Magnetic Resonance Angiography of Cervicocranial Dissection

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**Background:** A retrospective study of five patients with the clinical or magnetic resonance–based diagnosis of carotid dissection was done. Clinical data, imaging studies, treatment, and outcome were reviewed. The potential applicability of three-dimensional time-of-flight magnetic resonance angiography in these settings was evaluated.

**Summary of Report:** This modality reliably showed vascular abnormalities and focal, segmental, or aneurysmal dilatation when correlated with conventional angiograms in three patients. Turbulence and magnetic susceptibility at the acute turn of the carotid in the petrous canal led to a false-positive diagnosis on magnetic resonance angiography in one patient (in whom subtle fibromuscular hyperplasia was found with conventional angiography but missed with magnetic resonance angiography).

**Conclusions:** When combined with appropriate clinical signs, magnetic resonance imaging and magnetic resonance angiography can reliably establish the diagnosis of carotid dissection. Pitfalls of magnetic resonance angiography are discussed. *(Stroke 1993;24:126–131)*

**Key Words** • angiography, magnetic resonance • carotid artery diseases • cerebrovascular disorders

Recent reports indicate that cervical carotid dissection (CCD) is more common than previously recognized, tends to affect younger individuals (mean age, 40 years), and may account for up to 2% of all strokes. The typical symptoms of CCD can be subtle and the entity not suspected until stroke occurs. Cervical or facial pain, without or with an associated postganglionic Horner’s syndrome, can be the only clue to the lesion. A transient ischemic attack or a full-blown embolic stroke can also result. The etiologies of CCD range from mild neck turning and neck manipulation to direct trauma. Fibromuscular dysplasia and hypertension are conditions that also predispose to CCD. Because embolic stroke can be a devastating but preventable complication, verifying the suspicion of CCD with early diagnosis is important.

Magnetic resonance imaging (MRI) with conventional axial spin-echo technique can suggest the diagnosis by demonstrating a high signal intensity ring surrounding the narrowed central lumen (which lacks signal) of the carotid. The definitive diagnosis is established with conventional angiography, although distinguishing atherosclerotic narrowing from dissection may occasionally be difficult. More recently, magnetic resonance angiography (MRA) has been introduced into clinical practice and in combination with MRI offers the potential of more definitive, noninvasive diagnosis in the setting of CCD. This article describes the course of diagnosis, management, and follow-up of CCD in five patients using the combination of MRI, MRA, and conventional angiography to help clarify the role of and need for each modality.

**Subjects and Methods**

Five patients (three women, two men; age range, 31–60 years) in whom the suspicion of carotid artery dissection was based on clinical presentation and the combination of MRI and MRA studies had their records and imaging studies reviewed. Table 1 summarizes the clinical and imaging data of these patients.

All patients presented with acute onset of unilateral cervicofacial pain with associated ipsilateral postganglionic Horner’s syndrome (ptosis, miosis) for 7–21 days’ duration. None had a recognized, precipitant traumatic event. Patient 2 experienced Raeder’s paratrigeminal neuralgia (unilateral frontal headache over the fifth cranial nerve distribution), which was subsequently thought to be secondary to the injury to the parasympathetic fibers in the subpetrosal region of the internal carotid artery. Patient 3 had a history of chronic headache, hypertension, and sinusitis (in addition to the above symptoms), which were not relieved by his usual medications. One female patient had a previous history of bilateral mastectomy for documented breast carcinoma. Another female patient was taking oral contraceptives before the event; these were discontinued after the diagnosis was established.

All four patients with verified carotid dissection received anticoagulation therapy for a 3-month period. No complications occurred during the course of treatment. In
Table 1. Clinical and Imaging Data in Five Patients With Carotid Dissection

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (years)</th>
<th>Sex</th>
<th>History</th>
<th>MRI</th>
<th>Initial MRA</th>
<th>Conventional angiography</th>
<th>MRA follow-up/interval (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>M</td>
<td>3 weeks of R supraorbital and biocipitral headache, R Horner’s</td>
<td>Eccentric high signal intensity around lumen of RICA (subpetrous)</td>
<td>Segmental narrowing of RICA in subpetrous portion; suggestion of a flap and additive signal from adjacent subacute hematoma also seen</td>
<td>RICA dissection in high cervical region; 50–80% luminal narrowing</td>
<td>Normal/3</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>F</td>
<td>7 days of L neck and headache, ipsilateral Horner’s, and Raeder’s paratrigeminal neuralgia</td>
<td>Equivocal findings</td>
<td>Short segmental narrowing of LICA; suggestion of web</td>
<td>No web was found; dissection of LICA with 50% luminal narrowing</td>
<td>Near complete resolution/3. Normal/6</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>M</td>
<td>10 days of L temporal headache and L Horner’s, hypertension</td>
<td>Eccentric high signal collar around LICA and C2 level</td>
<td>Not performed (modality not available at time of presentation)</td>
<td>Long segmental narrowing (50%) with pseudoaneurysm</td>
<td>Persistent irregularity with aneurysmal dilatation/6. Improved with residual irregularity at same site/9</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>F</td>
<td>1 week of L neck and periauricular pain, L Horner’s</td>
<td>Eccentric high signal collar around LICA lumen (subpetrous)</td>
<td>Focal dilatation of LICA, followed by narrowed lumen</td>
<td>Not performed (as per neurologist, with strong clinical presentation)</td>
<td>Normal/3</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>F</td>
<td>1 week of R Horner’s and ipsilateral periorbital pain</td>
<td>Normal</td>
<td>Symmetrical bilateral irregularity at petrous canal; indeterminate study</td>
<td>No dissection; proximal fibromuscular dysplasia not seen on MRA</td>
<td>Not indicated with negative angiogram</td>
</tr>
</tbody>
</table>

MRI, magnetic resonance imaging; MRA, magnetic resonance angiography; M, male; F, female; R, right; L, left; ICA, internal carotid artery.

all four cases MRA and MRI were used as follow-up examinations to evaluate change in these lesions.

The MRI studies were performed at 1.5 T and used typical single excitation spin-echo technique for acquisition of 5-mm-thick slices obtained with 2-mm gaps. The T1-weighted sagittal technique used a repetition time (TR) of 600 msec and an echo time (TE) of 16–20 msec and served as the “localizer” for the axial T2-weighted sequence. The latter used a TR of 2,800 msec and a TE of 30 and 90 msec and was obtained with narrow band-width sampling. The T2-weighted sequence used flow compensation with gradient moment nulling. Two of the patients had, in addition, a third sequence performed using the T1-weighted parameters in the axial plane. Image matrix was 192×256 in all cases, and field of view ranged from 20 to 22 cm. MRA was performed using the time-of-flight approach with three-dimensional Fourier-transformation technique (Siemens Magnetom SP). A coronal three-dimensional slab was positioned to include the distal common carotid artery and internal carotid artery to the carotid siphon. A FISP (fast imaging with steady state free precession) three-dimensional sequence was used with the following parameters: TR=40 msec, TE=7 msec, flip angle=15°, matrix=256×256, partitions=64, field of view=250–280 mm. The acquisition time was just under 11 minutes. A coronal saturation slab was placed over the torcular to eliminate signal from the jugular veins. A parallel coronal saturation pulse was applied to the base of the tongue to reduce motion artifacts. The resultant data set was processed by the standard maximum intensity projection program to yield the MRA images at selected rotations.

Conventional angiography was performed in four of the five patients via typical Seldinger puncture, using a selective carotid catheterization approach. Cut film-screen as well as digital image acquisition was performed.

Results

Imaging

The initial MRAs were performed before the conventional angiogram except on patient 3, as noted in Table 1.
Magnetic Resonance Imaging

Of four patients with proven carotid dissection (Figures 1–4), three had a well-circumscribed eccentric collar of high signal intensity surrounding the signal void within a constricted lumen of the carotid artery on the side of the symptoms and signs (Figures 1A, 3A; Figure 4, left panel). The second patient had at best an equivocal narrowing of the subpetrous portion of the affected internal carotid artery (Figure 2A). Although the collar of high signal, when present, was seen on all the axial sequences, the late echo image of the long TR sequence showed it best.

Magnetic Resonance Angiography

MRA of the cervicocranial carotids showed an abnormality beginning in the proximal one third of the internal carotid artery in one patient (Figure 4, middle panel). In three others, it occurred between the distal half and the subpetrous portion of the affected internal carotid artery (Figures 1B, 1C, 2B, 3C). In two patients, the lesion appearance consisted of focal or diffuse and irregular narrowing of the lumen with distal restitution of the lumen. Short segment narrowing with bandlike defects suggesting a web in the subpetrous portion of the dissected segment was observed in patient 2 (Figure 2B). The first patient showed segmental narrowing and an apparent distal ectatic segment with a flap between two lumens, where conventional angiography showed only the narrowing (Figure 1B). The patient with no dissection showed focal signal loss narrowing the carotid lumen in symmetrical position just at the acute petrous turn of both carotid arteries (Figure 5, middle panel).

Correlation With Conventional Angiography

MRA reliably showed the corresponding level of abnormalities found with conventional angiograms in both the segmental and focal dissections. Irregular diffuse segmental or focal narrowing of the vasculature was seen equally well with both modalities in three pa-
patients (Figures 1B, 1D, 2B, 2C, 3B, 3C). In patient 3, who initially was studied with conventional angiography only, the follow-up MRA findings at 6 months correlated with the angiographic findings of a pseudoaneurysmal dilatation associated with the vessel irregularity (Figure 3B). The patient in whom conventional angiography disproved the lesion was initially found on MRA to have abnormal symmetrically bilateral and very focal irregular narrowing of both the internal carotid arteries just at the acute turn into the entrance of the petrous canals. In this same patient, fibromuscular change was also found in a more proximal section of the internal carotid artery (Figure 5, right panel), which was not appreciated on MRA.

Follow-up

MRI and MRA were performed in all four patients 3–9 months after the precipitating event. The MRI studies were all normal in these patients. MRA demonstrated the reconstitution of the normal contour and appearance of the vessel in three patients (Figures 1E, 2D; Figure 4, right panel). In patient 3 with narrowing and pseudoaneurysm formation, MRA demonstrated progressive improvement on the 6- and 9-month examinations without complete resolution of the irregularity and ectasia of the affected artery (Figures 3C, 3D).

Discussion

Our initial limited experience suggests that in the proper clinical context the combination of MRI and MRA can be used to definitively establish the diagnosis of carotid artery dissection.

Dissection of the cervical carotid arteries usually occurs 2 cm or more beyond the origin of the internal carotid artery.\textsuperscript{4,8,9} It usually stops before or at the entry into the petrous bone, where the rigid bony canal tends to limit further dissections. The etiologies are frequently idiopathic, but association with hypertension, fibromuscular dysplasia, oral contraceptive use, direct trauma, atherosclerosis, viral illness, or neck manipulation has been reported. The clinical presentations of patients have included postganglionic Horner’s (oculosympathetic palsy) and hemicrania, without or with cerebral ischemic symptoms and delayed neurological deficits. Horner’s syndrome was seen in all of the patients in our

Figure 2. Patient 2. Panel A: Magnetic resonance imaging; axial spin-echo image 2,800/90/1. Equivocal narrowing of left internal carotid artery is suggested (arrowhead). Panel B: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; flip angle (FA), 15°; repetition time (TR), 40 msec; echo time (TE), 7 msec. Short segmental narrowing of left internal carotid artery at the entrance to petrous canal with weblike appearance (arrowhead). Panel C: Angiography with digital subtraction of left carotid artery. No web was found. There is 50% focal luminal narrowing and irregularity of petrous portion (arrowheads). Panel D: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; FA, 15°; TR, 40 msec; TE, 7 msec at 3 months. Complete resolution is shown.
report and should raise strongly the possibility of the lesion, particularly when associated with ipsilateral cephalgia. Because of the dissection under the endothelial lining, the resulting luminal narrowing hampers normal blood flow and may generate thrombus and emboli. Approximately 60% of the cases of CCD can resolve over time; however, stroke may result if embolization or thrombosis occurs. The prompt recognition of the disease and rapid institution of anticoagulant therapy can prevent such consequences, allowing healing of the lesion. This favorable course of events was illustrated by the experience reported here.

In the past, suspected carotid dissection was diagnosed with two imaging modalities: Doppler ultrasound and

Figure 3. Patient 3. Panel A: Magnetic resonance imaging; axial spin-echo image 2,800/30/1. Eccentric high signal intensity surrounding lumen of left internal carotid artery at C2 level (arrow). Panel B: Angiography with digital subtraction. Long segment of luminal irregularity and stenosis of left internal carotid artery. Irregular pseudoaneurysmal dilatation is also seen (arrow). Panel C: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; flip angle (FA), 15°; repetition time (TR), 40 msec; echo time (TE), 7 msec at 6 months. Persistent irregularity of the dissected vessel with corresponding area where aneurysmal dilatation (arrow) was seen. LE, left. Panel D: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; FA, 15°; TR, 40 msec; TE, 7 msec at 9 months (different angle). Further improvement of the irregularity without complete resolution is shown.

Figure 4. Patient 4. Left panel: Magnetic resonance imaging; axial spin-echo image 2,800/30/1. Eccentric high signal intensity surrounding narrowed lumen of subpetrous left internal carotid (arrowhead). Middle panel: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; flip angle (FA), 15°; repetition time (TR), 40 msec; echo time (TE), 7 msec. Long segment of narrowing of left internal carotid artery to skull base, preceded by proximal focal dilatation (arrowheads). Right panel: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; FA, 15°; TR, 40 msec; TE, 7 msec at 3 months. Severe stenosis of the segment has resolved (arrowhead).
The apparent pitfall of dissection in carotid arteriography. A recent article on three-dimensional Fourier-transformation MRA of carotid and vertebral arteries included cases of carotid dissection in the study. However, to our knowledge, the potential applicability of MRA in carotid dissection has not been examined. Before its availability, the characteristic findings on axial MRI have been described as an eccentric high signal collar, presumably representing the intramural hematoma, surrounding the narrowed lumen, which is void of signal. This was seen in three of our four patients, but the fourth required MRA for the diagnosis. MRA shows advantages as a noninvasive tool allowing multiplanar and multidirectional vessel imaging and projection without the need for injectable contrast agent. Also, it is easily performed as part of an MRI study, which may be already ordered in patients in whom carotid dissection is suspected. Our preliminary findings suggest that dissections are reliably depicted by the combination of MRI and MRA. MRA shows well the irregularities and narrowings of the dissected vessels subsequently depicted by conventional angiography. Aneurysmal dilatation can also be suggested on MRA findings, as seen in one of our patients. MRA showed its usefulness as a noninvasive tool for follow-up study in these cases, documenting the persistence or the resolution of the disease.

Pitfalls exist with MRA. When the axial spin-echo images at the level of the dissection show the high signal surrounding the narrowed vascular lumen, MRA can give the appearance of vessel widening. This is presumably due to the additive signal from the methemoglobin emanating from the clot in the vessel wall and the high-flow lumen combining on the maximum pixel intensity algorithm to simulate a wider than normal vessel. Fortunately, the flaplike appearance separating the two compartments and the clearly narrow vessel proximally allowed easy diagnosis of dissection in conjunction with MRI.

Another pitfall of MRA was found in this experience. The apparent symmetrical bilateral luminal narrowing of the carotid arteries at the entrance to the petrous canal seen in one of our patients with appropriate clinical signs of dissection was misleading (Figure 5, middle and right panels). Most likely the combination of turbulence due to the acute turn of the vessels and the magnetic susceptibility effects of the air-containing mastoid cells nearby led to signal loss simulating vessel narrowing. This petrous turn of the carotids has shown similar changes in other patients in our experience. The use of phase-contrast MRA technique may help to resolve the issue in questionable cases in the future. Finally, at the present time our MRA technique proved not sensitive to the subtle change of fibromuscular disease, as seen in one of our patients (Figure 5).

Although in most cases contrast angiography may no longer be necessary for detecting dissection, in the face of strong clinical suspicion and an equivocal MRI/MRA examination, it is still the "gold standard" in the investigation of the disease and some of its predisposing conditions, such as fibromuscular hyperplasia.

References

Figure 5. Patient 5. Left panel: Magnetic resonance imaging: axial spin-echo image 600/15/1. No focal abnormality found. Middle panel: Magnetic resonance angiography; three-dimensional Fourier-transformation time-of-flight technique; flip angle, 15°; repetition time, 40 msec; echo time, 7 msec. Bilateral symmetrical irregularity at acute turn of internal carotid arteries into petrous canal (arrow). Right panel: Angiographic subtraction. No abnormality is found in petrous segment; subtle changes of fibromuscular disease are seen proximally, which was not appreciated on magnetic resonance angiography study (arrowheads).
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