Intracranial vessel wall abnormalities in young stroke patients at 7.0 tesla MRI

Nikki Dieleman[1], Anja G. van der Kolk[1], Susanne J. van Veluw[2], Anita A. Harteveld[1], Catharina J.M. Frijns[2], Peter R. Luijten[1], and Jeroen Hendrikse[1]
[1]*Department of Radiology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands,* [2]*Department of Neurology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands*

Introduction: Ischemic stroke is relatively rare in young patients, and often not caused by atherosclerosis, but by other, more difficult to diagnose, diseases, like intracranial dissections, cardioembolic stroke and vasculitis. Regular clinical workup in these patients includes conventional field strength MRI, digital subtraction angiography, cerebrospinal fluid, and blood examinations. However, after this extensive workup, an accurate diagnosis still remains challenging in a large group of patients. For adequate treatment, early discrimination between different causes of ischemic events is essential. Therefore, other methods are needed for the differentiation between these causes. Intracranial vessel wall MRI is an emerging technique to show subtle changes of the intracranial arterial vessel wall, and may provide insight into the underlying aetiology. Ultrahigh-field strength MRI, like 7.0 tesla (7T), has the advantage of an increased signal-to-noise ratio compared to lower field strengths, enabling a higher spatial resolution and higher lesion conspicuousness, within acceptable scan time. In this study, we aimed to demonstrate patterns of vessel wall abnormalities in young stroke patients using 7T intracranial vessel wall MRI.

Materials and Methods: This retrospective study was approved by the institutional Review Board of our institution. All patients gave written informed consent. Imaging was performed on a 7T whole body system (Philips Healthcare, Cleveland, OH, USA) with a 32-channel receive coil and volume transmit/receive coil for transmission (Nova Medical, Wilmington, MA, USA). For clinical purpose, a patient-specific imaging protocol was obtained, after regular clinical workup using conventional-field strength MRI, for nine young stroke patients, consisting of at least a high-resolution Fluid-Attenuated Inversion Recovery (FLAIR) sequence and a whole brain Magnetization Preparation Inversion Recovery Turbo Spin Echo (MPIR-TSE) intracranial vessel wall sequence[1] before and after contrast administration. Before acquisition of the contrast enhanced MPIR-TSE[1] sequence, 0.1 mL/kg of a gadolinium-containing contrast agent (Gadobutrol, Gadovist 1.0 mmol/mL, Bayer Schering Pharma, Newbury, UK) was administered to the patient. The following scan parameters were used: whole brain MPIR-TSE sequence, field-of-view (FOV) 250x250x190mm^3, acquired resolution 0.8x0.8x0.8mm^3, repetition time (TR) 3952ms, inversion time (TI) 1375ms, echo time (TE) 37ms, scan duration approximately 11min; FLAIR sequence, FOV 250x250x190mm^3, acquired resolution 0.8x0.8x0.8mm^3, TR/TE/TI 8000/300/2250ms, scan duration approximately 13min. Vessel wall abnormalities, enhancement, and ischemic lesions were scored by three independent raters (vessel wall: ND, JH, and AK; infarcts: ND, JH, and SV) using an offline workstation; for assessment of enhancement, pure contrast enhancement images were produced by registering and subtracting pre- from post-contrast MPIR-TSE images in MeVisLab v2.5.

Results: Imaging was successful in all nine patients (mean age 42 years, range 27 - 65; 5 females). Intracranial vessel wall abnormalities were identified in seven patients (78%). Intracranial vessel wall abnormalities were found at multiple locations, totaling 44 lesions, of which 11 enhanced after contrast administration. In all patients with intracranial vessel wall lesions, the vessel wall abnormalities were present in the arteries of the flow territories in which the ischemic events occurred and in three patients also arteries in other flow territories were affected. Table 1 gives an overview of the different patterns of vessel wall abnormalities found in the nine patients and their clinical diagnoses. Figure 1 shows an example of abnormalities found in a patient with intracranial dissection.

Conclusion: 7T MRI was able to identify different patterns of vessel wall abnormalities in a heterogeneous group of young stroke patients. Two patients without vessel wall abnormalities were diagnosed with Susac's syndrome and possible vasculitis. To our knowledge, Susac's syndrome has not been related to vessel wall abnormalities; however, vessel wall enhancement is commonly seen in patients with vasculitis[2,3,4]. Since our patient had been, previously, under treatment, vessel wall enhancement was not expected[5]. Our results show that, in this heterogeneous patient group, different patterns of vessel wall abnormalities exist, which might serve as diagnostic marker for the discrimination between causes of stroke in young patients; a larger study should reveal whether these patterns persist.

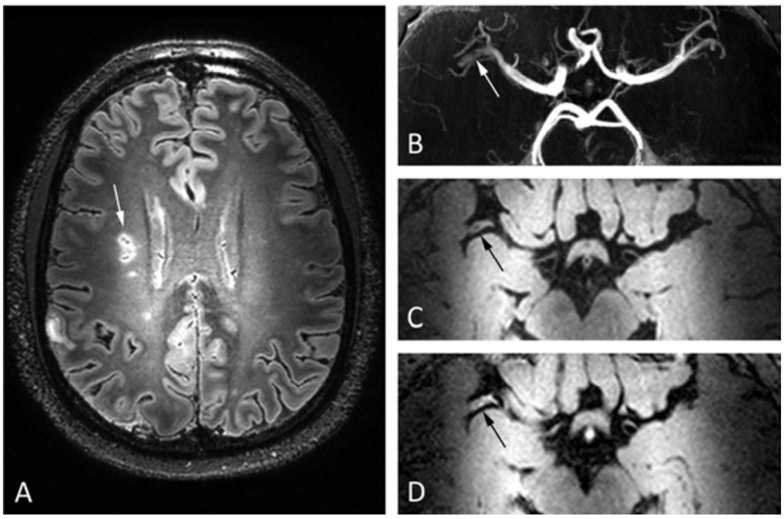

Figure 1. A 52-year-old male (patient #7 Table 1) presented with paresis of the left arm and headache based on dissection of the right middle cerebral artery (MCA). ***A.*** *Transverse 7.0 tesla (7T) fluid-Attenuated inversion recovery image shows multiple recent small subcortical infarcts of the right MCA territory, corresponding to a dissection of the right M1/M2 segment of the MCA on transverse time-of-flight MR angiogram (white arrows) (**B**). Transverse 7T 3D magnetization preparation inversion recovery turbo spin echo images before (**C**) and after (**D**) contrast administration, show the dissection of the right MCA in more detail, and enhancement of the vessel wall at the location of the dissection (**D**) (black arrows).*

Table 1. Patterns of vessel wall abnormalities and clinical diagnosis

Patient	Location of vessel wall lesion	Thickening pattern	Enhancement pattern	Clinical diagnosis
1	-	-	-	Susac's syndrome
2	-	-	-	Possible vasculitis
3	VA, ICA, Bif ICA-A1-M1 R	concentric	+	RCVS
4	M1 R	eccentric/concentric	+	Young stroke, unknown cause
5	A1, ICA, Bif ICA-A1-M1 R, M1, M2 L, BA, P1 L	eccentric	+	Atherosclerosis
6	bif ICA-A1-M1 R, ICA, M1, M2 L, PCOM R, P1, P2, BA, VA	concentric	-	Possible Sneddon's syndrome
7	ICA R, M1 R, M2 R, VA L	concentric	+	Intracranial dissection
8	Bif ICA-A1-M1, M1 R, PCOM, BA	eccentric	-	Unknown cause
9	ICA, Bif ICA-A1-M1 R, P2 L	concentric	+	Atherosclerosis

Abbreviations: A1 and A2: 1st and 2nd segment of anterior cerebral artery; BA: basilar artery; ICA: internal carotid artery; M1 and M2: 1st and 2nd segment of the middle cerebral artery; P1 and P2: 1st and 2nd segment of the posterior cerebral artery; PCOM: posterior communicating artery; RCVS: reversible cerebral vasoconstriction syndrome; VA: vertebral artery; bif ICA-A1-M1: bifurcation ICA-A1-M1; L: left; R: right.

References: [1]Van der Kolk AG, *European Radiology* 2013; [2]Kuker W, *Cerebrovascular Diseases* 2008; [3]Pfefferkorn T, *J Neuroimaging* 2013; [4]Saam T, *Br J Radiol* 2010; [5]Mandell DM, *Stroke* 2012.