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Predictive Value of Head-Neck CTA Combined with ABCD2 Scale Score for Patients with Cerebral Infarction of Vertebrobasilar Transient Ischemic Attack (TIA)

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Background: The present study was designed to evaluate the predictive value of head-neck computed tomography angiography (CTA) combined with ABCD2 score scale for patients with cerebral infarction of vertebrobasilar transient ischemic attack (TIA).





Material/Methods: A total of 92 patients with TIA who were admitted to our hospital from January 2014 to June 2015 were enrolled in this study. ABCD2 score and CTA combined with ABCD2 score were assessed.

Results: The incidence of cerebral infarction was highest in the high-risk group, followed by the middle-risk group and low-risk group. The incidence of cerebral infarction was related to the degree of stenosis in head-neck CTA, which was highest in the severe stenosis group, followed by the moderate stenosis group and mild stenosis/normal group, with significant differences. The incidence of cerebral infarction in patients with cerebral artery stenosis was correlated with the incidence of cerebral infarction in the head and neck CTA, which was severe > medium > normal/low ($P < 0.05$).

Conclusions: The ABCD2 score can accurately predict the early development from TIA to cerebral infarction. If it is used in combination with head-neck CTA; CTA combined ABCD2 score can further improve the accuracy of prediction, which makes it feasible for use in prediction of the development of vertebrobasilar TIA to cerebral infarction.

MeSH Keywords: **Cerebral Infarction • Ischemic Attack, Transient • Predictive Value of Tests**

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Background

Transient ischemic attack (TIA) type cerebral infarction is defined as the infarction of corresponding area of responsible arteries after TIA [1,2]. It has been reported that 5% of TIA patients will develop cerebral infarction within 24 hours, 5% within 48 hours, 10% within 1 week, 9% within a month, and 10–20% within 3 months [3]. Therefore, the early stage of TIA is the period with the highest risk of developing to cerebral infarction. Early detection and intervention are the keys to preventing and avoiding secondary cerebral infarction after TIA. As the incidence, morbidity, recurrence rate, and mortality of cerebral infarction are high, it is a serious threat to human health. TIAs have been found to be a strong predictor of subsequent stroke and death [4]. Prognostic clinical scores (ABCD2 and ABCD3-I), as well as specific clinical signs and symptoms (e.g., fluctuations), have been used to predict early stroke risk in patients admitted to the hospital after TIA [5]. However, these scores are of limited value in predicting if a patient with acute stroke symptoms will have a TIA with complete resolution of symptoms or a stroke with persistent symptoms and disability. Previous studies have shown that the ABCD2 score is a good predictor of post-TIA possible cerebral infarction, but this method does not consider the predictive value of vascular imaging for TIA patients [6]. The aim of the present study was to evaluate the predictive value of computed tomography angiography (CTA) combined with ABCD2 score for patients with vertebrobasilar TIA in order to further improve the prognosis and quality of life for patients after TIA.

Material and Methods

General information

A total of 92 patients with TIA who underwent treatment from January 2014 to June 2015 in our hospital were recruited, including 47 males and 44 females, aged 22–81 years, average age 54.3 ± 21.3 years, and TIA duration of 6–54 minutes (mean, 40.8 ± 9.2 minutes). All study participants met the diagnostic criteria of TIA [7], and head and neck CTA examination did not find bleeding, occupying lesions, or responsible and symptomatic lesions. The clinical manifestations of patients included single-limb or unilateral weakness, numbness, aphasia or dubbing, dizziness, poor memory, unresponsiveness, and unclear vision. Medical history included hypertension in 43 cases, diabetes in 30 cases, coronary heart disease in 21 cases, tumors in 3 cases, and the other diseases in 16 cases. The treatment was conducted according to the patient's actual condition, appropriate to give other symptomatic treatment, such as statin and anti-platelet or thrombolytic drugs.

Inclusion criteria

Inclusion criteria included: 1) all patients met the diagnostic criteria for TIA, including transient neurological impairment caused by local brain or retinal ischemia, typical clinical symptoms lasting ≤ 1 hour; 2) clinical manifestations included acute neurological dysfunction, associated with microembolization and hemodynamics disturbance; 3) imaging examination revealed no hemorrhage or occupancy and could explain the symptoms of the lesion; 4) clinical data including age, sex, medical history, clinical symptoms, head and neck CTA, electrocardiogram (ECG) and other test results were complete; and 5) all participants provided informed consent and signed the consent form.

Exclusion criteria

Exclusion criteria included: 1) the hospitalization duration was less than 1 week; 2) clinical manifestations included partial seizures or disturbance of consciousness, migraine aura, metabolic diseases, and glaucoma; 3) patients had atrial fibrillation and other cardiogenic ischemic stroke, hemorrhagic cerebrovascular disease, and brain dysfunction caused by other non-vascular causes; 4) patients had hematological diseases and diabetes; 5) no focal performance; and 6) incomplete medical history.

Material and Methods

General information collection

General information including age, sex, and associated risk factors of all participants was collected and categorized. A total of 92 patients were included in this study: 46 women (50%) and 46 men (50%) with a mean age of 65.8 (range 28–92 years).

ABCD2 score

The symptoms and duration of each episode of TIA were collected and recorded. For repeated episodes of TIA, the longest duration was used. Scoring criteria [8] included 5 main elements – age, clinical manifestations, duration of symptoms, blood pressure, and diabetes – with a maximum score of 7 points (Table 1). The subjects were divided into low-risk (0–3), intermediate-risk (4–5), and high-risk (6–7) based on the scores obtained.

Combination methods

Patients were scanned with a TOSHIBA Aquilion 256-slice scanner. The protocol was as follows (256 MDCT protocol, and in brackets 64 MDCT): kVP 120, mAs 300 with dose modulation, slice thickness 0.9 mm (1 mm), increment 0.45 mm (0.5 mm), rotation time 0.5 s, FOV 220 mm. The protocol

Table 1. ABCD2 scoring criteria.

Risk factors	Criteria	Point
Age	≥60 years	1
Clinical manifestations	Unilateral weakness	2
	Dysarthria but not limb dysfunction	1
Symptom duration	≥60 min	2
	<60 min	1
Blood pressure	≥90/140 mmHg	1
Diabetes	Yes	1

included bolus tracking technique (automated tracking of the aortic arch lumen for enhancement during injection of the contrast material bolus). A total of 85 cc of Ultravist 370 mg (370 mg iodide per 100 cc of solution, Bayer Healthcare) was injected at a rate of 5 cc per s. This was followed by 20 cc of saline chaser. The scan was initiated automatically 10 s after the enhancement of the aortic arch lumen reach 150 HU. The stenosis percentage of vertebrobasilar artery was assessed according to North American Symptomatic Endarterectomy Stenosis Staging Criteria, including 100% occlusion, 71–99% severe stenosis, 31–70% moderate stenosis, ≤30% mild stenosis/normal. Stenosis percentage (%)=[(distal stenotic artery–most stenotic artery) diameter/distal stenotic artery diameter]×100%. Head and neck CTA results were assigned to certain points with head and neck occlusion of 3 points, severe stenosis of 2 points, moderate stenosis of 1 point, normal/mild stenosis of 0 points. We combined ABCD2 score and head-neck CTA results to form a new rating scale with a total of 6 points. According to the maximum value of sensitivity and specificity, the diagnostic cutoff line of the risk levels with low-risk 0–3 points and high-risk 4–6 points.

Observation indicators

The incidence of cerebral infarction occurred within 7 days after onset of TIA was recorded. The development from TIA to cerebral infarction was identified according to the clinical manifestations of patients.

Statistical analysis

Categorical variables were described using frequency and percentage. Continuous variables were evaluated for normal distribution using histograms and Q-Q plots. Normally distributed continuous variables were described using mean (standard deviation, SD), and nonnormally distributed continuous variables were described by median (interquartile range, IQR).

Table 2. The Relationship between ABCD2 scores and cerebral infarction.

ABCD2 score	TIA (n)	CI [n (%)]
High-risk	41	9 (22.0)
Intermediate-risk	30	4 (10.0)
Low-risk	21	1 (9.5)
Z value		8.394
P value		<0.01

High risk vs. low risk: $\chi^2=18.204$, $P<0.01$; intermediate risk vs. low risk: $\chi^2=10.349$, $P<0.05$.

Interobserver agreement was described using Bland-Altman plots; a fixed bias was evaluated using the single-sample *t*-test. Reliability between observers was evaluated using ICC (intraclass correlation coefficient) for absolute agreement. Spearman correlation coefficient was used to assess the relationship between neck adiposity tissue volume (NATV) and annual wellness visit (AWV) with body mass index (BMI) and neck cross-sectional areas (NCSAs). The Kruskal-Wallis test and Mann-Whitney U test were used to evaluate the difference in NATV and AWV between BMI categories. Kaplan-Meier curves and log-rank tests were used to evaluate mortality during follow-up in patients in the upper quartile of NAT: AWV versus lower quartiles. Univariate Cox regression was used to evaluate the crude and age- and sex-adjusted association between NAT: AWV and all-cause mortality. Hazard ratio with 95% CI was reported. All statistical analysis was performed using SPSS v22 and $P < 0.05$ was considered statistically significant.

Results

The relationship between ABCD2 scores and cerebral infarction

As shown in Table 2, the cerebral infarction incidence of the high-risk group was highest, followed by the intermediate-risk group and low-risk group ($Z=8.394$, $P<0.01$), showing a significant positive correlation.

The relationship between the degree of vertebrobasilar artery stenosis and the incidence of cerebral infarction

As shown in Table 3, the incidence of cerebral infarction was related to the degree of stenosis in the patients with severe cerebral stenosis ($P<0.05$), with the order of severity > moderate > normal/mild ($Z=10.231$, $P<0.05$) showing a positive correlation ($r=1.283$, $P<0.05$).

Table 3. The relationship between the degree of vertebrobasilar artery stenosis and the incidence of cerebral infarction.

The degree of vertebrobasilar artery stenosis	TIA (n)	CI [n (%)]
Total occlusion	0	0
Severe	19	8 (42.1)
Moderate	33	5 (15.2)
Mild/normal	40	1 (2.5)
Z value		10.231
P value		<0.05

Severe vs. moderate: $\chi^2=10.249$, $P<0.05$; severe vs. normal/mild: $\chi^2=21.093$, $P<0.01$; moderate vs. normal/mild: $\chi^2=9.126$, $P<0.05$.

Table 4. The incidences of cerebral infarction in computed tomography angiography (CTA) and CTA combined with ABCD2 score in different risk stratification patients.

Degree	Value	ABCD2	CI	CTA combined with ABCD2	CI
Low-risk	0	5	1	4	1
	1	13	2	13	2
	2	20	2	24	2
	3	23	3	22	1
Total		61	8	63	6
High-risk	4	19	1	17	2
	5	8	3	7	3
	6	4	2	3	1
	7	0	0	2	2
Total		31	6	29	8

The incidences of cerebral infarction in CTA and CTA combined with ABCD2 score in different risk stratification patients

As shown in Table 4, based on ABCD2 score, cerebral infarction occurred in 8 patients (13.1%) in the low-risk group (n=61) and 6 patients (19.4%) in high-risk group (n=31). Based on CTA combined with ABCD2, there were 6 patients (9.5%) who had cerebral infarction in the low-risk group (n=63) and 8 patients (27.6%) in the high-risk group (n=29).

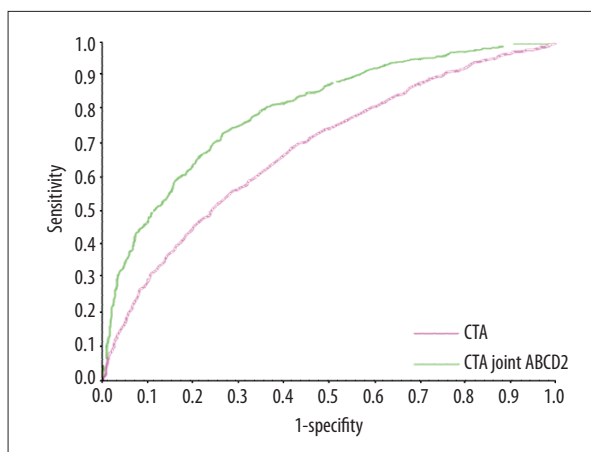


Figure 1. The receiver operating characteristic curve of head-neck computed tomography angiography (CTA) and CTA combined with ABCD2 score.

Predictive value of head-neck CTA and CTA combined with ABCD2 score for cerebral infarction risk after 1 year of TIA

As shown in Figure 1, the area under the receiver operating characteristic (ROC) curve predicted by CTA after 1 year of onset of TIA was 0.683 (95% CI 0.606–0.794, $P<0.05$) with 0.610 maximum sensitivity and 0.403 specificity. The area under the ROC curve predicted by ABCD2 score combined with CTA was 0.801 (95% CI 0.740–0.842, $P<0.05$), with 0.832 maximum sensitivity and 0.352 specificity.

Discussion

As a common neurological disease, TIA is an independent risk factor for stroke, and repeated attacks can eventually progress to cerebral infarction. The underlying mechanisms may be ipsilateral blood supply decompensation, recurrent ischemia in the marginal zone, and infarction center necrosis [1,9,10]. Previous studies have shown that patients with vertebrobasilar TIA have a higher risk of recurrence of cerebral infarction, especially when it is repeated. The risk stratification of patients with TIA was evaluated by a scientific and convenient method. The risk of recurrence was evaluated, and the corresponding stratification management was used for the patients with TIA. The knowledge of recurrence risk of the patients was enhanced, and the secondary prognosis of TIA patients was followed up. Therefore, how to accurately predict the progression of TIA to cerebral infarction is the focus of clinical research.

ABCD2 score scale is one of the few tools currently used to predict the recurrence risk of ischemic events, which has predictive value for the development from TIA to cerebral infarction [11–14]. The majority of items in the scale involve risk factors of ischemic stroke recurrence. The higher the ABCD2 score, the greater the probability of cerebral infarction in TIA patients [15–17]. In addition, the inflammatory theory, micro-embolic theory, and hemodynamic changes theory are more concentrated on explanation of the TIA mechanism. The TIA caused by internal and external carotid arterial stenosis has been widely recognized by clinicians, especially cerebral infarction caused by TIA from vertebrobasilar artery stenosis. Major vessel occlusive disease is an independent risk factor for stroke onset at 1 week after TIA. Therefore, the use of ABCD2 score combined with head and neck vascular lesions imaging can improve the predictive value of existing methods.

CTA is widely used in clinical evaluation of head and neck vascular stenosis, which can clearly show the location and extent of vascular stenosis. The present study has shown that cerebral infarction is significantly associated with the degree of

stenosis. Previous studies have shown that there are varying degrees of plaque ulcers and (or) atherosclerosis in lesions of TIA patients, which can affect blood supply to the brain. The impact is minimal when the stenosis is mild. When the stenosis reaches 50–70%, hemodynamics are disturbed, causing low perfusion TIA, which can progress to cerebral infarction in some severe cases [18–20]. The results from the present study are consistent with studies discussed aforementioned. Based on ABCD2 score risk stratification, the cerebral infarction rate of low- and high-risk groups were 13.1% and 19.4%, respectively. Based on ABCD2 combined with CTA risk stratification, the cerebral infarction rate of low- and high-risk groups were 9.5% and 27.6%, respectively. In the present study, we used ABCD2 combined with CTA to predict the occurrence of cerebral infarction of TIA patients 1 year after the onset of TIA in order to provide TIA patients with further risk stratification to provide individual treatment programs. The results showed that the area under the ROC curve predicted by CTA was 0.683 (95% CI 0.606–0.794, $P < 0.05$). The area under the ROC curve predicted by ABCD2 score combined with CTA was 0.801 (95% CI 0.740–0.842, $P < 0.05$), which further demonstrated that CTA combined with ABCD2 score can more accurately predict the occurrence of cerebral infarction.

Conclusions

ABCD2 score can effectively predict early progression of cerebral infarction from TIA. If it is combined with head-neck CTA examination, it can further improve the prediction accuracy, which demonstrated that CTA combined with ABCD2 score can predict the progression of vertebrobasilar artery TIA to cerebral infarction. A limitation of this study is that in to make the prediction method more simple and convenient, we did not cover all possible risk factors.

Conflict of interest

None.

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