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Usefulness of 3-Tesla magnetic resonance arterial spin-labeled imaging for diagnosis of cranial dural arteriovenous fistula

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ABSTRACT

Background and purpose: Conventional digital subtraction angiography (DSA) has been a useful tool for the diagnosis of cranial dural arteriovenous fistula (cDAVF). In most patients with cDAVF, blood flow through the arteriovenous shunt was pooled at diseased veins and/or sinuses. Therefore, we speculated that pooled blood at diseased veins in patients with cDAVF could be detected on arterial spin-labeled imaging (ASL). The purpose of the present study was to investigate the usefulness of ASL to detect cDAVF.
Materials and methods: Consecutive 13 patients with cDAVF who were admitted to our hospital between April 2013 and September 2016 were included in our study. We performed magnetic resonance imaging (MRI), including ASL, before DSA and within 7 days after treatment for all of our patients. The accuracy for diagnosis of cDAVF was compared between conventional MRI findings and ASL findings. We also investigated the difference in ASL findings before and after treatment.
Results: We could detect venous ASL signals in 12 patients, and this was more sensitive for diagnosis of cDAVF versus conventional MRI findings. ASL found the same location of cDAVF as conventional angiography. After successful treatment, venous ASL signals disappeared.
Conclusions: ASL might be useful to detect cDAVF and predict the location of diseased sinuses.

1. Introduction

Although conventional digital subtraction angiography (DSA) has been a useful tool for diagnosis, classification, and monitoring of recurrence or progression of cranial dural arteriovenous fistula (cDAVF), magnetic resonance imaging (MRI) findings were also reported to be helpful to evaluate cDAVF [1–6]. Early diagnosis of cDAVF is important because delayed diagnosis may lead to a poor outcome [7]. However, cDAVF may be easily misdiagnosed early in the course of disease, especially in asymptomatic patients.

Arterial spin-labeled imaging (ASL) is a relatively novel MRI technique that utilizes water protons in the arterial water blood as endogenous tracers to assess cerebral blood flow (CBF) [8]. Arterial blood protons labeled at the proximal portion to the brain with radiofrequency pulses diffuse into the brain tissue once they reach the capillary bed. Obtaining a signal at a determined time delay, indicating labeled protons can be found in the capillaries. The labeled protons were thought to lose their signal before entering the veins because the T1 decay occurs during the transit time and the tissue exchange. Under the presence of arteriovenous shunting, arterial blood moves directly into the veins without passing the capillaries or brain tissue, and the labeled protons may retain their signals in the intracranial veins. Le et al. reported that venous ASL signals were useful to detect small intracranial arteriovenous malformations [9]. In most patients with cDAVF, blood pooled at diseased veins and/or sinuses is related to arteriovenous shunt. We speculated that the pooled blood could be detected venous ASL signals in patients with cDAVF. We investigated whether or not ASL was useful to diagnose the presence and location of cDAVF, and we compared the findings on ASL before and after treatment.

2. Methods

2.1. Patients

The study was approved by the local ethics committee, and was based on patient consent. This was a retrospective study of consecutive 13 patients with cDAVF, who were admitted and treated in our hospital between April 2013 and March 2016.

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2.2. Treatments

The treatment strategy of cDAVF is tailored individually to each patient, and the goal of treatment is to occlude the AV shunt without interfering with the normal venous return. Trans-arterial embolization (TAE) using a liquid embolic agent (n-butyl-2-cyanoacrylate; NBCA, Onyx®) requires penetration of the embolic agent through the feeding vessels into the veins and/or sinuses. In patients with venous occlusions or venous stenosis, which may limit a trans-venous approach, TAE is effective. Trans-venous embolization (TVE) is useful in patients with diseased sinuses isolated from the normal venous return. We created strategies for radical treatment and prevention of complications. In this study, TVE was performed in all of our patients using cerebral aneurysm coils. TVE was performed using a trans-femoral vein approach, and micro-catheters were advanced to diseased sinuses via ipsilateral or contralateral internal jugular veins using a micro-guidewire. After catheterization, we performed coiling until AV shunt disappearance on DSA was confirmed. All operations were performed under general anesthesia.

2.3. Imaging protocol

MRI examinations were performed with a 3-Tesla (T) MRI scanner (Discovery MR 750; GE Healthcare, Milwaukee, WI) equipped with an eight-channel phased-array head coil. All patients were examined with diffusion-weighted imaging (DWI), magnetic resonance angiography (MRA), T2-weighted imaging (T2-WI), and ASL. The imaging sequences and parameters were as follows: DWI: field of view (FOV): 24 cm, matrix: 128 × 128, repetition time (TR): 6000 ms, echo time (TE): 65 ms, slice thickness: 5 mm, gap: 0 mm, number of slices: 30, b-factor: 1000, number of excitations = 2, and acceleration factor: 2; MRA FOV: 22 cm, matrix: 512 × 224, TR: 30 ms, TE: 2.8 ms, flip angle: 17°, slice thickness: 1.2 mm, and number of slices: 66; and T2-WI gradient echo FOV: 24 cm, TR: 3500 ms, TE: 84 ms, flip angle: 28°, slice thickness: 5 mm, gap: 0 mm, and number of slices: 18. ASL images were acquired with the following parameters: 512 sampling points on 8 spirals, FOV: 24 cm, reconstructed matrix: 64 × 64, TR: 4632 ms, TE: 10.5 ms, NEX: 2, post-labeling delay: 2000 ms, slice thickness: 4 mm, and number of slices: 36.

We performed MRI, including ASL imaging, before conventional DSA to confirm cDAVF. MRI scanning was also performed within 7 days after treatment. We evaluated whether or not venous ASL signals, the difference in ASL findings before and after treatment, and the location of cDAVF using ASL. We investigated whether MRI findings, especially on ASL, were useful to diagnose the presence and location of cDAVF without conventional angiography. We also evaluated previously reported MRI findings, such as white matter hyperintensity, dilated vessels, venous pouches, concentration of feeding arteries, and flow-related enhancement at cerebral sinuses and veins on maximum intensity projection (MIP) images of time of flight (TOF) MRA (Fig. 1) [1–4]. We compared the accuracy with which these findings could both diagnose and locate cDAVF. MRI abnormalities were determined by a consensus between two neurologists who were familiar with MRI interpretation and did not have any patient information.

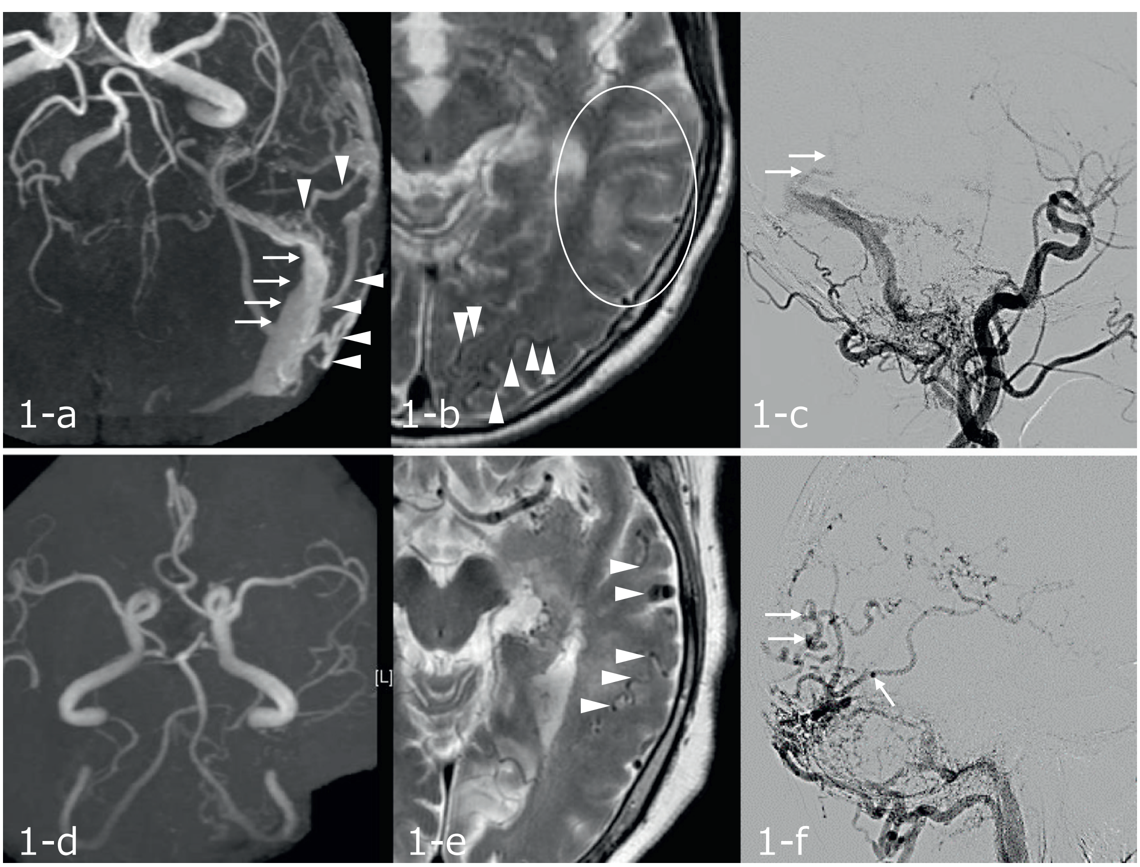

Fig. 1. Previously reported conventional MRI findings in our patients. 1a, b, and c are from case 4; 1d and e are from case 7. 1a. MRA shows concentration of meningeal branches (white arrow heads) and abnormal flow enhancement at left transverse sinus (white arrows). 1b. T2-weighted image (T2-WI) shows abnormal flow voids (white arrow heads) and high intense lesion of white matter (white circle). 1c. Conventional digital subtraction angiography (DSA) of left common carotid artery shows cranial dural arteriovenous fistula (cDAVF) at left transverse sinus (TS) and retrograde leptomeningeal drainage (white arrows). 1d. MRA shows no abnormality. 1e. T2-WI shows abnormal flow void (white arrow head). 1f Conventional DSA of left external carotid artery shows cDAVF at left TS, and retrograde leptomeningeal drainage (white arrows).