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Motoomi Ohkawa*

Naomi Fujiwara†

Tsutomu Katoh‡

Yasutane Mori**

Satoru Nakano††

Masatada Tanabe‡‡

Yasumasa Honjo§

Seigo Nagao¶

*Kagawa Medical University,

†Kagawa Medical University,

‡Kagawa Medical University,

**Kagawa Medical University,

††Kagawa Medical University,

‡‡Kagawa Medical University,

§Kagawa Medical University,

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Abstract

High-resolution magnetic resonance venography (HR-MRV) of intracranial subependymal veins using a two-dimensional Fourier-transform time-of-flight technique was performed on normal volunteers and clinical cases of cerebral disease. For the pulse sequence, fast-field-echo sequence was used with the following parameters: TR/TE/ flip angle = 34ms/12ms/50deg., 256 x 256 matrix, 1 mm effective slice thickness, 150mm field of view, and one signal acquisition. Sequential vertical coronal sections were taken against the skull base. The anterior septal vein, the medial atrial vein, the anterior caudate vein and thalamostriate vein were detected in all subjects. In all clinical cases, HR-MRV was equal in diagnostic capability to conventional cerebral angiography.

KEYWORDS: high-resolution MR venography, MR angiography, subependymal veins

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Detection of Subependymal Veins Using High-Resolution Magnetic Resonance Venography

Motoomi OHKAWA*, Naomi FUJIWARA, Tsutomu KATO, Yasutane MORI, Satoru NAKANO, Masatada TANABE, Yasumasa HONJO^a and Seigo NAGAO^a

Departments of Radiology and ^aNeurological Surgery, Kagawa Medical University, Kagawa 761-07, Japan

High-resolution magnetic resonance venography (HR-MRV) of intracranial subependymal veins using a two-dimensional Fourier-transform time-of-flight technique was performed on normal volunteers and clinical cases of cerebral disease. For the pulse sequence, fast-field-echo sequence was used with the following parameters: TR/TE/flip angle = 34 ms/12 ms/50 deg., 256 × 256 matrix, 1 mm effective slice thickness, 150 mm field of view, and one signal acquisition. Sequential vertical coronal sections were taken against the skull base. The anterior septal vein, the medial atrial vein, the anterior caudate vein and thalamostriate vein were detected in all subjects. In all clinical cases, HR-MRV was equal in diagnostic capability to conventional cerebral angiography.

Key words: high-resolution MR venography, MR angiography, subependymal veins

Intracranial magnetic resonance venography (MRV) was first reported by Edelman *et al.* in 1989 (1), and is now used for detecting dural venous sinus thrombosis (1-3). However, all these studies (1-3) were aimed at detecting main venous sinus with no study of MRV's ability to detect deep fine cerebral veins. Now, with recent advances in high-resolution imaging, it has become possible to obtain images of fine arteries. The purpose of the present study was to evaluate the ability of high-resolution MRV (HR-MRV) to detect subependymal veins.

Materials and Methods

The HR-MRV was performed on 20 healthy volunteers ranging in age from 26 to 64 years, and then on

another group of 15 patients aged 58 to 78 years. Present in the patient population were 11 cases of brain tumor, 3 cases of cerebrovascular disease and one case of intracranial infection.

HR-MRV technique. All studies were performed with a 1.5-T superconductive magnet system (Gyroscan, Philips, Netherlands). For the pulse sequence, the 2D-time of flight (TOF) method employing fast-field-echo was used. Parameters were: 34 ms/12 ms/50 deg. (repetition time [TR]/echo time [TE]/flip angle), 256 × 256 matrix with a 150 mm field of view (FOV), 1.5 mm slice thickness with a 0.5 mm overlap, and one signal acquisition. By using sagittal imaging, coronal imaging vertical to the base of the skull was specified in such a range that the corpus callosum could be seen. To avoid imaging the arterial system, the presaturation pulse was placed inferior to the imaging volume to suppress signals from inflowing arterial spins.

In the normal volunteers, three radiologists (M.O., N.F., T.K.) evaluated the five subependymal veins including the septal vein (SV), the posterior septal vein (PSV) and the medial atrial vein (MAV) in the medial group and the anterior caudate vein (ACV) and the thalamostriate vein (TSV) in the lateral group (Fig. 1). In clinical cases, the detectability of subependymal veins by HR-MRV was also compared with conventional cerebral angiography on both the anterior/posterior and lateral projection, and pathological changes as seen on the images were evaluated. In HR-MRV, the cranio-caudal view was also used in the evaluation.

Results

In the normal volunteers, both the SV and the MAV

* To whom correspondence should be addressed.

could be completely identified (Fig. 2). However, the PSV could not be identified in these subject. Of the lateral group of subependymal veins, both the ACV and the TSV could be identified easily in the volunteers (Table 1). In particular, the TSV formed the pseudo-venous angle on the left side in one case, on the right side in 4

cases and on both sides in 2 cases, which could be observed easily in all cases (Fig. 3).

In clinical cases, HR-MRV was similar to the venous phase of conventional cerebral angiography on both the anterior posterior and lateral projection. All subependymal veins except for the PSV were easily detected by

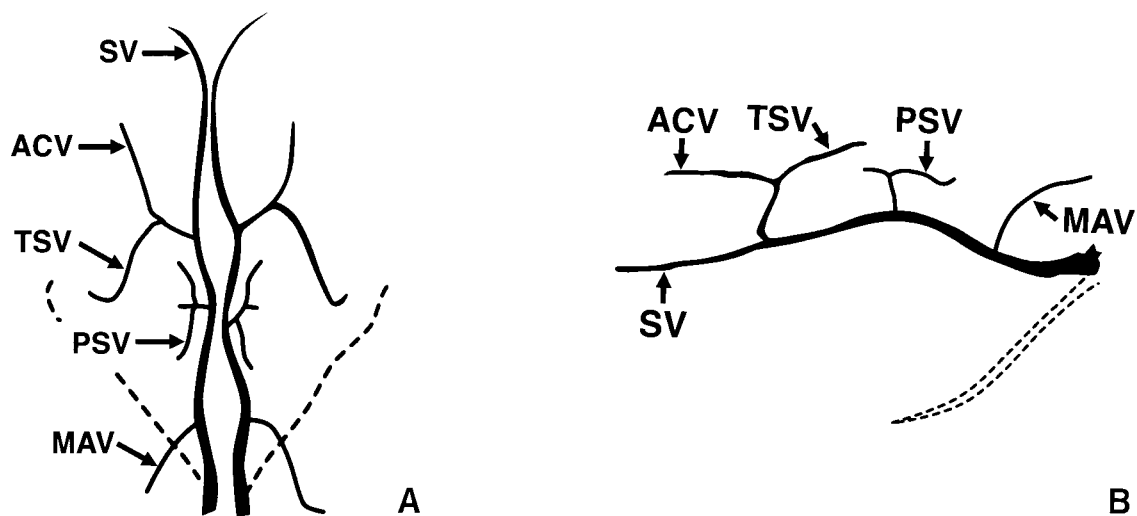


Fig. 1 Schema of five subependymal veins used for radiological evaluation. A: Cranio-caudal view; B: Lateral view. SV: Septal vein; ACV: Anterior caudate vein; TSV: Thalamostriate vein; PSV: Posterior septal vein; MAV: Medial atrial vein.

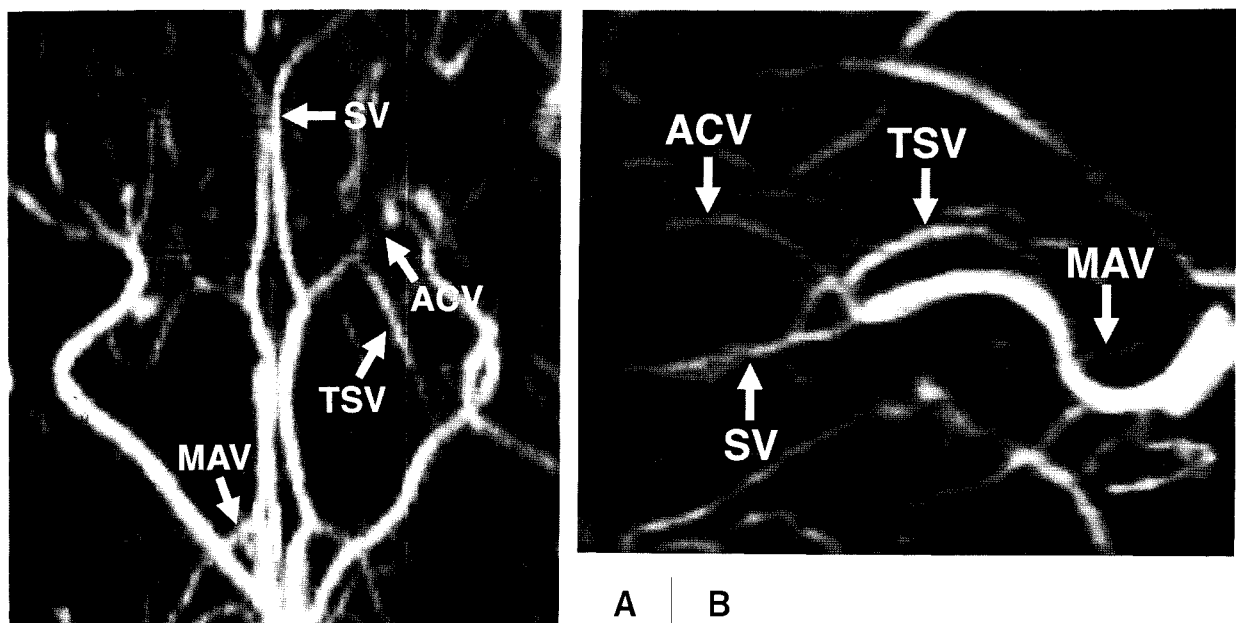


Fig. 2 High-resolution magnetic resonance venography (HR-MRV) of a healthy volunteer. The HR-MRV clearly shows four subependymal veins but not the posterior septal vein. A: Cranio-caudal view; B: Lateral view. SV: Septal vein; ACV: Anterior caudate vein; TSV: Thalamostriate vein; MAV: Medial atrial vein.

Table 1 Detectability of subependymal veins

Type	Number of subjects Identified / Total	SV		PSV		MAV		ACV		TSV	
		Rt	Lt	Rt	Lt	Rt	Lt	Rt	Lt	Rt	Lt
Normal	13/20	○	○	×	×	○	○	○	○	○	○
Rt-variant	4/20	○	○	×	×	○	○	○	○	●	○
Lt-variant	1/20	○	○	×	×	○	○	○	○	○	●
Bil-variant	2/20	○	○	×	×	○	○	○	○	●	●

SV: Septal vein; PSV: Posterior septal vein; MAV: Medial atrial vein; ACV: Anterior caudate vein; TSV: Thalamostriate vein.

Lt: Left; Rt: Right; Bil: Bilateral.

○: Detected; ●: Pseudovenous angle; ×: Undetected.



Fig. 3 HR-MRV of a healthy variant case. The thalamostriate vein forms the pseudovenous angle on both sides (arrows). HR-MRV: See Fig. 2.

both HR-MRV and conventional cerebral angiography. In tumor cases showing mass effect, the subependymal veins which were stretched and displaced by tumor mass could be assessed (Fig. 4). In vascular disease cases, such as venous angioma, enlargement of subependymal veins and other anomalous veins were also clearly visible (Fig. 5). These pathological changes were also observed cranio-

caudal view of HR-MRV (Figs. 4D, 5C).

Discussion

The slow flow sensitivity of the 2D-TOF MR angiography technique and its application in the evaluation of the intracranial venous system was initially described by Edelman *et al.* (1). A more critical look at this technique using a combination of direct coronal, sagittal, and axial imaging planes was subsequently reported by Mattle *et al.* (2). However, these (1-2) and other (3) reports of MRV were aimed at detecting major venous sinuses, and there have been no studies of deep fine cerebral vein imaging. On the other hand, with recent developments in imaging technology, it has become possible to obtain high-resolution images of arteries.

In the 2D-TOF method of MR angiography as compared with the 3D-TOF method, it is not easy to make thinner slices, and therefore obtain high-resolution images (4). In the present study, to compensate for thick slices, wide overlap was employed to achieve an effective slice thickness of 1 mm or less. We used a slice thickness of 1.5 mm while the overlapping width was set at 0.5 mm. Due to the overlapping width of 30% or more, the imaging range per unit time became thinner and an effective slice thickness of 1 mm was achieved. FOV, matrix and encoding volume were also specified so that the pixel size corresponding to the diameter of the subependymal vein could be attained. Theoretically, smaller pixel size is preferable. However, as it gets smaller, the S/N ratio drops. Therefore, we used a pixel size of about 0.6 mm × 0.6 mm.

In the present study, we succeeded in identifying most of the subependymal veins which had not been imaged in detail thus far by HR-MRV in both normal volunteers and

in clinical cases with cerebral disease. The technique was also effective for evaluating macroscopic blood vessel structure of tumors for preoperative planning and in observing blood vessel anomalies.

In using the 2D-TOF method, one important factor is the relation between the direction of blood flow and that of slicing. In other words, it is necessary to achieve a

more efficient inflow effect. It has been shown that subependymal veins are arranged in an anterior to posterior direction (5). Therefore, in the present study, it was necessary to have coronal slices. This enabled us to identify the pseudovenous angle where the TSV enters the posterior portion of the internal cerebral vein, which is different from its usual structure. Furthermore, in

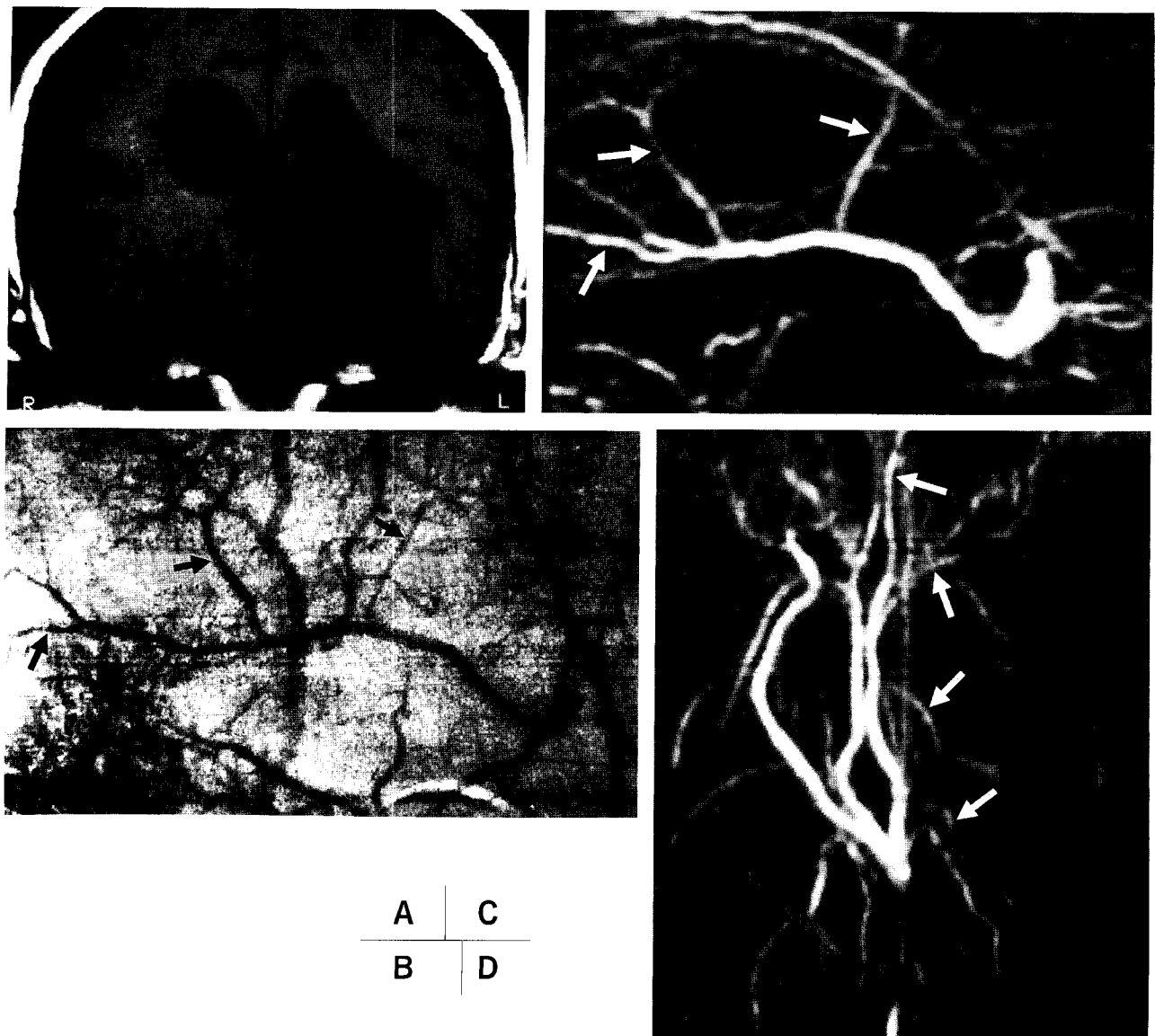


Fig. 4 Radiological findings in a tumor case in which the epidermoid originated from the left cerebello-pontine angle and extended to the supratentorial region. **A**: Coronal noncontrast T1-weighted MR image shows a hypointense large mass from the infratentorium to the supratentorium; **B**: Lateral view of the venous phase of a conventional left internal carotid angiogram shows subependymal veins (arrows) which are stretched by a large mass; **C**: Lateral HR-MRV view of subependymal veins (arrows) is similar to the conventional angiogram shown in **B**; **D**: Cranio-caudal HR-MRV view of subependymal veins (arrows) shows stretching and shifting from left to right. HR-MRV: See Fig. 2.

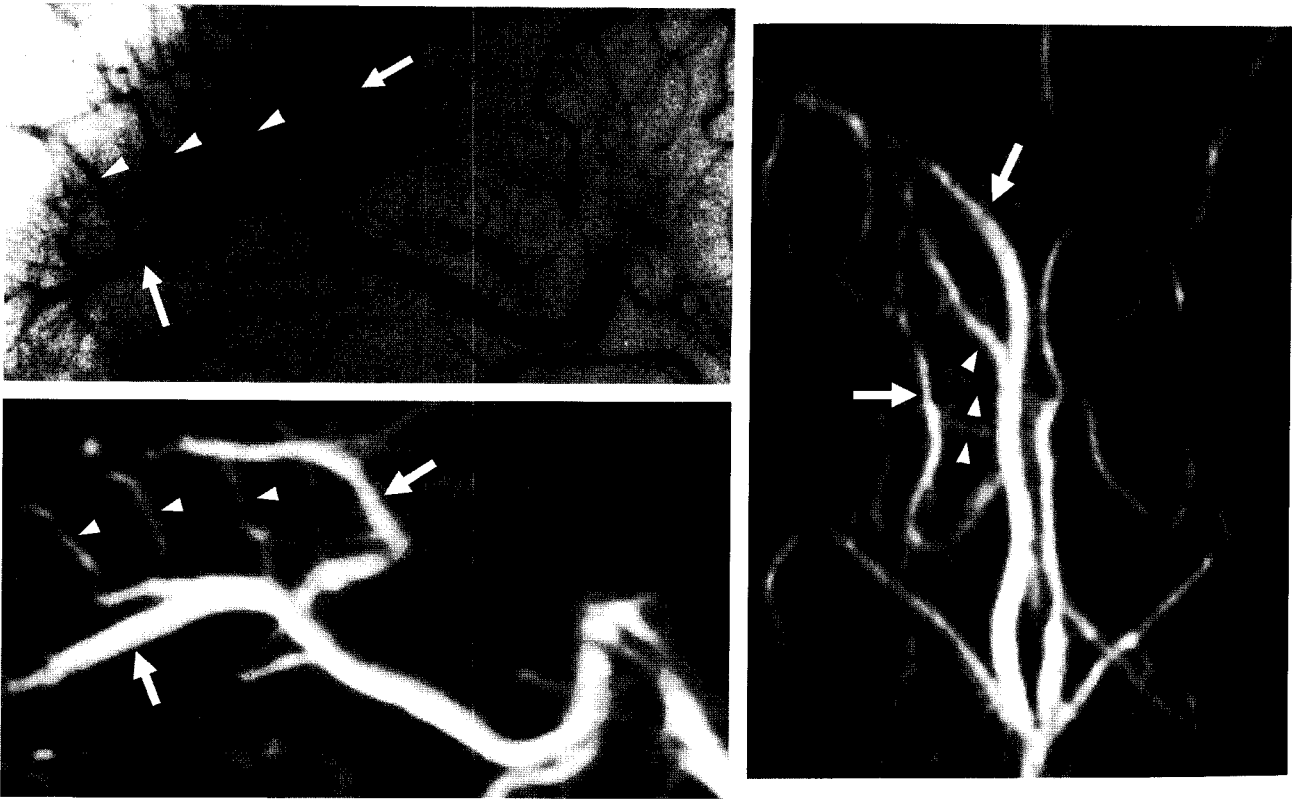


Fig. 5 Radiological findings in a case with right frontal venous angioma. **A** (Upper left): Lateral view of the venous phase of a conventional right internal carotid angiogram shows enlarged subependymal veins (arrows) and anomalous veins (arrow heads); **B** (Lower left): Lateral view of HR-MRV is similar to the conventional angiogram shown in **A**; **C** (Right): Cranio-caudal view of HR-MRV shows enlarged subependymal veins (arrows) and anomalous veins (arrow heads). HR-MRV: See Fig. 2.

imaging the coronal slices, it was necessary to obtain a number of slices to describe all subependymal veins. However, it has also been reported that sagittal slices on an angle would be enough to take images of internal cerebral veins (3). Further studies are required to determine the best direction of slicing for improved imaging of subependymal veins.

In conclusion, four subependymal veins including the SV, the MAV, the ACV, and the TSV were successfully imaged in detail by the 2D-TOF HR-MRV method using a coronal image, in 20 healthy volunteers and 15 clinical cases with cerebral diseases. In all clinical cases, HR-MRV was similar to conventional cerebral angiography. The results suggest that a more effective understanding of the blood vessels in a lesion can be achieved by combining HR-MRV with HR-MRA.

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