Parenchymal hypointense foci associated with medullary venous malformations: evaluation by susceptibility weighted MR imaging at 3.0 tesla

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Purpose

1, Medullary venous malformation [MVM], also called developmental venous anomaly or venous angioma, is the most common type of vascular malformation. The risk of hemorrhage in the context of MVM is considered to be very low, but it has never been evaluated by SWI at 3.0 Tesla.

2, Several types of brain parenchymal abnormalities within the drainage territory of MVM have been identified; these include white matter hyperintensity [WMH] on T2WI and FLAIR imaging. The pathologic correlation and etiology of WMH in the drainage territory of MVM remains unknown. However, it has been speculated that WMH reflects leukoaraiosis, which histopathologically includes edema, demyelination and gliosis resulting from chronic venous hypertension caused by anomalous venous drainage.(1,2)

3, The goal of the present study was to evaluate the prevalence of hypointense foci (i.e., microhemorrhage or cavernous malformation [CM]) associated with MVM and to evaluate the relationship between the hypointense foci and white matter hyperintense lesions WMH.
Methods and Materials

Patient Population

Forty-nine patients who underwent MR examination including SWI at our institution during the last 5 years were included in this study. One patient was excluded because of susceptibility artifacts caused by postoperative changes around the MVM, and another four patients were excluded because the MVM region was not sufficiently included on SWI. Thus, 44 sides in 44 consecutive patients (age range, 2-80 years; mean age, 51 years) were included in the final analysis.

MR Technique

All brain MR imaging was obtained with a 3.0 Tesla MR system (Signa EXCITE HD, General Electric, Milwaukee, WI, USA) using an eight-channel phased-array coil (USA Instruments, Aurora, OH, USA).

Axial T2-weighted fast spin echo (FSE) images was obtained with the following imaging parameters: repetition time (TR)/echo time (TE), 4000/95 msec; 512 ´ 320 matrix, 21 cm field of view (FOV), section thickness/intersection gap, 5/1.5 mm. For susceptibility weighted MR imaging, phase-sensitive imaging was performed with a 3D SPGR sequence with flow compensation, using the following imaging parameters: TR/TE, 45/30 msec; flip angle, 20°; FOV, 21 cm; matrix, 512 ´ 192; section thickness, 1.5 mm, acquisition time, 7 min 40-50 sec. Phase-sensitive images were post-processed using a high-pass filter, and the images were converted into negative phase masks that were multiplied four times into the corresponding magnitude images using research software (PSiRecon: GE Yokogawa Medical Systems, Tokyo, Japan). A minimum intensity projection (phase-sensitive image) was used to display the processed data using contiguous 10.5-mm-thick sections with 7 mm overlap in the transverse plane (Advantage workstation ver. 4.1, General Electric, Milwaukee, WI, USA).

Image Reading

Two neuroradiologists who were blinded to the patients' clinical information independently reviewed SWIs and T2WIs. Assessments included the presence of hypointense foci around MVM on SWI and the presence of the in the drainage territory of the MVM on T2WI. The drainage territory was defined as the brain parenchyma directly adjacent to the MVM. Discordance between two radiologists was resolved by consensus. To minimize bias, T2WI assessments were performed 3 months after SWI assessments.

Statistical Analysis
The relationship between hypointense foci and WMH was assessed by Chi-square testing. A difference with a P value of <0.05 was considered statistically significant.
Results

Hypointense foci were observed on SWI in 50.0% (22/44) of patients, and WMH was observed on T2WI in 54.5% (24/44) of patients. WMH was more frequently observed in patients with hypointense foci (17 of 22) than in patients without hypointense foci (7 of 22 patients) (p<0.01). (Fig.1,2,3,Table1)

Discussion

1. This study used SWI to demonstrate that the prevalence of hypointense foci, indicating microhemorrhage or CM, was higher than previously suspected in patients with MVM (reported prevalence of hematoma 3%, ICH annual risk 0.15% to 0.68%, CM occurs in 2 to 18% of patients with MVM). (3-9) The discrepancy in the prevalence of hemorrhage and CM between this study and previous studies may be related to the fact that SWI at 3.0 Tesla MR was used in this study. By using SWI at 3.0 Tesla, we were able to detect even minute hemorrhage and CM, in contrast to previous studies.

2. There was a significant relationship between hypointense foci and WMH. Although the exact events leading to de novo formation of CM in patients with MVM is unclear, some investigators have speculated that development of venous hypertension and resultant microhemorrhages from the fragile vessel wall of the MVM may induce reactive angiogenesis and subsequent CM formation. (8-11) Hong et al. reported that angioarchitectural factors of MVM causes disturbances in blood flow and may lead to CM within the territory of MVM by increasing venous pressure. (11) Results from the present study support the theory that microhemorrhage and CM are related to venous congestion caused by abnormal venous drainage. Taken together, these data suggest that venous congestion caused by angioarchitectural or other factors leads to WMH and subsequent CM formation. Hence, these two phenomena are likely to occur simultaneously.

3. These data also suggest that SWI is required to assess the presence of hypointense foci and that SWI may be indicated when WMH is present adjacent to MVM. In addition, careful follow-up examination using SWI should be performed to assess whether there is a change in size of the hypointense foci, because CM is considered an active lesion characterized by dynamic behaviors, including enlargement, regression, and de novo formation. Furthermore, several studies reported that clinical presentation of patients with both MVM and CM is nearly always related to the CM, reflecting its potential for epileptogenesis and symptomatic hemorrhage. (3,7,9)
Fig. 1: A 64-year-old male with MVM in the right frontal lobe. a, SWI shows MVM in the right frontal lobe and hypointense foci around the MVM(arrow). b, T2WI shows WMH around the MVM(arrow).

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Fig. 2: A 25-year-old female with MVM in the right cerebellum. a, SWI shows MVM in the right cerebellum and hypointense foci around the medullary veins. b, T2WI shows WMH around the MVM.

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Fig. 3: A 75-year-old male with MVM in the right parieto-temporal lobe. a, SWI shows MVM in the right parieto-temporal lobe and minute hypointense foci around the MVM(arrow). b, T2WI shows WMH around the MVM(arrow).

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**Table 1**: Distribution of patients based on the presence of hypointense foci and WMH

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Conclusion

The prevalence of hypointense foci, indicating microhemorrhage or CM, was higher than previously suspected in patients with MVM. Further, there was a significant relationship between hypointense foci and WMH. These results support the hypothesis that microhemorrhage or CM are related to venous congestion caused by abnormal venous drainage. We conclude that SWI is useful for the detection of microhemorrhage or CM in patients with MVM, especially when associated with WMH.
References


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