Magnetic Resonance Angiography of Cerebral Arteriovenous Malformations

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Abstract

Magnetic resonance (MR) angiography as a method for the long-term follow-up of cerebral arteriovenous malformations (AVMs) was assessed in 14 patients with cerebral AVMs. These patients were either untreated or treated with transarterial embolization and/or stereotactic radiosurgery (gamma knife). Two-dimensional and three-dimensional (3D)-time-of-flight (TOF) techniques were useful for following AVMs with a small nidus and few feeders and drainers which were either untreated or had been treated only a few months previously. 3D-TOF MR angiography with a contrast agent was more useful for visualizing the vascular structure, including the residual nidus, during long-term follow-up of treated AVMs.

Key words: magnetic resonance angiography, brain, arteriovenous malformation, gadolinium-diethylenetriaminepenta-acetic acid, long-term follow-up

Introduction

Magnetic resonance (MR) angiography is a very useful technique for the non-invasive evaluation of many vascular abnormalities, including aneurysms, arteriovenous malformations (AVMs), occlusions, and venous thrombosis. Conventional angiographic techniques for following AVMs are invasive and incur substantial risks, which often preclude the close and frequent monitoring of AVMs following treatment.

Here we describe our experience using MR angiography for the long-term follow-up of patients with cerebral AVMs.

Patients and Methods

We reviewed clinical data from 14 patients with cerebral AVMs admitted to our department after 1987 and who were either untreated or treated with transarterial embolization (TAE) and/or stereotactic radiosurgery (SRS; gamma knife). Table 1 summarizes the clinical data from the 14 patients, eight males and six females, aged from 20 to 58 years (mean 37 yrs). Initial presentations included: intracerebral hematoma (ICH) (4 patients), ventricular hemorrhage (VH) (1), subarachnoid hemorrhage (2), epilepsy (3), leg weakness (1), and incidental (3). Two patients were treated with TAE, two with SRS, two with combined TAE and SRS, and eight patients were not treated. The duration of the follow-up ranged from 5 to 84 months (mean 28 mos). We excluded patients with AVMs who underwent surgery, because surgical clips caused artifacts on time-of-flight (TOF) images.

All MR angiograms in this study were obtained using a 1.0-T system (Magnetom Impact; Siemens, Munich, Germany) combined with magnetic transfer saturation (MTS) and tilted optimized non-saturated excitation (TONE). Two-dimensional (2D)- and three-dimensional (3D)-TOF techniques with compensated fast imaging with steady precession were utilized in the steady-state sequence (repetition time 36-39 msec, echo time 10 msec, flip angle 20 degrees, slice thickness 0.8 mm, 64 partitions, slab 54 mm, matrix 256 x 256 or 128 x 128, field of view 120-200 x 120-200). MR angiography was performed every 6 months in the untreated population, and every 3 months in the treated population. Gad-
olinium-diethylenetriaminepenta-acetic acid (Gd-DTPA) (0.2 mmol/kg) was used in some cases. The images were generated with maximum-intensity postprocessing. In this study, a giant AVM nidus was defined as greater than 6 cm in its largest dimension, as determined by MR imaging.

### Results

The 3D-TOF technique was excellent for imaging small untreated AVMs, while the 2D-TOF technique was useful despite the poor spatial resolution for visualizing slow flow in dilated and draining vessels (Cases 1-3, 10, 12-14) (Figs. 1 and 2). In all patients treated with TAE, SRS, or both, the size of the AVM nidus was seen to diminish gradually. 3D-TOF MR angiography was poor for visualizing the vascular structure, including the residual nidus, of some treated AVMs (Cases 1-4, 6). In these cases, visualisation of the nidus, feeder, and peripheral blood vessels on 3D-TOF MR angiograms was improved by the administration of Gd-DTPA (Figs. 3 and 4). MR angiographical visualization of the vascular structure was difficult in the acute stage of ICH or VH which occurred in five patients (Cases 4-8) (Fig. 5). Visualization of the vascular structure was poor in four patients with giant AVM nidi (Cases 5, 7, 9, 11) (Fig. 5).

### Discussion

Our study found that 2D- and 3D-TOF techniques were useful for following small AVMs prior to treatment. The 3D-TOF technique is best for the visualiza-
Fig. 2 Case 3. Pretreatment T₂-weighted MR image (left), and coronal 3D-TOF (center) and sagittal 2D-TOF (right) MR angiograms showing an AVM nidus (approximately 4 cm in diameter) in the right parietal lobe, fed by the right middle cerebral artery, and draining into the superior sagittal sinus and right inferior sagittal sinus.

Fig. 3 Case 1. T₂-weighted MR image (left), and 3D-TOF (center) and Gd-DTPA-enhanced 3D-TOF (right) MR angiograms 13 months after combined therapy with TAE and SRS showing the residual AVM nidus, which was detectable by MR angiography following the administration of Gd-DTPA (right, arrow).

Fig. 4 Case 3. T₂-weighted MR image (left), and 3D-TOF (center) and Gd-DTPA-enhanced 3D-TOF (right) MR angiograms 7 months after SRS showing the nidus had diminished slightly. Visualization of the residual AVM nidus was improved with Gd-DTPA (right).

tion of arterial feeders, while 2D-TOF is good for assessing the draining veins. Gd-DTPA is reported to improve the visualization of the draining veins when used with the 3D-TOF technique. We found that Gd-DTPA did improve visualization, but the assessment of individual blood vessels was difficult because of overlap between the feeders, drainers, and surrounding blood vessels. In particular, intravenous contrast enhancement was not beneficial in patients who were either untreated or had been treated only a few months previously. Visualization of the vasculature was also difficult in patients with
hemorrhage originating from the AVM, seen as a region of high signal intensity on T1-weighted MR images, since the hemorrhage also appeared as a region of high signal intensity on the MR angiograms. MR angiograms were also poor in patients with giant AVM nidi and multiple feeders, because the AVM nidus overlapped with vascular structures. MR angiography performed best in AVM patients with few feeders and drainers and a small nidus. We used the combination of MTS and TONE to reduce background signals due to brain parenchyma and fat tissues and achieve better visualization of the vasculature.2,6)

Previous reports have suggested that 3D-TOF MR angiography is useful for planning the radiosurgical approach to cerebral AVMs and for following the dynamics of obliteration after irradiation,9) and is very useful for the follow-up of thalamic and brainstem AVMs after SRS.4,5) In our AVM patients treated with TAE and/or SRS, 3D-TOF MR angiography was poor for visualizing the nidus, probably because of the reduced nidus and diminished flow. In these patients, 3D-TOF MR angiography with Gd-DTPA was more useful for visualizing the vascular structure, including the residual nidus. An intravenous contrast agent, in combination with presaturation, can improve the visualizing power of MR angiography.

2D- and 3D-TOF techniques were useful for following AVMs with a small nidus and few feeders and drainers, which were either untreated or had been treated only a few months previously. During long-term follow-up, visualization of the cerebral vasculature on 3D-TOF MR angiograms was improved with administration of a contrast agent.

References


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