High-resolution Magnetic Resonance Imaging Reveals Hidden Etiologies of Symptomatic Vertebral Arterial Lesions

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Background: Symptomatic intracranial vertebral artery (VA) disease has various clinical features and poor neurological outcomes. The disease is believed to result from atherosclerotic stenosis, occlusion, or spontaneous VA dissection. The underlying histopathology of symptomatic intracranial VA disease has only been studied at postmortem, and no in vivo imaging investigation has been conducted despite the increased sophistication of imaging techniques. *Methods:* The authors performed high-resolution magnetic resonance imaging (HR-MRI) of intracranial vertebral arteries in 9 patients, suspected of a VA pathology by magnetic resonance imaging (MRI), magnetic resonance angiography, and digital subtraction angiography. *Results:* HR-MRI allowed the authors to determine the following: (1) atherosclerotic plaque is composed of a large lipid core with intraplaque hemorrhage and calcification, (2) nonstenotic atherosclerosis exhibits diffuse vessel wall thickening and plaque protruding toward perforating arteries, and (3) spontaneous VA dissection exhibits large intramural hematoma in a false lumen with complete occlusion of the true lumen. In addition, VA hypoplasia was easily differentiated from atherosclerotic stenosis, by direct visualization of a narrow lumen diameter without arterial wall thickening. Furthermore, etiologic diagnoses based on classical MRI, angiography, and digital subtraction angiography were changed in 3 patients after HR-MRI. Additional information on plaque stability, indicating the possibility of unstable plaque, was found in 4 patients. *Conclusions:* The application of HR-MRI in stroke patients with VA pathologies enabled the authors to determine the underlying pathophysiologies. These findings could be used to improve risk stratification and treatment decision making in symptomatic intracranial VA disease. **Key Words:** Acute stroke—imaging—magnetic resonance imaging—plaque—vertebral artery—posterior circulation.

Magnetic resonance imaging (MRI) is a safe and noninvasive technique that is not dependent on X-rays. Furthermore, contrast between different tissues can easily be obtained and amplified using contrast agents. These characteristics render MRI well positioned for monitoring atherosclerotic disease progression or to guide therapy in the brain. In particular, magnetic resonance angiography (MRA) can well visualize intracranial arterial diseases, such as atherosclerotic stenosis or aneurysms, or extracranial carotid or vertebral artery (VA) diseases. Although

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Table 1. *Clinical and imaging details*

Patient number	Age/sex	Risk factor	DWI lesion	MRA	DSA	HR-MRI	Figure
1	70, M	DM, HTN	Lt. LM	Lt. VA hypoplasia	Lt. V4 occlusion	Heterogeneous, crescentic mural hematoma at Lt. V4	Fig 1 and Supplementary Fig 2
2	48, M	DM, HTN	Bilateral MM	Bilateral V4 focal stenosis	Distal Lt. V4 (65%), Rt. V4 (55%) stenosis	Heterogeneous, crescentic mural hematoma at Lt. V4	Fig 2
3	73, M	Smoking	Lt. PICA	Lt. V3 occlusion	Bilateral. PICA termination	Concentric wall thickening and calcification, at Lt. V4	Fig 3
4	63, M	DM, HTN, OMI	Rt. LM, Rt. PICA	Normal	Rt. PICA orifice focal stenosis	Eccentric wall thickening and enhancement, at PICA origin of Rt. V4	Fig 4 and Supplementary Fig 2
5	64, F	HTN	Lt. LM	Normal	Ulcer-like lesion in Lt. V4	Homogeneous, even thickness wall enhancement at Lt. V4	Fig 5
6	43, M	Smoking	Rt. LM	Rt. V4 occlusion	Rt. V4 gradual occlusion	Completely collapsed true lumen, false lumen with large mural hematoma	Fig 6
7	35, F	None	Lt. LM	Normal	Lt. V4 dissection	Homogeneous, eccentric wall thickening at PICA origin of Lt. V4	Supplementary Fig 1
8	87, M	PFO	Lt. PICA	Normal	Normal	Normal	No
9	76, F	DM, HTN	Normal	Bilateral V4 severe stenosis	Distal Lt. V4 (75%), Rt. V4 (90%) stenosis	Heterogeneous, eccentric wall thickening and enhancement, at Rt. V4	No

Abbreviations: DM, diabetes mellitus; DSA, digital subtraction angiography; DWI, diffusion-weighted imaging; F, female; HR-MRI, high-resolution magnetic resonance imaging; HTN, hypertension; LM, lateral medulla; Lt., left; M, male; MRA, magnetic resonance angiography; MM, medial medulla; OMI, old myocardial infarction; PFO, patent foramen ovale; PICA, posterior inferior cerebellar artery; Rt., right; VA, vertebral artery.