Clinical Findings of Intracranial Vertebral Artery Disease Using Magnetic Resonance Angiography

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Abstract- The vertebral artery lesion has a variety of clinical characteristics. We sought to clarify the clinical patterns and the location of the intracranial vertebral artery (ICVA) diseases according to analyses of images obtained using magnetic resonance angiography (MRA). We studied vascular lesions, risk factors, symptoms, signs, and outcomes in 35 patients with ICVA disease (3 had bilateral occlusion; 9, unilateral occlusion; 6, bilateral stenosis; and 17, unilateral stenosis). The most common site of unilateral and bilateral lesions was the distal ICVA after the origin of posterior inferior cerebellar artery (PICA). We found accompanying basilar artery disease in 28.6% of patients with unilateral and bilateral ICVA disease. The majority of the ICVA lesions were associated with internal carotid arteries disease (48.8%). The common vascular risk factors were hypertension (71%), diabetes mellitus (34%), hyperlipidemia (31%), smoking (29%), and coronary artery disease (23%). Eighteen patients (51.4%) had transient ischemic attacks (TIAs) only, 10 patients (28.6%) had TIAs before stroke, and 5 patients (14.3%) had strokes without TIAs. Most patients (80%) with TIAs, with or without stroke, had multiple episodes. Vertigo or dizziness, ataxia, limbs weakness and abnormal gait were the common symptoms and signs. At 6 months follow-up, 66.7% patients had no symptoms or only slight symptoms that caused no disability. Our data showed (1) the usual location of ICVA disease (occlusion or severe stenosis) was distal to PICA, especially near the vertebrobasilar junction; (2) the risk factors were hypertension, diabetes mellitus, hyperlipidemia, smoking, and coronary artery disease; (3) patients with ICVA disease had a high frequency of accompanying internal carotid, middle cerebral, or basilar artery disease; (4) vertigo or dizziness, and ataxia were the common symptoms and signs; (5) TIA was the most common clinical pattern; (6) the outcome was favorable, except in cases with bilateral ICVA occlusion.

Key Words: Clinical findings, Intracranial vertebral artery, Magnetic Resonance Angiography

Acta Neurol Taiwan 2004;13:120-125

INTRODUCTION

Occlusion of the vertebral artery (VA) causing posterior circulation ischemia has a variety of different vascular pathologies at various locations as well as diverse pathogenic mechanisms.

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Received April 16, 2004. Revised May 26, 2004.
Accepted August 11, 2004.

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Occlusion of the VA is usually seen at the point where the VA originates from the subclavian artery or the aorta and also between the C-1 vertebral body and the point of penetration of the dura. When the occlusion is low, near the subclavian artery, the high cervical and distal portions are usually patent and fed by anastomotic branches from the occipital artery or cervical arteries; these patients often have transient ischemic attacks (TIAs) rather than stroke[1]. When the occlusion is higher in the neck or intracranial, anastomosis with the external carotid artery or thyrocervical trunk is no longer a viable option. Caplan[2] described 9 patients with severe intracranial vertebral artery (ICVA) occlusive disease who were selected because of poor outcome. Bogousslavsky et al.[3] analyzed retrospectively the outcome in patients with bilateral ICVA disease who were included in the Extracranial to Intracranial Bypass Study. We sought to clarify the clinical features and to correlate these with the severity and location of the ICVA disease according to the findings of magnetic resonance angiography (MRA). Conventional angiography was the diagnostic study of choice, but magnetic resonance scanning presents an excellent, rapid, noninvasive alternative for confirming vascular occlusion or stenosis.

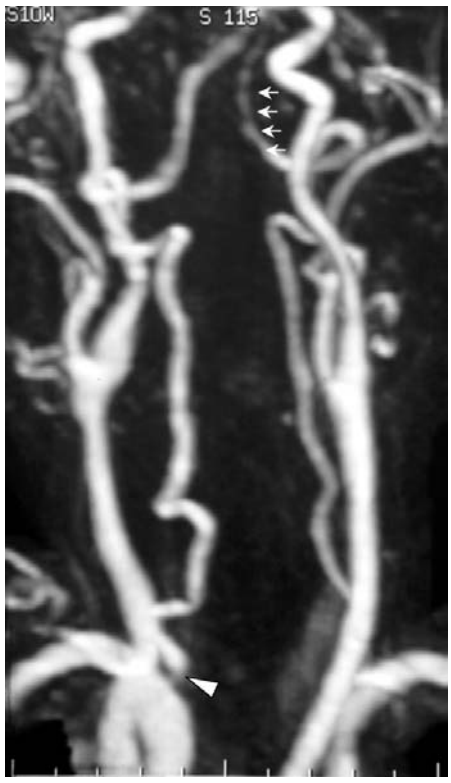

Figure 1. A 74-year-old man. Gadolinium-enhanced MRA of head and neck showed severe stenosis of left distal VA (proximal to orifice of left PICA) (small white arrows), and stenosis of right proximal VA (arrow head).

METHODS

Using a registry of 110 patients (identified and entered retrospectively from January 1, 1999 through December 31, 2001) with intracranial and extracranial VA occlusion or severe stenosis (>50%) from the Taichung Veterans General Hospital, we selected and studied 35 cases with intracranial (distal) VA occlusion or severe stenosis. The diagnosis was made by MRA imaging, and the clinical data were analyzed from the clinical charts. The 35 cases (35/110 [31.8%]) had unilateral or bilateral intracranial VA severe stenosis or occlusion, including a case with unilateral VA hypoplasia, two with contralateral VA hypoplasia, and one with contralateral proximal VA stenosis. The excluded cases (75/110 [68.2%]) were unilateral or bilateral proximal VA stenosis or occlusion, and distal VA lesion with unilateral proximal VA stenosis or occlusion. Detailed clinical information from the 35 patients included vascular

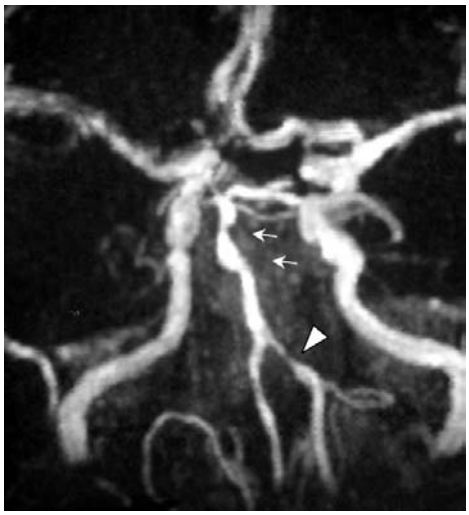

Figure 2. A 79-year-old mane. 3DTOF MRA of brain revealed severe stenosis of left distal VA (arrow head), and stenosis of distal BA (small white arrows).

lesions, risk factors, symptoms, signs and outcome. We excluded patients in whom cardiac embolism was the most likely cause of stroke.

All patients underwent MRA and were studied using a 1.5-T Signa MR imaging system. The three-dimensional time-of-flight MRA was used to investigate the intracranial arteries. Images were obtained using a gradient-echo pulse sequence with "spoiling" of residual transverse magnetization known as spoiled gradient-recalled acquisition in the steady state. We reviewed the original imaging films, and relied on radiological reports.

ICVA disease was disclosed in the region just after dural penetration via orifice of posterior inferior cerebellar artery (PICA) to vertebrobasilar junction. We divided the intracranial posterior circulation territory (IPCT) into 3 levels[4]. Proximal IPCT included the regions supplied by the ICVAs (medulla and PICA-supplied region of cerebellum). Middle IPCT included the regions supplied by the basilar artery up to its superior cerebellar artery branches (pons and AICA-supplied region of cerebellum). Distal IPCT included the regions supplied by the distal basilar artery (directly penetrating midbrain), thalamic branches, superior cerebellar arteries, and posterior cerebral arteries. The ICVA lesions were divided into: Unilateral occlusion (or severe stenosis), bilateral occlusion (or severe stenosis), and those combined with stenosis or occlusion of other cerebral large arteries. Occlusion of the ICVA was inferred when there was no flow signal on MRA, and severe stenosis was defined as narrowing of the lumen by 50% or more, based on results of MRA. We used a modified Rankin Scale to describe the each patient's condition.

RESULTS

Thirty-five patients (28 men, 7 women; ranging in age from 21-81 years; mean age, 67.9 years) were included in the study. Three patients had bilateral ICVA occlusion; 9 patients had unilateral ICVA occlusion; 6 patients had bilateral ICVA stenosis; and 17 patients had unilateral ICVA stenosis.

Imaging findings

The most common site of unilateral or bilateral lesion was in the distal ICVA after the origin of posterior inferior cerebellar artery. We found accompanying basilar artery disease (10/35 [28.6%]) in patients with unilateral and bilateral ICVA disease. In most patients the proximal basilar artery was affected. The majority of the ICVA lesions were associated with middle cerebral arteries disease (9/35 [25.7%]) and internal carotid arteries disease (17/35 [48.8%]). Table 1 shows the ICVA lesions associated other large arteries disease.

Clinical findings

Eighteen patients (51.4%) had TIAs only, 10 patients (28.6%) had TIAs before stroke, and 5 patients (14.3%) had strokes without TIAs. Two patients (5.7%) had stenosis of unilateral distal vertebral artery, but no clinical manifestation. Most patients (28/35 [80%]) with TIAs, with or without stroke, had multiple episodes.

Table 1. *ICVA lesions associated other large arteries disease*

Associated arteries disease	Unilateral ICVA (n=26)	Bilateral ICVA (n=9)	Total ICVA (n=35)
Occlusion			
BA	0	0	0
BA and (ICA / MCA / both)	0	1 and (0/0/1)	1
ICA / MCA / both	1/0/0	0	1
Stenosis			
BA	0	1	1
BA and (ICA / MCA / both)	4 and (1/2/1)	4 and (1/2/1)	8
ICA / MCA / both	6/5/3	1/0/1	16
No involving ICA or MCA	7	1	8

Number indicates the no. of patients; BA: basilar artery; ICA: internal carotid artery; MCA: middle cerebral artery; both: ICA+MCA.

Table 2. *Frequency of symptoms and Signs (n=35)**

Symptoms	No. (%) of Patients	Signs	No. (%) of Patients
Vertigo and dizziness	20 (57)	Ataxia	7 (20)
Weakness	15 (43)	Babinski sign	6 (17)
Abnormal gait	13 (37)	Hemiparesis	5 (14)
Slurred speech	7 (20)	Sensory loss	3 (9)
Decreased alertness	5 (14)	Nystagmus	2 (6)
Nausea or vomiting	3 (9)	Facial hypalgesia	2 (6)
Double vision	3 (9)	Horner syndrome	2 (6)
Face numbness	2 (6)	Quadriparesis	1 (3)
Headache	1 (3)	Visual field defect	1 (3)

* Many patients had more than 1 symptom.

Table 3. *Stroke localization in patients with infarcts*

IPCT	Unilateral lesion (n=26)	Bilateral lesion (n=9)	Total, patients (n=35)
Proximal only	1	1	2
Middle only	2	0	2
Distal only	3	2	5
Proximal + middle	0	2	2
Proximal + distal	0	0	0
Proximal + middle + distal	0	2	2
Middle + distal	1	1	2
No infarct	19	1	20

Number indicates the number of patients; IPCT: intracranial posterior circulation territory
Proximal IPCT included the regions supplied by the ICVAs (medulla and PICA-supplied region of cerebellum). Middle IPCT included the regions supplied by the basilar artery up to its superior cerebellar artery branches (pons and AICA-supplied region of cerebellum). Distal IPCT included the regions supplied by the distal basilar artery (directly penetrating midbrain), thalamic branches, superior cerebellar arteries, and posterior cerebral arteries.

Vertigo or dizziness, ataxia, limbs weakness, and abnormal gait were the common symptoms and signs (Table 2). Vertebrobasilar artery territory infarction was found in 15 patients (15/35 [42.8%]), in 3 patients (3/3 [100%]) with bilateral ICVA occlusion, in 4 patients (4/9 [44.4%]) with unliteral ICVA occlusion, in 5 patients (5/6 [83.3%]) with bilateral ICVA stenosis, and in 3 patients (3/17 [17.6%]) with unilateral ICVA stenosis. Table 3 shows the different levels of infarcts in patients with ICVA disease. Six of the patients had isolated and combined proximal territory posterior circulation infarcts. Nine patients with unilateral or bilateral ICVA lesion had a tendency more distal territory infarcts.

The common vascular risk factors were hypertension (25 patients [71%]), diabetes mellitus (12 [34%]), hyperlipidemia (11 [31%]), smoking (10 [29%]), and coronary artery disease (8 [23%]). Other risk factors such as cardiac diseases other than coronary artery disease, previous stroke, peripheral vascular disease, hypercoagulopathy, and others were found in less than 10% of patients. The main cause of ICVA disease was probably atherothrombosis, and in one case, a rare cause of it was suspicious arterial dissection in a 21 years old patient.

The outcome shows that 12 patients (12/15 [80%]) had some impairment in activities of daily living at discharge. Follow-up at more than 6 months showed: 10 patients (10/15 [66.6%]) had no symptoms or only slight symptoms that caused no disability.

DISCUSSION

The vertebral artery can be conveniently divided into

4 anatomical segments[4,5]. The proximal (V1) segment begins at the origin of the vertebral artery from the subclavian artery and ends at the point of entry into the transverse foramen of the vertebral column, typically at C6. The vertebral artery (V2) then ascends through the transverse foramina (transverse multiple foramina from C6 to C2), exits at C2, runs posteriolaterally around the atlas (V3), and then penetrates the dura mater to become the intracranial vertebral artery (V4). We studied ICVA lesions involving the V4 segment. Patients with ICVA disease usually have multiple stroke risk factors, especially hypertension, diabetes, hyperlipidemia and cigarette smoking.

The frequency and importance of bilateral ICVA disease has been widely discussed in the literature[2,3,6]. Caplan[2] described a selected series of 9 patients who had severe bilateral ICVAs symptomatic occlusive disease, 8 patients died and the other patient was left in locked-in state and subsequently died. Bogousslavsky et al.[3] in contrast, selected 10 patients with bilateral ICVA disease who were being considered for extracranial to intracranial anterior circulation bypass, and described a much more benign course at follow-up. Most patients with bilateral ICVA occlusive disease have hypertension, other major occlusive lesions and TIAs before stroke[6]. In our study, nearly one-fourth of patients with ICVA disease had bilateral lesion (occlusion or severe stenosis). Most patients (8/9 [88.9%]) with bilateral ICVA disease had posterior circulation infarcts. Twenty-eight patients with ICVA disease (80%) had TIAs, and recurrent TIAs were especially common in patients with bilateral ICVA disease. Symptoms that reflected vestibulocerebellar, motor, and cranial nerve abnormalities were most prominent during TIAs. The main components of the vestibulocerebellar system, the vestibular nuclei and their connections with the vestibulocerebellar structures in the cerebellar vermis, lie directly within the core of ICVA supply, explaining the frequency of vertigo and ataxia during TIAs. The pathogenesis of TIAs in patients with bilateral ICVA disease probably involves embolism and hypoperfusion[6].

Patients with unilateral ICVA disease were likely to have acute-onset strokes without preceding TIAs than were patients with bilateral ICVA disease[7]. Patients with unilateral ICVA disease often had distal territory posterior circulation infarcts presumably caused by intra-arterial embolism from the ICVA lesions[4]. Some of our patients (7/26 [26.9%]) with unilateral ICVA disease had posterior circulation infarcts.

Previous reports have shown a strong association of ICVA with infarction in the proximal posterior circulation territory which include the medulla[4,8] and PICA-supplied region of cerebellum[9,10]. However, in our series, six patients (6/15 [40%]) had isolated or multiple infarcts that involved the proximal posterior circulation territory. Nine patients (9/15 [60%]) with infarction had a tendency toward more distal territory involvement. Because flow from the ICVA through PICA around the cerebellum through the other long circumferential cerebellar arteries (anterior inferior cerebellar arteries and superior cerebellar arteries) forms such an important potential pathway, we explored whether the location of the ICVA lesions in reference to the origins of the PICAs influenced the clinical findings and outcomes. When flow through one or both PICA is reduced because of ICVA obstruction proximal to or at the PICA origins, flow to the pons and midbrain is compromised. We posited that the location and distribution of posterior circulation infarction and patient outcomes might be influenced by whether neither, one or both ICVA lesions were located before the PICA origins. As predicted, the proximal intracranial territory was less often involved if the ICVA lesion was distal PICA. The middle territory was more often involved when both ICVA lesions were distal PICA, effectively causing reduced flow in the proximal basilar artery[6].

Our patients with ICVA disease often had intracranial/extracranial large arteries lesions, including the basilar, internal carotid, and middle cerebral arteries. Some authors have reported[6,11] that patients with ICVA disease have a high frequency of stenosis in accompanying basilar and extracranial carotid and vertebral arteries. The chronic development of occlusive lesions usually allows for the development of extensive collateral circulation. The collateral blood flow arises from anterior circulation via the posterior communicating arteries, and from within the posterior circulation through the long cerebellar arteries, the anterior spinal artery, and the lep-

tomeningeal arteries[2,3,11,12].

The short- and long-term outcomes are usually favorable. However, patients who also have basilar artery occlusive lesions, presumed embolism to the distal territory, or bilateral occlusive lesions have a poor prognosis. In one previous study, the prognosis was described as favorable with no further ischemia[13] and in other studies no increased mortality in the presence of ICVA disease was noted[2,13,14]. Only Caplan et al reported a poor outcome, although their series was selected to include patients with severe bilateral ICVA disease who had progression of symptoms[2]. Further analyses of the clinical patterns and locations of ICVA disease in a larger group of patients based on the MRA findings are warranted.

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