A pneumatized anterior clinoid mimicking an aneurysm on MR imaging

Report of two cases

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The advent of magnetic resonance (MR) imaging has marked a new era in neuroimaging — particularly in terms of diminishing the need for more invasive diagnostic procedures. A cautionary note should be sounded, however, about an important limitation of standard spin-echo MR studies. Two patients were referred for angiography because MR imaging indicated the presence of a "paraclinoid aneurysm." In retrospect, these findings were due instead to a pneumatized anterior clinoid. Angiography could have been avoided had this pitfall been recognized, and had a gradient-echo flow-imaging protocol been utilized. This latter approach (which does not replace spin-echo imaging) is more sensitive to flowing blood and thus allows differentiation of an air space from a nonthrombosed aneurysm.

KEY WORDS □9 magnetic resonance imaging □9 cerebral aneurysm □9 anterior clinoid

In the United States, the incidence of ruptured intracranial aneurysms may be as high as 30,000 cases per year, with as many as 60% of these people dying within 6 months after rupture. It is for this reason that many physicians have a relatively low threshold for aggressive diagnostic imaging when an aneurysm is suspected. Until recently, computerized tomography (CT) and cerebral angiography have been the mainstays of such imaging. Now, however, magnetic resonance (MR) imaging has proven to be a sensitive, accurate, noninvasive method for evaluating intracranial disease. Observation of blood flow in a noninvasive manner without the need for injecting contrast agents, as well as the unprecedented sensitivity to prior hemorrhage, are distinct advantages over CT and angiography in the evaluation of patients with a suspected cerebrovascular abnormality. Cerebral aneurysms may be identified on MR images by their location and signal characteristics. The nature of the MR signal emanating from flowing blood is complex and depends on multiple flow characteristics such as velocity, acceleration, pulsatility, turbulence, lumen geometry, and the relaxation properties of blood, to name a few. Rapidly flowing blood within an aneurysm usually produces a signal-void area on routine spin-echo MR imaging.

Two cases are presented where this signal-void appearance was due to a normal anatomic variant: namely, an asymmetrically pneumatized anterior clinoid. The suspicion of an aneurysm prompted the performance of unnecessary (in retrospect) angiography. We suggest that adjunctive flow-sensitive imaging sequences, such as gradient-echo acquisition, may be used to confirm routine spin-echo MR pulse sequences that show a signal-void area suspicious for an aneurysm.

Case Reports

Case 1

This 23-year-old man presented with a 1-month history of progressive loss of vision and severe headaches. Formal ophthalmological evaluation revealed a right superior quadrantanopsia. Neurological examination was otherwise normal. Cerebrospinal fluid (CSF) analysis, echocardiography, and laboratory studies demonstrated no abnormality. Standard T₁- and T₂-weighted spin-echo MR imaging, performed at 0.35 tesla, revealed a rounded area of signal loss in the region of the right paraclinoid carotid artery but was otherwise unremarkable (Fig. 1). The patient was diagnosed as having a "probable right paraclinoid aneurysm."
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**Fig. 1.** Case 1. *Left:* Axial spin-echo T₁-weighted (TR = 500 msec, TE = 30 msec) magnetic resonance image at the level of the midbrain. Note the rounded area of signal loss in the right paraclinoid region (*arrow*). *Center* and *Right:* Corresponding dual-echo T₂-weighted (TR = 2000 msec, TE = 40 and 80 msec) images better delineate the signal-void area. Note the apparent “neck” (*thin arrow*) of the suspected aneurysm associated with the ipsilateral right internal carotid artery. The circle of Willis may be identified at this level by linear areas of signal loss in a pentagonal distribution.

**Fig. 2.** Case 1. Right internal carotid angiogram, anteroposterior view. No aneurysm is identified in the paraclinoid region. The pneumatized anterior clinoid is easily seen (*short arrows*). Note the normal, non-aerated left anterior clinoid (*long arrow*).

Selective right internal carotid artery (ICA) and left vertebral artery angiography was performed with electroencephalography (EEG) in preparation for a temporary balloon occlusion test of the right ICA. Angiography revealed a hyperpneumatized anterior clinoid, but no vascular abnormality (Fig. 2). Postangiography CT scans through the cavernous region confirmed this finding (Fig. 3).

**Case 2**

This 60-year-old man presented with vague complaints which included "dizziness and discomfort" in the right side of his head. His medical history was remarkable for recurrent bilateral external otitis and serous otitis in the right ear, for which he was treated with a tympanostomy tube. There was no history of tinnitus, visual disturbance, or unusual headaches. Neurological examination was normal. Standard T₁- and T₂-weighted spin-echo MR imaging, performed at 0.6 tesla, revealed a rounded area of signal loss in the region of the right paraclinoid carotid artery (Fig. 4). A small
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FIG. 4. Case 2. Left Pair: Axial spin-echo T₁-weighted (TR = 500 msec, TE = 30 msec) magnetic resonance images at the level of the midbrain and optic chiasm. Note the well-circumscribed area of signal loss in the right paracroid region (arrows). The slightly higher image (right) contains a small amount of increased signal within suspected abnormality; although this was initially interpreted as possible turbulence within a paracloid aneurysm, it may be retrospectively attributed to partial-volume-averaging artifact from the adjacent higher slice. Right Pair: Corresponding dual-echo T₂-weighted (TR = 2000 msec, TE = 60 and 120 msec) images again demonstrate the rounded area of signal loss (large arrows). Note the apparent posterior displacement of the ipsilateral right middle cerebral artery (small arrows).

amount of internal signal within the presumed aneurysm was identified on the T₁-weighted sequence (Fig. 4 left pair), which was attributed to turbulent blood flow, but retrospectively may be explained by partial-volume averaging artifact. Except for an abnormal signal within the mastoid air cells (representing the patient’s known otitis/mastoiditis), the MR studies were unremarkable. A diagnosis of a probable “giant right paracloid aneurysm” was made.

Selective right ICA and left vertebral artery angiography was performed with EEG monitoring as in Case 1, but no vascular abnormality was demonstrated; however, the hyperpneumatized anterior clinoid was readily identified. Postangiography CT scanning through the cavernous region confirmed the presence of an asymmetrically pneumatized anterior clinoid.

Comment

A retrospective evaluation of 350 randomly selected CT studies was performed to assess the frequency of asymmetrically pneumatized anterior clinoids among a larger population of patients referred for CT studies. This review revealed 16 patients (4.6%) with an asymmetrically aerated anterior clinoid.

Discussion

These two cases show how an improper or insufficient MR pulse sequence selection may not only obscure anatomy (or pathological anatomy) but can simulate actual pathology. Unlike CT and angiography, which utilize the single physical property of x-ray attenuation (electron density) to determine the image appearance, MR imaging uses a variety of properties, including proton density, magnetic susceptibility effects, relaxation values (T₁, T₂), and flow dynamics. Furthermore, the appearance of blood flow on MR images results from a complex interaction between numerous factors related to flow hydrodynamics (direction, velocity, acceleration, pulsatility, turbulence, lumen geometry, flow profile), and imaging system parameters (relaxation time, echo delay time, pulse sequence, gating, slice thickness, slice spacing, number of signal averages, field of view). These latter parameters may be manipulated to affect outcome of imaging by either suppressing or enhancing flow phenomena, depending on the goal of imaging. Most routine spin-echo MR images display vessels as signal-void areas owing to the dominant effects of high-velocity signal loss and spin-phase changes. The technical aspects underlying these phenomena are beyond the scope of this article. Simply put, the appearance of a signal-void area has to do with the fact that a finite time elapses between the stimulation of the scanned nuclei by the radiofrequency pulse and their subsequent emission of the MR signal; the components of the blood change their position during this time, and are out of the plane of section by the time the spin echo is received. Dense bone and air may similarly appear as areas of signal loss on T₁- and T₂-weighted imaging, but this is due to an intrinsic paucity of mobile protons. Hence, there is a potential for confusion in distinguishing the ICA from bone in the clinoid region.

There are two techniques by which aneurysms may be differentiated from normal anatomy on MR images. First, gradient-echo (also known as “partial flip angle”) techniques have supplemented conventional spin-echo sequences in the evaluation of vascular structures. Unlike spin-echo images, flowing blood moving in a direction perpendicular to the scan plane appears bright on gradient-echo images (Fig. 5). Gradient-echo sequences are not a replacement for standard spin-echo imaging. Although they provide increased sensitivity to calcification, hemorrhage, and flow in less than half the imaging time, they suffer from reduced...
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Fig. 5. Coronal gradient-echo (TR = 100 msec, TE = 20 msec, 60° flip angle) magnetic resonance image in a different patient (not reported here) demonstrating flow enhancement within the middle cerebral arteries (curved arrows), the A1 segment of the anterior cerebral artery (straight arrows), and superior sagittal sinus (large curved arrow). Metallic artifacts (open arrows) are present over the right frontal region due to ventricular shunt catheter. Flow artifacts are also noted in the region of the lateral ventricles (V) due to hydrocephalus. SS = sphenoid sinus. Note the inferior spatial resolution, increased susceptibility to artifacts, and inferior gray-white matter differentiation when compared to standard spin-echo imaging.

Fig. 6. Suggested protocol for imaging in a patient whose magnetic resonance (MR) studies raise suspicion of a paraclinoid aneurysm (PCA). The spin-echo (SE) MR image is performed preferably with motion/flow artifact suppression techniques. If there is still significant concern about the possibility of a paraclinoid aneurysm, even after a negative gradient-echo flow study, a computerized tomography scan may be used to settle the decision about the need for angiography.

T2 contrast, limited signal-to-noise ratio, and increased artifacts induced by magnetic susceptibility. Since the territory around the circle of Willis is often plagued by CSF and vascular pulsation artifacts which may mimic or obscure an aneurysm, recently developed motion artifact suppression techniques may be a second useful approach. These techniques reduce motion and flow artifacts by using gradient-echo sequence computed to cancel velocity, acceleration, and pulsatile components of involuntary motions. It adds no extra imaging time.

Based on the foregoing considerations, a protocol is suggested for patients in whom MR studies lead to the suspicion of a paraclinoid aneurysm (Fig. 6). Simply by virtue of its juxtaposition to cortical bone, a possible paraclinoid aneurysm should generate a heightened level of skepticism when standard spin-echo imaging is used. The use of a supplementary gradient-echo sequence in the above-described patients would have suggested that the suspected "paraclinoid aneurysm" was an artifact, thus obviating angiography. A noncontrast CT scan may provide additional evidence that bone and/or air, rather than an aneurysm, is responsible for the signal-void area.

Is the potential for this kind of error very likely? In an attempt to gain insight into this question, 350 randomly selected CT studies were evaluated for the presence of an asymmetrically aerated anterior clinoid. Sixteen cases (4.6%) were identified. Thus, the likelihood of this pitfall on routine spin-echo MR imaging is not trivial. Even so, it should be avoidable when adjuvant flow-sensitive pulse sequences are utilized.

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References

2. Axel L: Blood flow effects in magnetic resonance imaging. AJR 143:1157-1166, 1984

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