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Case Report

The prominent hypointense vessel sign on susceptibility-weighted imaging (SWI) as a potential imaging biomarker for poor clinical outcome in acute ischemic stroke (AIS) ☆

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ABSTRACT

Susceptibility-weighted imaging (SWI) is a relatively new magnetic resonance imaging (MRI) technique used in the workup and diagnosis of brain pathologies. In the context of acute ischemic stroke (AIS), it is increasingly becoming useful in the diagnosis, treatment, and further management of these patients. An elderly man with metabolic syndrome presented to us with an acute onset of right sided body weakness and aphasia. Urgent imaging via MRI noted a left middle cerebral artery (MCA) occlusion. Diffusion-weighted imaging (DWI)/fluid attenuated inversion recovery (FLAIR) mismatch was noted with an acute infarct involving the left MCA territory; hence, treatment with intravenous (IV) thrombolysis was administered. On SWI, the prominent hypointense vessel sign was noted. Recanalization of the occluded left MCA was seen on diagnostic cerebral angiography post IV thrombolysis, however, the patient was noted to have early neurological deterioration (END) and poor early stage clinical outcome, despite repeat MRI showing recanalization of the left MCA occlusion and reversal of the prominent hypointense vessel sign on SWI. Presence of the prominent hypointense vessel sign on SWI in AIS patients is associated with poor clinical outcome, unsuccessful recanalization rates, END, poor early stage clinical outcome, and infarct core progression. Some studies have shown an association between this imaging sign and poor

Abbreviations: AIS, acute ischemic stroke; GCS, Glasgow Coma scale; MCA, middle cerebral artery; NIHSS, National Institutes of Health Stroke Scale; MRI, magnetic resonance imaging; DWI, diffusion-weighted imaging; SWI, susceptibility-weighted imaging; TNK, tenecteplase; NCCT, noncontrasted computed tomography; CRP, C-reactive protein; END, Early neurological deterioration.

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collateral circulation status. Therefore, this imaging sign could potentially prove to be a useful imaging biomarker. However, more studies are needed to validate this theory.

Background

Susceptibility-weighted imaging (SWI) is a relatively new magnetic resonance imaging (MRI) technique which utilizes the magnetic susceptibility differences of various tissues. In the context of brain pathologies, tissues such as iron, blood, and calcification can be better depicted, or made more conspicuous. As more centers utilize MRI as the first line imaging method for acute ischemic stroke (AIS), the usefulness of this sequence is increasingly becoming more apparent. We describe a patient presenting to our institution with a left sided middle cerebral artery (MCA) large vessel occlusion, who was noted to have the prominent hypointense vessel sign on SWI, and the patient's clinical outcome post recanalization with intravenous (IV) thrombolysis.

Case presentation

An elderly man with uncontrolled diabetes mellitus complicated with left above knee amputation 4 years ago, hypertension, and dyslipidemia woke up on the day of presentation with right sided body weakness and aphasia. He presented to the hospital 3 hours after waking up, and was last seen well the night before at 12 midnight. Upon examination, his Glasgow Coma Scale (GCS) was 10/15 (E4 V1 M5), the blood pressure was 169/115 mmHg with a pulse rate of 84 beats per minute (sinus rhythm), and the oxygen saturation was 99% under room air. He was afebrile; random blood sugar was 13 mmol/L. His total National Institutes of Health Stroke Scale (NIHSS) score was 25. Urgent MRI showed acute infarct at the left middle cerebral artery (MCA) territory, with diffusion-weighted imaging (DWI) and Fluid Attenuated Inversion Recovery (FLAIR) mismatch. Magnetic resonance angiography showed a left M1 segment occlusion. SWI noted prominent hypointense vessel sign at the affected side (Figs. 1A-E). Although his Modified Rankin Scale (MRS) prior to this episode was 3, he was independent in his activities of daily living and was able to ambulate freely with his wheelchair. As there was no contraindication for thrombolysis, intravenous (IV) tenecteplase (TNK) at 0.25 mg/kg was given; he was then taken straight to the angiography suite, where complete revascularization without mechanical thrombectomy was observed (TICI grade 3) (Fig. 1F). At 2.5 hours after thrombolysis, his NIHSS improved to 20, mainly due to improvement of motor power in the upper and lower limbs of the initial paretic side. However at 24 hours, he was noted to be drowsy and was not obeying commands with an increase of the NIHSS score to 30, in keeping with early neurological deterioration (END). A repeat non-contrasted computed tomography (NCCT) of the brain was done immediately, which revealed no intracranial hemorrhage. Blood investigations showed white cell count was 10×10^9/L, hemoglobin was 15 g/dL, platelet was 215×10^9/L, C-reactive protein (CRP) was 5.0 mg/L, urea was 4.5 mmol/L and creatinine was 85 μmol/L. Other electrolytes and thyroid function test were unremarkable. The chest radiograph was normal. Thus, his neurological deterioration was attributed to delirium evidenced by the 4AT test which gave a score of 12, suggestive of delirium likely precipitated by the stroke. Repeated MRI on day 5 of admission as per our institution's protocol noted small new infarcts at the left MCA territory, with no evidence of hemorrhage and no vessel occlusion, with resolution of the prominent hypointense vessel sign seen on the initial MRI (Fig. 2). Throughout the admission, his delirium improved and his NIHSS remained equivocal at 20 until the day of discharge.

Discussion and conclusions

SWI is a relatively new MRI technique which utilizes the magnetic susceptibility differences of various tissues, such as blood, calcification, and iron. Thus, in the context of brain pathologies, this sequence is useful in the detection of microhemorrhages, slow-flow vascular malformations, brain tumor characterization, neurodegenerative diseases, as well as detecting calcifications in a multitude of pathological conditions [1]. The utilization of this MRI sequence in the field of stroke medicine has turned out to be increasingly important, with the recognition of certain imaging features—among them being the prominent hypointense vessel sign.

The prominent hypointense vessel sign is an imaging sign seen on SWI in patients with acute ischemic stroke (AIS). In patients with AIS, a sudden deficit of oxygenation to the brain tissue eventually leads to an increase in the oxygen extraction fraction, when the concentration of deoxyhemoglobin surpasses that of oxyhemoglobin. This phenomenon in turn causes the vessels of the affected brain tissue, namely the cortical veins and the subependymal and medullary veins in the deep white matter to be seen more prominently, and increased in number in relation to the contralateral unaffected cerebral hemisphere [2]. Making matters worse, the slow flow (due to the vascular occlusion) contributes to higher levels of deoxyhemoglobin and dilatation of the cerebral veins [3,4]. This was seen in our patient, who had an acute large vessel occlusion of the left middle cerebral artery (MCA), with the SWI sequence showing prominent veins distributed along the left MCA territory.

The presence of this imaging sign in AIS has prompted further research to look at its significance and impact to clinical decision making. Wang et al, in their study of 40 patients presenting with acute MCA occlusion, discovered that the presence of this imaging sign is associated with poor outcome [5].

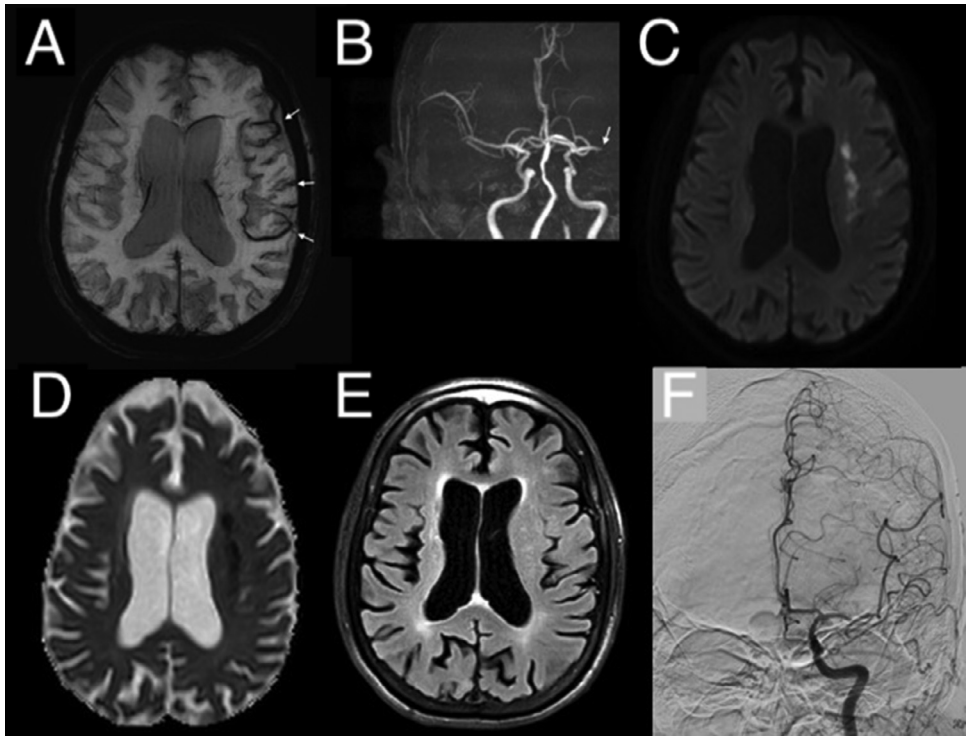

Fig. 1 – (A) Prominent hypointense vessels are noted at the region of the left middle cerebral artery (MCA) on the susceptibility-weighted imaging (SWI) sequence (white arrows). (B) MRA (magnetic resonance angiography) image showing cut-off of the M1 segment of the left MCA (white arrow). (C, D) Diffusion-weighted imaging (DWI) (C) and apparent diffusion coefficient (ADC) (D) images showing restricted diffusion representative of acute infarcts at the left MCA territory. (E) No corresponding hyperintensity is noted on the fluid attenuated inversion recovery (FLAIR) image (evidence of DWI-FLAIR mismatch). (F) Angiographic left ICA run showing recanalization of the truncated M1 segment of the left MCA, compared to the MRI done prior to the patient entering the angiography suite. Mechanical thrombectomy was not pursued in view of spontaneous complete recanalization observed (TICI 3).

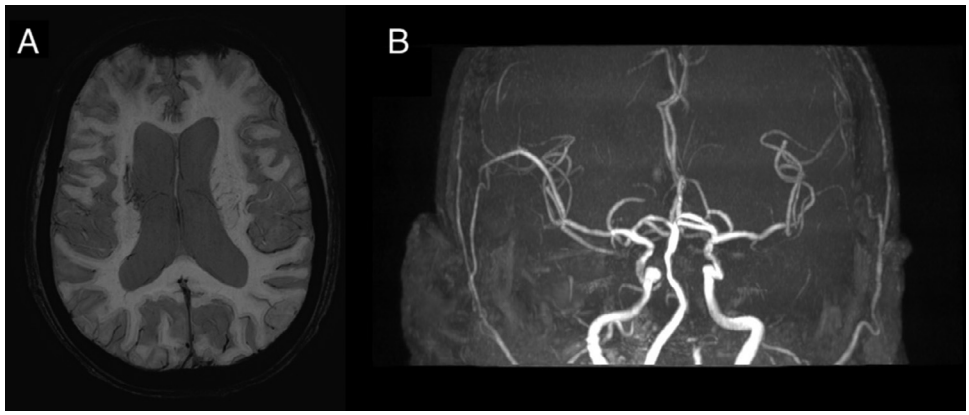

Fig. 2 – (A) Repeat MRI on day 5 shows near complete resolution of the prominent hypointense vessel sign, on the susceptibility-weighted imaging (SWI) sequence. (B) MRA image showing revascularization of the previously occluded left MCA.

Chen et al., in their study of 22 patients with MCA infarction, found that in 15 patients that exhibited this imaging sign, 13 patients demonstrated infarct growth on the second MRI and poor early stage clinical outcome. No difference was noted in the late stage clinical outcome between the groups with and without this imaging sign on SWI [6]. Another study which looked at 124 patients with acute MCA stroke within 3 days found that in those with the SWI finding of the prominent hypointense vessel sign, patients who demonstrated prominent medullary veins fared worse [7]. In the context of END, Liu

et al in their study of 61 patients suffering from symptomatic stenosis or occlusion of the internal carotid artery (ICA) or the MCA whom were treated with recombinant tissue plasminogen activator (r-tPA), found that those with the imaging sign were more significantly affected.

One possible explanation for these findings could be attributed to the relation between the presence of this imaging sign on SWI and the status of the collateral circulation. Kim et al looked at 152 patients with AIS due to occlusion or stenosis of the unilateral ICA and/or MCA (M1 segment) evaluated within 8 hours of symptom onset. The SWI collateral grade, a grading that compares the degree of prominent cortical/medullary veins present in relation to the collateral-perfusion grade via multiphase MR angiography was used and noted that patients with higher SWI collateral grades (either no or only mildly prominent veins) were independently associated with favorable functional outcome [8]. They concluded that collateral estimation using the prominent vessel sign on SWI is clinically reliable, with prognostic value. A recent study [9] which evaluated the prominent cortical vessels on SWI in comparison with leptomeningeal collaterals on multiphasic CTA found that the presence and extent of prominent vessels on SWI were associated with worse functional outcomes, and a lower successful recanalization rate. Moreover, the presence of prominent cortical vessels predicted outcomes better than good collaterals on multiphasic CTA. Therefore, the available evidence at this juncture suggests that prominent veins on SWI are potentially a viable surrogate marker for poor collateral circulation status, and thus, clinical outcome in patients with AIS. This at least holds true with our patient, whom was successfully treated with recanalization therapy but was complicated with END and poor early stage clinical outcome.

SWI is proving to be a useful sequence in patients with AIS. The presence of the prominent hypointense vessel sign, based on available data, is potentially a useful imaging biomarker to predict clinical outcome and successful recanalization. However, more data is needed to validate this theory, and we believe that the decision to treat (or not) should not solely rely on a single imaging biomarker, rather a comprehensive look at the individual patient with consideration of all possible avenues.

Ethics approval and consent to participate

Not applicable.

Patient consent

The patient provided informed written consent for the publication of this manuscript.

Availability of data and materials

All data reported are available from the corresponding author, upon reasonable request.

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