MR Angiography in the Diagnosis of Cerebral Venous Angiomas : 3D TOF Versus Phase Contrast

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Purpose: To seek adequate sequence of MR angiography (MRA) on developmental venous anomaly in the brain.

Material and Methods: We collected ten cases who demonstrated developmental venous anomaly on MR image. Eight patients among them, both 3D time-of-flight (TOF) with or without Gadolinium-DTPA enhancement and phase contrast (PC) were performed: TOF without enhancement in five, TOF with enhancement in six, and PC with 10 cm/sec in five, PC with 30 cm/sec in three, and PC with 5 cm/sec velocity encoding (VNEC) in two cases.

Results: On enhanced 3D TOF, both dilated collecting veins and medullary veins were well depicted in five of six cases, however, the signal intensity of the collecting and medullary veins are less than arteries. Dilated hyperintense collecting veins were well demonstrated on 3D PC with below the 10 cm/sec VNEC in all seven cases, but the medullary veins were poorly defined. Unenhanced 3D TOF MRA could not reveal any dilated collecting and medullary veins in all five cases.

Conclusion: Enhanced 3D TOF could demonstrate the collecting and medullary veins of developmental venous anomaly, however, 3D PC with below the 10 cm/sec VNEC could show the dilated collecting and larger draining veins. We considered that combined enhanced 3D TOF MRA and PC with VENC 10 cm/sec can substitute for conventional angiogram in the diagnosis of developmental venous anomaly.

Index Words: Magnetic resonance (MR), vascular studies
Brain neoplasms, MR
Angioma, central nervous system

INTRODUCTION

Venous angioma of the brain consists of multiple, radially oriented dilated medullary veins that drain into transcerebral collecting veins. Like the epidemiology and clinical signs and symptoms, the embryologic development of venous angioma is not well understood. Recently, these lesions are not considered as a type of true vascular malformations but in an extreme anatomic variant or developmental venous anomalies (DVAs). A prevailing developmental concept suggests that these lesions represent an arrest of venous development, after arterial development is nearly complete. Such an arrest presumably results in the retention of primitive, embryologic medullary veins that drain into a single, large collecting vein (1). Today, most investigators (2-7) consider that venous angioma of the brain is an incidental finding of little clinical relevance, and it rarely is associated with complications, such as hemorrhage. Venous angioma is a benign variety of intracranial vascular lesions (8) that is frequently discovered on contrast enhanced computed tomographic (CT) scans (9, 10) or magnetic resonance (MR) studies (11-16).

The MR angiography (MRI) findings of venous angioma were described on a few previous reports (1, 17). We reported our experience of various MRA techniques in venous angioma. The main purpose of this study was to obtain adequate sequences of MRA in the
diagnosis of venous angioma in the brain. The MRA techniques that we performed were three-dimensional(3D) time-of-flight (TOF) (18, 19) and phase-contrast (PC) (20, 21) MR angiography.

PATIENTS and METHODS

We experienced ten patients who demonstrated venous angioma on conventional MR and/or CT images, which were examined with high resolution CT scanner (Hilight, GE Medical system, Milwaukee, USA) and 1.5 T superconducting MR (Signa, GE Medical Systems, Milwaukee, USA). Eight of them underwent both of 3D-TOF and PC MRA with the Multisequence Vascular Package (GE Medical Systems). Contrast enhanced 3D-TOF was also performed in six patients. 3D PC was done with variable velocity encodings, such as, 30 cm/sec in two, 25 cm/sec in one, 10 cm/sec in five, 7 cm/sec in one and 5 cm/sec in two patients. A 60–64 section 3D TOF and PC sequences required approximately 9 minutes 28 seconds and 14 minutes 45 seconds respectively. The parameters of 3D TOF were as follows: 46/5.5–6.4/fr; one excitation; 512 × 192 matrices; flip angle, 25°; FOV, 16–19 cm; 1.0 mm thickness with maximal velocity encoding of 5–30 cm/sec. For contrast enhancement, gadopentetate dimeglumine (Magnevist, Schering, Berlin) was administered with 0.1 mmol/kg. We also used maximum intensity projection (MIP) and interaxial vascular image (IVI) techniques for better defined oblique images of venous angioma.

Our evaluation of MRA focused on two points; the first was the capability to visualize the draining and medullary veins of venous angioma, and the second was to compare the intensities of draining and medullary veins between 3D-TOF and PC MRA techniques.

RESULTS

Venous angioma was demonstrated by MR and/or CT images in 10 patients, five men and five women ranging in age from 7 to 48 years. Of our cases, seven were in supratentorial and three in cerebellar hemisphere. Venous angioma was mostly an incidental finding but was associated with nonspecific headache in four and cavernous hemangioma in two patients. There was one patient with a right orbital hemangioma.

On T1-weighted images, the main draining vein was hypointense in eight and isointense in two patients. On T2-weighted images the lesion was hypointense in five, hyperintense in two, mixed in two and isointense in one patient. All our cases revealed enhancing med-
ullary and draining veins on enhanced T1-weighted and/or CT images (Fig. 1a, b, 2a, b, 3a).

On MRA, 3D PC image below the 10 cm/sec velocity encoding clearly showed the hyperintense dilated draining veins in all eight cases (Fig. 1c, 2c, 3b). On the other hand, enhanced 3D TOF images were well depicted the dilated draining as well as medullary veins in six patients except one whose medullary veins were faintly outlines. In this technique, the signal intensities of those veins were slightly less intense than those of arteries (Fig. 1d, 2d, 3c). Enhanced 3D-TOF MRA findings were well correlated with conventional angiographic finding (Fig. 3d). However, MR angiography with unenhanced 3D TOF could not demonstrate any dilated draining and medullary veins in five cases.

**DISCUSSION**

Venous angioma in the brain is usually encountered as incidental findings in patients with nonspecific complaints. Neuropathologically they are composed of dilated medullary veins, located in the white matter that converge towards a central dilated draining vein (8-10, 12). Saito and Kobayashi (22) suggested that venous angiomas occur when an accident in embryogenesis results in an occlusion or maldevelopment of the normal venous drainage of part of the brain. This assumption regarding the congenital nature of venous angiomas is also supported by the complete absence of normal draining veins in the region of the malformation and by venous infarction of the adjacent brain occurs following removal of the venous angioma (2). Lasjaunias et al (4) suggested that the name “venous angioma” should be changed to “developmental venous anomaly” to reflect this characteristic more precisely. Therefore the lesion is purely venous, without increase in number or size of the arteries in or around the body of the venous angioma. Histopathologically, neuroglial tissue is found between the abnormal vessels (15). On magnetic resonance images, the venous angioma usually appeared as a hypointense tubular lesion with a “caput medusae” configuration on both T1- and T2-weighted images (11-15). Coronal and sagittal images could occasionally demonstrate the convergence of medullary veins to the transcranial draining veins. However, angiography is generally accepted as the diagnostic standard for venous angiomas. The typical conventional angiographic image is that of radiating medullary veins, collecting centrally into a large draining vein and terminating in a superficial cortical vein or a dural sinus (9, 10, 22, 23).

Previous reports have explored the efficacy of MRA in depicting intracranial vascular structures. However, the MRA findings of venous angioma have rarely been reported. Truwit (1) described briefly about the MRA sequences and its role in the diagnosis of intracranial venous angioma. Hustone et al (17) also reported the MRA findings in one patient with venous angioma. Our studies have used 3D-TOF(24, 25) and/or PC (26, 27) techniques for MRA of venous angioma in ten patients and we compared the MRA findings of venous angioma between those two different techniques.
As we know, 3D TOF techniques clearly depict high velocity proximal arteries and the use of gadopentetate dimeglumine have optimized the visualization of venous structures (28). These TOF principle could be applied to demonstrate the medullary and draining veins of venous angioma. Six of our cases whose MRA was performed after contrast enhancement nicely demonstrated the medullary and draining veins together. Those MRA images by using MIP and IVI were comparable to the images of conventional angiographic images.

In contrast to TOF technique, the 3D PC technique permits flexible imaging of fast or slow flow by varying the amount of velocity encoding. With a maximum velocity encoding of 5 cm/sec, motions as slow as cerebral spinal fluid flow can be demonstrated. In such sequence, venous and arterial flow are aliased and not well seen. With a maximum velocity encoding of 10 - 20 cm/sec, slow venous flow is well depicted. As the velocity encoding is increased above 30 cm/sec, arterial flow is resolved and progressively less venous flow is demonstrated (19). So, PC MRA of venous angioma in our eight patients usually showed the draining veins of venous angioma with the low flow-encoding velocities of 5 - 10 cm/sec.

In our study, the images by 3D PC with 10 cm/sec velocity encoding and enhanced 3D TOF directly depicted the medullary and draining veins because venous structures were of interest. Therefore, if the findings of venous angioma were typical on contrast enhanced MR images and MR angiography, we think that further invasive conventional angiographic examination could be avoided. We concluded that the most appropriate sequence of MRA in the diagnosis of venous angioma was the enhanced 3D TOF. Because the enhanced 3D TOF can demonstrate both the medullary and draining veins while 3D PC with velocity encoding of 10 cm/sec usually showed the draining veins only.

REFERENCES

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Fig. 3. Twelve-year-old boy with hemorrhagic cavernous hemangioma
a. Enhanced T1-weighted MR image shows enhancing linear draining and medullary veins near the frontal horn of right lateral ventricle (arrows).
b. PC(10 cm/sec) MRA axial view represents hyperintense draining veins (arrows).
c. Enhanced TOF MRA oblique lateral (IVI; 0/-30/0) view well demonstrates both "opened umbrella configuration" of medullary veins and dilated draining veins (arrows). Lobulated high signal intensity mass-like lesion is an methemoglobin state of hemorrhagic cavernous hemangioma.
d. Lateral view of carotid angiogram reveals typical radiating collection of medullary veins that are collected into large draining veins and terminating superficial middle cerebral vein (arrows).


자기공명 혈관조영술을 이용한 정맥 혈관종의 진단: 3 Dimensional Time-of-Flight과 Phase Contrast의 비교

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목 적: 정맥혈관종(뇌 정맥기형)의 진단을 위한 자기공명혈관조영술(MRA)에서 적절한 pulse sequence를 찾아내고 3D time-of-flight (TOF)와 phase contrast (PC)에서 정맥기형의 소견과 그 차이점을 알아보고자 하였다.

대상 및 방법: 자기공명영상에서 정맥혈관종으로 진단된 10예 중 3D TOF와 PC 기법으로 자기공명혈관조영술을 시행한 8예를 대상으로 하였다. 3D TOF을 행한 환자중 6예는 조영증강을 하였고, 5예는 조영증강을 하지 않았다. 3D PC 혈관조영의 velocity encoding은 2예는 30 cm/sec, 1예는 25 cm/sec, 5예는 10 cm/sec, 그리고 7 cm/sec와 5 cm/sec를 각각 1예씩 시행하였다.

결 과: 조영증강을 하고 시행한 3D TOF에서 6예 모두 유입정맥과 수질정맥을 다 보여주었으나 이러한 정맥들의 신호강도는 동맥보다 낮았다. 다양한 velocity encoding을 얻은 3D PC 중 10 cm/sec 이하의 velocity encoding에서는 수질정맥들은 잘 보이지 않았으나 유입정맥들은 고신호강도로 뚜렷이 나타났다. 조영증강을 하지 않은 3D TOF에서는 전 5예에서 유입 및 수질정맥이 전혀 보이지 않았다.

결 론: 조영증강을 한 3D TOF MRA는 정맥혈관종의 진단에 있어서 고식적인 혈관조영술을 대치할 수 있을 것으로 사료되었다.