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Evaluation of symptomatic uterine fibroids in candidates for uterine artery embolization: comparison between ultrasonographic and MR imaging findings in 68 consecutive patients

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Abstract

Ultrasonographic and magnetic resonance (MR) imaging examinations of 68 women with uterine fibroids were reviewed to determine whether MR imaging may alter the therapeutic approach based on ultrasonography alone before uterine embolization. Therapeutic decisions based on ultrasonography alone were compared to those obtained after MR imaging. Discordant findings between both examinations involved 51 women (75%), and 19 (28%) had their therapeutic approaches based on ultrasonography alone altered by MR imaging. Ultrasonography and MR imaging showed concordant findings in 17 women (25%) for whom no changes in therapeutic option were made. MR imaging alters the therapeutic approach based on ultrasonography alone in 28% of candidates for uterine artery embolization.

Keywords: Uterine fibroids: Uterine artery embolization; Ultrasound; Magnetic resonance imaging

1. Introduction

During recent years, dramatic improvements in the treatment of uterine fibroids have reinforced the need for an accurate pretherapeutic evaluation. Consequently, a careful preoperative evaluation is critical to better select women with uterine fibroids who may be amenable to conservative treatment [1–4]. Several strategies are currently available for the treatment of uterine fibroids. Because of surgical refinements, myomectomy can be performed using an endoscopic approach, either by hysteroscopy or by laparoscopy [2–4]. In addition, uterine artery embolization has proven efficiency and safety in that task [4–6]. Moreover, these conservative techniques can be combined and tailored to the specific case [7]. Because conservative procedures are less invasive and allow better fertility by comparison with classical surgical approaches, they have gained wide acceptance among the gynecologic community. However, each technique has specific indications, limitations, and potential complications [8,9]. Currently, the size, the number, and the location of the fibroids are important information to best determine the most appropriate therapeutic approach and to help predict potential complications and failure [1,5,9,10]. In addition, the presence of associated adenomyosis or endometriosis, which is best detected with magnetic resonance (MR)

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imaging [11,12], has substantial impact on the therapeutic decision [13].

Although MR imaging has a well-known potential for the diagnosis of uterine fibroids [1,14,15] and a major role in planning therapeutic approach for women with uterine fibroids [9,10,16], this technique is still rarely performed in this specific indication. Paradoxically, at many institutions, the therapeutic decision is commonly based on the results of ultrasonography alone. One reason may be that, to our knowledge, a few studies have compared the relative merits of ultrasonography with those of MR imaging in the decision-making process [17,18] so that there is no definite consensus upon the most appropriate imaging technique which should be done for an optimal pretherapeutic evaluation.

Accordingly, we performed this retrospective study with two goals in mind. First, we wanted to compare the information provided by ultrasonographic examination, including transvaginal and transabdominal approach, with that given by MR imaging in women with symptomatic uterine fibroids who are candidates for uterine artery embolization. Second, we wished to determine at what extent the results of MR imaging might alter the therapeutic approach based on the results of ultrasonography alone in this specific population.

2. Materials and methods

2.1. Patients

All procedures were performed in our institution in accordance with institutional review board guidelines. Informed consent was obtained from the patients, who agreed to have their personal medical and imaging data used for research purposes.

From October 2007 through February 2008, the database of our institution was queried to identify all women with symptomatic uterine fibroids who were considered as potential candidates for uterine artery embolization. Sixty-eight consecutive women, with a mean age of 40.3 years (range: 25–56 years), were identified and then retrospectively included in the study. They all presented with symptomatic uterine fibroids, and the dominant symptoms at the time of presentation included metrorrhagia and/or menorrhagia (n=50; 50/68; 74%), pelvic discomfort or pain (n=29; 29/68; 43%), or pressure symptoms in the form of urinary frequency (n=11; 11/68; 16%). Thirty-four women (34/68; 50%) had a keenness to preserve the uterus for future fertility. Fourteen women (14/68; 21%) had had prior myomectomy by laparotomy, and four (4/68; 6%) had recurrent symptomatic fibroids after prior uterine artery embolization.

Medical reports and multidisciplinary therapeutic decisions were prospectively registered in our hospital medical database (Middlecare, Lincoln, Boulogne, France). In all women, ultrasonography and MR imaging were performed less than 1 month from each other.

2.2. Ultrasonography

All ultrasonographic examinations were performed using a standardized protocol by a panel of six radiologists with a large experience in pelvic and abdominal ultrasonography and were interpreted prospectively. An Aplio (Toshiba, Tokyo, Japan) ultrasonographic unit was used. All women had first transabdominal and then transvaginal ultrasonographic examination. Transabdominal studies were made with a 3.5-MHz probe, and a 5.0-MHz probe was used for endovaginal studies, with field of view adjusted for best resolution. Women were asked to void before endovaginal examination. During each ultrasonographic examination, uterine and fibroid size, as well as subendometrial halo thickness, was measured with electronic calipers. Uterine and fibroid volumes were determined with the following formula: $A\times B\times C\times 0.52$, where A, B, and C represent the dimensions in the three orientations assuming that the fibroids had an ellipsoid shape [16].

When multiple fibroids were present, the diameters of the codominant fibroids were measured. The diagnosis of adenomyosis was made when a poorly defined area of abnormal echogenicity was present in the myometrium. Abnormal myometrial echogenicity was considered present when the myometrium was heterogeneous with increased or decreased echogenicity by comparison with a presumably normal adjacent myometrium [12]. The exact location of all visible fibroids was noted to improve further correlation with MR imaging findings. For all ultrasonographic examinations, pertinent and representative images were stored on hardcopy films.

2.3. MR imaging

All MR examinations were performed with the same protocol, using a 1.5-T clinical MR unit (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany) with 18 receiver channels and using one anterior torso phased-array coil with six channels and two posterior spine clusters with three channels each, with the patient in a supine position. The gradient strength of the magnet was 45 mT/m with a maximal gradient slope of 200 mT/m. All patients had T2-weighted fast spin-echo (T2WFSE) and T1-weighted three-dimensional gradient-echo sequence. No specific bowel preparation was used before MR examination, and no antispasmodic agents were given to the patients. The patients voided immediately before the start of MR study.

T2WFSE MR images were obtained in the axial and sagittal planes with and without fat suppression with the following parameters: repetition time (TR), 6140 ms; echo time (TE), 143 ms; matrix size, 384×384; section thickness, 6 mm; intersection gap, 1.2 mm; voxel size, 0.8×0.8×6.0 mm^3; field of view, 300–340 mm; number of signal averages, 1; parallel imaging (Generalized Autocalibrating Partially Parallel Acquisitions (GRAPPA), with acceleration factor of 2); echo train length, 26; echo spacing, 11.9 ms; receiver bandwidth, 129 Hz/

pixel; 20 axial sections acquired; acquisition time, 120 s; acquisition time, 2 min 46 s.

T1-weighted MR images were obtained in the axial and sagittal planes with fat suppression with the following parameters: TR, 5.9 ms; TE, 2.4 ms; flip angle, 15°; matrix size, 174×192; section thickness, 1.8 mm; voxel size, 1.5×1.5×1.8 mm^3; field of view, 280–300 mm; number of signal averages, 1; parallel imaging (GRAPPA, with acceleration factor of 2); 88 axial partitions acquired; acquisition time, 26 s.

The number of visible fibroids was tabulated. Uterine volume and fibroid volume were calculated using the same formula as with ultrasonography. Each visible fibroid was categorized as submucosal (or paraendometrial), intramural, subserosal, or pedunculated. The presence of diffuse or focal widening of the junctional zone with a width of more than 12 mm was considered as an indicator of adenomyosis [12].

2.4. Image analysis and therapeutic decision

Ultrasonographic reports and hardcopy images were analyzed by two interventional radiologists and two gynecologists working in conference. A therapeutic approach based on ultrasonographic findings was first decided according to uterine volume, number, size, location of fibroids, and, if any, associated diseases such as endometriosis, adenomyosis, or adnexal masses. No attempt was made to individually analyze the information provided by transabdominal and transvaginal ultrasonography because both approaches were performed prospectively during the same session. Then, MR imaging examinations were reviewed using a PACS viewing station (Directview, 10.1 sp1 version, Kodak-Carestream Health, Rochester, NY, USA) by the same four observers who decided on a therapeutic approach based on MR imaging findings, using the same criteria as for ultrasonography for image analysis. Therapeutic strategies based on the results of MR imaging were thus compared with those obtained with ultrasonography. In case of discordant findings between ultrasonography and MR imaging, the latter was considered correct.

The indications for each therapeutic approach were determined in a standardized fashion. Surgery and uterine artery embolization were the favored options only for women with symptomatic fibroids after failure of first-line medical treatment or for women who desired future pregnancy. Laparoscopic myomectomy was decided for the resection of three or less fibroids (whatever their location) with a cumulated diameter of less than 9 cm [3]. Hysteroscopic resection was decided for submucosal fibroids with a diameter of less than 5 cm when the posterior myometrial wall had a thickness of more than 4 mm [19]. When five or less than five fibroids were present, surgical myomectomy was the preferred option. When more than five fibroids were present, uterine artery embolization was the preferred option. Uterine artery embolization was also considered as an alternate option to hysterectomy in women who had had prior surgical myomectomy or for whom risky surgery was anticipated [5,20]. The presence of a large, subserosal or submucosal fibroid was a contraindication for exclusive uterine artery embolization because of the risk of bowel necrosis or further vaginal discharge. In specific cases with multiple fibroids present and when uterine artery embolization alone or surgery alone was considered potentially risky, a combination of the two techniques was decided [7]. When present, adenomyosis was considered as a contraindication for uterine artery embolization in women over 35 years old, and surgery was preferred [13,20].

2.5. Data analysis

Descriptive statistics were calculated for all variables evaluated on ultrasonography and MR imaging. Quantitative (continuous) variables, including uterine and fibroid volume and number of fibroids, were expressed as means, 95% confidence intervals (CIs), medians, first quartiles, third quartiles, and ranges and compared with the paired Student's *t* test or, when not applicable, the Wilcoxon signed rank test. Qualitative variables, including fibroid location (submucosal, transmural, or subserosal), presence of more than five fibroids, presence of more than 10 fibroids, presence of adenomyosis, hydrosalpinx, ovarian cyst, endometrial thickening (defined as more than 12 mm), and uterine polyp, were compared with the χ^2 test or, when not applicable, the Fisher's exact test.. Calculations were performed with the R v. 2.8 software (R Foundation, http://www.r-project.org/). All statistical tests were two-tailed, and statistical significance was considered at $P<.05$ for all comparisons.

3. Results

3.1. Imaging findings

The results of ultrasonography and MR imaging are reported in Tables 1 and 2.

On ultrasonography, the median uterine volume was 462 cm^3 (q_1, 229 cm^3; q_3, 889 cm^3), and on MR imaging, the median uterine volume was 729 cm^3 (q_1, 290 cm^3; q_3, 1314 cm^3). The 31% difference (95% CI: 11%–53%) between the two techniques for uterine volume measurement

Table 1
Comparison between ultrasonographic and MR imaging quantitative findings in 68 women with symptomatic uterine fibroids

	Ultrasonography	MR imaging	*P* value
Uterine volume (cm^3)	462 (229; 889)	729 (290; 1314)	.024 [a]
Number of fibroids	4 (3; 5)	4 (3.8; 7)	.0008 [b]
Fibroid diameter (mm)	50 (35; 72)	58 (37; 77)	.06 [a]

Values are shown as median (first quartile; third quartile).

[a] Student's *t* test.

[b] Wilcoxon rank sum test.

Table 2
Comparison between ultrasonographic and MR imaging qualitative findings in 68 women with symptomatic uterine fibroids

Variables	Format	Ultrasonography	MR imaging	*P* value
>5 Fibroids	Absent	56 (82.4; 71.2–90.5)	37 (54.4; 41.9–66.6)	<.001 [a]
	Present	12 (17.6; 9.5–28.8)	31 (45.6; 33.5–58.1)	
>10 Fibroids	Absent	67 (98.5; 92.1–1)	67 (98.5; 92.1–1)	>.999 (NS) [b]
	Present	1 (1.5; 0.0–7.9)	1 (1.5; 0.0–7.9)	
Submucosal	Absent	59 (86.8; 76.4–93.8)	55 (80.9; 69.6–89.4)	.49 (NS) [a]
	Present	9 (13.2; 6.2–23.6)	13 (19.1; 10.6–30.5)	
Transmural	Absent	11(16.2; 8.4–27.1)	9 (13.2;6.2–23.6)	<.81 (NS) [a]
	Present	57 (83.8; 72.9–91.6)	59 (86.8; 76.4–93.8)	
Subserosal	Absent	51 (75.0; 63–84.7)	45 (66.2; 53.7–77.2)	.35 (NS) [a]
	Present	17 (25.0; 15.3–37)	23 (33.8; 22.8–46.3)	
Adenomyosis	Absent	66 (97.1; 89.8–99.6)	50 (73.5; 61.4–83.5)	.000014 [b]
	Present	2 (2.9; 0.4–10.2)	18 (26.5; 16.5–38.6)	
Hydrosalpinx	Absent	66 (97.1; 89.8–99.6)	65 (95.6; 85.6–98.4)	>.999 (NS) [b]
	Present	2 (2.9; 0.4–10.2)	3 (4.4; 0.9–12.4)	
Ovarian cysts	Absent	56 (82.4; 71.2–90.5)	64 (94.1; 85.6–98.4)	<.06 [b]
	Present	12 (17.6;9.5–28.8)	4 (5.9; 1.6–14.4)	
Endometrial thickening	Absent	58 (85.3;74.6–92.7)	67 (98.5; 92.1–1)	<.0088 [b]
	Present	10 (14.7;7.3–25.4)	1 (1.5; 0.0–7.9)	
Uterine polyp	Absent	67 (98.5; 92.1–1)	66 (97.1; 89.8–99.6)	>.999 (NS) [b]
	Present	1 (1.5; 0.0–7.9)	2 (2.9; 0.4–10.2)	

Data are raw numbers; numbers in parentheses are percentages, followed by 95% CIs. NS indicates not significant.

[a] χ^2 test.
[b] Fisher's exact test.

was significant (Student's *t* test, *P*=.024). This difference exceeded 10% in 55 women (55/68; 81%; 95% CI: 69.5%–89.4%) and 20% in 42 women (42/68, 61.7%; 95% CI: 49.2%–73.3%). On ultrasonography, the median diameter of the dominant fibroid was 50 mm (q_1, 35 mm; q_3, 72 mm) and 58 mm (q_1, 37 mm; q_3, 72 mm) on MR imaging, but the difference was not significant (Student's *t* test, *P*=.06).

Ultrasonography allowed the depiction of significantly less fibroids than MR imaging did (Wilcoxon rank sum test, *P*=.0008) (Fig. 1). Twelve women (12/68; 17.6%) were found to have more than five fibroids, whereas MR imaging showed more than five fibroids in 31 women (31/68; 45.6%) (*P*<.001). By comparison with MR imaging used as the reference standard, the sensitivity of ultrasonography for the detection of women with more than five fibroids was 38.7% (12/31; 95% CI: 21.8%–57.8%). Both ultrasonography and MR imaging showed more than 10 fibroids in only one woman (1/68; 1.5%; 95% CI: 0%–7.9%).

Regarding fibroid localization, nine submucosal fibroids were found on ultrasonography. Of these, only four were actually confirmed in this location on MR imaging (Fig. 2); the other five were deemed interstitial on MR imaging. Regarding subserosal fibroids, ultrasonography showed 17 fibroids in this location, whereas 23 subserosal fibroids were actually present on MR imaging (Fig. 1).

On ultrasonography, hydrosalpinx was found in two women. Of these, only one was confirmed on MR imaging, whereas the other case was deemed to be a peritoneal cyst on MR imaging. In addition, MR imaging showed hydrosalpinx not seen on ultrasonography in two women. The sensitivity and the specificity of ultrasonography for the diagnosis of hydrosalpinx were 33.3% (1/3; 95% CI: 0%–100%) and 98.5% (64/65; 95% CI: 91.7%–100%), respectively.

On ultrasonography, two women were found to have findings consistent with adenomyosis. Of these, one case was confirmed on MR imaging, whereas the other was excluded on MR imaging. On MR imaging, 18 women were found to be affected by this condition (Fig. 3). By comparison with MR imaging used as the reference standard, the sensitivity and the specificity of ultrasonography for the detection of adenomyosis were 5.5% (1/18; 95% CI: 0.1%–27.3%) and 98.3% (50/51; 95% CI: 89.3%–99.9%), respectively. Endometriosis was detected on MR imaging but not with ultrasonography in one woman. Of the 12 cases of ovarian cysts or mass seen with ultrasonography, only four were confirmed by MR imaging. All of these four cases were considered as functional ovarian cysts. In one woman, a mass adjacent to the uterus was erroneously considered from left ovarian origin, whereas it was actually a subserosal fibroid on MR imaging (Fig. 4). Two women had one uterine polyp each detected on MR imaging. Of these, one was detected on ultrasonography, and the other was erroneously diagnosed as submucosal fibroid.

3.2. Impact of MR imaging on therapeutic strategy

Concordant findings between ultrasonography and MR imaging were found in 17 women (17/68, 25%) for whom the results of MR imaging did not alter the therapeutic option. Discordant findings between ultrasonography and MR imaging involved 51 women (51/68; 75%). In 19 women (19/68; 28%) with discordant findings, the results of

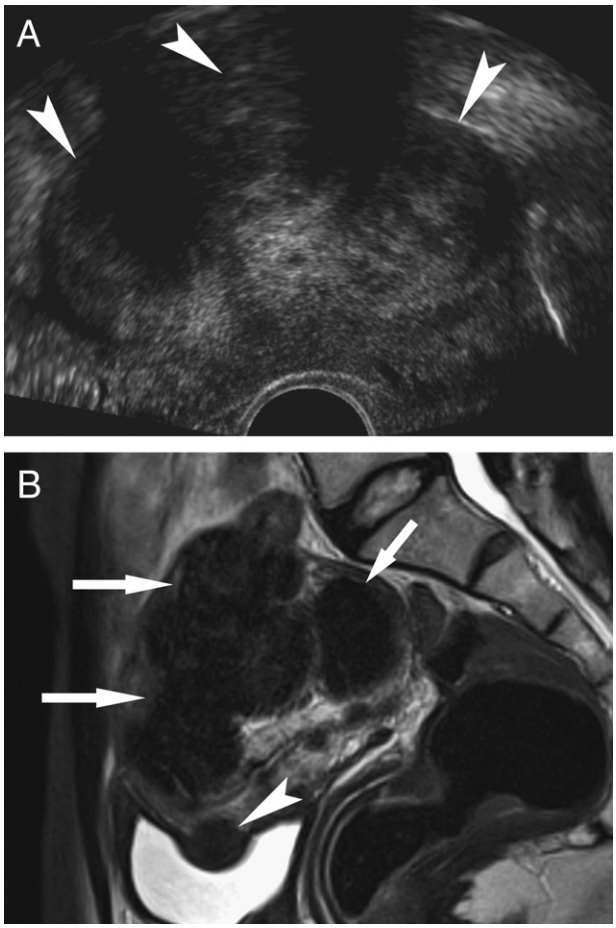

Fig. 1. Ultrasonographic and MR images from a 45-year-old woman with uterine fibroids who was a candidate for uterine artery embolization. (A) Ultrasonography shows multiple fibroids whose location was considered as interstitial (arrowheads). (B) MR imaging in the sagittal plane confirms interstitial fibroids (arrows) but shows additional subserosal fibroids (arrowhead). The initial therapeutic strategy based on ultrasonographic findings alone was changed from uterine artery embolization to laparotomic myomectomy owing to MR imaging findings.

MR imaging altered the therapeutic approach based on ultrasonographic findings alone.

In 32 women (32/68, 47%) with discordant findings, the results of MR imaging did not alter the therapeutic approach based on ultrasonographic findings alone. Discordant findings consisted in a greater number or size of fibroids on MR imaging in 24 women (24/68, 35%), erroneous submucosal localization of fibroid on ultrasonography in 3 women (3/68, 4%), and presence of adenomyosis detected on MR imaging only in 5 women (5/68, 7%).

In 19 women (19/68; 28%) with discordant findings, the results of MR imaging altered the therapeutic approach based on ultrasonographic findings alone. Table 3 provides the description of changes in therapeutic strategies due to the results of MR imaging.

Hysteroscopic resection was considered first in eight women on the basis of ultrasonographic findings alone. After MR imaging, initial strategy was changed into uterine artery embolization and laparoscopic myomectomy (one case each) in two women because ultrasonography erroneously suggested submucosal fibroids that were deemed interstitial on MR imaging.

Laparoscopic myomectomy was considered first in 10 women on the basis of ultrasonographic findings alone. After MR imaging, the therapeutic approach was changed in five women (5/10; 50%). For two women, ultrasonography showed findings consistent with single fibroids, whereas MR imaging showed features typical for mass-forming adenomyosis in one of them and associated adenomyosis in the other so that they both ultimately received a medical treatment only. In two other women, the number and size

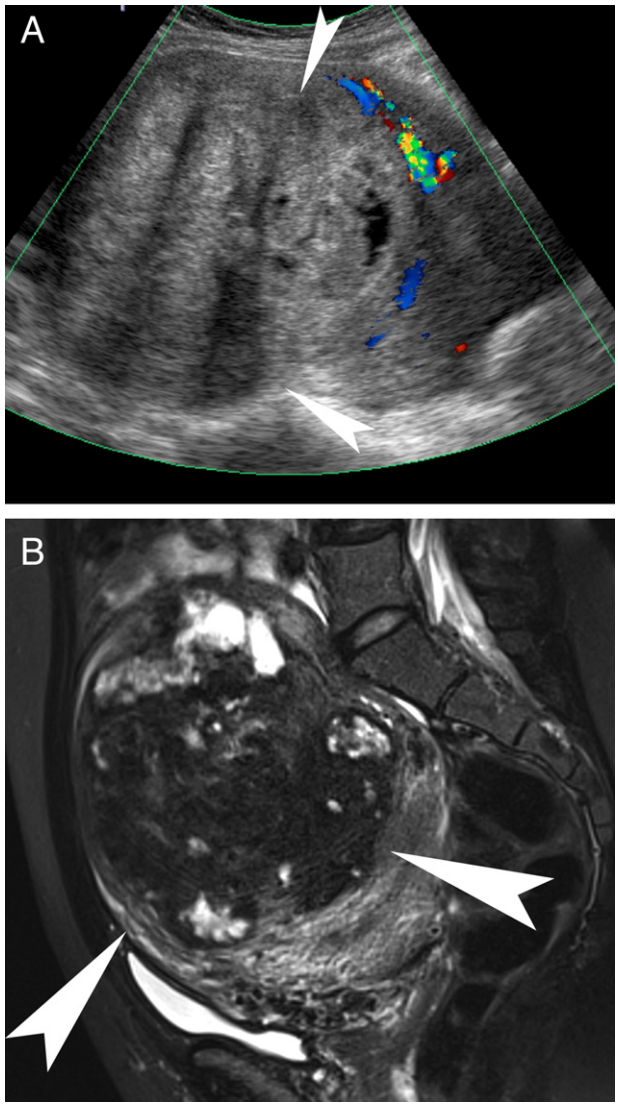

Fig. 2. Ultrasonographic and MR images from a 37-year-old woman with uterine fibroids who was a candidate for uterine artery embolization. (A) Ultrasonography shows a large fibroid (arrowhead) which was considered submucosal. (B) MR imaging shows a large heterogeneous fibroid (arrowheads) which was considered interstitial. The initial therapeutic strategy based on ultrasonographic findings alone was changed from hysterectomy to uterine artery embolization owing to MR imaging findings.

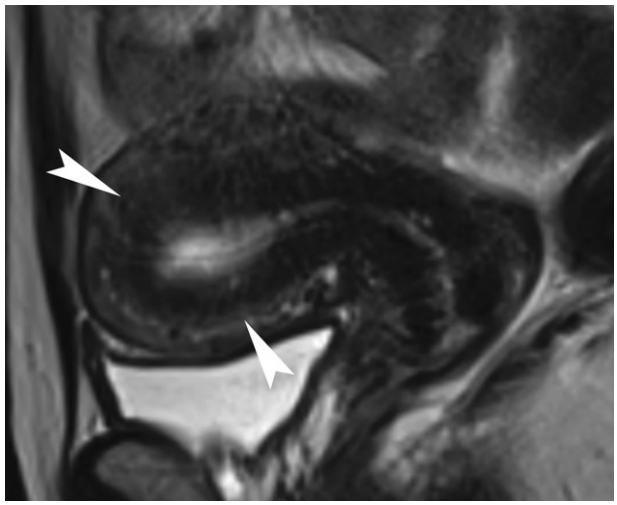

Fig. 3. Magnetic resonance image from a 41-year-old woman with uterine fibroids who was a candidate for uterine artery embolization. Ultrasonography depicted a single interstitial fibroid (not shown), which was confirmed on MR imaging. MR image in the sagittal plane shows thickening of the junctional zone (arrowheads) consistent with adenomyosis not seen on ultrasonography. The initial therapeutic strategy based on ultrasonographic findings alone was changed from uterine artery embolization to complementary medical treatment owing to MR imaging findings.

of uterine fibroids were markedly underestimated with ultrasonography alone, and MR imaging showed more than three fibroids with a cumulated diameter of more than 9 cm so that laparotomy was actually performed. The remaining woman had only one fibroid visible on ultrasonography, whereas multiple fibroids were found on MR imaging so that she had had uterine artery embolization.

Myomectomy by laparotomy was proposed as a first-line strategy in 14 women on the basis of ultrasonographic findings alone. After MR imaging, the therapeutic approach was changed in three women (3/14; 21.4%). The three women had a number of fibroids that were substantially underestimated on ultrasonography by comparison with MR imaging so that uterine artery embolization was preferred to extensive myomectomy.

Uterine artery embolization was proposed as a first-line strategy in 18 women on the basis of ultrasonographic findings alone. After MR imaging, the therapeutic approach was changed in seven women (7/18; 38.9%). Severe adenomyosis was diagnosed on MR imaging in four women: three benefited from further medical treatment, and one woman ultimately asked for hysterectomy. For the other two women, submucosal fibroids were visible on MR imaging so that hysteroscopic resection was performed. The remaining woman was found to have a large subserosal fibroid that contraindicated uterine artery embolization so that laparoscopic myomectomy was performed.

Hysterectomy was proposed as a first-line strategy in 17 women on the basis of ultrasonographic findings alone. After MR imaging, the therapeutic approach was changed in only one woman (1/17; 5.9%). In this woman, ultrasonographic features suggested submucosal fibroids whose presence contraindicated uterine artery embolization, whereas MR imaging showed interstitial fibroids so that uterine artery embolization was actually performed. For the 16 women who finally underwent hysterectomy, the initial surgical approach was never altered by the results of MR imaging.

Conservative medical treatment was proposed as a first-line strategy in one woman on the basis of ultrasonographic findings alone. In this woman, ultrasonography failed to depict a subserosal fibroid of 6 cm in diameter and erroneously suggested the presence of endometrial thickening, whereas MR imaging detected the fibroid and excluded endometrial thickening. This woman had laparoscopic myomectomy due to the information provided by MR imaging instead of a medical treatment.

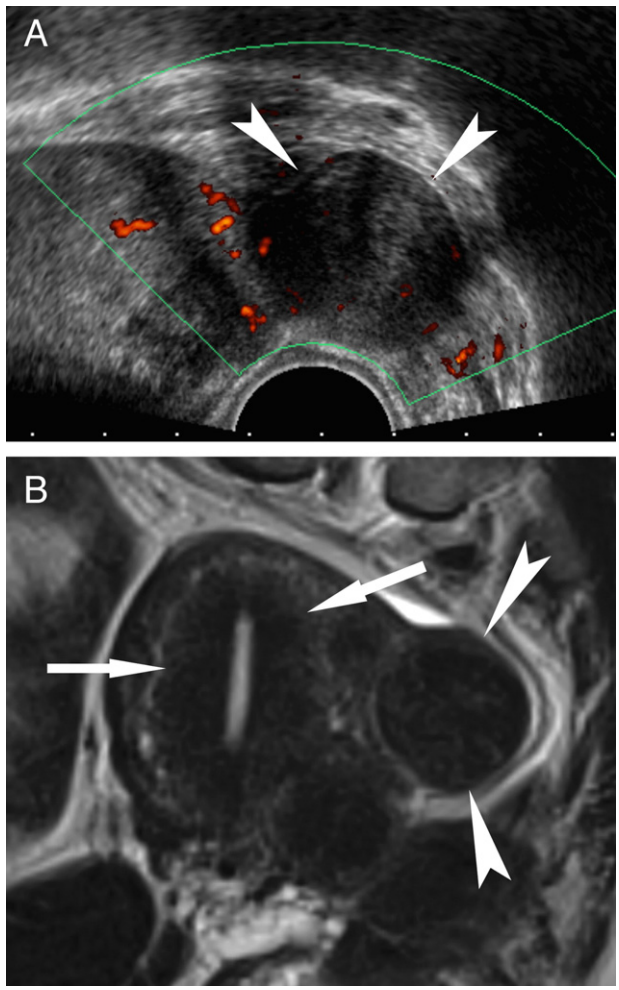

Fig. 4. Ultrasonographic and MR images from a 38-year-old woman with uterine fibroids who was a candidate for uterine artery embolization. (A) Ultrasonography shows a poorly vascularized mass (arrowheads) adjacent to the uterus, which was considered from ovarian origin. (B) MR imaging demonstrates that the mass is actually a subserosal fibroid (arrowheads) and depicts thickening of the junctional zone (arrows) consistent with adenomyosis that was not seen on ultrasonography. The initial therapeutic strategy based on ultrasonographic findings alone was changed from laparoscopy to uterine artery embolization owing to MR imaging findings.

Table 3
Changes in therapeutic strategies after MR imaging in 19 women with symptomatic uterine fibroids

Patient no.	Initial strategy	MR imaging findings	Final strategy
1	Hysteroscopic myomectomy	No submucosal fibroids	Uterine artery embolization
2	Hysteroscopic myomectomy	No submucosal fibroids	Laparoscopic myomectomy
3	Laparoscopic myomectomy	No fibroids. Adenomyoma	Complementary medical treatment
4	Laparoscopy	Adenomyosis and multiple fibroids	Uterine artery embolization
5	Laparoscopic myomectomy	Multiple fibroids	Laparotomic myomectomy
6	Laparoscopic myomectomy	Fibroids diameter >9 cm	Laparotomic myomectomy
7	Laparoscopic myomectomy	Coexisting adenomyosis	Complementary medical treatment
8	Laparotomic myomectomy	More than 5 fibroids	Uterine artery embolization
9	Laparotomic myomectomy	More than 5 fibroids	Uterine artery embolization
10	Laparotomic myomectomy	More than 5 fibroids	Uterine artery embolization
11	Uterine artery embolization	Coexisting adenomyosis	Hysterectomy
12	Uterine artery embolization	Coexisting adenomyosis	Complementary medical treatment
13	Uterine artery embolization	Large subserosal fibroids	Laparotomic myomectomy
14	Uterine artery embolization	Coexisting adenomyosis	Complementary medical treatment
15	Uterine artery embolization	Single interstitial 3-cm fibroid	Complementary medical treatment
16	Uterine artery embolization	Submucosal fibroid	Hysteroscopic myomectomy
17	Uterine artery embolization	Submucosal fibroids	Hysteroscopic myomectomy
18	Hysterectomy	No submucosal fibroids	Uterine artery embolization
19	Medical treatment	No endometrial enlargement	Laparoscopic myomectomy

4. Discussion

Ultrasonography is the first-line imaging examination for the diagnosis of uterine fibroids. When considering the diagnosis of uterine fibroid on a per-patient basis, ultrasonography has a sensitivity and a specificity of 99% and 90%, respectively, which are values similar to those obtained with MR imaging [14]. However, when imaging is performed for deciding upon the therapeutic strategy, a more precise evaluation, including number, size, and location of the uterine fibroids, as well as the presence of adenomyosis, is needed. The results of our study show that the information provided by ultrasonography alone is insufficient and would lead to inappropriate therapeutic decision in approximately one fourth of the patients.

In our study, only 1 of 18 cases of adenomyosis was diagnosed with ultrasonography. When present, adenomyosis markedly impacts the therapeutic strategy [18,20]. MR imaging appears as the best imaging technique for the diagnosis of associated adenomyosis, especially in the presence of uterine fibroids [11]. The sensitivity of ultrasonography for the diagnosis of adenomyosis relies on the experience of the operator, whereas the results of MR imaging examination are more reproducible when reviewed by different radiologists [15]. In a routine setting, the sensitivity of ultrasonography for the diagnosis of adenomyosis is poor by comparison with that of MR imaging.

Although MR imaging carries a high degree of accuracy, this technique is not routinely performed in pretherapeutic evaluation of uterine fibroids. This is in part due to its expensiveness. However, MR examination is recommended by several authors when uterine artery embolization is considered [1,5,17]. Indeed, complications can occur after uterine artery embolization in the presence of submucosal fibroids (endometritis, vaginal discharge) or subserosal fibroids (bowel necrosis) [6,8]. Although we agree that submucosal or subserosal fibroids are not uniformly considered as contraindications for uterine artery embolization, we and others believe that patients should be informed of these potential risks and that a precise mapping remains necessary before uterine artery embolization. For Spielmann et al. [17], the therapeutic strategies were modified in up to 22.5% of the cases after MR imaging when uterine artery embolization was first considered. In our study, when ultrasonographic findings alone suggested uterine artery embolization, the strategy was changed in 38.9% of patients after MR imaging. Conversely, in six women for whom uterine artery embolization was initially disregarded because of ultrasonographic findings, MR imaging showed findings that favored this minimally invasive approach. The lack of precision in the fibroid mapping and adenomyosis diagnosis on ultrasonography is the critical endpoint here. Our study reaffirms the need for MR imaging before uterine artery embolization.

There are no current recommendations for the specific application of MR imaging as an imaging test when a surgical conservative approach is considered in women with symptomatic uterine fibroids. However, surgical decision mostly depends on the size, number, and location of fibroids [3]. In our experience, MR imaging has an important impact on therapeutic decision when laparoscopy is firstly proposed. We found that the initial strategy was modified in 50% of the cases owing to MR imaging findings. Most of the changes were due to the presence of coexisting adenomyosis on MR imaging or a misevaluation of fibroid size and location on ultrasonography. As a consequence, MR imaging should be the preferred imaging test if available because it carries a higher degree of accuracy for the diagnosis of adenomyosis. Recently, Rajan et al. [18] have shown that MR imaging is more correct than ultrasonography in determining the

number or the location of fibroids in approximately 12% of the cases.

Because of a more correct detection of the number of fibroids, MR imaging is also helpful for patients for whom myomectomy using laparotomy is considered on the basis of ultrasonographic findings. Underestimation of the number of fibroids with ultrasonography was observed in 21.4% of our patients. In these patients, uterine artery embolization was preferred instead of extensive myomectomy because potential intraoperative risks, including hemorrhage and urinary tract injuries, were anticipated based on MR imaging findings [21].

MR imaging had no benefit when hysterectomy was first considered after ultrasonography. Adenomyosis did not alter the therapeutic decision in these cases. However, hysterectomy is usually proposed despite the patients' desire for a conservative approach because of the existence of massive submucosal or subserosal fibroids. Here again, a precise mapping is critical, and MR imaging might show a greater impact in a larger cohort of patients. The surgical route for hysterectomy was never modified after MR imaging. Indeed, decision on the surgical route was mainly based on clinical findings and patient history.

Several limitations may be raised with respect to our study. The first relates to the retrospective nature, which might have introduced selection bias. A second limitation relates to the limited number of patients. A third limitation is due to the fact that no controlled group was obtained so that the actual impact of MR imaging on the final decision and on the outcome was not fully evaluated.

In conclusion, we do not advocate the use of MR imaging as a screening method for the diagnosis of uterine fibroid, but our analysis demonstrates that MR imaging should be the favored imaging technique for the evaluation of uterine fibroids when invasive treatment (either uterine artery embolization or surgery) is considered after failure of medical treatment. When total hysterectomy is considered, MR imaging has no added value and does not alter the treatment option, whatever its results. Conversely, when a conservative treatment is considered, the therapeutic strategy is often changed by the detection of findings unseen on ultrasonography. In many cases, ultrasonography does not provide pertinent information with respect to fibroid localization or presence of adenomyosis to best decide on the most appropriate therapeutic approach. The actual question that remains unanswered is to determine to what extent MR imaging improves the outcome in women with symptomatic uterine fibroids. This should be further evaluated prospectively using unbiased, large, and well-designed studies.

References

[1] Cura M, Cura A, Bugnone A. Role of magnetic resonance imaging in patient selection for uterine artery embolization. Acta Radiol 2006;47:1105–14.

[2] Indman PD. Hysteroscopic treatment of submucous myomas. Clin Obstet Gynecol 2006;49:811–20.

[3] Dubuisson JB, Chapron C. Uterine fibroids: place and modalities of laparoscopic treatment. Eur J Obstet Gynecol Reprod Biol 1996;65:91–4.

[4] Pelage JP, LeDref O, Soyer P, Kardache M, Dahan H, Abitbol M, et al. Fibroid-related menorrhagia: treatment with superselective embolization of the uterine arteries and midterm follow-up. Radiology 2000;215:428–31.

[5] Marshburn PB, Matthews ML, Hurst BS. Uterine artery embolization as a treatment option for uterine myomas. Obstet Gynecol Clin North Am 2006;33:125–44.

[6] Walker WJ, Pelage JP. Uterine artery embolisation for symptomatic fibroids: clinical results in 400 women with imaging follow up. BJOG 2002;109:1262–72.

[7] Malartic C, Morel O, Fargeaudou Y, Le Dref O, Fazel A, Barranger E, et al. Conservative two-step procedure including uterine artery embolization with Embosphere and surgical myomectomy for the treatment of multiple fibroids: preliminary experience. Eur J Radiol 2010, doi:10.1016/j.ejrad.2010.10.014.

[8] Spies JB, Spector A, Roth AR, Baker CM, Mauro L, Murphy-Skrynarz K. Complications after uterine artery embolization for leiomyomas. Obstet Gynecol 2002;100:873–80.

[9] Verma SK, Bergin D, Gonsalves CF, Mitchell DG, Lev-Toaff AS, Parker L. Submucosal fibroids becoming endocavitary following uterine artery embolization: risk assessment by MRI. AJR Am J Roentgenol 2008;190:1220–6.

[10] Omary RA, Vasireddy S, Chrisman HB, Ryu RK, Pereles FS, Carr JC, et al. The effect of pelvic MR imaging on the diagnosis and treatment of women with presumed symptomatic uterine fibroids. J Vasc Interv Radiol 2002;13:1149–53.

[11] Bazot M, Cortez A, Darai E, Rouger J, Chopier J, Antoine JM, et al. Ultrasonography compared with magnetic resonance imaging for the diagnosis of adenomyosis: correlation with histopathology. Hum Reprod 2001;16:2427–33.

[12] Reinhold C, Tafazoli F, Mehio A, Wang L, Atri M, Siegelman ES, et al. Uterine adenomyosis: endovaginal US and MR imaging features with histopathological correlation. Radiographics 1999;19:S147–60.

[13] Levgur M. Therapeutic options for adenomyosis: a review. Arch Gynecol Obstet 2007;276:1–15.

[14] Dueholm M, Lundorf E, Hansen ES, Ledertoug S, Olesen F. Accuracy of magnetic resonance imaging and transvaginal ultrasonography in the diagnosis, mapping, and measurement of uterine myomas. Am J Obstet Gynecol 2002;186:409–15.

[15] Volkers NA, Hehenkamp WJ, Spijkerboer AM, Moolhuijzen AD, Birnie E, Ankum WM, et al. MR reproducibility in the assessment of uterine fibroids for patients scheduled for uterine artery embolization. Cardiovasc Intervent Radiol 2008;31:260–8.

[16] Ghai S, Rajan DK, Benjamin MS, Asch MR, Ghai S. Uterine artery embolization for leiomyomas: pre- and postprocedural evaluation with US. Radiographics 2005;25:1159–72.

[17] Spielmann AL, Keogh C, Forster BB, Martin ML, Machan LS. Comparison of MRI and sonography in the preliminary evaluation for fibroid embolization. AJR Am J Roentgenol 2006;187:1499–504.

[18] Rajan DK, Margau R, Kroll RR, Simons ME, Tan KT, Jaskolka JD, et al. Clinical utility of ultrasound versus magnetic resonance imaging for deciding to proceed with uterine artery embolization for presumed symptomatic fibroids. Clin Radiol 2011;66:57–62.

[19] Fernandez H, Kadoch O, Capella-Allouc S, Gervaise A, Taylor S, Frydman R. Hysteroscopic resection of submucous myomas: long term results. Ann Chir 2001;126:58–64.

[20] Pelage JP, Jacob D, Fazel A, Namur J, Laurent A, Rymer R, et al. Midterm results of uterine artery embolization for symptomatic adenomyosis: initial experience. Radiology 2005;234:948–53.

[21] Ginsburg ES, Benson CB, Garfield JM, Gleason RE, Friedman AJ. The effect of operative technique and uterine size on blood loss during myomectomy: a prospective randomized study. Fertil Steril 1993;60:956–62.