Related Factors of Asymmetrical Vein Sign in Acute Middle Cerebral Artery Stroke and Correlation with Clinical Outcome

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Objective: The aim of our study was to analyze the related factors of asymmetrical cortical vein sign (ACVS) and asymmetrical medullary vein sign (AMVS) on susceptibility-weighted imaging (SWI) in patients with acute middle cerebral artery (MCA) stroke and whether their presence can be used as an independent predictor for clinical outcome. *Methods:* According to the presence of ACVS and AMVS on SWI, 124 patients with acute MCA stroke within 3 days were divided into several different groups. In addition, those patients were also divided into good and poor outcome group by using the modified Rankin Scale at 3 months after stroke. We investigated respectively the differences in magnetic resonance imaging findings and the clinical data among those different groups. *Results:* The ACVS was demonstrated in 90 of 124 patients. Of the 90 patients, 47 were accompanied with the AMVS. The rest of 34 patients showed no ACVS and AMVS. The infarct size and MCA status showed significant differences among the ACVS+, AMVS+ group; ACVS+, AMVS– group; and ACVS–, AMVS– group (all $P < .001$). Moreover, the ACVS, AMVS, and MCA occlusion were more common in the poor outcome group (all $P < .001$). In the multivariate logistic regression, AMVS ($P = .03$; odds ratios, .7; 95% confidence intervals, .6-1.82) was inversely associated with poor outcome. *Conclusions:* The ACVS and AMVS were correlated to the status of MCA steno-occlusion and infarct size, whereas the AMVS was proved to be independently related to the stroke severity and poor outcome rather than the ACVS. **Key Words:** Asymmetrical cortical vein sign—asymmetrical medullary vein sign—middle cerebral artery—stroke.

Introduction

Susceptibility-weighted imaging (SWI) is a modern magnetic resonance imaging (MRI) technique that is a high-resolution 3D phase-enhanced gradient echo method sequence. It is exquisitely sensitive to paramagnetic substances, such as deoxygenated blood, blood products, iron, and calcium.[1-3] Recently, SWI has been applied widely as a method available to evaluate intracerebral hemorrhage, hemorrhagic transformation, cerebral venous thrombosis, and assessment of brain tissue at risk for infarction.[4-8]

In clinical practice, we have noted that prominent hypointensity and enlargement of vessels in acute ischemic cerebral hemisphere with both cortical and deep venous drainage compared with the contralateral hemisphere. The presence of prominent dilated vessels along the course of the cortical veins (CV) on SWI has been called the “asymmetrical cortical vein sign (ACVS),” whereas the same status that occurred along the course of the subependymal and medullary veins (MV) in the deep white matter has been called the “asymmetrical

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Received March 1, 2017; revision received April 17, 2017; accepted May 14, 2017.

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1052-3057/$ - see front matter

http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2017.05.023

medullary vein sign (AMVS)" or "brush sign."[9-11] The prominence was thought to be correlated with the increased oxygen extraction fraction (OEF), and slow flow was thought to contribute to a higher level of deoxyhemoglobin or dilation of cerebral veins in response to ischemia.[12,13] However, ACVS or AMVS does not appear in every acute ischemic stroke case. The appearance of ACVS and AMVS seems to be pathophysiologically complex, and the clinical significance is still unclear. It has not been clearly established which clinical and radiological factors affect the appearance of ACVS and AMVS on SWI in acute cerebral ischemia. Furthermore, whether the presence of asymmetrical vein sign on SWI is associated with stroke severity and outcome in previous studies remains controversial.[14] Thus, the aim of the present study was to investigate the related factors of ACVS and AMVS on SWI in patients with acute middle cerebral artery (MCA) stroke and whether their presence were used as an independent predictor for stroke severity and outcome.

Materials and Methods

Patients

The patients with MCA stroke who were on drug conservative treatment, without intravenous or intra-arterial thrombolytic therapy, and who underwent MRI, including diffusion-weighted imaging (DWI), SWI, and time-of-flight magnetic resonance angiography (TOF-MRA) within 3 days from stroke onset, were retrospectively selected from the hospital database between March 2014 and June 2016. We included patients with unilateral MCA occlusion or stenosis but excluded patients with internal carotid artery occlusion or stenosis. The patients with lacunar infarcts, hemorrhage transformation, or moyamoya disease were also excluded. The following clinical data were reviewed: patient age, sex, history of hypertension, hyperlipidemia, diabetes mellitus, or atrial fibrillation, platelet, international normalized ratio level, time of onset of clinical symptoms at admission to the hospital, and National Institutes of Health Stroke Scale (NIHSS) score at admission. Clinical outcome at 3 months after stroke was assessed by using the modified Rankin Scale (mRS) which was dichotomized into good (mRS 0-1) and poor outcome (mRS 2-6). All subjects gave written informed consent before the study, and the protocols were approved by the human ethics committee of the hospital.

Imaging Techniques

Images were acquired on a 3T system (Magnetom Tim Trio or Skyra, Siemens Healthcare, Germany) with 12-channel head-matrix coil and identical technical parameters. The DWI sequence parameters were 5-mm axial slices with interslice gap of 1 mm, time repetition/time echo = 4500/71 ms, flip angle = 15°, b-value = 1000 s/mm^2, acquisition matrix = 192 × 192 pixels, field of view = 220 × 220 mm, and duration of 2 minutes and 2 seconds. The apparent diffusion coefficient maps were calculated. TOF-MRA was set to the following parameters: section thickness .5 mm, 4 slabs, time repetition/time echo = 21/3.43 ms, flip angle = 18°, acquisition matrix = 384 × 346 pixels, and duration of 3 minutes and 59 seconds. SWI data were collected with a 3D, fully flow-compensated gradient echo sequence using the following parameters: 72 slices, section thickness 1.5 mm with no interslice gap, time repetition/time echo = 20/27 ms, flip angle = 15°, acquisition matrix = 256 × 196 pixels, field of view = 220 × 220 mm, and voxel size = .9 × .9 × 1.5 mm; no interpolation was applied and duration was 2 minutes and 22 seconds. The entire duration of the MR imaging protocol was 12 minutes.

Image Analysis

An acute infarct area was defined as increased signal intensity on DWI and decreased signal intensity on apparent diffusion coefficient maps. The infarct extent was scored using the semiquantitative computed tomography scoring system, the Alberta Stroke Program Early Computed Tomography Score (ASPECTS).[15] The MCA territory was divided into 10 areas in this topographic system: caudate nucleus, lentiform nucleus, internal capsule, insula, M1, M2, and M3 (anterior, middle, and posterior third of the lower MCA territory, respectively), and M4, M5, and M6 (anterior, middle, and posterior third of the higher MCA territory, respectively). The location of infarct was based on the ASPECTS topographic system. To calculate the DWI-ASPECTS score, 1 point was subtracted from 10 for each area. A score of 10 is normal, wheareas 0 indicates diffuse infarction. Pathologic hypointense of the CV in the MCA cortex (M1-M6 and insular cortex) and deep MV in the periventricular white matter draining the caudate nucleus, lentiform nucleus, and internal capsule were scored if they were clearly asymmetric, enlarged, or more numerous on SWI by visual inspection and defined, respectively, as ACVS and AMVS. The MRA was rated by using the Thrombolysis in Myocardial Infarction grading scale: 0 = complete occlusion, which was defined as lack of low signal of a vascular segment and distal vessels; 1 = severe stenosis, which was defined as severe or critical stenosis of a vascular segment with significant reduction of flow signal distal to stenosis; 2 = mild-to-moderate stenosis, which was characterized by stenosis with normal distal flow signal.[16,17]

All initial magnetic resonance images were interpreted blindly to the clinical findings of each patient. The data collection and scoring were performed separately by 2 different neuroradiologists (Yu and Li, with 10 and 21 years of experience, respectively) who were blinded to the clinical data and other magnetic resonance images. SWI was scored before DWI to avoid a reading bias. Any case of disagreement was resolved by consensus reading.