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Diagnosis of Intracranial Aneurysms: Accuracy of MR Angiography at 0.5 T

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PURPOSE: Our goal was to determine the accuracy of MR angiography at 0.5 T for the diagnosis of intracranial aneurysms.

METHODS: We retrospectively studied 140 patients, 70 with acute subarachnoid hemorrhage, who were either at high or low risk for intracranial aneurysm. Three-dimensional time-of-flight MR angiography was typically performed to cover the circle of Willis, with a volume thickness of 30 mm. Conventional spin-echo MR images and MR angiograms were reviewed together, and the results were compared with those obtained at intraarterial cerebral angiography to determine the sensitivity and specificity of MR angiography.

RESULTS: Eighty-nine aneurysms (size range, 2 to 27 mm; 25 aneurysms < 5 mm) were identified at intraarterial cerebral angiography. Six aneurysms were missed by MR angiography and two were doubtful (sensitivity, 91% to 93%; specificity, 100%). Missed aneurysms were located outside the MR angiographic acquisition volume (n = 3) or on the carotid siphon (n = 3; size = 2, 3, and 5 mm).

CONCLUSION: Even if MR angiography presents some restrictions in acquisition volume and spatial resolution, the detection rate of intracranial aneurysms is excellent at 0.5 T in both asymptomatic patients and in those with subarachnoid hemorrhage. A midfield system is not a restriction to the detection of intracranial aneurysms by MR examination.

Intraarterial cerebral angiography remains the standard method of detecting intracranial aneurysms, but magnetic resonance (MR) angiography has been reported to be a valuable alternative (1). The major advantage of MR angiography is that it is noninvasive and relatively fast and cheap compared with intraarterial cerebral angiography, but MR angiography is generally considered less accurate than intraarterial angiography and its clinical role in the diagnostic work-up of aneurysms has not been clearly established (2–4).

The diagnosis of intracranial aneurysms poses different challenges according to the patient population. With the refinement of microsurgical techniques and the development of endovascular procedures, it is now possible to treat intracranial aneurysms before rupture, with a low rate of mortality and morbidity (2, 5, 6). There is thus a growing interest in detecting unruptured aneurysms, and in this population a noninvasive procedure is highly desirable. Preliminary reports have shown that MR angiography is accurate in depicting intracranial aneurysms, and this technique has been proposed as a reliable screening test (1, 7–12). Recent studies have been more circumspect as to the accuracy of MR angiography in detecting small aneurysms (13, 14). Before this technique gains final acceptance as a diagnostic test, studies with larger numbers of patients are needed to define its actual sensitivity and specificity. In patients with subarachnoid hemorrhage (SAH), MR examination is controversial, since in this life-threatening circumstance, the diagnostic procedure must be highly accurate. Because MR angiography is less reliable than intraarterial arteriography, its role in this population is unclear and still needs to be defined (2, 3, 9, 15).

Most previous studies have been conducted with high magnetic field units. Our purpose was to evaluate the accuracy of MR angiography at 0.5 T for the diagnosis of intracranial aneurysms in a large population of both asymptomatic patients and those with SAH.

Methods

Subjects

The study population was selected from a group a 398 consecutive patients who underwent intracranial three-dimensional time-of flight (TOF) MR angiography in our MR unit between October 1993 and May 1996. All patients who underwent intraarterial cerebral angiography within 6 weeks of MR angiography were included in this retrospective study. One hundred forty patients met this criterion, and no subject was excluded because of poor-quality MR angiograms. The study population included 72 female and 68 male subjects, 3 to 81 years old (mean age, 49 ± 15 years). The indications for MR angiography are listed in Table 1.

MR Angiography

All examinations were performed on a 0.5-T superconductive system with a quadrature receive-only head coil. The imaging protocol included both conventional spin-echo and angiographic MR sequences. If the patient was referred because of suspected intracranial aneurysm, transverse T2-weighted spin-echo images at 2194/30–90/2 (repetition time/echo time/excitations) and coronal T1-weighted spin-echo images (555/20/4) were obtained with a section thickness of 4 mm (gap, 0.4 mm; matrix, 180 × 256). In the other cases, at least transverse or coronal T2-weighted spin-echo images with a section thickness of 6 mm were available (gap, 0.6 mm; matrix, 180 × 256). Typically, the 3-D TOF MR angiogram consisted of a 30-mm-thick transverse slab with 30 partitions, a field of view of 180 mm, and a matrix size of 192 × 256, which resulted in a voxel size of 0.70 × 0.94 × 1 mm. The slab was centered on the circle of Willis except in three cases, in which it was located as a function of an aneurysm suspected elsewhere on the spin-echo image. In six cases, the slab was enlarged without changing the effective section thickness (covered volume, 35 to 42 mm). In seven cases, thicker sections were used (1.1 to 1.4 mm), and in four cases, MR angiography was performed after administration of contrast material. A regular dose of 0.1 mmol/kg of gadopentetate dimeglumine was given to evaluate a suspected parenchymal lesion. In all these cases, MR angiograms were acquired after regular spin-echo contrast-enhanced images had been obtained. The other parameters of the gradient-echo MR angiographic sequence were 30–33/8/2, 17° flip angle, first-order motion compensation, gradient spoiling, and venous presaturation pulse applied superiorly to the slab. The acquisition time of this sequence was 5 minutes 30 seconds. In 13 cases, a faster MR angiographic sequence was used (25/6; acquisition time, 4 minutes 20 seconds), and in five cases, a magnetization transfer prepulse was incorporated (42/6; acquisition time, 7 minutes 10 seconds).

A maximum intensity projection (MIP) algorithm was used to reconstruct angiogramlike images. Two sets of 48 MIP images were generated around head-to-foot and right-to-left axes for a total of 360°. Two hard-copy films of 12 selected MIP images (15° increments for a total of 180° around each axis) were printed for the interpretation.

Intraarterial Digital Subtraction Angiography

Pancerebral selective intraarterial angiography using the femoral route was performed on digital subtraction angiographic (DSA) equipment. Studies were obtained with a 0.6-mm focal spot and included at least two orthogonal views of each vessel. Additional oblique projections were acquired in patients with suspected aneurysms. The images were displayed with a 512 × 512 matrix. For clinical reasons, only one carotid artery was examined in one case, and the posterior circulation was not examined in three cases. In 13 patients with no angiographic evidence of SAH, intraarterial DSA was repeated a few weeks later.

Image Evaluation

All MR angiograms were reviewed together in a blinded fashion by two neuroradiologists who were experienced in the interpretation of MR angiograms. Hard copies of the MR angiograms and spin-echo images were used for the evaluation, and a consensus was reached as to whether aneurysms were present, absent, or doubtful. In case of doubt about the presence of an aneurysm, the entire set of MIP images was studied in cine mode, the source images of the angiographic data were reviewed, and a targeted MIP was used if necessary. Aneurysms were categorized by location, and their size was measured on the MR images, because good agreement between measurements obtained on MR angiograms and intraarterial DSAs had previously been reported (7, 8, 16). Calipers were used to measure the greatest length of aneurysms on MIPs if they were smaller than 12 mm, and on spin-echo images if they were larger than 12 mm. If aneurysms were visible only on the intraarterial DSAs, size was estimated in relation to the diameter of the internal carotid artery. Intraarterial DSAs were reviewed together by two other neuroradiologists blinded to the clinical history and the results of the MR examination. The presence or absence of an aneurysm and its location when present were established by means of consensus.

The sensitivity and specificity of the MR examination were calculated in comparison to that of intraarterial DSA by determining the number of false-positive, false-negative, true-positive, and true-negative findings on MR angiograms. If angiography was repeated, the results of the second study were used as the standard of reference. A comparison between the results of the first and second intraarterial DSA studies allowed us to calculate the sensitivity of the initial angiography. First, the number of aneurysms was used as the unit of analysis, but only the sensitivity was calculated, because the number of true-negative findings was undefined. Therefore, a separate analysis was performed using the number of patients as the unit of measure. All findings of at least one aneurysm were considered positive. In this case, the sensitivity, specificity, and 95% confidence intervals were recorded. Sensitivity and specificity were calculated twice with respect to doubtful aneurysms, which were classified as positive for the first calculation and as negative for the second calculation.

TABLE 1: Characteristics of the study population

Initial Diagnosis	No. of Patients	No. of Patients with Aneurysms	No. of Aneurysms
Subarachnoid hemorrhage			
Acute	70	49	53
History	3	1	1
Intraparenchymal hemorrhage	6	1	1
Suspected aneurysm on another imaging study	11	10	15
Suspected aneurysm on spin-echo MR images	4	4	5
Ophthalmoplegia	2	2	2
Cerebroocclusive vessel disease	34	4	8
Carotid-cavernous fistula	6	1	1
Diverse findings	4	2	3
Total	**140**	**74**	**89**

Results

Table 1 summarizes the characteristics of the study population. On intraarterial DSAs, 89 aneurysms were seen in 74 patients. Twenty-five aneurysms were smaller than 5 mm, 51 were between 5 and 10 mm, and 13 were larger than 10 mm. Figure 1 details the comparison between MR imaging and intraarterial-DSA as a function of the size and location of the aneurysms. The sensitivity and specificity of MR imaging are recorded in Table 2.

Six aneurysms were missed on the MR examinations, including two that were also missed on the first intraarterial DSA study. In three cases, the aneurysm was located outside the circle of Willis and was not included in the MR angiographic acquisition volume. The three other missed aneurysms were all located on the carotid siphon, and their estimated size was 2, 3, and 5 mm, respectively. In one of these cases, MR angiography was performed with a section thickness of 1.2 mm, and in an other case, MR angiography was performed between the first negative intraarterial DSA study related to a vasospasm and the second

positive intraarterial DSA study. Two aneurysms smaller than 5 mm were doubtful on MR examination. In both cases, an aneurysm was confirmed at intraarterial DSA, but one was visible only on the second intraarterial DSA study.

On the initial intraarterial DSA study, five aneurysms were not detected (five false negatives, 84 true positives) leading to a sensitivity of 94%. If the number of patients with at least one aneurysm was considered, there were five false negatives and 69 true positives, for a sensitivity of 93%. The missed aneurysms on the first intraarterial DSA study were related to severe vasospasm in one case and to methodological limitations in two cases (inadequate location of the field of view for an aneurysm of the posterior inferior cerebellar artery and no submento-vertical projection for an aneurysm of the anterior communicating artery visible only on this view [Fig 2]). We have no clear explanation for the two other missed aneurysms, which were visible on MR angiography in one case and doubtful in the other case.

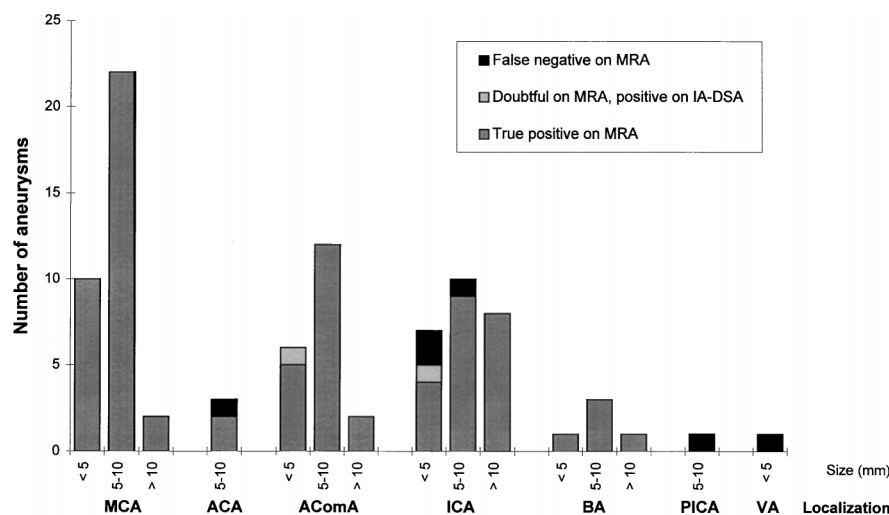We did not find any major limitation in performing

Fig 1. Results of MR angiography versus intraarterial DSA in the detection of aneurysms. The aneurysms are distributed according to their size and location. *MCA* indicates middle cerebral artery; *ACA*, anterior cerebral artery; *AComA*, anterior communicating artery; *ICA*, internal carotid artery; *BA*, basilar artery; *PICA*, posterior inferior cerebellar artery; and *VA*, vertebral artery.

TABLE 2: Results of MR examination for detecting aneurysms

MR Findings	All Patients without (n = 66) and with (n = 74) Aneurysms	All Aneurysms (n = 89)	Aneurysms < 5 mm (n = 25)	Aneurysms in Patients with SAH (n = 53)
Doubtful aneurysms classified as positive				
True positive	69	83	22	50
False negative	5	6	3	3
False positive	0	0	0	0
True negative	66	NA	NA	NA
% Sensitivity (95% confidence interval)	93 (85, 98)	93	88	94
% Specificity (95% confidence interval)	100 (95, 100)	NA	NA	NA
Doubtful aneurysms classified as negative				
True positive	67	81	20	48
False negative	7	8	5	5
False positive	0	0	0	0
True negative	66	NA	NA	NA
% Sensitivity (95% confidence interval)	91 (81, 96)	91	80	91
% Specificity (95% confidence interval)	100 (95, 100)	NA	NA	NA

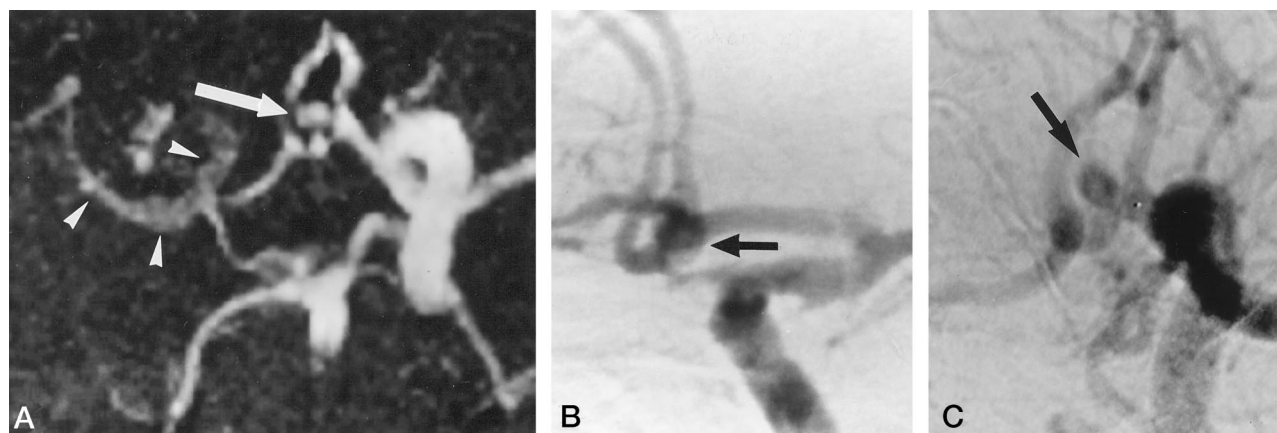Note.—SAH indicates subarachnoid hemorrhage; NA, not available.

FIG 2.   Patient with acute SAH, treated 15 years earlier for an aneurysm of the right internal carotid artery by ligation of the common right carotid artery.

A, Noncontrast MR angiogram. Slightly oblique craniocaudal projection shows a 4-mm aneurysm of the anterior communicating artery (*arrow*). Note the decreased signal into the right middle cerebral artery and the upper part of the right internal carotid artery (*arrowheads*) due to the ligation of the common right carotid artery and the slow flow provided by collateral circulation.

B, Initial intraarterial DSA (left carotid arteriogram). Anteroposterior oblique view fails to depict the aneurysm. The anterior communicating artery (*arrow*) was described as "dilated" in relation to the ligation of the common right carotid artery.

C, Second intraarterial DSA performed 2 weeks later. The submentovertical oblique view confirmed the presence of the aneurysm (*arrow*) but the aneurysmal neck is poorly defined. Intraarterial DSA performed after surgery (not shown) revealed a residual aneurysmal neck similar to the neck depicted at MR angiography.

MR imaging in patients with acute SAH. Most of these patients tolerated the examination without any problem. Severe agitation in a few patients necessitated the administration of intramuscular sedatives before the examination. Some patients had a severe alteration of neurologic status and were intubated, ventilated, and monitored by the intensive care team when the MR examination was performed. When MR angiography was performed within the first week after hemorrhage, blood components did not compromise the imaging quality.

Discussion

The aim of our study was to evaluate the diagnostic accuracy of MR angiography at 0.5 T for the detection of intracranial aneurysms. In the overall study population, the sensitivity for detecting aneurysms was 91% to 93%. The specificity for identifying patients without an aneurysm was 100%.

The determination of sensitivity and specificity is dependent on the effectiveness of the standard of reference. In our series, the false-negative rate was 6% on the first intraarterial DSA study, in accordance with results obtained by previous investigators (17, 18); however, this number may be underestimated, as only 13 patients underwent a second intraarterial DSA study. It is possible that some aneurysms were not detected at intraarterial DSA, resulting in an inflated estimate of the accuracy of MR angiography.

Our results are similar to those obtained in previously reported preliminary studies and are better than those of large series reported more recently (1, 4, 8–10, 13–16). Our good results may be explained by several factors. First, two neuroradiologists reviewed the data by consensus, a procedure that considerably reduces the number of false-negative findings that

may be detected retrospectively. Second, spin-echo images and 24 MIPs were systematically inspected, and source images were available if necessary. Multiple MIPs and/or display in cine mode were essential in avoiding overlapping of vessels, which was a substantial problem in some previous studies (14). The examination of source images does not need to be systematic, but it should be used to confirm doubtful findings, especially in the region of the internal carotid artery (9, 19). Spin-echo images are useful in the diagnosis of giant aneurysms, which may be underestimated on 3-D TOF MR angiograms because of mural thrombi, slow flow, and saturation effects. These images are also helpful for identifying SAH and methemoglobin in subacute thrombus. When present, acute SAH was generally visible on proton density–weighted images, and its location helped the reviewers to identify the presumed site of ruptured aneurysm. Third, in our study population, only 25 (28%) of the 89 aneurysms were less than 5 mm in diameter. Korogi et al (14) reported an overall sensitivity of 63% for MR angiography, but in their series, 60 (77%) of 78 aneurysms were less than 5 mm in diameter.

Preliminary results comparing MR angiography performed at 0.5 T and 1.5 T have shown that sensitivity in the detection of intracranial aneurysms was lower at 0.5 T than at 1.5 T (M. Takashashi, "3DFT Time-of-Flight MR Angiography for Intracranial Aneurysms: 1.5-T versus 0.5-T," presented at the 21st Congress of the European Society of Neuroradiology, Budapest, Hungary, September 1995). In our study, MR angiography was not performed in the same patients at both magnetic fields, so no direct comparison was possible. Nevertheless, our results are equal to or better than all previous studies performed at 1.5 T or 1.0 T. Good-quality MR angiograms were ob-
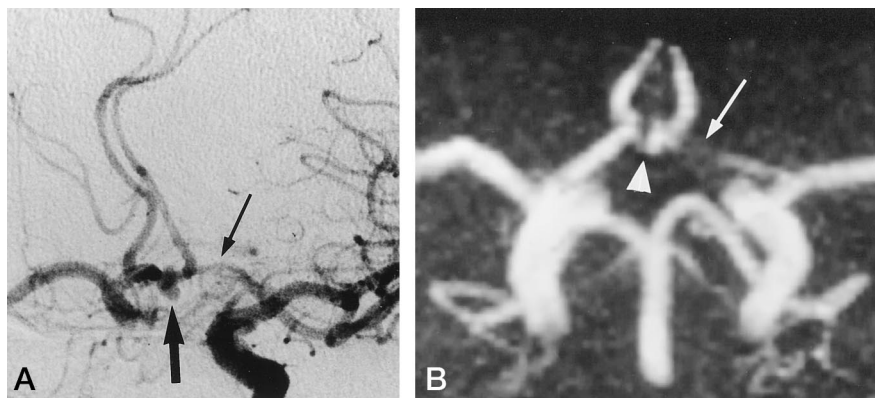
FIG 3. Patient with acute SAH.

A, Intraarterial DSA (left carotid arteriogram). Anteroposterior oblique view shows a 3-mm aneurysm of the anterior communicating artery (*wide arrow*).

B, Despite its small size, the aneurysm is visible on a noncontrast MR angiogram, slightly oblique anteroposterior projection, but it is poorly characterized (*arrowhead*). Note the narrowing of the A1 segment of the left anterior cerebral artery (*thin arrow* in *A* and *B*) on both the intraarterial DSA and the MR angiogram. This does not represent a vasospasm but rather is hypoplasia. An MR angiogram obtained some time after the acute event showed an unchanged narrowing, confirming the diagnosis of hypoplasia.

tained at 0.5 T with short acquisition times, and the detection rate of intracranial aneurysms was excellent.

Most authors agree that 5 mm is the critical size under which some aneurysms may be missed prospectively (7, 9–11, 13, 14). In our series, the sensitivity of MR angiography was 80% to 88% in detecting aneurysms under 5 mm. The 0.5-T magnet used in our study does not seem to represent a disadvantage for detecting small aneurysms when we compare our results to previous studies with higher-field units. Two factors limit the delineation of small vascular structures on MR angiograms: the intrinsic spatial resolution and the contrast-to-noise ratio. The voxel size used in our study allowed the detection of aneurysms as small as 2 to 3 mm. This actual spatial resolution should be sufficient to detect most aneurysms greater than 2 mm, but might be too large to characterize the aneurysms fully and especially to delineate the aneurysmal neck (Fig 3). To increase spatial resolution, MR angiographic sequences with thinner sections and a 512×512 matrix should be used (8, 13, 15, 20). A 0.5-T system could be a limiting factor for applying high-resolution MR angiography because of its lower signal-to-noise ratio as compared with a 1.5-T magnet. To keep a sufficient signal-to-noise ratio, the number of acquisitions should be increased, as this results in a longer acquisition time.

Recently, it has been suggested that high-resolution MR angiography does not improve the detection rate of aneurysms (16). In the detection of small aneurysms, the poor contrast between some vascular structures and the background is probably the major drawback of MR angiography. The addition of a magnetization transfer saturation prepulse or, when methemoglobin is present, the use of phase-contrast MR angiography, improves background suppression (7, 11–13, 15, 21). It is often the poor signal created by complex flow that limits the visualization of some vascular structures on MR angiograms, and this problem is encountered at any field strength (2–4). Typically, small aneurysms of the internal carotid artery are difficult to identify because turbulent flow in the carotid siphon and the proximity of air-filled structures degrade the intravascular signal. Smaller voxels and a shorter echo time increase the imaging quality by reducing intravoxel dephasing. A midfield system

has the advantage of decreasing susceptibility artifacts near the carotid siphon. Administration of a paramagnetic contrast agent allows better delineation of small vessels and aneurysms with slow and/or complex flow; however, in the carotid region, this is of limited value because enhanced venous structures superimpose on arterial vessels and decrease the visibility of aneurysms (2, 4, 22). Therefore, we do not recommend contrast material for routine examinations.

The complex anatomy and vascular loops in the regions of the internal carotid and anterior communicating arteries also decrease the detection of small aneurysms in these areas. The use of multiple and targeted MIPs are particularly important to inhibit the overlapping of vessels (Fig 4) (7, 14). Conventional MIP postprocessing may be an important limiting factor in the quality of MR angiograms (23). Improvements in postprocessing methodology should be able to increase the contrast-to-noise ratio on processed images acquired at any magnetic field. Alternative algorithms, including volume rendering or surface shading, soft thresholding and depth cuing of unrestricted techniques (STANDOUT), and "endovascular" three-dimensional display, have been shown to improve the delineation of aneurysms and adjacent arterial anatomy (16, 24–26).

The limited acquisition volume is another drawback of MR angiography. In our study, three of the six missed aneurysms were outside the circle of Willis and were not included in the field of view. Locksley (27) found that approximately 10% of aneurysms involved with SAH were located in peripheral or cerebellar vessels. We chose to cover only the circle of Willis in order to have a fast MR angiographic sequence, suitable even for uncooperative patients, and to avoid saturation effects in the 3-D slab. With our method, an aneurysm located outside the circle of Willis was included in the MR angiographic acquisition volume only if the aneurysm was large enough to have been suspected on previous spin-echo images. The use of multiple overlapping 3-D slabs may overcome this limitation in patients able to tolerate longer acquisition times (7, 8, 12, 20).

Most authors consider MR angiography to be a reliable screening test for the diagnosis of intracranial aneurysms in asymptomatic patients who are at in-
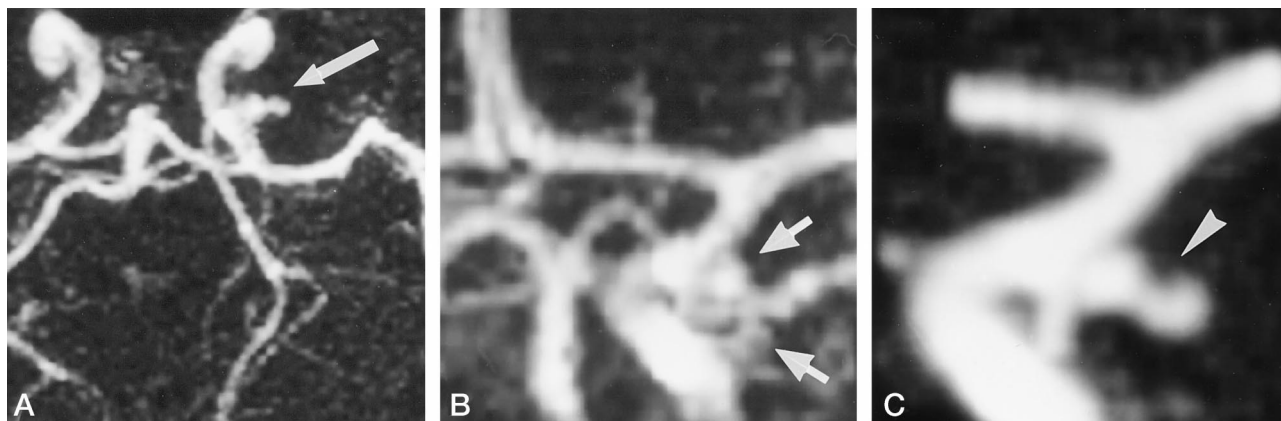
FIG 4. Noncontrast MR angiography in a patient with acute SAH.
A, Craniocaudal projection shows a 7-mm left internal carotid artery aneurysm (*arrow*).
B, The anteroposterior projection does not show the aneurysm well because of the overlapping of several hyperintense structures (*arrows*).
C, Targeted MIP in the same projection clearly shows the aneurysm (*arrowhead*).

FIG 5. Noncontrast MR angiography in a patient with acute SAH. The slightly oblique anteroposterior (*A*) and craniocaudal (*B*) projections clearly depict a 5-mm aneurysm in the middle cerebral artery (*arrows*). The neck of the aneurysm and its relation to the sylvian bifurcation are well defined. Aneurysms in this location are the easiest to detect with MR angiography.
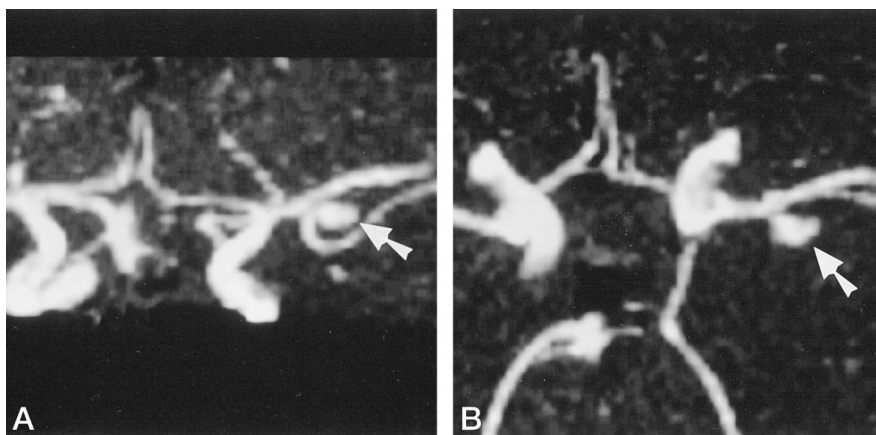
creased risk for an aneurysm or in stable patients with symptoms compatible with the presence of an aneurysm (7, 9, 12). Our results confirm that MR imaging combined with MR angiography is ideal for screening studies, because its sensitivity and specificity are sufficiently high, the imaging time is short, and the procedure is noninvasive. In patients with SAH, the role of MR imaging combined with MR angiography is more controversial. Some authors have stated that an MR examination is inappropriate in these patients because of the difficulty of monitoring persons with an impaired level of consciousness, the lack of cooperation of some patients, the limited acquisition volume and spatial resolution of MR angiography, the inability to detect acute SAH on MR images, or, conversely, the superimposition of subacute blood components on TOF images (1–3). Other studies have demonstrated the ability to apply MR angiography with good results in patients with SAH (9, 15, 28). In our series of 70 patients with acute SAH, good-quality MR studies were obtained after stabilization of life parameters, even in patients with a severely impaired clinical status. With these patients, a 0.5-T system has several potential advantages: it is less sensitive to motion artifacts and generally less noisy

than a high-field unit, and it allows the possibility of having a respirator and infusion pump in the magnet room.

Our experience also confirmed the results reported by Ogawa et al (29) concerning the successful detection of acute SAH on proton density–weighted images acquired at 0.5 T. In patients with acute SAH, the sensitivity of MR examination was 91% to 94% for the detection of intracranial aneurysms. In the same subgroup, intraarterial DSA performed in the acute phase (but not necessarily on the same day as MR angiography), detected only 91% of the aneurysms. When performed under good conditions, however, intraarterial DSA remains the most accurate and reliable diagnostic method in the diagnostic workup of intracranial aneurysms. Because an untreated aneurysm is a life-threatening condition after an initial SAH, intraarterial DSA must be performed in all patients in whom MR angiographic findings are negative.

Most authors agree that intraarterial DSA is mandatory before planning the treatment of an intracranial aneurysm (2, 4, 7). In the present era of economic restrictions, MR angiography cannot be justified for all symptomatic patients who then undergo intraarte-
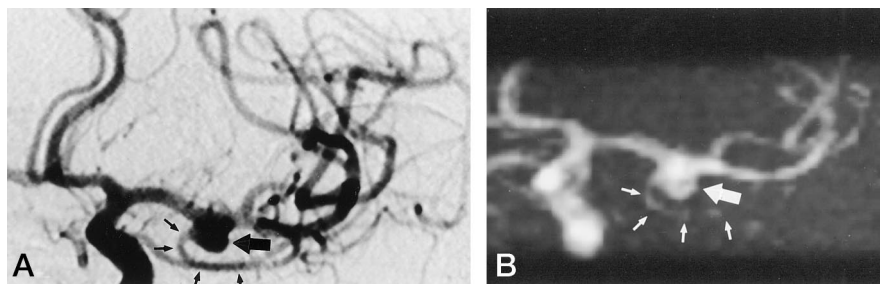
FIG 6.   Patient with polycystic kidney disease and acute SAH.

A, Intraarterial DSA (left carotid arteriogram). Anteroposterior oblique view shows a 4-mm aneurysm of the middle cerebral artery (*large arrow*) and a vessel emerging from the aneurysmal sac (*small arrows*).

B, Noncontrast MR angiogram in the same projection as *A* shows the aneurysm (*large arrow*) and the small artery arising from the aneurysmal sac (*small arrows*). Because of the presence of this vessel, the aneurysm was coated with acrylic glue.
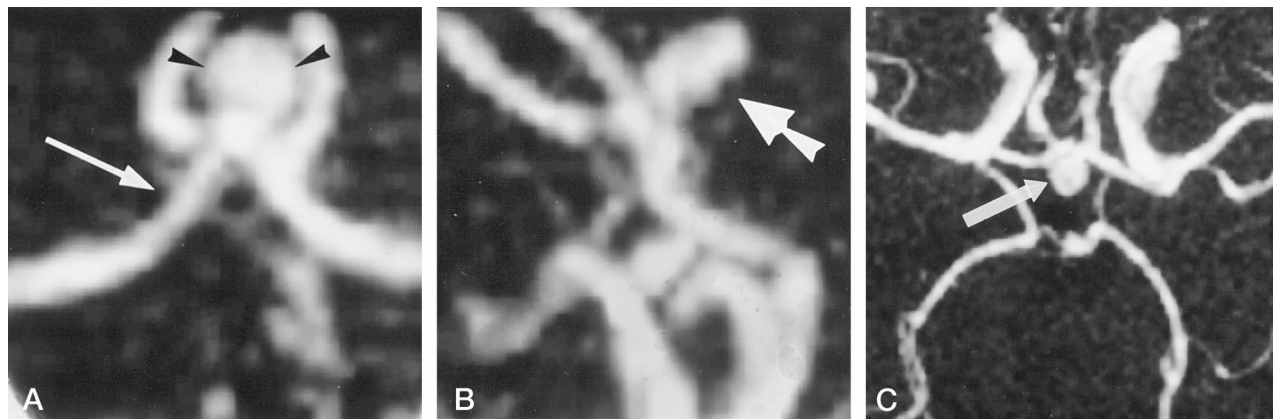

FIG 7.   Noncontrast MR angiograms in a patient with acute SAH.

Anteroposterior (*A*) and slightly oblique lateral (*B*) projections show an 8-mm aneurysm of the anterior communicating artery (*arrowheads* in *A* and *arrow* in *B*). Its shape, posterosuperior orientation, and relation to nearby vessels are clearly depicted. The slight narrowing of the distal aspect of the A1 segment of the right anterior cerebral artery (*arrow* in *A*) is possibly related to a slight vasospasm with no significant hemodynamic repercussion. A few days later, severe spasm developed with bifrontal ischemia.

C, The craniocaudal projection shows the aneurysm (*arrow*) and the patency of the circle of Willis. Even if the spatial resolution is inferior to that obtained with intraarterial DSA, all the information needed to plan the treatment is provided by MR angiography.

rial DSA whatever the results of MR angiography. Aside from the essential detection of an ruptured aneurysm, for the MR examination to have real clinical value, it must depict specific characteristics of the lesion and surrounding vessels, rendering intraarterial DSA unnecessary. Relevant anatomic characteristics must be delineated, including the parent vessel, the aneurysmal neck, and the relationship of the aneurysm to nearby small vessels (Figs 5 and 6). The presence or absence of other aneurysms or of an arteriovenous malformation, associated atherosclerotic cerebrovascular disease, the patency of the circle of Willis, and the presence of vasospasm must also be determined (2, 30, 31) (Fig 7). Under favorable circumstances, one can use MR angiography to help address these considerations before planning the treatment of an intracranial aneurysm. It is therefore not unreasonable to think that diagnostic intraarterial DSA could be avoided in some cases.

Conclusions

Our study has shown that, on a 0.5-T system, MR imaging combined with 3-D TOF MR angiography is accurate in detecting intracranial aneurysms. Further studies should determine if 0.5 T is a limiting factor in fully characterizing aneurysms, obviating diagnostic intraarterial DSA in some cases.

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