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Authors	Lohne,P.N.; de Vries,J.; Klazen,C.A.; Boekkooi,P.F. et al
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Uterine Artery Embolization for Symptomatic Adenomyosis with or without Uterine Leiomyomas with the Use of Calibrated Tris-acryl Gelatin Microspheres: Midterm Clinical and MR Imaging Follow-up

Paul N.M. Lohle, MD, PhD, Jolanda De Vries, PhD, Caroline A.H. Klazen, MD, Peter F. Boekkooi, MD, PhD, Harry A.M. Vervest, MD, PhD, Albert J. Smeets, MD, Leo E.H. Lampmann, MD, PhD, and Thomas J. Kroencke, MD

PURPOSE: To evaluate clinical and magnetic resonance (MR) imaging results after uterine artery embolization (UAE) in women with symptomatic adenomyosis with or without uterine leiomyomas.

MATERIALS AND METHODS: Thirty-eight women with symptomatic adenomyosis with or without uterine leiomyomas were treated with UAE with calibrated tris-acryl gelatin microspheres. Based on MR findings, women were categorized as having pure adenomyosis (group A; $n = 15$), adenomyosis dominance with fibroid tumors (group B; $n = 14$), or fibroid tumor dominance with adenomyosis (group C; $n = 9$).

RESULTS: Heavy menstrual bleeding, pain, and bulk-related symptoms at last follow-up at a median of 16.5 months (range, 3–38 months) were compared with baseline symptoms. With follow-up MR imaging at a median of 12 months (range, 3–36 months), changes in uterine volume, leiomyoma volume, junctional zone thickness, and contrast enhancement of adenomyosis were assessed. After embolization, adenomyosis infarction could be depicted on contrast medium-enhanced MR in 44.1% of cases. Median reductions of uterine volume, fibroid tumor volume, and junctional zone thickness were 44.8%, 77.1%, and 23.9%, respectively. In group A, three patients needed additional surgery after UAE, in addition to two in group B and one in group C. In the remaining 32 patients, except for one patient in group C, all preexisting symptoms (eg, bleeding, pain, bulk-related symptoms) improved or resolved after UAE. Overall, 84.2% of women were satisfied with the results of UAE.

CONCLUSION: In this study, midterm results (at a median of 16.5 months) showed that UAE in symptomatic adenomyosis with or without uterine leiomyomas is effective. Hysterectomy was avoided in the vast majority of patients. MR imaging showed reduction of uterine volume and junctional zone thickness.

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Abbreviations: TE = echo time, TR = repetition time, UAE = uterine artery embolization

ADENOMYOSIS, defined by Bird in 1979, is a benign invasion of endometrium into the myometrium that pro-

duces a diffusely enlarged uterus that microscopically exhibits ectopic non-neoplastic endometrial glands and

stroma surrounded by the hypertrophic and hyperplastic myometrium (1,2). Although most patients are asymptomatic, adenomyosis may lead to heavy menstrual bleeding, pain, and enlargement of the uterus in as many as 35% of cases (3). Adenomyosis is estimated to occur in 5%–70% of women (3,4), frequently between 40 and 50 years of age. The clinical diagnosis is challenging, as the presenting symptoms overlap with common uterine disorders such as fibroid tumors of the uterus (3,5). Between 60% and 80% of women with adenomyosis have co-existing pelvic disease (5,6), mostly in

From the Departments of Radiology (P.N.M.L., C.A.H.K., A.J.S., L.E.H.L.) and Obstetrics and Gynecology (P.F.B., H.A.M.V.), St. Elisabeth Ziekenhuis; Department of Medical Psychology (J.D.V.), Tilburg University, Tilburg, The Netherlands; and Department of Diagnostic and Interventional Radiology (T.J.K.), Charité Universitätsmedizin, Berlin, Germany. Received October 5, 2006; final revision received April 12, 2007; accepted April 16, 2007. **Address correspondence to** P.N.M.L., Department of Radiology, St. Elisabeth Ziekenhuis, Hilvaren-

beekseweg 60, 5022 GC Tilburg, The Netherlands; E-mail: radiol@knmg.nl

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the form of fibroid tumors accompanying adenomyosis. Magnetic resonance (MR) imaging or ultrasonography (US) may be used to diagnose adenomyosis. In this study, we used only MR imaging because it is known that US is less sensitive in the diagnosis of adenomyosis (7).

Conservative treatment such as hormonal therapy is an option, but hysterectomy is usually required to provide these patients a definite solution for their symptoms (8). Uterine artery embolization (UAE) is reported to be an efficient nonsurgical alternative in the treatment of heavy menstrual bleeding, pain, and bulk-related symptoms associated with leiomyomas of the uterus (9–18). The objective of UAE is to cause tumor infarction, resulting in substantial reduction of the uterine and tumor volumes. The effectiveness of UAE to achieve persistent symptomatic improvement in patients with adenomyosis is still unclear.

The purpose of our study was to prospectively evaluate midterm clinical outcomes and MR imaging results after UAE performed with the use of calibrated tris-acryl gelatin microspheres (CTGMs) in 38 women with symptomatic adenomyosis with or without uterine leiomyomas.

MATERIALS AND METHODS

Patient Population and Selection Criteria

Between April 2001 and July 2004, in two participating hospitals (St. Elisabeth Ziekenhuis in Tilburg, The Netherlands; and Charité, Berlin, Germany), a prospective study was conducted including women with symptomatic uterine adenomyosis undergoing UAE. In both institutions, all women in the present study who were initially referred for UAE because of suspected symptomatic uterine leiomyomas underwent MR imaging routinely to verify the diagnosis and to exclude patients who were not suitable for UAE.

During the study period, all eligible consecutive women with adenomyosis based on MR imaging ($n = 38$) were included. No patients dropped out of the study. The women were divided into three groups: group A had adenomyosis only, group B had adenomyosis dominance and fibroid tumors, and

group C had adenomyosis and fibroid tumor dominance. The diagnosis of adenomyosis was established with MR imaging. Adenomyosis was defined as diffuse or focal broadening of the junctional zone with low myometrial signal intensity on T2-weighted images, exceeding 12 mm in thickness with or without punctate high intensity myometrial foci corresponding to myometrial cysts (19). Classification of patients into group B or C based on the estimated amount of adenomyosis or fibroid tumor tissue was done by two experienced MR imaging radiologists (P.N.M.L., T.J.K.) who independently analyzed the MR images for each patient. Disagreements in interpretation were resolved by consensus.

Inclusion criteria were (i) adenomyosis with or without one or more uterine fibroid tumors and (ii) self-reported heavy menstrual bleeding, pain, and/or bulk-related symptoms of which insufficient clinical results were obtained with previous medical therapy or conservative surgery. Exclusion criteria were postmenopausal status, malignancy, pedunculated fibroid tumors with a small stalk, and current pregnancy. Women seeking future fertility were not excluded. The ethical committee approved this study and informed consent was obtained from all women.

Preprocedural Imaging

Pelvic MR imaging was performed in all 38 women before and after UAE during follow-up. Both treatment centers used a similar protocol with equivalent equipment. MR imaging on the 1.5-T superconducting scanner (Magnetom Vision or Magnetom Symphony; Siemens Medical Systems, Erlangen, Germany) was performed with a torso phased-array coil. After an initial localization scan, sagittal and transaxial T2-weighted turbo spin-echo images (repetition time [TR], 4300–7000 msec; echo time [TE], 96–115 msec; 512 matrix; slice thickness, 5 mm) covering the uterus were taken after intramuscular injection of 20 mg butyl-scopolamine to reduce bowel motion artifacts. In addition, transaxial, coronal, and sagittal breath-hold T2-weighted half-Fourier acquired single-shot turbo spin-echo images (TR, ∞ ; TE, 65 msec; flip angle, 150°; 128 × 256 matrix; 7-mm slice thick-

ness) were obtained. T1-weighted imaging included a fat-suppressed gradient recalled echo sequence (TR, 182–187 msec; TE, 4.1 msec; flip angle, 90°; matrix, 107–115 × 256; slice thickness, 5 mm) before and after intravenous administration of a weight-adjusted dose (0.1 mmol/kg body weight) of gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany). MR imaging on the 1.5-T superconducting scanner (Intera; Philips, Best, The Netherlands) was performed with a synergy body coil. After a survey multistack scan, sagittal and transaxial T2-weighted turbo spin-echo images (TR, 3500 msec; TE, 90 msec; 256 matrix; slice thickness, 5 mm) covering the uterus were taken. In addition, T1-weighted spin-echo imaging was performed with phase-encoded artifact reduction (TR, 550 msec; TE, 14 msec; flip angle, 90°; 204 × 256 matrix; slice thickness, 6 mm; fold-over direction, anterior posterior) before and 5 minutes after intravenous administration of a weight-adjusted dose (0.5 mmol/kg body weight) of gadodiamide (Omniscan; Amersham Health, Eindhoven, The Netherlands).

Procedure and Angiographic Endpoint of Embolization

After being categorized based on the tissue volume ratio of adenomyosis versus leiomyomas depicted on MR imaging, the patients underwent UAE. Embolization was performed under local anesthesia, antibiotic prophylaxis, and sedation by administration of 2.5–5 mg midazolam when required, and a bladder catheter was placed in all cases. From a right common femoral artery approach, the left internal iliac artery was catheterized with a hydrophilic 0.035-inch J-tipped guide wire and a 4-F C2 Glide catheter (Boston Scientific, Natick, Mass) or a Rösch inferior mesenteric catheter (Cook, Bloomington, Ind). Road-map or selective digital subtraction angiography of the anterior division of the left internal iliac artery and uterine artery was performed. A microcatheter was positioned in the horizontal part of the left uterine artery distally from the angiographically visualized cervicovaginal branches, followed by embolization with CTGMs (size 500–700 μm in all cases; additional microspheres 700–900 μm in size were used

in a few cases), such as Embosphere or EmboGold microspheres (Biosphere Medical, Roissy, France). The same procedure was repeated on the opposite side.

During a short period of time, one treatment center switched completely from Embosphere microspheres to EmboGold microspheres for UAE because they seemed easier to work with. After being informed by other physicians about possible side effects of EmboGold particles in UAE, they resumed the use of Embosphere microspheres. The other center used only Embosphere microspheres. In a few patients, additional microspheres 700–900 μm in size were used to reduce the total number of CTGM vials and to limit the duration of the procedure in cases of large uterine volume.

Each vial (2 mL) of microspheres was mixed with 10 mL of contrast medium (Omnipaque [Schering] or Imeron [Bracco-Byk Gulden, Konstanz, Germany]) and 5 mL saline to obtain a stable suspension of the microspheres. The angiographic embolization endpoint was defined as complete stasis of contrast agent in the ascending segment of the uterine artery during selective digital subtraction angiography at the end of the embolization procedure. Both treatment centers are still using this protocol with complete stasis as the angiographic embolization endpoint specifically for women with adenomyosis.

Technical success was assessed and defined as completion of the embolization in both uterine arteries with documentation of the chosen embolization endpoint outlined previously. The use of microcatheters, intracatheter aggregation, and blockage by the embolic agent was determined. The volume of CTGMs used was recorded for all 38 women and for each group separately.

Clinical and Imaging Follow-up Protocol

The 38 women treated with UAE underwent prospective clinical and MR imaging follow-up (3, 6, and 12 months and last follow-up), the findings of which were compared with baseline after categorization in group A, B, or C. Clinical response was assessed by comparing the results of a standardized clinical questionnaire dis-

tributed before UAE; at 3, 6, and 12 months; and at the last follow-up after UAE during an outpatient clinic consultation. Patients were asked to classify changes in bleeding symptoms, pain, and bulk-related symptoms as worsened, unchanged, or improved or resolved during regular office visits. Overall, satisfaction was scored as very satisfied, satisfied, or not satisfied, and was assessed in all patients. Clinical symptoms (heavy menstrual bleeding, pain, and bulk-related symptoms) at last follow-up were compared with baseline symptoms.

Gynecologic interventions after UAE were recorded, including emergent or elective hysterectomy or myomectomy, dilation and curettage, hysteroscopic tumor resection, endometrial ablation, or a second embolization. A major intervention was defined as a hysterectomy, a definitive myomectomy, or a second embolization. Definitive myomectomy was defined as an abdominal myomectomy of the major tumor(s) present or a hysteroscopic resection of a solitary submucosal tumor. When a patient underwent a major intervention, she was censored from further follow-up in the study. Until a patient was censored, we retrieved all information, consistent with our follow-up procedure. Failure of UAE was recorded if the patient needed a major intervention or showed no improvement at final follow-up (16). All complications after UAE were recorded. Major complications, defined as events requiring immediate additional therapy (including emergent hysterectomy) or resulting in permanent adverse sequelae (including permanent amenorrhea) or death, were recorded. Transient amenorrhea, tumor expulsion, skin rash, and infection requiring nominal therapy were considered minor complications.

Pelvic MR imaging was performed in all women with use of a 1.5-T scanner at the last follow-up visit after UAE. Uterine and tumor volume, junctional zone thickness, and contrast enhancement of adenomyosis were compared with the findings of baseline MR imaging. The pattern of adenomyosis was classified as focal or diffuse according to the categories published by Jha et al (4). The affected tissue of adenomyosis was calculated with use of the maximum junctional

zone thickness perpendicular to the uterine cavity before and after UAE and was measured at the same location in each patient.

Uterine and dominant tumor volume (if tumor was present) were calculated based on the assumption that they were ellipsoid structures according to the following formula:

$$4/3 \times \pi \times r_1 \times r_2 \times r_3$$

with r_1 , r_2 , and r_3 being the radius of the uterus in three perpendicular planes. Volume reductions of the uterus and dominant tumor were calculated by comparing volumes before embolization with volumes at the last MR imaging follow-up. The volumes at last MR imaging follow-up were subtracted from the volumes before UAE, divided by the volumes at last MR imaging follow-up, and multiplied by 100 to obtain the percentage of shrinkage/reduction.

Enhanced T1-weighted images obtained before and after treatment were compared to assess evidence of infarction of adenomyosis and tumors if present. The percentage of infarction was subjectively assigned at last follow-up and compared with baseline findings for tissue area affected by adenomyosis and tumor, and infarction percentage measurements were divided into the following categories: 0%, 1%–25%, 26%–50%, 51%–75%, 76%–99%, and 100%. Two radiologists experienced in MR imaging (P.N.M.L., T.J.K.) independently analyzed the MR images for each patient. Disagreements in interpretation were resolved by consensus.

Statistical Analysis

Mean, median, range, and SD of affected tissue thickness by adenomyosis and uterine and tumor volumes were assessed before and after UAE. Also, differences between women who did versus did not receive additional therapy were examined. These differences were compared with use of the Student *t* test, and *P* values less than .05 were considered to indicate significance.

The following results after UAE with microspheres were compared for women categorized in groups A, B, and C: change of symptoms, patient satisfaction, uterine and tumor vol-

ume reductions, minor and major complications, and additional embolization or hysterectomy. Statistical analysis consisted of a paired Student *t* test to detect differences across time for uterine volume and tumor volume, Kruskal-Wallis tests to compare the three groups in terms of clinical parameters, and χ^2 tests to examine differences in symptoms among the three groups. SPSS software (version 12.0.1; SPSS, Chicago, Ill) was used for the analyses. *P* values lower than 0.05 were considered statistically significant.

RESULTS

The mean age of women treated was 44.7 years (SD, 4.2). The majority of patients were white (*n* = 33), two were black, and three were Asian. Patients were assigned to the previously defined three groups as follows: group A comprised 15 women with a mean age of 43.9 (SD, 4.9) with adenomyosis only; group B comprised 14 women with a mean age of 45.1 years (SD, 4.1) with adenomyosis dominance and fibroid tumors; and group C comprised nine women with a mean age of 45.3 years (SD, 3.3) with adenomyosis and fibroid tumor dominance. Of the 38 participants, 37 reported heavy menstrual bleeding, 30 reported pelvic pain, and 15 reported bulk-related symptoms before UAE.

Before UAE, all participating women underwent one or more treatments without sufficient clinical result, such as iron supplementation, hormonal treatments, gonadotropin-releasing hormone analogue treatment, use of a levonorgestrel-containing intrauterine device, hemostatic agents, analgesic agents, or myomectomy.

Technical Results

Technical success was achieved in all patients, all 38 of whom received bilateral UAE. The CTGMs—Embosphere or EmboGold microspheres—were used in 32 and six women, respectively. The median volume of CTGMs used in the 38 patients in total was 5.5 mL (mean, 6.4 mL; SD, 4.3). In group A, the median CTGM volume was 5 mL (mean, 5.6 mL; SD, 3.0); in group B, it was 5.5 mL (mean, 7.2 mL; SD, 5.8); and in group C, it was 7 mL (mean, 6.4 mL; SD, 3.6). Embolization

through microcatheters was performed in all patients. Intracatheter aggregation and blockage did not occur in any of the embolization procedures.

Major Complications

There was no procedure-related mortality. No events requiring immediate additional therapy occurred and no emergent hysterectomy was required. Permanent amenorrhea occurred in five women, who did undergo additional surgery (15.6%). All women who developed permanent amenorrhea were 45 years of age or older. These women were significantly older than women who did not develop permanent amenorrhea (*P* = .019). There was no difference in occurrence of permanent amenorrhea after UAE among groups A, B, and C.

Minor Complications

Directly after UAE, transient amenorrhea occurred in eight of the 25 women without additional surgery for whom this information was known (32.0%). These women were not significantly older than women who did not develop transient amenorrhea. There was no difference in occurrence of transient amenorrhea after UAE among groups A, B, and C. Spontaneous tumor expulsion occurred in five women (15.6%) 3–6 months after UAE.

Additional Procedures

Six women (15.8%) had additional therapy after UAE: one woman underwent adenomyosis resection and five women had a hysterectomy after UAE with a lack of resolution or improvement of symptoms. In these six women, the self-reported symptoms after UAE were heavy menstrual bleeding and pain in five women and bulk-related symptoms (ie, urinary frequency) in two women. The adenomyosis resection occurred 13 months after UAE. The hysterectomies occurred between 8 and 34 months after UAE (mean, 14.2 months). These women did not differ from women who did not have an additional procedure with regard to rate of shrinkage or devascularization.

Clinical Results

The last clinical follow-up occurred at a mean of 18 months (median, 16.5 months; SD, 11) in the whole patient group, and at 15 months in group A (median, 12 months; SD, 10), 17 months in group B (median, 15 months; SD, 11), and 24 months in group C (median, 24 months; SD, 10).

In group A, two women underwent hysterectomy and one underwent an adenomyoma resection. In group B, two women underwent hysterectomy, and in group C, one woman underwent a hysterectomy despite initial improvement in bleeding symptoms and pain.

Symptoms reported by the remaining patients are shown in the **Table**. Before UAE, all women except one in group C reported heavy menstrual bleeding. A substantial number of patients reported pain before UAE. Bulk-related symptoms were less common in group A than in the other groups. None of the 12 women showed worsening of any symptom after UAE. All symptoms improved or resolved after UAE. Only one woman reported worsening of pain.

At last clinical follow-up, all patients were very satisfied or satisfied. The percentages of patients who were very satisfied were 83.3% in group A, 75% in group B, and 50% in group C. The other patients reported that they were satisfied with the treatment. The six patients who underwent additional surgery were unsatisfied with the procedure.

MR Results

The last MR imaging follow-up was at a median of 12 months (range, 3–36 months). Five of the 38 women enrolled in the study underwent a hysterectomy and one woman underwent an adenomyoma resection after UAE. The median uterine volume in these 32 cases before UAE was 233 mL (range, 101–879 mL). At the last MR imaging follow-up after UAE, median uterine volume was 143.5 mL (range, 33–689 mL), which represented a significant difference (*P* < .001). The median uterine volume decrease was of 44.8% (range, –72.3% to 77.8%). The median leiomyoma volume before UAE in the 32 women with MR imaging follow-up was 15.24 mL (range, 0.69–382.00 mL).

Symptoms and Clinical Features of the Three Groups				
Symptom	Group A (n = 12)	Group B (n = 12)	Group C (n = 8)	P Value
Bleeding				
Before UAE	12	12	7	.213
Resolved after UAE	7	8	3	
Improved after UAE	5	4	4	
Unchanged after UAE	0	0	0	
Worsened after UAE	0	0	0	.890
Pain				
Before UAE	9	10	5	.575
Resolved after UAE	6	7	2	
Improved after UAE	3	3	3	
Unchanged after UAE	0	0	0	
Worsened after UAE	0	0	1	.446
Bulk-related				
Before UAE	3	6	6	.038
Resolved after UAE	2	4	6	
Improved after UAE	1	2	0	
Unchanged after UAE	0	0	0	
Worsened after UAE	0	0	0	.302
Uterine volume*	305.7	310.8	443.4	.551
Decrease of the uterine	46.1	40.3	43.0	.675
Thickness of affected tissue by adenomyosis*	32.8	33.2	17.8	.011

* Mean of all women (N = 38) in each group.

At the last MR imaging follow-up, the median leiomyoma volume was 1.25 mL (range, 0–221.00 mL), which represented a significant difference ($P = .027$). The median leiomyoma volume decrease was 79.68% (range, –117.39% to 100%).

At last MR imaging follow-up, the median of reduction of adenomyosis junctional zone thickness was 23.9% (range, –4.5% to 68.8%). Infarction of tissue affected by adenomyosis after UAE could be detected in 15 of 34 women (44.1%) with contrast medium-enhanced MR imaging. In these 15 women, there was a median infarction rate of adenomyosis of 90% (range, 10%–100%; mean, 75.7%). In the patients with a fibroid tumor infarction ($n = 19$), the infarction rate was 100% (range, 1%–100%; median, 84.5%). Two patients did not have a tumor infarction, and no information on this was available for two patients.

Comparison of Results among Groups

Data on the three groups with regard to uterine volumes, thickness of affected tissue, and symptoms before UAE is shown in the **Table**. The three groups differed neither with regard to uterine volume before UAE nor in the decrease of uterine volumes after UAE. There was a difference in thick-

ness of affected tissue by adenomyosis before UAE in the three groups, with group C having less thickness. Infarction of adenomyosis after UAE did not differ significantly ($P = .218$). In addition, the groups did not differ in the percentage decrease of adenomyosis zone thickness after UAE ($P = .095$). With regard to the percentage of patients reporting heavy menstrual bleeding, pain, and bulk-related symptoms before UAE, the three groups differed only in bulk-related symptoms. The three groups did not differ significantly concerning the percentage of patients reporting complete resolution or improvement of symptoms after UAE (**Table**). There was also no difference in patient satisfaction after UAE among groups ($P = .255$). In addition, no difference was found in terms of additional surgery after UAE in the three groups (three of 15 in group A, two of 14 in group B, and one of nine in group C; $P = .803$), nor in complications after UAE regarding amenorrhea or tumor expulsion ($P = .755$). Finally, age was not related to satisfaction at last clinical follow-up ($P = .241$).

DISCUSSION

The aim of this study was to evaluate the clinical symptoms and MR

imaging results after UAE in 38 women with symptomatic adenomyosis. Our midterm results showed that UAE with CTGMs is effective. Hysterectomy was avoided in the vast majority of patients and symptoms improved or resolved. After UAE, MR imaging showed reduction of uterine volume and junctional zone thickness.

The cause of bleeding in adenomyosis is still unknown, but may be a result of decreased myometrial contraction caused by the inability to complete vessel contraction (3,5,20). Definitive treatment for adenomyosis is hysterectomy. Hormonal therapy or endometrial ablation may be helpful but are not durable. UAE is successful in treating symptomatic uterine fibroid tumors; however, when associated with adenomyosis, UAE is considered contraindicated. Early reports have related clinical failure in UAE for symptomatic uterine leiomyomas to the presence of viable tissue of adenomyosis (9,11,13,21). Recently, there have been reports with marked short-term improvement of symptoms in patients with pure adenomyosis or in conjunction with uterine leiomyomas (4,6,22–24). Kitamura et al described good short- and midterm clinical results after UAE in a small group of patients with pure or dominant adenomyosis (23). Pelage et al reported

encouraging short-term results (94%), but the success rate had decreased from 94% to 55% after 2 years (24).

To date, midterm results after UAE with CTGM only in women with adenomyosis have not been published in a larger study than this with clinical and MR imaging follow-up. In this study with prospectively collected data, we found that UAE with CTGM in symptomatic adenomyosis is feasible and safe, with a low risk of complications or additional surgery and no significant difference among the three patient groups. Our findings confirmed the results reported by others (4,6, 22–24). In addition, our study demonstrated that embolization with 500–700- μm CTGMs in symptomatic adenomyosis has a high midterm clinical success rate for heavy menstrual bleeding, pain, and bulk-related symptoms, with no significant difference among the three groups. Two other studies demonstrated no significant difference in clinical outcome between groups of women with pure and dominant adenomyosis at short- and midterm follow-up after UAE with nonspherical 500–710- μm polyvinyl alcohol (PVA) particles alone or nonspherical 355–500- μm PVA particles and 500–700- μm CTGMs (4,23). In our study, at a median of 16.5 months after UAE with 500–700- μm CTGMs, significant patient satisfaction was achieved that was not related to age or group. With shorter clinical follow-up, comparable initial results have been described by Siskin et al (6) at 8.2 months and Kim et al (22) at 3.5 months after the use of nonspherical PVA particles 355–500 μm or 250–710 μm in size. In addition, others reported durable good clinical results after 1 year (4,23). However, Pelage et al (24), who used 355–500- μm nonspherical PVA particles or 500–900- μm CTGMs, reported encouraging short-term results at 3 months but disappointing results at 1 and 2 years in a subgroup of patients.

Both treatment centers in the present study are still using the UAE protocol as presented previously with 500–700- μm CTGMs and complete stasis as the angiographic embolization endpoint for women with adenomyosis. This “aggressive” approach has been abandoned by many interventional radiologists and is currently not recommended for UAE because of complications such as necrosis, sepsis,

or death (25,26). Although we share the general consensus opinion concerning UAE, we have a different view on UAE in women with symptomatic adenomyosis. In contrast to uterine leiomyomas with the perifibroid plexus, adenomyosis has a deep and/or more diffuse distribution throughout the myometrium, lacking a defined arterial supply (27). Histopathologic examination of specimens showed accumulation of particles in the perifibroid plexus with tumor infarction. To the contrary, in the cases of adenomyosis, particles were randomly distributed throughout the myometrium and foci of adenomyosis remained unaltered (28). The difference in vascularization might explain the reported higher failure rate after UAE in women with adenomyosis compared with UAE for fibroid tumors.

The currently available data do not seem to indicate a preferred embolic agent for use in women with symptomatic adenomyosis. Although based on speculation, deep penetration with the embolic agent seems to be needed to reach and create optimal infarction of areas with adenomyosis. As opposed to nonspherical PVA particles, CTGMs are able to target tiny arterial branches of the adenomatous tissue deeply into the uterine stroma to create sufficient tissue infarction. It has been demonstrated that CTGMs, with their characteristics and constant predictive behavior, penetrated deeper than nonspherical PVA particles (29). In addition, we believe complete stasis in the ascending segment of the uterine artery will help hamper the formation of collateral vessels.

In accordance with the finding of previous studies (4,6,22,23), the assessment of uterine volume change showed a significant decrease after UAE (44.8%). In addition, there was no significant difference in uterine volume shrinkage in our study among the three patient groups. Accompanying fibroid tumors in groups B and C shrank according to the UAE data, with no significant difference between groups. We confirmed that junctional zone thickness decreased after UAE, which has also been reported by others in pure adenomyosis or adenomyosis in the presence of fibroid tumors, regardless of which condition is dominant (4,6,22,23).

Fibroid tumor infarction after UAE can be well depicted on contrast medium-enhanced MR imaging. Infarction of adenomatous tissue could be detected in 44% of the women. In these women, we achieved a 90% median infarction rate in adenomatous tissues with the use of CTGMs. Others have reported infarction rates of 40%–74% with the use of nonspherical PVA particles or a combination of nonspherical PVA particles and 500–700- μm CTGMs (4,22,23). In our study, the adenomyosis infarction rate and shrinkage of adenomatous zone thickness after UAE showed no difference between the three groups.

There are several limitations to this study. First, it has been reported that the junctional zone thickness and degree of enhancement varies minimally with the menstrual cycle (30,31). We did not take the menstrual cycle of our patients into consideration in evaluating the junctional zone. Second, ideally the reader of the MR images is blinded as to whether a patient belongs to group A, B, or C, but in the present study this was not possible because the reader will always perceive the presence of pure adenomyosis (ie, group A) or adenomyosis accompanied by few leiomyomas (ie, group B) or many leiomyomas (ie, group C). We did ensure that patient records were not consulted before assessment of the follow-up MR images. Third, the satisfaction scale was asymmetric and skewed in a positive direction. A more balanced scale might have resulted in less variable results. And finally, we also recognize the relative small sample size of this study, which implies that the results should be interpreted with care. In addition, we do not have long-term follow-up and therefore cannot comment on long-term durability of UAE in women with adenomyosis. However, contrary to earlier reports, our midterm follow-up results (median, 16.5 months), based on independent observations of prospectively collected data in two treatment centers, strongly suggest that it no longer seems justified to withhold UAE treatment from women with bleeding, pain, or bulk-related symptoms based on the presence of adenomyosis with or without associated fibroid tumors. The results showed at least temporary relief of symptoms, after which repeat UAE is an option to consider in case of recur-

rent symptoms. Although our midterm results showed that UAE in symptomatic adenomyosis with or without uterine fibroid tumors is effective, further research is needed with larger groups of patients and longer follow-up.

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