Magnetic Resonance Imaging and Dynamic CT Scan in Cervical Artery Dissections

M. Zuber, MD; E. Meary, MD; J.-F. Meder, MD; J.-L. Mas, MD

Background and Purpose The typical magnetic resonance imaging picture of arterial dissection, namely, a narrowed eccentric signal void surrounded by a semilunar signal hyperintensity (corresponding to the mural hematoma) on T1- and T2-weighted images, has been repeatedly reported, but the sensitivity of magnetic resonance imaging for the diagnosis of cervical dissection is poorly known. Another technique, dynamic computed tomography, may provide evidence of mural hematoma, but there has been no systematic evaluation of this technique. The aims of this study were to assess both the sensitivity of routine 0.5-T magnetic resonance imaging for the detection of a typical picture of cervical artery dissection and the value of dynamic computed tomographic scans to provide evidence of dissecting hematoma.

Methods Fifteen consecutive patients with angiographically confirmed extracranial internal carotid (n=9) or vertebral (n=10) dissections were studied using a standardized 0.5-T spin-echo magnetic resonance imaging protocol with axial slices. Twelve of these patients had dynamic computed tomographic scans at the site of the dissection suggested by angiography.

Results A typical magnetic resonance imaging picture of cervical artery dissection was observed in 12 of 15 (80%) patients and in 13 of 19 (68%) dissected vessels. The sensitivity of magnetic resonance imaging was higher in internal carotid (78%) than in vertebral (60%) dissections and in stenotic-type dissections (85%) than in occlusive or aneurysmal-type dissections. Dynamic computed tomographic scan showed the mural hematoma in 11 of the 12 (92%) patients and in 12 of 15 (80%) dissected vessels.

Conclusions Routine 0.5-T magnetic resonance imaging with axial slices is a sensitive technique for the diagnosis of dissection, but in about 20% of patients with cervical artery dissection magnetic resonance imaging will demonstrate no typical abnormality. Dynamic computed tomographic scans are a sensitive neuroimaging procedure to confirm the presence of the mural hematoma, but it needs to be directed by prior angiography. (Stroke. 1994;25:576-581.)

Key Words • carotid arteries • computed tomography • dissection • magnetic resonance imaging • vertebral artery

Extracranial carotid and vertebral artery dissections are widely recognized as causes of stroke, particularly among young patients. Angiography has long been considered the gold standard for the diagnosis of cervical artery dissection. As this procedure carries a risk of cerebral complications, noninvasive diagnostic approaches such as magnetic resonance imaging (MRI) and ultrasonography have been developed. However, the sensitivity of these techniques for the diagnosis of cervical dissection remains poorly known. Some reports describe a picture suggestive of cervical artery dissection on dynamic computed tomography (CT), but there has been no systematic evaluation of this technique.

The aims of this study were to assess both the sensitivity of routine 0.5-T MRI for the detection of a typical picture of cervical artery dissection and the value of the dynamic CT scan to provide evidence of mural hematoma in cervical dissections.

Subjects and Methods

Fifteen consecutive patients (6 men and 9 women; mean age, 37.3 years; range, 28 through 54 years) were included in this study. The diagnosis of dissection was based on a compatible clinical picture and distinctive angiographic features.

The most frequent clinical presentation consisted of headache and/or neck pain associated with symptoms of cerebral ischemia (n=9). The remaining patients presented with ischemic symptoms alone (n=1), painful Horner syndrome (n=2), neck pain and lower cranial nerve palsy (n=1), neck pain and CS root involvement (n=1), or isolated neck pain (n=1).

Conventional angiography was performed within 6 weeks of clinical onset in all 15 patients and within 3 weeks of clinical onset in 9 patients. The following angiographic pictures were considered to be consistent with the diagnosis of cervical artery dissection: irregular, scalloped, or smooth stenosis of the internal carotid (distal to the carotid sinus) or vertebral arteries extending a variable distance, often with abrupt reconstitution of the lumen ("stenotic-type dissection"); gradually tapered occlusion beginning distal to the carotid bifurcation or nonspecific vertebral artery occlusion associated with a contralateral irregular stenosis ("occlusive-type dissection"); and aneurysmal dilatation of the internal carotid artery, with subsequent improvement or normalization on control angiography ("aneurysmal-type dissection"). Three patients had bilateral vertebral artery dissection and 1 had one bilateral internal carotid artery dissection, providing a total of 19 cervical artery dissections (10 vertebral and 9 internal carotid arteries). Thirteen (8 vertebral and 5 internal carotid) dissections were of the stenotic type, 4 (2 vertebral and 2 internal carotid) of the occlusive type, and 2 (internal carotid) of the aneurysmal type (Table 1). Routine laboratory tests (complete blood cell count, erythrocyte sedimentation rate, protein electrophoresis, antinuclear antibodies, glucose, serum cholesterol and triglyceride levels, and prothrombin and activated partial thromboplastin times) and routine cardiac investigations (clinical examination, electrocardiography, and chest X-ray) were normal in all patients. Transthoracic and transesophageal
### TABLE 1. Cervical Artery Dissections: MRI Findings

<table>
<thead>
<tr>
<th></th>
<th>Typical Picture</th>
<th>Nontypical Picture</th>
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<td><strong>Angiographic</strong></td>
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<tr>
<td></td>
<td>Occlusive</td>
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MRI indicates magnetic resonance imaging.

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**Fig 1.** Left internal carotid artery dissection (stenotic type). A, Angiogram (9 days after clinical onset) showing severe narrowing of artery. Arrow indicates level of the magnetic resonance image (MRI) and dynamic computed tomographic (CT) scan slices. B, Axial T1-weighted (repetition time, 500 msec; echo time, 20 msec) MRI: an eccentric signal void (large arrow) surrounded by a semilunar hyperintensity (small arrows) (typical MRI picture). Curved arrow indicates normal right internal carotid artery. C, Dynamic CT scan at the same level: an eccentric contrast enhancement (corresponding to residual lumen) (long arrow) surrounded by a relative hypodensity compared with the muscle (corresponding to mural hematoma), itself surrounded by a thin annular enhancement (small arrows) (typical dynamic CT scan picture). Thick arrow indicates normal right internal carotid artery.
Right internal carotid artery dissection (occlusive type). A, Angiogram (5 weeks after clinical onset) showing a gradually tapered occlusion. Arrows 1 and 2 indicate the levels of the magnetic resonance image (MRI) slices (B and C, respectively). B, Axial T1-weighted (repetition time [TR], 500 msec; echo time [TE], 20 msec) MRI scan showing a typical MRI picture of dissection (arrow) at the level of the preocclusive stenotic segment. C, Axial T1-weighted (TR, 500 msec; TE, 20 msec) MRI scan showing nonspecific hypersignal covering the full section of the artery (arrow) distal from the level at which occlusion was confirmed angiographically.

Follow-up investigations using angiography and/or ultrasound (duplex scanning, continuous-wave Doppler, and transcranial Doppler) were obtained in 11 patients 2 through 6 months after the initial angiography. These investigations showed normalization or improvement of the dissection (on at least one side) in 9 patients (11 arteries). In 2 patients with an occlusive-type internal carotid artery dissection, the occlusion persisted on the follow-up angiography. Four patients refused follow-up investigations. Two of them had, in addition to angiography, an initial ultrasonic examination that showed a pattern suggestive of dissection, namely, hemodynamic signs of stenosis with increased arterial diameter and decreased pulsatility.

Magnetic Resonance Imaging

MRI was performed within 1 week after angiography in all 15 cases using a GE 0.5-T MR Max. All patients were explored with the same protocol irrespective of the results of angiography. Eight to 10 axial slices (thickness, 4 to 6 mm; interslice gap, 4 to 6 mm) were obtained in T1- (repetition time [TR], 500 msec; echo time [TE], 20 msec) and T2-weighted (TR, 2000 msec; TE, 25/100 msec) spin-echo sequences. Because of the longer length of the extracranial vertebral artery compared with the extracranial internal carotid artery, the interslice gap was larger for the study of the vertebral arteries. A cranial coil with slices from C3 through C4 to the base of the petrous bone was used when the clinical presentation suggested a carotid artery dissection. In case of clinically suspected vertebral artery dissection, a cervical coil was used with slices from C6 through C7 to the occipital foramen. MRI results were reviewed independently by a neurologist and a neuroradiologist to assess the presence of a typical picture of dissection, which was defined as an eccentric signal void (corresponding to the residual lumen) surrounded by a semilunar hyperintensity (corresponding to the mural hematoma) on T1- and T2-weighted images (Fig 1B). We did not consider as diagnostic of dissection the association of a central signal void with a surrounding annular hyperintensity because this picture has been observed in various conditions. Both examiners agreed on the presence or absence of a typical picture of dissection for all cases in our study. When MRI pictures were nontypical,
FK3 3. Cervical artery dissections with normal magnetic resonance image scan. Left, Left vertebral artery dissection. Angiogram (10 days after clinical onset) showing a limited dissection of the second segment of the artery. Right, Left vertebral artery dissection. Angiogram (6 weeks after clinical onset) showing irregularities without frank narrowing of the second segment of the artery.

Dynamic CT Scan
Dynamic CT scan was performed in 12 patients (15 arteries) on an Elscint CT scan (Exel 2400) within 1 week after angiography except for 1 patient (1-month delay). Contrast material (40 mL) was injected at a rate of 4 mL/s. A 2-second scan time was used with a 4-second interscan delay. Six images were obtained without slice increment. Slice thickness was 2.5 mm. Axial images were obtained at a single level, which was chosen according to the site of dissection on angiography. In the patient with bilateral internal carotid artery stenotic-type dissections, the single-level axial slices included dissected segments of both internal carotid arteries. In the 2 patients with bilateral vertebral dissections, CT scan slices included a stenotic segment of the vertebral artery on one side and an apparently occluded segment of the contralateral vertebral artery.

The presence of a typical picture of dissection was judged independently of MRI results. The typical dynamic CT scan picture was defined as an eccentric contrast enhancement (corresponding to the residual lumen) surrounded by a relative hypodensity compared with the muscle (corresponding to the mural hematoma), itself surrounded by a thin annular enhancement (Fig 1C). This "target" picture was chosen according to previous reports.12-15

FK3 4. Left Internal carotid artery dissection (aneurysmal type). Left, Angiogram (6 weeks after clinical onset) showing aneurysmal dilatation. Arrow indicates the level of the magnetic resonance image (MRI) slice. Right, Axial T1-weighted (repetition time, 500 msec; echo time, 20 msec) MRI showing narrowing of the lumen with apparent isointense arterial wall thickening (arrows).

Results
Magnetic Resonance Imaging
A typical MRI picture of cervical artery dissection was observed in 12 of 15 (80%) patients and in 13 of 19 (68%) dissected vessels including 7 of 9 (78%) internal carotid and 6 of 10 (60%) vertebral arteries. It was found in 11 of 13 (85%) stenotic arteries (5 of 5 internal carotid arteries and 6 of 8 vertebral arteries), in 1 of 2 internal carotid arteries with aneurysm, and in 1 of 4 vessels with occlusion (1 of 2 internal carotid arteries) (Table 1). In this case, the typical MRI picture was observed at the level corresponding to the preocclusive stenotic segment on the angiogram (Fig 2). MRI was normal in 2 stenotic-type vertebral artery dissections. In

angiograms were reviewed and compared with MRI to determine the potential reasons for false-negative MRI.
observed in the majority of our patients, which is also an excellent argument in favor of the diagnosis. In addition, a typical CT scan was seen in all arteries. Normalization or improvement of the arterial abnormalities on subsequent investigations was found in 11 of 12 patients (92%) and in the last 3 cases the mural hematoma was not visualized, although the MRI slices included not only the occlusive but also the preocclusive segments of the arteries. No MRI picture suggestive of dissection was observed in any of the 41 (21 internal carotid and 20 vertebral) angiographically normal arteries.

### Dynamic CT Scan

A typical dynamic CT scan picture of cervical artery dissection was found in 11 of 12 patients (92%) and in 12 of 15 (80%) dissected vessels, including 8 of 8 (100%) internal carotid and 4 of 7 (57%) vertebral arteries. It was observed in 9 of 10 vessels (90%) with stenotic-type dissection (5 of 5 internal carotid arteries and 4 of 5 vertebral arteries), in both internal carotid arteries with aneurysmal-type dissection, and in 1 internal carotid artery with occlusive-type dissection (Table 2). The dynamic CT scan was normal in one stenotic-type vertebral artery dissection and showed punctiform peripheral contrast enhancement in 2 occlusive-type vertebral artery dissections. Dynamic CT scan was normal in the 41 angiographically nondissected arteries.

In patients who had both investigations, dynamic CT scan showed a typical picture of dissection in all arteries with typical MRI. In addition, a typical CT scan was observed in one vessel with aneurysmal-type dissection and nontypical MRI.

### Discussion

Although angiography is not always definitive in the diagnosis of dissection, it is commonly regarded as the gold standard diagnostic procedure. In this series, all patients had angiographic features strongly suggestive of dissection. Normalization or improvement of the arterial abnormalities on subsequent investigations was observed in the majority of our patients, which is also an excellent argument in favor of the diagnosis.

The typical MRI picture of cervical artery dissection on axial slices, namely, a narrowed eccentric signal void surrounded by a semilunar signal hyperintensity (corresponding to the mural hematoma) on T1- and T2-weighted images, has been repeatedly reported. In the largest study comparing MRI and angiography, Gelbert et al found this typical picture in 14 of their 15 cases of cervical artery dissections. However, the sensitivity of MRI cannot be derived from this study, since axial images were obtained at the levels suggested by angiographic evidence of dissection.

The aim of the present study was to assess the sensitivity of a routine, standardized 0.5-T MRI protocol for the detection of a typical picture of dissection. This type of routine MRI examination can be easily performed when cervical artery dissection is suspected on clinical grounds. We did not use coronal and sagittal slices because Gelbert et al report that they did not improve the yield of MRI for the diagnosis of dissection. In the present study, the routine MRI protocol would have allowed the diagnosis of dissection in 80% of the patients if it had been proposed as the first neuroimaging investigation. The sensitivity of MRI was higher in internal carotid than in vertebral dissections and in stenotic-type dissections than in occlusive or aneurysmal-type dissections (Table 1).

The sensitivity of MRI depends on several interrelated factors, such as the size and longitudinal extension of the mural hematoma, the presence of a thrombus in the true arterial lumen, and the delay between clinical onset and MR imaging. Small intramural hematomas may be missed if a large intelslice gap or thick slices are used. In the present study, 2 dissected arteries were normal on MRI. Angiography showed a stenosis limited to a very short segment of the vertebral artery in 1 case and mural irregularities without frank narrowing of the artery in the other (Fig 3). It is possible that in these 2 cases the mural hematoma was not visualized because of its small volume and/or limited longitudinal extension.

A major pitfall of conventional MRI is that it does not assist in distinguishing between intraluminal thrombus and intramural hematoma. In recent occlusive-type dissections, MRI usually shows a nonspecific hypersignal covering all the section of the artery (Fig 2C). In some cases, however, slices through the preocclusive stenotic arterial segment may show a typical picture of dissection. This was the case in one of our 4 occlusive-type dissections (Fig 2B). In the 3 other occlusive-type dissections, angiography showed a stenosis limited to a short segment of the artery; in the other, it showed irregularities without marked narrowing of the arterial caliber (Fig 3). In the 4 remaining arteries, MRI showed a narrowing of the lumen with an apparent isoointense arterial wall thickening (1 internal carotid aneurysmal-type dissection) (Fig 4), a hypersignal covering the full section of the vessel (1 vertebral and 1 internal carotid occlusive-type dissection), and a punctiform isosignal within a hypersignal covering the full section of the vessel (1 vertebral occlusive-type dissection). In the latter 3 cases the mural hematoma was not visualized, although the MRI slices included not only the occlusive but also the preocclusive segments of the arteries. No MRI picture suggestive of dissection was observed in any of the 41 (21 internal carotid and 20 vertebral) angiographically normal arteries.

### Table 2. Cervical Artery Dissections: Dynamic CT Scan Findings

<table>
<thead>
<tr>
<th>Angiographic Lesion Type</th>
<th>Typical Picture</th>
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<td>Delay</td>
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<td>Internal carotid arteries</td>
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<td>9 d, 3 w, 3 w, 5 w</td>
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<td>Occlusive</td>
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<td>Aneurysmal</td>
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<td>5 w, 5 w</td>
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<td>Vertebral arteries</td>
<td></td>
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<tr>
<td>Stenotic</td>
<td>4</td>
<td>6 d, 7 d, 10 d, 3 w</td>
</tr>
<tr>
<td>Occlusive</td>
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</table>

CT indicates computed tomography.
dissections, a nonspecific hypersignal was also observed at the preocclusive level. This hypersignal may have been due to the retrograde extension of the thrombus during the time interval between angiography and MRI or to flow modifications in the stump of the occluded artery.

As the mural hematoma is an evolving lesion, its signal changes with time.6,18 The typical hyperintensity (semilunar-shaped) on T1- and T2-weighted images is characteristic of the semiacute phase. In the few studies of dissections with sequential MRI, this hyperintensity decreased on the control MRI performed 7 weeks after clinical onset.6,18 In the present study, the typical semilunar-shaped hyperintensity was present in 8 of the 9 stenotic-type dissections explored within the first 3 weeks and in 3 of the 4 explored from 3 through 6 weeks after clinical onset.

Dynamic CT scan findings in cervical artery dissections have rarely been reported.12-15 A mural thickening, eccentric in distribution and describing a spiral around the vessel from level to level, is reported by Petro et al13 in five stenotic-type dissections of the internal carotid arteries. More recently, Dal Pozzo et al15 have described a picture composed of a narrowed central or eccentric enhancement (residual lumen) surrounded by a hypodensity (mural hematoma), itself surrounded by a thin annular contrast enhancement in 2 of 3 dissected internal carotid arteries. This picture was similar to our so-called target picture (Fig 1). However, whether the dynamic CT target picture is common or anecdotal in cervical artery dissection has not been previously studied. The interpretation of the peripheral component of the target picture (the thin annular contrast enhancement) remains speculative. It could correspond to the visualization of injected vasa vasorum in the adventitial layer. The injection of the venous plexuses could also account for this picture in cervical vertebral arteries (no venous plexuses surround the internal carotid arteries), although the trapezoid shape of the injected perivertebral venous plexuses typically differs from the thin peripheral annular contrast enhancement observed in a case of dissection.

In the present study, a typical dynamic CT scan picture of cervical arterial dissection was found in 92% of the patients and in 80% of the dissected vessels. It was more frequently observed in stenotic-type and internal carotid dissections than in vertebral artery dissections (Table 2).

A major drawback of dynamic CT scan (single-level slices) is that prior angiography is required to determine the appropriate level. Therefore, indications of dynamic CT scan in these conditions are limited. It may be helpful to confirm the presence of a mural hematoma when angiography is not conclusive and MRI cannot be performed or as a noninvasive means of following the subsequent anatomic course of the dissection. The sensitivity of dynamic incremental CT scan (multilevel slices) as an initial diagnostic procedure for the diagnosis of cervical dissection remains to be assessed. This technique, however, will require the injection of a large volume of contrast material.19

In conclusion, the present study showed that routine 0.5-T MRI with axial slices is a sensitive technique for the diagnosis of cervical artery dissection. The sensitivity of MRI is higher in internal carotid than in vertebral artery dissections and in stenotic-type dissections than in occlusive or aneurysmal-type dissections. However, our data suggest that in about 20% of patients with cervical artery dissection, MRI will demonstrate no typical abnormality. The value of magnetic resonance angiography combined with conventional MRI to detect cervical artery dissection is being assessed.20,21 This study further demonstrated that dynamic CT scan is a sensitive neuroimaging procedure for confirming the presence of the mural hematoma, but it needs to be directed by prior angiography.

References
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