	32	2 (6.3)	6 (18.8)	6 (18.8)
Abnormal				
ABCD^2 score ≤ 3 points	40	3 (7.5)*	7 (17.5)*	9 (22.5)*
ABCD^2 score >3 points	39	14 (35.9)†,‡	28 (71.8)†,‡	38 (97.4)†,‡

* $P=.008$, ABCD^2 score ≤ 3 points, comparison between patients with DWI abnormalities and the normal.
† $P<.001$, ABCD^2 score >3 points, comparison between patients with DWI abnormalities and the normal DWI patients.
‡ $P<.001$, comparison between DWI abnormal ABCD^2 score >3 Points and ABCD^2 score ≤ 3 points.

stenosis, and the difference was statistically significant ($P=.007$) (Table 2).

3.4. The value of ABCD^2 score combined with DWI in predicting cerebral infarction in patients with TIA from 2 days to 30 days

Table 3, in the patients with low risk ABCD^2 score ≤ 3 points, the incidence of cerebral infarction of DWI abnormalities was significantly higher than that of normal DWI ($P<.05$). In TIA patients with medium risk and high risk ABCD^2 score >3, the incidence of cerebral infarction of DWI abnormalities was significantly higher than that of normal DWI. The difference was statistically significant ($P<.05$). With DWI abnormalities, the incidence of cerebral infarction of ABCD^2 score >3 points was higher than that of ABCD^2 score ≤ 3, the difference was statistically significant ($P<.05$).

3.5. The value of ABCD^2 score combined with MRA for predicting the occurrence of cerebral infarction within 2 days to 30 days in patients with TIA

As shown in Table 4, in TIA patients with low-risk ABCD^2 score ≤ 3 points, the incidence of cerebral infarction was significantly higher in the patients with $\geq 50\%$ artery stenosis than that in $<50\%$ artery stenosis, and the difference was statistically significant ($P=.017$). In TIA patients with medium risk and high risk ABCD^2 score >3 points, the incidence of cerebral infarction was significantly higher in the patients with $\geq 50\%$ artery stenosis than that in $< 50\%$ artery stenosis, and the

Table 4

Comparison of incidence of cerebral infarction within 2d, 7d and 30d in TIA patients with different ABCD^2 score combined with MRA performance.

MRA artery stenosis degree	TIA (cases)	2 days (cases/%)	7 days (cases/%)	30 days (cases/%)
<50%				
ABCD^2 score ≤ 3 points	47	0 (0)	1 (2.1)	2 (4.2)
ABCD^2 score >3 points	37	7 (18.9)	15 (40.5)	15 (40.5)
≥50%				
ABCD^2 score ≤ 3 points	64	3 (4.7)*	7 (10.9)*	10 (15.6)*
ABCD^2 score >3 points	34	9 (26.5)†,‡	18 (52.9)†,‡	29 (85.3)†,‡

* $P=.017$, ABCD^2 score ≤ 3 points, artery stenosis $\geq 50\%$ and artery stenosis $<50\%$ were compared.
† $P<.001$, ABCD^2 score >3 points, artery stenosis $\geq 50\%$ and artery stenosis $<50\%$ were compared.
‡ $P<.001$, artery stenosis $\geq 50\%$, ABCD^2 score >3 points and ABCD^2 score ≤ 3 points were compared.

difference was statistically significant ($P < .001$). In the patients with ≥50% artery stenosis, the incidence of cerebral infarction was higher in the patients with $ABCD^2$ score >3 points than that in $ABCD^2$ score ≤3 points, and the difference was statistically significant ($P < .001$).

3.6. The value comparison of $ABCD^2$ score combined with DWI and MRA ("$ABCD^2$ + DWI + MRA" score) and $ABCD^2$ score for predicting the incidence of cerebral infarction within 2d to 30d in TIA patients

The area under the curve of "$ABCD^2$ + DWI + MRA" and $ABCD^2$ score predicting the occurrence of cerebral infarction in 2 days was 0.782 (0.683–0.857) ($P = .000$) and 0.748 (0.656–0.847) ($P = .000$), respectively, as shown in Figure 1A; The area under the curve of "$ABCD^2$ + DWI + MRA" and $ABCD^2$ score predicting the occurrence of cerebral infarction in 7 days was 0.839 (0.751–0.898) ($P = .000$) and 0.801 (0.717–0.885) ($P = .000$), as shown in Figure 1B. The area under the curve of"$ABCD^2$ + DWI + MRA" and $ABCD^2$ score predicting the occurrence of cerebral infarction in 30 days was 0.780 (0.693–0.867) ($P = .000$) and 0.757 (0.666–0.848) ($P = .000$), respectively, as shown in Figure 1C.

4. Discussion

Transient ischemic attack (TIA) is a transient, reversible neurological deficits attack due to focal cerebral or retinal ischemia and without acute infarction. The most clinical symptoms of TIA will recover within 1 to 2 hours, with no neurological deficits symptoms and signs left, no evidence of acute cerebral infarction in images. For its etiology and

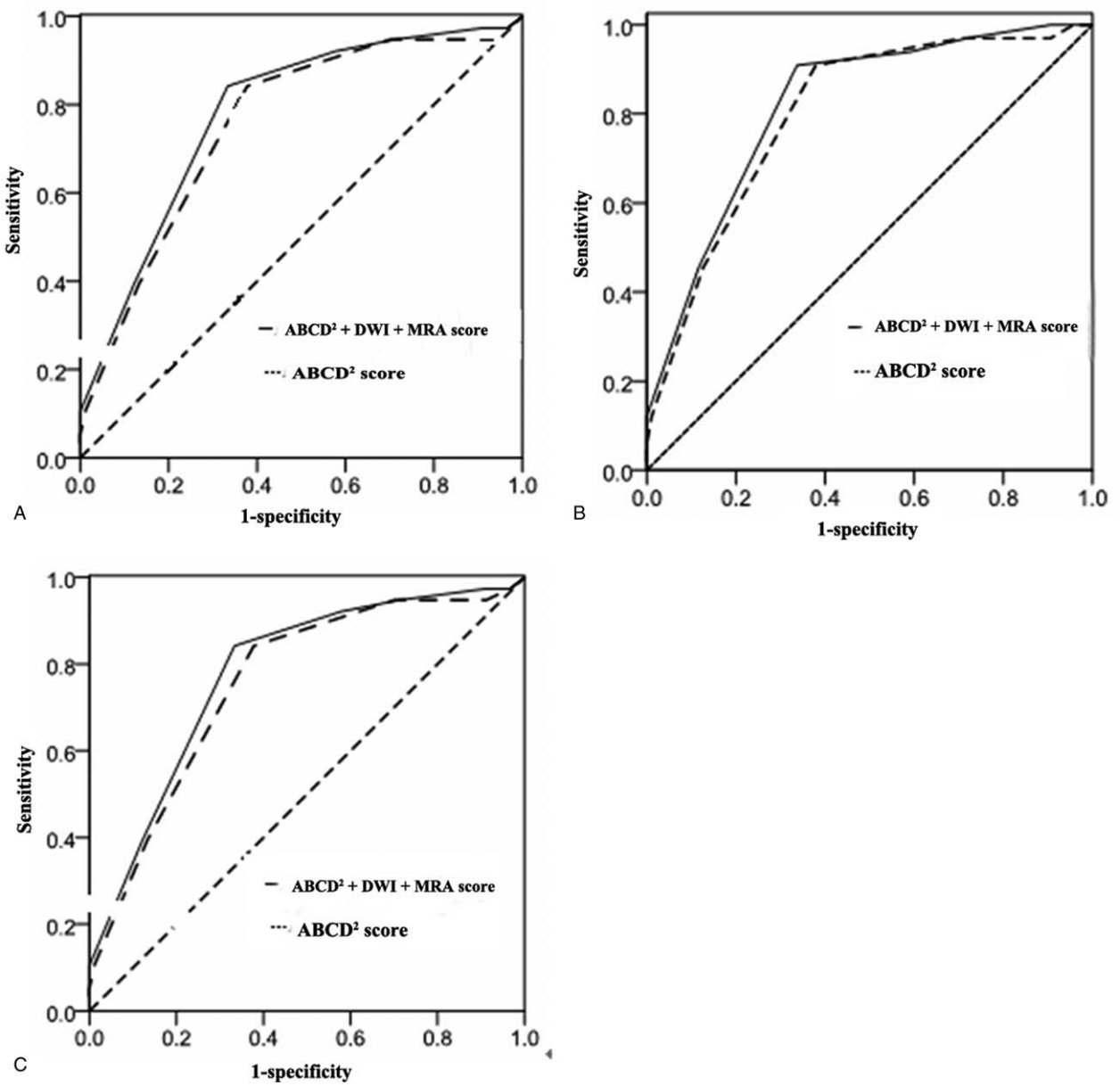

Figure 1. ROC curve of "$ABCD^2$ + DWI + MRA" score and $ABCD^2$ score predicting the incidence cerebral infarction in 2 days (A), 7 days (B) and 30 days (C).

mechanism, there are many theories such as microembolization, large-artery atherosclerosis,[3] hemodynamic changes. TIA is often recurrent, and about one-third of patients will progress to cerebral infarction. Cerebral infarction, also called ischemic stroke, occurs as a result of disrupted blood flow to the brain due to problems with the blood vessels that supply it. From Table 2, the incidence of cerebral infarction was 30.8% (56/182) in 30 days, 23.1% (42/182) in 7 days and 10.4% in 2 days (19/182)) after TIA in 182 patients in this group, They were higher than the incidence reported in the literature;[18–20] the reasons may be related to small size of samples on the one hand; and the other hand, may be related to more serious conditions of illness of the hospitalization subjects. This suggests that TIA patients' cerebrovascular disease is not stable, with a higher risk of TIA recurrence and early stroke. Therefore, TIA is a "small stroke, a big risk"; an early risk stratification assessment for TIA patients, rapidly identifying and treating high-risk patients are vital to prevent the development of cerebral infarction. It supported that TIA triage directly from the emergency department with acute MRI and neurological consultation.[2] However, Ginko infusions and Ozagrel infusion were used for 7 days in this study, both of which have anti-platelet aggregation effects; in theory, the incidence of cerebral infarction should be reduced, but increased, and this is the limitation of this study. Therefore, it is necessary to carry out further studies including patients who did not receive intravenous transfusion of Ginko infusions and Ozagrel.

Johnston et al[1] proposed a simple scale $ABCD^2$ score method to predict the risk of early cerebral infarction after the onset of TIA, and this study verified this method; Table 2 showed that in terms of the incidence of cerebral infarction, $ABCD^2$ score with higher risk was higher than that with medium risk, and that with medium risk was higher than that with low risk, $P < .05$, which indicated that the occurrence of cerebral infarction in patients with high and medium $ABCD^2$ score was significantly increased, which proved that the high-risk patients could be screened out by $ABCD^2$ score method and this method has a certain clinical value.

With the development of medical imaging technology and the deepening of research, it was found that $ABCD^2$ score model had its shortcomings: predictive factors were mainly clinical symptoms and history, lack of participation of auxiliary examination, and some low-risk patients with abnormal imaging still had very high incidence of cerebral infarction.[20] DWI has a very high sensitivity and specificity to early and super-early cerebral ischemia, it can distinguish the acute and chronic cerebral ischemia, and the researches[21,22] reported that the overall incidence of DWI abnormalities in TIA patients was 37% to 49%; from Table 2 showed that the incidence of DWI abnormal lesions found after examination in this group was 43.4% (79/182), consistent with it. From Table 3, the incidence of early cerebral infarction in the TIA patients with abnormal DWI was significantly higher than that in the normal group, and the incidence of cerebral infarction in patient $ABCD^2$ score > 3 points was significantly higher than that in the patients with $ABCD^2$ score ≤ 3 points, $P < .05$, which indicated that the incidence of cerebral infarction was significantly increased in patients with DWI abnormalities. However, it is still controversial whether DWI abnormalities mean cerebral infarction; in our study, the infarction focus hadn't been found in some patients in the subsequent MRI reexaminations, which indicated that if the cerebral blood supply was restored early, part of damages showed in DWI may be completely reversible, and thrombolytic therapy that we conducted for some TIA patients also confirmed the fact. Some studies also showed that all abnormal lesions in DWI in hyperacute phase were still persistent in the subacute phase, indicating that cerebral infarction had occurred.[23,24] The clinical application value of DWI needs further study. MRA examination can better show intracranial blood vessels, although the artifacts may occur for small vascular lesions, compared with the DSA examination, it is non-invasive, and can show intracranial Willis vascular ring lesions more clearly than intracranial Doppler ultrasound, is worthy of widely clinical promotion. From Table 4, in patients with $ABCD^2$ score ≤ 3 points after TIA, the incidence of cerebral infarction of intracranial artery stenosis $\geq 50\%$ was significantly higher than that in patients with intracranial artery stenosis $<50\%$ ($P < .05$); in patients with intracranial arterial stenosis $\geq 50\%$, the incidence of cerebral infarction of $ABCD^2$ score > 3 points was significantly higher than that in patients with $ABCD^2$ score ≤ 3 points ($P < .05$), this consistented with previous study,[15] which indicated that the more serious the degree of intracranial arterial disease and the higher the ABCD2 score, the higher the incidence of cerebral infarction; and showed that ABCD2 score was positively correlated with the degree of arterial stenosis, this support the study[25] indicated that ABCD and ABCD2 scores with similar accuracy for artery stenosis were both independent predictors for various categories of artery stenosis. So timely detection and evaluation of vascular disease, and giving the corresponding treatment was very important for improving the prognosis of patients with TIA.[15] This study showed that in low-risk group (ABCD2 score ≤ 3 points) of TIA patients, the incidence of cerebral infarction was still high in the patients with DWI abnormalities and artery stenosis $\geq 50\%$. Thus, in the study that "ABCD2 + DWI + MRA" scoring method was used to predict the risk of cerebral infarction in TIA patients, Figures 1, suggested that the combination of ABCD2 score and DWI and MRA imaging could further improve the accuracy of predicting cerebral infarction, especially in predicting the incidence of cerebral infarction in 7 days after TIA. The results of Table 4 and Figures 1 are in agreement with those findings in the previous study, which indicated that large-artery disease was independent predictors of future stroke after TIA and incorporating etiology of TIA and DWI positivity into the ABCD2 score can improve the ability to predict stroke and death within 6 months after TIA.[3]Figure 1 showed that the ROC curves of "ABCD2 + DWI + MRA" were closer to the upper left corner than those of "ABCD2", indicated that "ABCD2 + DWI + MRA" were more valuable than "ABCD2" in predicting cerebral infarction after TIA. The value of AUC of "ABCD2 + DWI + MRA" (0.782 in 2 days, 0.839 in 7 days, 0.780 in 30 days) were larger than those of "ABCD2" (0.748 in 2 days, 0.801 in 7 days, 0.757 in 30 days), which indicated that "ABCD2 + DWI + MRA" were more accurate than "ABCD2" in predicting cerebral infarction after TIA. This seems to be consistent with the high incidence of cerebral infarction after TIA with abnormal DWI in Table 2. However, due to the small size of samples in this study, no obvious difference can be shown from the ROC curve, and more serious conditions of illness of the hospitalization subjects in this study, resulting in the difference between Table 2 and Figure 1, which is also the limitation of this study, so we should increase the samples and adding TIA patients with mild illness for further study.

The independent risk factors for cerebral infarction after TIA are not yet fully defined and their prognostic score models are also being improved.[7,13–15] and in patients with TIA, despite an association between ABCD and ABCD2 scores and underlying craniocervical artery stenosis, but the clinical utility was limited by unsatisfactory sensitivity and specificity.[25] This study shows

that compared with ABCD2 score, ABCD2 score combined with DWI and MRA can further improve the accuracy of predicting cerebral infarction after TIA. However, the sample size of this study is small, and patients with initial DWI changes were included in the study, therefore, to verify the results, further studies needs to be carried out using a larger sample size and excluding patients with initial DWI changes.

Author contributions

Conceptualization: Fang Gu.
Data curation: Chenhao Zhang, Yanjing Zang, Lei Hu, Qin Song, Weidong Zhao, Hongshun Liu, Fang Gu.
Formal analysis: Chenhao Zhang, Yanjing Zang, Lei Hu, Qin Song, Weidong Zhao, Hongshun Liu, Chunliang Zhang.
Investigation: Chenhao Zhang, Lei Hu, Fang Gu.
Methodology: Chenhao Zhang, Hongshun Liu.
Project administration: Fang Gu.
Resources: Lei Hu, Qin Song, Weidong Zhao, Hongshun Liu, Chunliang Zhang.
Software: Yanjing Zang, Qin Song, Weidong Zhao, Chunliang Zhang.
Supervision: Yanjing Zang.
Validation: Chunliang Zhang.
Writing – original draft: Chenhao Zhang.
Writing – review & editing: Fang Gu.

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