Clinical Features and Outcomes of Takayasu Arteritis with Neurological Symptoms in China: A Retrospective Study

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ABSTRACT. ***Objective.*** To describe the clinical features and longterm outcomes of patients with Takayasu arteritis (TA) in China who experienced neurological symptoms.

Methods. A retrospective study was undertaken of patients with TA who attended a single study center from 2002 to 2013, who also exhibited neurological symptoms (n = 274). Clinical and imaging features were analyzed, as well as longterm outcomes.

Results. The mean age at disease onset was 28.2 ± 11.2 years, with a female-to-male ratio of 4.3:1. The most common neurological manifestation was dizziness (214, 78.1%), the most frequent type of TA was type III (112, 40.9%), and the most common affected artery was the left subclavian (147, 53.6%). Involvement of 3 or 4 branches of the aortic arch was observed in 28% of patients. Among 30 patients experiencing a stroke (10.9%), steno-occlusive lesions of the subclavian artery and common carotid artery were frequently observed in patients with ischemic stroke, while steno-occlusive lesions of the descending aorta, abdominal aorta, and/or renal arteries were more frequently observed with hemorrhagic stroke. Heart failure was the most common cardiovascular event in those who died (n = 6) and in surviving cohorts.

Conclusion. Neurological features in patients with TA were variable, and correlated with the number of arteries and the site of artery involvement. Resistant hypertension was one of the most important risk factors for hemorrhagic stroke in patients with TA. (First Release August 1 2015; J Rheumatol 2015;42:1846–52; doi:10.3899/jrheum.150097)

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Takayasu arteritis (TA) is an uncommon form of primary systemic vasculitis, and has been described in different parts of the world. TA is a nonspecific inflammatory disease of unknown etiology that causes stenosis, occlusion, or dilation of the aorta and its major branches[1]. Initial signs and symptoms of TA include fever of undetermined origin, neck pain, and generalized malaise. Subsequently, signs and symptoms of organ ischemia may develop, which differ widely by the location of the affected vessels. Occasionally, signs and symptoms of cerebral ischemia and visual impairment occur. Neurological manifestations including dizziness, headache, visual disturbance or loss, stroke, and transient ischemic attack (TIA) are present in about 57–80% of patients with TA[2]. Previous studies reported the clinical features of patients with TA in Europe, Mexico, the United States, South America, Japan, and India[2,3,4,5,6]. Although Li-xin, *et al* had described neurological manifestations of patients with TA in China, the sample size was very small[7]. Therefore, we performed a retrospective study with a much larger sample size to describe the clinical features, laboratory characteristics, imaging findings, treatment, and followup of patients with TA in China who had cerebrovascular manifestations.

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MATERIALS AND METHODS

Study population. There were 610 consecutive patients with TA in Fuwai hospital between 2002 and 2013. All patients fulfilled at least 3 of the 6 criteria for TA according to the American College of Rheumatology[8]. Abnormal angiographic findings were defined as dilation, aneurysm, stenosis ≥ 50%, and occlusion or near occlusion whereby stenosis was ≥ 95%. Cerebrovascular events included TIA and stroke. TIA was defined as a brief episode of neurological dysfunction caused by focal brain or retinal ischemia, with clinical symptoms typically lasting less than 1 h, and without evidence of acute infarction[9]. Stroke was defined as an episode of acute

neurological dysfunction presumed to be caused by ischemia or hemorrhage, persisting ≥ 24 h or until death. Ischemic stroke was an episode of neurological dysfunction caused by focal cerebral, spinal, or retinal infarction. Hemorrhagic stroke was caused by intracerebral hemorrhage or by subarachnoid hemorrhage[10]. The diagnosis of subclavian steal syndrome should be considered in patients with posterior cerebral circulatory insufficiency aggravated by upper limb exercise.

In the vertebral ischemic form of subclavian steal syndrome, upper extremity exertion may cause lightheadedness, syncope, vertigo, ataxia, diplopia, motor deficits, or upper limb claudication. Duplex ultrasonography may identify reversal of flow in a vertebral artery[11]. Bentall surgery was done in some patients with involvement of aortic valve and who had preexisting dilatation of the aortic sinuses and sinotubular junction. Combined replacement of the aortic valve, aortic sinuses, and ascending aorta is the preferred method of treatment[12].

Baseline and followup measurements. The following additional data were obtained: age, sex, age at onset, delay to diagnosis, clinical features, laboratory characteristics, pattern of vascular involvement, treatment, and longterm outcome. Patients were classified into 4 categories according to the arteries involved: type I, the aortic arch and its branches; type II, the descending aorta and abdominal aorta; type III, the combined features of type I and type II; and type IV, the pulmonary artery[13].

Statistics analysis. Data were analyzed using SPSS software (version 19.0). Continuous variables were described as mean ± SD, while categorical variables were presented as the number (or percent) of subjects. The chi-squared test was used to analyze the proportional differences between groups. Binary logistic regression analysis was used to find the predictive factors, including age at disease onset, delay to diagnosis, disease activity, steno-occlusive lesions of subclavian artery (SCA), common carotid artery (CCA), vertebral artery (VA), and brachiocephalic artery (BCA) for neurological manifestations in patients with TA. A p value < 0.05 (2-sided) was considered statistically significant.

RESULTS

General characteristics. Among the 610 patients, 274 patients (44.9%) had cerebrovascular manifestations, including dizziness, headache, syncope, visual disturbance or loss, stroke, and TIA. All of the 274 patients had undergone imaging, including peripheral vascular angiography (201 patients), coronary and pulmonary angiography (1 patient each), computed tomography angiography (CTA, 61 patients), and magnetic resonance imaging (MRI) angiography (10 patients). Nine patients who received surgical treatment and pathological examination had done CT 3-D reconstruction of the aorta and its branches postoperatively. All patients had systematic examination of supraaortic branches. The numbers of patients who had brain CT, MRI, or transcranial Doppler imaging were 67, 26, and 3, respectively. The study included 274 patients (222 female and 52 male; female-to-male ratio 4.3:1), with a mean age of 36.5 ± 12.9 years (range 6.4–69.1 yrs). The general characteristics of the patients are listed in Table 1. Sixteen patients had been diagnosed with tuberculosis. For vascular involvement, the most frequent presentation was type III (112, 40.9%), followed by type I (72, 26.3%), and type II (55, 20.1%).

Clinical manifestations. Systemic symptoms such as fever, neck pain, and generalized malaise were found in 21 (7.7%), 5 (1.8%), and 8 (2.9%) patients, respectively. Dizziness (214, 78.1%) and headache (70, 25.5%) were the most common neurological manifestations, while visual disturbance or loss, syncope, and TIA presented in 58 (21.2%), 60 (21.9%), and 58 (21.2%) patients, respectively. Four patients were blind in both eyes and 1 patient had visual field deficits in the right eye. Only 30 patients (10.9%) were reported to have had a stroke, including 7 patients with stroke as the first manifestation of TA. Twenty patients had a stroke before the diagnosis of TA was made, and 10 patients experienced stroke after TA was confirmed. Twenty-seven patients (9.9%) had ischemic stroke, 2 patients had hemorrhagic stroke, and 1 patient had ischemic and hemorrhagic stroke sequentially. Among patients with TIA, there were 2 patients who had simultaneously experienced ischemic stroke.

Laboratory results. Laboratory tests revealed the mean erythrocyte sedimentation rate (ESR) was 16.0 ± 20.1 mm/h in men (reference value < 15 mm/h), 19.1 ± 18.9 mm/h in women (reference value < 20 mm/h), and 18.6 ± 19.1 mm/h in total. The C-reactive protein level was 9.4 ± 15.8 mg/l (reference value 0–8 mg/l). A total of 132 patients (48.2%)

Table 1. General characteristics of 274 patients with Takayasu arteritis (TA) who have neurological manifestations.

General clinical characteristics	No. or Value	Proportion (%)
Female	222	81.0
Mean age, yrs*	36.5 ± 12.9	
Disease onset age, yrs**	28.2 ± 11.2	
Time lag, months***	52.4 ± 5.5	
Inflammatory symptoms		
Fever	21	7.7
Neck pain	5	1.8
Generalized malaise	8	2.9
Cardiovascular risk factors		
Hypertension	199	72.6
Diabetes mellitus	8	2.9
Hyperlipidemia	17	6.2
Tobacco user		
Current	18	6.6
Previous	24	8.8
Neurological manifestations		
Dizziness	214	78.1
Headache	70	25.5
Visual disturbance or loss	58	21.2
Syncope	60	21.9
TIA	58	21.2
Stroke	30	10.9
Ischemic stroke	27	9.9
Hemorrhagic apoplexy	2	0.7
Ischemic and hemorrhagic stroke	1	0.4
Laboratory variables		
ESR, mm/h†	18.6 ± 19.1	
CRP, mg/l‡	9.4 ± 15.8	

* Mean age of the patient's first presentation to a doctor owing to TA. ** Mean age of the patients with TA initially manifested as neurological features. *** Time lag between diagnosis of TA and onset of neurological symptoms. † ESR reference value < 15 mm/h in men and < 20 mm/h in women. ‡CRP reference value 0–8 mg/l. CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; TIA: transient ischemic attack.

were classified as active stage of TA. After doing chi-square analysis, we found that the frequency of headache had no significant difference between the active stage and nonactive stage patients (21.2% vs 29.6%, p = 0.128), and moreover, dizziness was more common in patients of the nonactive stage than in the active stage (83.8% vs 72.0%, p = 0.020). Nevertheless, the frequency of syncope, cerebrovascular events, and visual disturbance was much greater in patients of the active stage than in those in the nonactive stage (31.1% vs 13.4, p < 0.001; 55.3% vs 6.3%, p < 0.001; 28.0% vs 14.8%, p = 0.008). We identified that syncope, cerebrovascular events, and visual disturbance were associated with disease activity (p < 0.001; p < 0.001; p = 0.007).

Imaging results. Involved arteries are listed in Table 2. Binary logistic regression analysis revealed a significant association with neurological manifestations for steno-occlusive lesions of SCA (OR 7.3, 95% CI 1.6–33.4, p = 0.011), steno-occlusive lesions of CCA (OR 0.6, 95% CI 0.4–0.8, p = 0.028), and delay to diagnosis (OR 4.9, 95% CI 1.1–18.7, p = 0.021). According to the imaging results, the left SCA (147, 53.6%) was the most frequently affected artery among the aortic arch branches, followed by the left CCA (111, 40.5%), right SCA (100, 36.5%), right CCA (84, 30.7%), BCA (49, 17.9%), left VA (29, 10.6%), and right VA (23, 8.4%). Single and double involvement of SCA and CCA were observed in 65 and 58 patients, respectively. Involvement of either double SCA with double CCA, a single SCA with double CCA, or double SCA with a single CCA were observed in 32, 27, and 18 patients, respectively. Steno-occlusive lesions of the thoracic aorta and abdominal aorta were observed in 41 (15.0%) and 58 (21.2%) patients, respectively. Fifty-nine patients (21.5%) were observed to have steno-occlusive lesions of double renal arteries, and 73 patients (26.6%) had involvement of a single renal artery. Artery lesions were characterized by high density and calcifications of the aortic wall based on CTA precontrast images, a thickened wall with enhancements in the arterial and venous phases, and a low-attenuation ring in the venous phase. Continuous artery involvement was more common than skip lesions[14]. Early arterial wall thickening could be depicted in MRI T2-weighted images, showing high-intensity signal that correlated with vessel wall inflammation and edema[15]. Diagnostic imaging is fundamental to the diagnosis of TA and is essential for monitoring the disease. Lesions characteristic of TA include short and segmental or long and diffused stenosis, either fusiform or saccular aneurysm dilation, or a combination of the two[16].

Involved arteries associated with neurological manifestations are listed in Table 3. Of the 214 patients with dizziness, the number of patients who had steno-occlusive lesions of 1 or both SCA, CCA, or VA were 138, 94, and 29, respectively. Twenty-two patients had steno-occlusive lesions of both SCA and CCA, in conjunction with the VA. A total of 132 patients were found to have subclavian steal. One patient with dizziness had aneurysm of the left CCA that led to insufficiency of anterior circulation. Dizziness was associated with involvement of SCA (chi-squared = 10.9, p = 0.001) and VA (chi-squared = 15.8, p = 0.001). Chi-square test showed there is no significance between SCA and VA in the patients with dizziness (82.6% vs 17.4%, chi-squared = 3.3, p = 0.069). Thirty-four of the 58 patients with visual disturbances or loss, and 37 of the 58 patients with TIA, had lesions of single or double CCA (mainly double CCA). TIA was associated with lesions of SCA (chi-squared = 17.9, p < 0.001). Patients who were blind in both eyes were associated with severe stenosis or occlusive lesions of double CCA and double SCA. In patients experiencing visual disability, double steno-obstructive vessels (CCA or SCA) were frequently observed. Visual disturbance was associated with lesions of CCA (chi-squared = 6.2, p = 0.012).

Among the 27 patients with ischemic stroke, 13 had steno-occlusive lesions of the SCA combined with steno-occlusive lesions of the CCA or VA, and 8 had steno-occlusive lesions of the SCA, CCA, or VA. In the remaining 6 patients, 2 had severe aortic regurgitation and

Table 2. Involved arteries in patients with Takayasu arteritis.

	Total Lesions, n	Dilation, n	Aneurysm, n	Stenosis 50–70%, n	Stenosis 70–95%, n	Occlusion or Near Occlusion, n
Left CCA	111	4	1	30	15	61
Right CCA	84	6	0	34	9	35
Left SCA	147	5	0	17	21	104
Right SCA	100	8	3	11	17	61
Left VA	29	3	0	8	5	13
Right VA	23	3	0	8	7	5
BCA	49	7	0	27	5	10
Descending aorta	41	7	7	10	16	1
Abdominal aorta	58	7	7	25	15	4
Left renal artery	91	4	1	16	42	28
Right renal artery	95	3	2	19	38	33

CCA: common carotid artery; SCA: subclavian artery; VA: vertebral artery; BCA: brachial artery.

Table 3. Involvement of arteries associated with neurological manifestations.

		Dizziness, n = 214	Visual Disturbance or Loss, n = 58	TIA, n = 58	Ischemic Stroke, n = 28	Hemorrhagic Stroke, n = 3
SCA	Single	96	24	22	15	2
	Double	42	15	22	6	0
CCA	Single	50	10	11	7	0
	Double	44	24	26	5	1
VA	Single	23	11	14	2	0
	Double	6	2	3	0	0
SCA + CCA		77	32	33	12	1
SCA + VA		29	12	17	1	0
CCA + VA		22	12	13	0	0
SCA + CCA + VA		22	12	13	0	0

TIA: transient ischemic attack; SCA: subclavian artery; CCA: common carotid artery; VA: vertebral artery.

had undergone Bentall surgery, while the other 4 had renovascular hypertension (HTN) with only 1 or 2 lesions of SCA or CCA. The CTA of patients who had undergone Bentall surgery indicated that the CCA and SCA were severely affected. Ischemic stroke was associated with steno-occlusive lesions of CCA (chi-squared = 10.3, p = 0.001). Two patients with hemorrhagic stroke had renal artery occlusive lesions, resulting in renovascular HTN. One patient who had experienced repeated hemorrhagic stroke was notable for refractory and steadily increasing blood pressure. After TA was confirmed, imaging revealed severe stenosis of the abdominal aorta as the cause of the high blood pressure. These latter 3 patients had no lesions of the SCA, CCA, or VA.

The brain CT imaging of the 2 patients who had hemorrhagic stroke showed a single, hyperdense, small, round lesion of parenchymal hematoma in the basal and internal capsule. One patient who had a hemorrhagic stroke had brain MRI imaging, and T2-weighted axial images of the brain showed 30 × 20 mm subacute hemorrhage in the left occipital lobe, while T1-weighted images showed hyperintensity suggestive of subacute hemorrhage. The brain CT of ischemic stroke showed distinct boundary, single or multiple lamellar low-density shadow, without mass effect.

The pathological result of patients who received Bentall surgery showed myxoid degenerative changes in media in the aortic valve, with or without intimal and adventitial fibrosis, degeneration of the internal elastic lamina and atrophy of the media, and infiltration of inflammatory cells (predominantly lymphocytic with granuloma formation and giant cells involving the media and adventitia) in the ascending aorta.

The 5 patients who were blind had fluorescein angiography in the ophthalmology outpatient department. All of the 58 patients with visual disturbance had fundus examination. The most frequent manifestation was ischemic retinopathy (showing retinal pallor due to central retinal artery stenosis or occlusion, superior temporal vein stenosis or occlusion, and delay of the venous filling time), with or without microaneurysm, capillary nonperfusion, neovascularization, and arteriolovenular anastomosis.

Therapy. Revascularization of branches of the aortic arch, the aorta, and the renal artery are shown in Table 4. Percutaneous transluminal angioplasty (PTA) was more frequently performed than stent implantation. The latter procedure was preferred in those patients who had experienced an aortic dissection. For patients with involvement of supraaortic branches, the number of patients who received PTA (75) was 2.5 times the number of patients who received stent implant (30). The overall restenosis was 34.5%, and restenosis of PTA and stent implant were 37.3% and 40.0%, respectively. Secondary HTN caused by lesions of the renal artery or abdominal aorta affected 172 patients. Revascularization of renal artery and abdominal aorta was performed in 101 and 12 patients, respectively. The remaining 59 patients were prescribed antihypertensive agents only. Nine patients who had severe aortic valve regurgitation received Bentall surgery. During followup, a total of 224 patients (81.8%) were prescribed glucocorticoids (prednisone) with an initial dose of 20–40 mg/day. The dose was then gradually reduced to 5 or 10 mg/day for at least 6 months. Immunosuppressive agents were given to 6 patients because of relapse during glucocorticoid dose reduction. Antiplatelet therapy was administered to 207 patients (75%) as follows: aspirin monotherapy (104), clopidogrel monotherapy (4), and aspirin and clopidogrel dual therapy (99). The dual antiplatelet therapy regime was followed for 3 months before clopidogrel was withdrawn.

Followup study. After being discharged from hospital, 175 patients (63.9%) were followed for 3.7 ± 0.3 years (range 0.27–10.8 yrs). Sixty-two patients were still taking low-dose prednisone (14.0 ± 8.4 mg/day, range 2.5–30 mg) after the full followup period. Two patients were given cyclophosphamide. A total of 6 patients died. The causes of death were new onset of cerebral hemorrhage in 2 patients and heart failure in 4 patients (including 1 patient whose initial symptom was ischemic stroke). Of the 10 patients whose baseline clinical symptom was stroke, 1 patient died of heart

Table 4. Revascularization therapy and restenosis of patients.

	PTA, n	Restenosis, n (%)	Stent Implant, n	Restenosis, n (%)	Surgery, n	Restenosis, n (%)	Total, n	Restenosis, n (%)
Supraaortic branches	75	28 (37.3)	30	12 (40.0)	14	1 (7.1)	119	41 (34.5)
SCA	52	20 (38.5)	18	7 (38.9)	5	1 (20.0)	75	28 (37.3)
CCA	11	3 (27.3)	8	3 (37.5)	8	0	27	6 (22.2)
VA	8	3 (37.5)	4	2 (50.0)	0	0	12	5 (41.7)
BCA	4	2 (50.0)	0	0	1	0	5	2 (40.0)
Abdominal aorta	3	2 (66.7)	9	4 (44.4)	0	0	12	6 (50.0)
Descending aorta	0	0	16	7 (43.8)	2	0	18	7 (38.9)
Renal artery	65	10 (15.4)	34	9 (26.5)	2	0	101	19 (18.8)
Total	143	40 (28.0)	89	32 (36.0)	18	1 (5.6)	250	73 (29.2)

PTA: percutaneous transluminal angioplasty; SCA: subclavian artery; CCA: common carotid artery; VA: vertebral artery; BCA: brachiocephalic artery.

failure and 5 patients developed neurological sequelae, which included limb movement disorders in 4 patients and aphasia in 1 patient. Four patients experienced remission of TA without any sequelae. As for the surviving patients, 3 experienced heart failure, 2 had cerebral infarction, and 1 developed chronic renal failure. During followup, 3 patients had repeated ischemic strokes, which included sequelae such as mental retardation, movement, and speech disorders. These patients also received repeated revascularization of the aortic arch branches.

DISCUSSION

TA is a chronic vasculitis predominantly affecting women. Manifestations of TA vary widely depending on the site and degree of artery involvement. The average age at onset of neurological manifestations in our present study was 28.2 years. To our knowledge, neurological diseases are not common in women of this age; thus, it would be easy to fail to diagnose or misdiagnose such patients. Particular attention should be given when a young, female patient presents with dizziness, and vascular bruits are heard on examination in the cervical spine or supraclavicular region.

Neurological symptoms range from mild (such as dizziness) to fatal neurological events (stroke). About half of the patients with TA were reported to have neurological manifestations[7,17]. Comparison of the frequency of neurological manifestations between the previous series and the present study were listed in Table 5[2,4,7,14,18,19,20,21]. According to our study, the prevalence of neurological manifestations was 44.9%, which was similar to that reported by previous studies (44.0%, 42.9%)[17,22]. Dizziness was the most common neurological manifestation in our study (77.4%), which also corresponded with previous studies[14,17]. Multivessel involvement, such as SCA, CCA, and VA, was frequently observed in patients with dizziness. Because of longterm, chronic compensation, single vessel involvement is rarely observed in patients with dizziness. Binary logistic regression analysis revealed that steno-occlusive lesions of SCA, steno-occlusive lesions of CCA, and delay to diagnosis were significantly associated with neurological manifestations. Early diagnosis is crucial to prevent TIA or stroke from diffused lesions and severe ischemia in patients with involvement of CCA and SCA.

In our study, we found that certain severe neurologic presentations such as syncope, cerebrovascular events, and visual disturbance were more closely associated with disease activity. Where serial assessments were performed on patients, identification of predictors of subsequent stroke or visual loss would be useful.

Stroke is the most severe symptom of TA; it can cause serious neurological deficits that can make the prognosis more adverse[23]. In our study, a total of 13.8% of patients with

Table 5. Comparison of the frequency of neurological manifestations between the previous series and the present study.

	No. Patients	Dizziness, %	Headache, %	Visual Disturbance or Loss, %	Syncope, %	Cerebrovascular Accident	
						TIA, %	Stroke, %
Present study	274	78.1	25.5	21.2	21.9	21.2	10.9
China (1)	530	9.2	NM	11.4	4.4	NM	5.4
China (2)	60	74.1	55.6	59.3	NM	22.2	22.2
US	75	30–40	50–60	12	4	3	5
NIH	60	18	18	10	NM	8	
India	106	20–30	44	12	26		10
Europe	17	29.4	52.9	47.1	NM	5.9	11.8
Turkey	248	24	48	21	19	3	15
Korea	108	45.4	56.5	4.6	NM	NM	NM

TIA: transient ischemic attack; NIH: US National Institutes of Health; NM: not mentioned.

TA had cerebrovascular events, including TIA and stroke, which is in accordance with previous studies (10–20%)[15]. Reports of stroke as the first manifestation of TA are not common, with only a few known case reports[16,22,24]. In our study, only 7 patients experienced stroke as an initial manifestation. Because TA is uncommon, and its initial presentation mimics neurological events such as stroke, there can be a marked delay in diagnosis. The average interval between disease onset and diagnosis was 52.4 months in our study. Multiple and severe stenotic or occlusive lesions in the aortic arch and its main branches may cause ischemic stroke in patients with TA. Hemodynamic compromise in large-artery stenosis and other thromboembolic mechanisms play significant roles in ischemic stroke associated with TA[25]. In our study, there were 4 patients with ischemic stroke whose imaging results showed only 1 or 2 steno-ischemic lesions in the SCA or CCA. By contrast, their renal arteries were severely affected and they had a long history of HTN — the most likely reason for their ischemic stroke. Otherwise, hemorrhagic stroke was probably caused by a sudden elevation of blood pressure secondary to severe lesions of the descending aorta, abdominal aorta, or renal arteries.

Generally, there were fewer or milder lesions in the branches of the aortic arch. Those patients were characterized by a continuous elevation of blood pressure. Some patients experienced dizziness or headache even though they had multiple vessel lesions. Commonly, with abdominal aorta involvement over a long period, patients may compensate well, and good cerebral perfusion ensures they avoid a stroke. Some patients may present with dizziness or even syncope as soon as they are given antihypertensive agents. It is recommended that in patients with HTN and asymptomatic extracranial carotid or vertebral atherosclerosis, the blood pressure should be maintained below 140/90 mmHg. While in patients with HTN and symptomatic extracranial carotid or vertebral atherosclerosis, antihypertensive treatment is probably indicated during the hyperacute period, the benefit of treatment to a specific target blood pressure (e.g., below 140/90 mmHg) has not been established in relation to the risk of exacerbating cerebral ischemia. To date, there are no specified recommendations for the target blood pressure for patients with TA who have carotid or vertebral arteries involved. Nevertheless, we should open CCA and/or prescribe antihypertensive agents on the basis of a good cerebral perfusion, and blood pressure should be carefully monitored after revascularization. During followup in our study, 5 patients developed neurological sequelae and 1 patient died of heart failure. We recommend that, if suspected, young stroke patients should be examined for TA.

Revascularization strategies in TA include PTA, stent implantation, and vascular graft. In our study, PTA was more frequently observed than stent implantation in general. But for patients with involvement of abdominal or descending aorta, stent implant was more preferred. The restenosis of PTA and stent implant was 66.7% and 44.4%, respectively. The overall restenosis of PTA, stent implant, and surgery were 35.7%, 29.2%, and 5.6%, respectively. The poor results and high restenosis of endovascular treatment of TA have led to the development of drug-eluting technology to treat restenosis, which will be a new advance for revascularization of occlusive or severe stenosis lesions of arteries in patients with TA[26].

During followup, 3 patients were administered prednisone alone. These patients also had repeated ischemic strokes and had sequelae of mental retardation, and movement and language disorders. These patients also underwent repeated revascularization. One possible explanation might be that the vessel lesions in these cases were unusually long, diffuse, fibrotic, and almost totally occluded. Because this requires a higher balloon dilation pressure, it is possible that iatrogenic vascular injury led to vascular endothelial cell proliferation and recurrent stenosis.

When establishing the antihypertensive strategy of patients with TA with stroke, it is worth considering the degree of cerebral perfusion. In patients with lesions of the branches of the aortic arch, especially the SCA, the blood pressure of the lower limb should be measured.

Traditionally, patients with TA were given dual antiplatelet drugs (aspirin and clopidogrel). In recent years, a deeper understanding of the pathogenesis of TA has led to the realization that a daily dosage of 80 mg of aspirin was effective for the suppression of thromboxane B2[27,28,29,30], and a study led by de Souza suggested that lower daily doses of aspirin (100 mg or 200 mg) may be as effective as higher daily doses of aspirin such as 325 mg and 500 mg in protecting against ischemic events in patients with TA[31]. Thus, we recommend that a regular dose of aspirin (100 or 200 mg per day) be considered for patients with TA.

There are some limitations in our study. Although the sample size is large, this is a single-center retrospective study with a low followup rate. Moreover, the absence of systematic imaging procedures and a lack of brain images for many patients were also weaknesses. Multicenter, randomized, and controlled study should be designed in the future.

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