Preliminary Experience with Uterine Artery Embolization for Uterine Fibroids[1]

Scott C. Goodwin, MD
Suresh Vedantham, MD
Bruce McLucas, MD
Alice E. Forno, MD
Rita Perrella, MD

Index terms: Pelvic pain • Uterine artery, therapeutic blockade • Uterus, hemorrhage • Uterus, neoplasms

JVIR 1997; 8:517–526

Abbreviation: PVA = polyvinyl alcohol

PURPOSE: To evaluate the potential usefulness of transcatheter uterine artery embolization as a treatment for fibroid-related vaginal bleeding and pelvic pain refractory to hormonal therapy and myomectomy.

MATERIALS AND METHODS: Eleven patients (aged 27–55 years; mean, 44.2 years; none desiring future pregnancy) with refractory vaginal bleeding and/or chronic pelvic pain related to uterine leiomyomata underwent uterine artery embolization with use of polyvinyl alcohol (PVA) particles. Clinical improvement was assessed by detailed questionnaire at 2–9 months (mean, 5.8 months) after the procedure. Sonographic measurements of the uterus and dominant masses were obtained before and at 2 months after the procedure.

RESULTS: All 11 patients underwent technically successful embolization. Eight of nine women who completed the follow-up questionnaire reported noticeable symptomatic improvement, including three women with complete resolution of symptoms. One woman (the only patient undergoing unilateral embolization) exhibited no clinical response. Another patient developed endometritis and pyometra 3 weeks after the procedure, necessitating hysterectomy. Large reductions in uterine volume (average, 40%) and dominant fibroid size (average, 60%–65%) were sonographically demonstrated.

CONCLUSION: Uterine artery embolization represents a promising new method of treating fibroid-related menorrhagia and pelvic pain. Further investigation will be required to assess clinical response and durability, identify appropriate candidates, and define the optimal angiographic technique and PVA particle size.

UTERINE leiomyomata represent the most common pelvic tumors in women, with clinical and autopsy studies demonstrating their prevalence to be 20%–40% in women older than 35 years of age (1). Hysterectomy has traditionally been the primary treatment for symptomatic or rapidly enlarging leiomyomata, with these tumors accounting for one-third of all hysterectomies performed in the United States (1). In women wishing to preserve future childbearing potential, surgical or hysteroscopic myomectomy is currently considered the treatment of choice. Although some controversy exists concerning the morbidity of this procedure (2), most studies have shown multiple myomectomy to be associated with increased blood loss, operating time, pain, postoperative morbidity, and longer hospital stays than hysterectomy (1). In addition, 20%–25% of women undergoing myomectomy will ultimately require another surgical procedure for treatment of

[1] From the Departments of Radiological Sciences (S.C.G., S.V., R.P.) and Obstetrics & Gynecology (B.M., A.E.F.), University of California, Los Angeles Medical Center, CHS Building BL-423, 10833 Le Conte Ave, Los Angeles, CA 90095. From the 1997 SCVIR annual meeting. Received December 28, 1996; revision requested February 5, 1997; revision received March 1; accepted March 4. **Address correspondence to** S.C.G.

fibroids, usually hysterectomy. Hormonal therapy with use of progestational compounds or gonadotropin-releasing hormone agonists has been shown to result in dramatic symptomatic improvement and reduction of fibroid tumor size, but with rapid re-growth of leiomyomata to their original size within a few months of discontinuation of treatment (1). Because disadvantages of longer-term therapy include osteoporosis, menopausal symptoms, and amenorrhea (in women desiring childbearing), these agents are currently used as a temporizing measure in perimenopausal women or as a method of reducing tumor size and vascularity prior to surgery. Because of these limitations, uterine leiomyomata remain a cause of menorrhagia and chronic pelvic pain in a significant number of patients.

Recently, the preoperative use of transcatheter arterial embolization was reported to result in significantly diminished perioperative blood loss in women undergoing surgical myomectomy (3). In a related study, the same authors described significant fibroid tumor reduction and symptomatic improvement in women undergoing embolization as an alternative to myomectomy in the treatment of fibroid-related menorrhagia (4). We recently reported angiographic and clinical success with use of uterine artery embolization in two women with recurrent myomata (5) and are currently offering this procedure to our patients with recurrent fibroid-related symptoms despite previous treatment with hormonal therapy and invasive procedures. In this article, we describe our initial experience with embolization in this clinical setting, with attention to the evolving technical aspects of this procedure and the short-term results regarding safety, effectiveness, and tolerability.

MATERIALS AND METHODS

• Patients

Eleven patients, aged 27–55 years (mean, 44.2 years), with refractory vaginal bleeding (two women), pelvic pain (two women), or both (seven women) related to uterine leiomyomata were included in this prospective study (**Table 1**). Two women were postmenopausal, three women were perimenopausal, and six women were premenopausal. Of the last two groups, eight patients had additional gynecologic problems (six with tubal adhesions, one with endometriosis, and one with Asherman's syndrome). Because many of these women previously had infertility problems and none were desirous of future pregnancy at the time of the study, medical history screening was deemed sufficient to render remote the possibility of intercurrent pregnancy in this particular group of women. Four women had submucosal leiomyomata documented with hysteroscopy, and all women had pelvic ultrasound (US) examinations demonstrating leiomyomata, which were multiple in 10 of 11 women. One woman was anemic due to chronic menorrhagia. Every woman was evaluated by an experienced gynecologist (10 women by B.M., one woman by outside referral), whose clinical determination was that these tumors were the sole or major contributor to the patient's symptoms, which were incapacitating enough to warrant surgical intervention.

Every woman had undergone unsuccessful hormonal therapy for leiomyomata and previous invasive procedures for treatment of refractory bleeding or pain related to fibroids, including myomectomy (10 women), myoma lysis (three women), and endometrial ablation/fulguration (five women). All women underwent a hysteroscopy-directed endometrial biopsy to exclude endometrial cancer. No patients were known to have bleeding diathesis, chronic pelvic inflammatory disease, diabetes mellitus, vasculitis, previous pelvic irradiation, or other conditions that might predispose to hemorrhagic, ischemic, or infectious complications of embolization.

• Informed Consent

Each patient had the potential risks and benefits of uterine artery embolization explained to her by both gynecologist and interventional radiologist, and all questions were answered. The cited potential complications included, but were not limited to, groin hematoma or infection, contrast material–related renal failure, uterine or pelvic infection, tissue infarction, and cardiopulmonary sequelae of general anesthesia; possible consequences included hysterectomy and death. The availability of other treatment modalities (including myomectomy and hysterectomy) was emphasized, and perimenopausal women were made aware that hormonal changes during menopause might result in tumor regression even without therapy. Each patient was informed that detrimental effects of embolization on fertility had not been previously demonstrated but were nevertheless possible, and every patient was again questioned as to her desire for future pregnancy; each woman replied in the negative. Oral and written informed consent were obtained.

• Embolization Procedure

By means of a femoral arterial approach, pelvic arteriography was performed on a digital angiographic unit (Advantx; GE Medical Systems, Milwaukee, WI). A 5-F, Levin-1 catheter (Cook, Bloomington, IN) (nine patients) or a 4-F, C1 Glidecath (Medi-tech/Boston Scientific, Watertown, MA) (two patients) was used to catheterize the anterior division of the contralateral internal iliac artery. In patients with large uterine arteries, the same catheter was used to subselect and embolize the uterine artery (four patients). More often, a Tracker 18 microcatheter/Seeker wire combination (Target, Fremont, CA) was employed in a coaxial fashion to catheterize and embolize the uterine artery (seven patients). Subselective catheterization was facilitated by the use of digital roadmapping.

Table 1
Characteristics of Patients Undergoing Uterine Artery Embolization

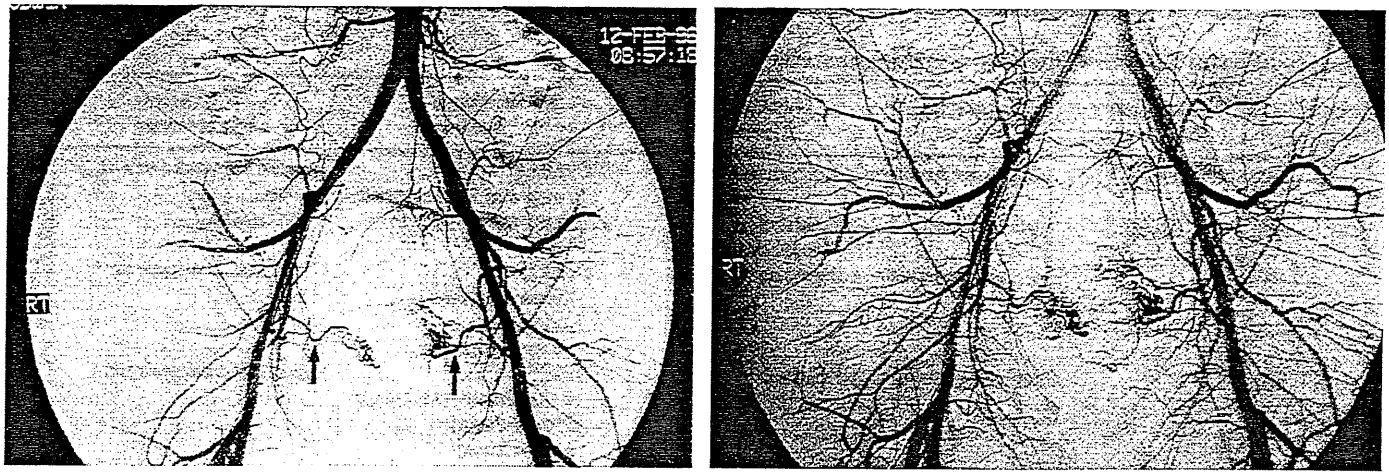
Patient No.	Age (y)	Previous Pregnancy	Menstrual Status	Gynecologic History	Previous Procedures	Current Symptoms
1	55	$G_4P_4Ab_0$	Postmenopausal	L ovarian cyst	TCMR L ovarian cystectomy	Bleeding* and pelvic pain
2	47	$G_1P_1Ab_0$	Perimenopausal	Adhesions Hydrosalpinx	Laparoscopic myoma lysis	Pelvic pain
3	45	G_0	Premenopausal	Adhesions	TCMR Adhesion lysis Abdominal myomectomy	Bleeding and pelvic pain
4	38	G_0	Premenopausal	Adhesions R ovarian cyst	TCMR R ovarian cystectomy Endometrial fulguration Adhesion lysis	Bleeding and pelvic pain
5	53	$G_2P_2Ab_0$	Perimenopausal	None	Abdominal myomectomy	Bleeding and pelvic pain
6	55	$G_7P_2mAb_5$	Postmenopausal	None	Abdominal myomectomy Endometrial fulguration	Bleeding and pelvic pain*
7	27	G_0	Premenopausal	Asherman's syndrome	TCMR Abdominal myomectomy L salp-oophorectomy	Pelvic pain
8	49	$G_3P_0Ab_3$ (mAb_2,tAb_1)	Perimenopausal	None	TCMR Endometrial fulguration Laparoscopic myoma lysis	Bleeding and pelvic pain*
9	41	$G_3P_1mAb_2$	Premenopausal	Adhesions L ovarian cyst	TCMR Adhesion lysis L ovarian cystectomy	Bleeding
10	44	$G_2P_0mAb_2$	Premenopausal	Adhesions	TCMR Abdominal myomectomy Bilateral tubal ligation Myoma lysis Endometrial fulguration Adhesion lysis	Bleeding with anemia
11	32	G_0	Premenopausal	Adhesions Endometriosis	Multiple myomectomy Multiple TCMR Adhesion lysis Endometrial fulguration	Bleeding and pelvic pain*

* Dominant symptom.
TCMR = transcervical myoma resection; mAb = miscarriage; tAb = therapeutic abortion.

Waltman loop technique (6) was usually used to enter the ipsilateral uterine artery, with subselective catheterization and embolization similarly performed. Polyvinyl alcohol (PVA) particles (500–700 μm) (Cook) were utilized for embolization in all patients except one (300–500 μm PVA); an average of 500 mg was used for bilateral embolization. The length of the entire procedure was 45–90 minutes, with an average of 75 minutes. An average of 100 mL (range, 50–150 mL) Omnipaque 300 contrast material (Winthrop Pharmaceuticals, New York, NY) was used. Although nine patients did receive prophylactic antibiotics (a single dose of a second-generation cephalosporin) prior to embolization, a strict protocol was not followed in this regard.

• Sedation and Analgesia

General anesthesia was administered to all women except one, who



a. b.

Figure 1. (a) Early arterial phase anteroposterior digital subtraction pelvic angiogram in a woman with uterine myomata shows filling of both uterine arteries (arrows) and hypervascularity in the uterine bed. (b) Anteroposterior projection in late arterial phase better demonstrates abnormal vascularity in both uterine artery territories.

received conscious sedation with midazolam and fentanyl. Immediately prior to embolization, five women had 100 mg of lidocaine injected directly into each uterine artery for periprocedural analgesia. All women received a 60-mg intravenous (nine patients) or intramuscular (two patients) dose of ketorolac tromethamine in the Post-Anesthesia Care Unit, and were monitored for 6 hours after the procedure in our Outpatient Observation Unit. Oral (codeine, oxycodone) and intravenous (morphine, hydromorphone) analgesics were given as needed to ensure patient comfort during this period. The total amount of postprocedure analgesia required and the duration of stay in the hospital were recorded. All patients were given a prescription of an oral analgesic on discharge from the Outpatient Observation Unit.

• Clinical Follow-up

Patients did not receive hormonal therapy during the study. All patients underwent follow-up gynecologic examination 2 weeks after embolization and at regular intervals (3–6 weeks) thereafter. In October 1996, each patient completed a written questionnaire, in which she was asked to grade her subjective symptomatic changes in bleeding and pelvic pain from the following choices: completely resolved, much or significantly improved, slightly improved, unchanged, slightly worse, or much worse. Each patient was also asked to comment on the tolerability of the procedure, whether her symptoms were still of such magnitude to warrant invasive therapy, and whether she would choose to undergo repeated embolization if her symptoms persisted or recurred.

• US Follow-up

Nine patients underwent transabdominal and endovaginal pelvic US prior to embolization and at 2 months after embolization. Longitudinal, anteroposterior, and transverse measurements of the uterus and dominant fibroids were obtained. Approximate uterine volume and volume of dominant fibroids were calculated with use of the formula for a prolate ellipsoid, as previously used in the literature (7). Percent volume reduction was calculated for each patient, and statistical comparison of pre-embolization and postembolization uterine volumes was accomplished (paired *t* test).

RESULTS

• Angiographic Findings

Pelvic arteriography demonstrated bilateral hypervascular uterine masses in six patients, unilateral hypervascular masses in two patients, and diffuse uterine hypervascularity without definable mass in three patients **(Fig 1).** Arterial-arterial anastomoses connecting the right and left uterine circulations were often present within the hypervascular masses **(Fig 2).** No arteriovenous fistulas or contrast material extravasation was seen. One patient early in our experience had a hypervascular mass in the right uterine body with no abnormality of the left side of the uterus. Because the left uterine artery was small and did not appear to supply any tumor, we elected to perform only unilateral embolization in this patient.

• Clinical Results

All 11 patients (100%) underwent technically successful uterine artery embolization **(Fig 3),** 10 bilateral and one unilateral **(Table 2).** No immediate complications were encountered, but one delayed complication resulting in hysterectomy did occur.

Of the 10 patients having uncomplicated procedures, nine completed follow-up questionnaire after 2–9 months (mean follow-up, 5.8 months), and one patient was lost to follow-up. Eight patients reported their dominant symptom (bleeding or pain) to be noticeably improved after embolization. This included one woman with "slight improvement," four with "significant improvement," and three with complete resolution of symptoms. One patient (the only woman who underwent unilateral embolization) demonstrated no response to therapy. When analyzed by symptom type, six of seven women with vaginal bleeding improved after embolization (two slightly, three significantly, and one with complete resolution). Eight of nine women with pelvic pain improved (one slightly, four significantly, and three with complete resolution).

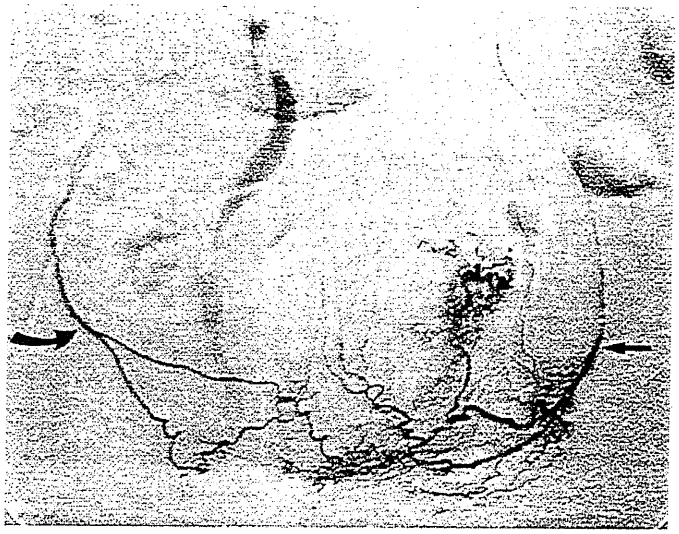


Figure 2. Anteroposterior digital subtraction angiogram obtained through a catheter in left uterine artery (straight arrow) clearly demonstrates cross filling of the right uterine artery (curved arrow) through arterial-arterial anastomoses within the fibroid uterus. Such pathways undoubtedly contribute to rapid collateral tumor revascularization in cases of unilateral or incomplete embolization.

• Complications

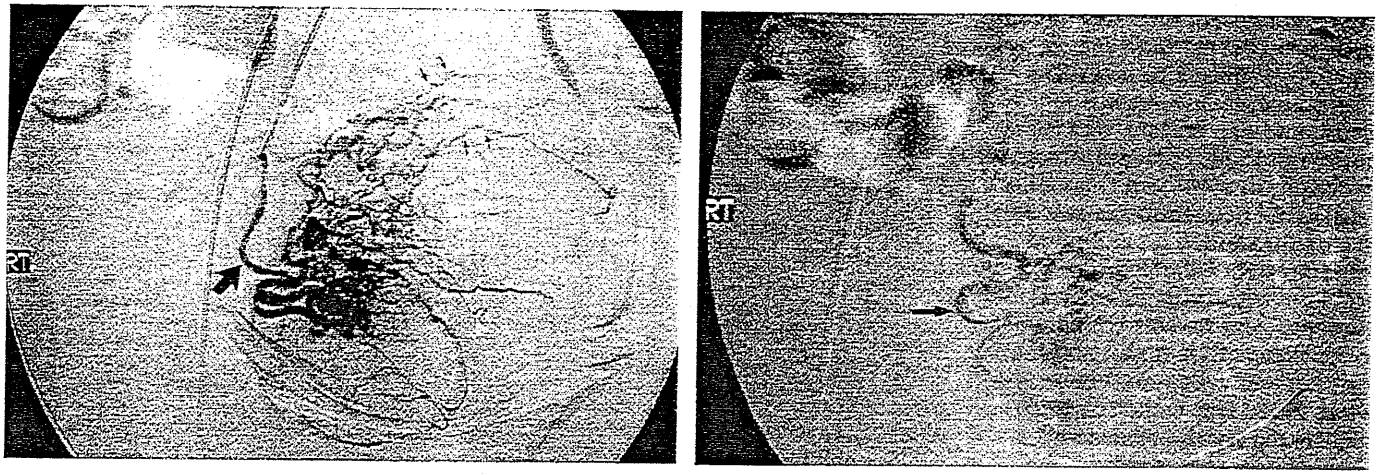
Patient 10 underwent uneventful bilateral embolization with 500–700-μm PVA particles, with a subsequent decrease in vaginal bleeding. Despite administration of preprocedural prophylactic antibiotics, she experienced increasing pelvic pain, fevers to 104°F, and leukocytosis of 22,000/mm^3 at 3 weeks after embolization. She was admitted to the hospital and intravenous antibiotics were instituted; pelvic pain improved significantly during the course of several days, but low-grade fever persisted. The patient insisted to be discharged as her pain improved, but returned 3 days later with recurrent high fevers and increasing pain despite oral antibiotics. Computed tomography (CT) demonstrated a large, fluid-containing left uterine mass within a diffusely enlarged uterus distended with fluid. Hysterectomy was performed; the presence of fibroid tumor shrinkage and necrosis, endometritis with endometrial necrosis, and pyometra was confirmed operatively and pathologically. Bilateral chronic salpingitis was an additional histologic finding. The patient was well at last follow-up.

• US Follow-up

Pre-embolization pelvic US in 11 patients demonstrated uterine enlargement in all women, with average dimensions of 10.5 cm (length) × 6.8 cm (anteroposterior) × 8.1 cm (transverse). Diffuse heterogeneity suggestive of myomatous change was noted in nine of 11 women, with discrete tumor masses identifiable in all patients. The visible masses were multiple in all but one woman, and were located submucosally (four women), intramurally (10 women), and subserosally (four women). The mean dominant fibroid diameter was 48 mm (range, 17–90 mm).

Nine patients underwent follow-up US 2 months after embolization. In one patient (patient 5), follow-up sonography was performed at a different institution and uterine size was not recorded. Uterine dimensions were significantly reduced after embolization in all eight of the remaining patients compared with previous measurements; in these patients, average uterine dimensions were 8.7 cm × 4.6 cm × 5.9 cm (calculated volume, 127.3 cm^3 ± 48.1) after embolization, compared with 9.8 cm × 5.8 cm × 7.3 cm (calculated volume, 224.1 cm^3 ± 99.3) before embolization ($P < .01$). The average reduction in uterine volume was 40% (range, 22%–61%). The size of dominant fibroids was reduced in eight of nine patients; of these, three patients' dominant fibroids were no longer visible at US and the other five patients demonstrated an average fibroid volume reduction of 58% (range, 29%–87%). One patient's dominant fibroids demonstrated no interval change. When sonographic disappearance of the dominant fibroid was counted as reduction to a size of 1 cm × 1 cm × 1 cm (an underestimate) or as 100% volume reduction (an overestimate), the calculated average fibroid volume reduction for the nine patients was 59% or 66%, respectively.

The patient whose dominant fibroids demonstrated no sonographic change did have a large uterine volume reduction and experienced an excellent clinical response. Findings in the single patient not demonstrating a favorable clinical response to embolization included a 34% uterine volume



a. b.

Figure 3. (a) Digital subtraction right uterine arteriogram demonstrates angiographic findings characteristic of uterine leiomyomata: enlarged uterine artery (large arrow), corkscrew- configuration arterial branches (small arrows), hypervascularity, and mass effect upon vessels. (b) Postembolization arteriogram shows occlusion of the right uterine artery (arrow) and absence of demonstrable vascularity in the tumor bed.

reduction and sonographic disappearance of fibroids.

- **Tolerability**

No complications of general anesthesia or conscious sedation occurred. In the immediate postprocedure period, seven of 10 patients experienced crampy pelvic pain, which was mild in four women, of moderate intensity in one woman, and severe in two women. Four of five women who received intra-arterial lidocaine for local uterine bed anesthesia experienced postprocedure pain, and this group included all three women with moderate or severe pain. This practice was therefore discontinued. Overall, two patients required oral analgesics and two patients received a single intravenous dose of hydromorphone or morphine in the Outpatient Observation Unit. No patient had pain that was severe or persistent enough to warrant a PCA pump, and all patients were discharged home on the day of the embolization procedure.

No postprocedure fevers were reported, except for the one woman who developed endometritis. In addition to this woman, two patients experienced pelvic cramping 1–2 weeks after the procedure, which was moderate in one patient and severe in one patient (the woman who had received 300–500 μm PVA particles). Oral analgesia was provided to these women, and symptoms resolved without recurrence. Of the eight patients with favorable outcome, seven reported satisfaction with the procedure and stated that they would choose to undergo repeated embolization if symptoms recurred and they were again given the choices of embolization, myomectomy, and hysterectomy.

DISCUSSION

In recent years, transcatheter embolization of the uterine arteries has proven effective in treating bleeding related to diverse obstetric and gynecologic conditions. We and others have advocated its use as first-line therapy for patients with postpartum and postoperative bleeding refractory to local measures (8–10). Uterine artery embolization has been successfully utilized in the treatment of hypervascular pelvic masses of various type, including abdominal pregnancy (11), cervical pregnancy (12), and arteriovenous malformations (13). Cervical cancer–related bleeding has historically presented special problems for surgeons because of poor overall patient condition, radiation-related tissue friability with altered healing, and anatomic distortion caused by previous surgical scarring, radiation fibrosis, and the presence of tumor. Pelvic embolization has nevertheless been successful in treating acute and chronic tumor bleeding in most patients reported in the literature to date (14,15).

Women with uterine fibroids are usually otherwise healthy, have never received pelvic irradiation, and are anatomically intact. While most arteriovenous malformations and cervical neoplasms demonstrate complex vascularity with multiple feeding vessels (including many with inferior mesenteric arterial supply) (16), the blood supply to uterine leiomyomata is almost exclusively derived from the uterine arteries (17). The amenability of uterine leiomyomata to embolotherapy should therefore be even greater than that of cervical cancer, with a lower risk of complications. Doppler US studies have demonstrated vascular regression in the leiomyomata of women showing improvement after treatment with hormonal agents, providing support for the concept of uterine devascularization in treating these lesions (18). The rationale for the use of embolization in this clinical setting

Table 2
Results of Uterine Artery Embolization

Patient No.	No. of Fibroids	Location	Dominant Fibroid Size (mm)	Uterine Artery Embolized	PVA Particle Size (μm)
1	Multiple	Submucosal Intramural	17	Right only	500–700
2	Multiple	Intramural Subserosal	36	Bilateral	500–700
3	Multiple	Intramural	37	Bilateral	300–500
4	Multiple	Intramural	19	Bilateral	500–700
5	Multiple	Intramural	90	Bilateral	500–700
6	Multiple	Intramural	43	Bilateral	500–700
7	Multiple	Intramural	70	Bilateral	500–700
8	Single	Submucosal	42	Bilateral	500–700
9	Multiple	Intramural Subserosal	79	Bilateral	500–700
10	Multiple	Submucosal Intramural Subserosal	74	Bilateral	500–700
11	Multiple	Submucosal Intramural Subserosal	25	Bilateral	500–700
Average			48 mm		

Patient No.	Duration of Follow-up (mo)	Result Bleeding	Result Pain	Uterine Volume Reduction (%)	Dominant Fibroid Reduction (%)
1	8.8	No change	No change	34	No longer visible
2	8.8		Resolved	33	61
3	7.0	Much improved	Much improved	40	87
4	6.4	Much improved	Much improved	22	No longer visible
5	6.3	Much improved	Much improved	Not measured	49
6	5.1	Slightly improved	Much improved	23	29
7	4.2		Resolved	61	63
8	2.7	Resolved	Resolved	61	0
9	Lost to follow-up				
10	Endometritis and hysterectomy after 3 weeks				
11	2.6	Slightly improved	Slightly improved	43	No longer visible
Average	5.8 months			40%	60%–65%

stems also from the unique advantages of this percutaneous approach, including potential fertility preservation, avoidance of surgical risks, shorter hospitalizations, and the ability to treat all myomata in the uterus in a single session.

The initial evidence in support of these ideas has been provided by the work of Ravina et al, who recently utilized percutaneous embolization as a preoperative adjunct to myomectomy; in this multicenter French study of 31 patients, embolization resulted in significantly decreased operative blood loss (3). In the course of this study, many women demonstrated significant symptomatic improvement after embolization alone, such that the referring gynecologists were postponing or cancelling the planned myomectomies. In a subsequent report (4), the same authors described the use of therapeutic embolization as an alternative to myomectomy for fibroid-related menorrhagia or pain in 16 women in whom hormonal therapy failed; 88% demonstrated significant symptomatic improvement and at least 70% had reductions in tumor volume.

In reconciling the results of the current study with those of the French investigators, it is important to characterize our patient population and consider the differences between the respective studies in this regard. In selecting women to include in our pilot study, we chose to be quite conservative because of the availability of other treatment modalities and the finite risk of complications. Women with preexisting medical problems were excluded, even though we believe embolization may ultimately prove more advantageous than surgery in

such patients. Despite the existence of studies (19) reporting resumption of normal menses and multiple full-term pregnancies after pelvic embolization, we decided to exclude women who desired future pregnancy potential; all women were counselled that detrimental effects on future fertility were unlikely but possible. Most importantly, in our study, embolization was offered as a last-resort treatment only to women in whom both hormonal and surgical modes of therapy had failed. In contrast, embolization was used as a primary alternative to myomectomy in the French study; while all women underwent unsuccessful hormonal therapy, only three had undergone previous myomectomy (4). Because of our inclusion criteria, the patients enrolled in our study may have had more refractory uterine pathology than most women with myomata, including the patients reported by Ravina et al.

The results of our study are nevertheless extremely encouraging, and are generally concordant with the findings of Ravina et al. Every woman undergoing bilateral embolization experienced a noticeable decrease in vaginal bleeding, with overall results similar to the 86% reported by Ravina. In addition, bilateral embolotherapy proved effective in reducing fibroid-related pelvic pain, suggesting that the indications for this procedure may be reasonably extended to include women with intractable pain. Excellent results were achieved in women with single and multiple masses, regardless of size. The sonographically observed large reductions in uterine size (40%) and fibroid tumor volume (60%–65%) were of similar magnitude to those reported in Ravina's series. A reliable correlation between US and clinical results could not be established in our small study because sonographic changes in uterine and fibroid volume did not predict the woman with failure of embolization. The reason for this discordance is unclear, and this finding is at variance with the results of the French series, in which the two women with clinical failure demonstrated no volume reduction. Potential explanations would include the possibility that this woman's bleeding was unrelated to leiomyomata, or that she underreported the degree of response for some other reason. Alternately, the degree of shrinkage may simply have been insufficient to produce a clinical response in this patient, and might possibly have been improved had bilateral embolization been performed. It should, however, be noted that in our series, the three patients having the best clinical results did manifest very large reductions in either uterine size or fibroid tumor volume. Therefore, such a correlation probably exists to a certain degree and will likely require the accrual of larger patient numbers to prove statistically.

Because the goal of uterine fibroid tumor embolization is more analogous to that of cancer-related bleeding as opposed to benign pelvic hemorrhage, we chose to use PVA particles of intermediate size. While Ravina et al (4) appear to have reliably achieved durable clinical responses with use of PVA particles ranging from 150–600 μm, we were able to obtain a similar frequency of clinical responses with comparable volume reductions while confining ourselves to 500–700-μm particles in this preliminary study. However, most patients (69%) in the Ravina series appear to have had complete symptom resolution, an outcome experienced by only 30% of women in our series; we believe this difference in our respective response quality may be explained by the discrepancy in PVA particle size. Likewise, the higher incidence, duration, and severity of postembolization pelvic pain in the French series may be accounted for by their use of the smaller particles. We did use 300–500-μm PVA particles in one woman, but she had severe pelvic pain immediately after the procedure and at 1 week after the procedure. Regarding response durability, we are currently unable to institute a valid comparison because of our relatively short interval follow-up, although we can say that our two responding patients with 7–8-month follow-up have maintained their clinical and sonographic improvements. Because one woman developed endometritis, we are somewhat wary about proceeding to a smaller particle size, especially because we did achieve a favorable therapeutic effect in every patient undergoing bilateral embolization with use of 500-700-μm particles. Therefore, while we do believe that qualitatively better responses may be achieved with use of smaller PVA particles, we plan to assess the durability of our clinical responses and the frequency of ischemia-related complications in more patients before considering a change in particle size.

No identifiable predisposing clinical factors could be identified in the one woman (patient 1) who reported no symptomatic change at the 2-month questionnaire; as noted above, we are inclined to attribute this treatment failure to the fact that this woman underwent unilateral uterine artery embolization. The decision to embolize only the right uterine artery was based on the location of the dominant fibroid tumor along the right lateral portion of the uterine body and the small size of the left uterine artery, which did not supply the tumor on the initial angiogram. Failure to perform bilateral embolization has been previously implicated in the literature as a cause of failure of pelvic embolotherapy for postpartum and postoperative bleeding (10). Uterine leiomyomata have been angiographically **(Fig 2)** and pathologically (17) shown to contain arterial anastomoses between right and left uterine arteries, and the French group has also noted treatment failures due to incomplete fibroid embolization (Ravina, personal communication). For these reasons, we do not recommend unilateral embolization.

Postembolization endometrial ischemia or infarction was likely a major factor contributing to the development of acute endometritis in one patient (patient 10), which occurred despite careful clinical screening, administration of prophy-

lactic antibiotics, and the use of 500–700-μm PVA particles. Retrospectively, no definite predisposing clinical factors could be identified, although the presence of anemia in this patient could conceivably have diminished the effectiveness of oxygen exchange in the embolized tissue bed. The presence of chronic salpingitis within the pathologic specimen was an unanticipated finding, and if associated with chronic endometritis could certainly have rendered the patient vulnerable to the development of acute endometritis. The previously obtained negative endometrial biopsy finding tends to mitigate against the presence of occult chronic endometritis in this woman, although she did happen to be the only patient who had received her previous clinical care at another institution. This biopsy specimen was obtained several months prior to embolization, so development of indolent endometrial infection in the interval months would be one possible explanation. Unfortunately, the extensive endometrial necrosis in the postembolization hysterectomy specimen precluded evaluation for chronic changes. The occurrence of this complication underscores the need for careful preprocedural evaluation in selecting candidates for this form of therapy.

Because the published experience with pelvic embolization has not been clear regarding the need to take this precaution, we did not implement a constant protocol for antibiotic prophylaxis (although most patients did receive a preembolization dose of intravenous antibiotics). Because we did observe one case of postembolization endometritis, we are currently providing intravenous antibiotics to all patients undergoing uterine artery embolization. Because postprocedure fever was only seen in the woman who developed endometritis, careful clinical examination is probably warranted in any patient with delayed fevers or pelvic pain, with consideration given to cross-sectional imaging of the pelvis and institution of antibiotic therapy. Depending on the results of imaging and the patient's clinical status, it may be possible to avoid surgical treatment of infectious complications, as CT-guided percutaneous abscess drainage has been reported successful (20).

Because most patients in Ravina's series (4) experienced severe pelvic pain in the postembolization period despite neuroleptic analgesia, we performed most procedures with general anesthesia, and administered intra-arterial lidocaine prior to embolization in our first five patients. Because the patients receiving lidocaine were actually experiencing more intense postprocedure pain, we soon abandoned this practice. The patient receiving conscious sedation tolerated the embolization procedure quite well, and we are therefore currently using conscious sedation during these procedures, capitalizing on one method by which percutaneous therapy can reduce patient risk; we have experienced no difficulty with intraprocedural pain control. The clinical staff were made aware of the probable need for pain control in the postprocedural period, and most patients in our series had pain easily controlled with ketorolac and oral analgesics, with only two patients requiring a single dose of narcotic analgesia. No patients needed a PCA pump for pain control; this difference from Ravina's experience may well be the result of the differences in PVA particle size alluded to earlier. Despite the incidence of postembolization pain, the level of patient satisfaction was high, and most women stated that they would prefer to undergo repeated embolization if symptoms recurred. Avoidance of overnight hospitalization was a significant contributor to patient satisfaction and represents a major advantage of embolotherapy over surgery.

Technically, the embolization procedure evolved somewhat over the course of this study. We did not find it necessary to utilize a vascular sheath in any patient, and all procedures were done with use of 4–5-F catheters. We were able to embolize many uterine arteries with use of the 5-F, Levin-1 catheter; however, more than half of the uterine arteries we embolized demonstrated flow-limiting arterial spasm with entry of the 5-F catheter, necessitating administration of 100–300 μg of intra-arterial nitroglycerin. We therefore used a 4-F Glidecath in some patients, resulting in easier catheter positioning and less vasospasm; however, kinking of this catheter occurred readily, rendering the ipsilateral catheterization problematic due to difficulty in forming a Waltman loop. Currently, we place the 5-F, Levin-1 catheter within the uterine artery orifice, enabling us to pass a Tracker microcatheter/Seeker wire combination distally in the uterine artery. Once subselective catheterization is achieved in this manner, the 5-F catheter is pulled back into the internal iliac artery to prevent vasospasm and ensure adequate antegrade flow during embolization. We find the use of digital roadmapping invaluable in expediently selecting the uterine artery from the myriad internal iliac branches, and its use has allowed us to maintain total procedure times at 45–90 minutes. It should be stressed that careful attention to catheter location and meticulous handling of embolic materials are essential to safe embolization because introduction of PVA particles into the wrong internal iliac artery branches can result in ischemia to pelvic organs, including the bladder and rectum. This procedure should therefore be performed only by trained interventional radiologists using modern digital angiographic equipment.

CONCLUSION

Uterine artery embolization represents a promising new method of treating refractory symptoms related to uterine leiomyomata. Patients undergoing bilateral embolization can expect excellent short-term results with respect to both menorrhagia and pelvic pain, with concomitant reductions in uterine size and fibroid tumor volume. The procedure is generally well toler-

ated by patients, and possesses the advantages of shorter hospitalizations, potential fertility preservation, and the ability to treat all uterine myomata in a single session. The optimal angiographic protocol has yet to be defined, particularly with reference to the relationship of PVA particle size to the quality and durability of clinical responses, and to the frequency of ischemic complications. Further investigation will also enable valid comparison between embolization and other treatment modalities, with probable identification of more subsets of patients likely to benefit from this approach.

References

1. Wallach EE. Myomectomy. In: Thompson JD, Rock JA, eds. Te Linde's Operative Gynecology, 7th ed. Philadelphia: J.B. Lippincott, 1992; pp 647–662.
2. Hutchins FL. Abdominal myomectomy as a treatment for symptomatic uterine fibroids. Obstet Gynecol Clin North Am 1995; 22:781–789.
3. Ravina JH, Bouret JM, Fried D, et al. Value of preoperative embolization of uterine fibroma: report of a multicenter series of 31 cases. Contraception, Fertilitie, Sexualite 1995; 23:45–49.
4. Ravina JH, Herbreteau D, Ciraru-Vigneron, et al. Arterial embolization to treat uterine myomata. Lancet 1995; 346:671–672.
5. McLucas B, Goodwin SC, Vedantham S. Embolic therapy for myomata. Min Invas Ther Allied Technol 1996; 5:336–338.
6. Waltman AC, Courey WR, Athanasoulis CA, et al. Technique for left gastric artery catheterization. Radiology 1973; 109:732–734.
7. Orsini LF, Salardi S, Pilu G, Bovicelli L, Cacciari E. Pelvic organs in premenarcheal girls: real-time ultrasonography. Radiology 1984; 153:113–116.
8. Vedantham S, Goodwin SC, McLucas B, Mohr G. Uterine artery embolization: an underutilized method of controlling pelvic hemorrhage. Am J Obstet Gynecol 1997, in press.
9. Greenwood CH, Glickman MG, Schwartz PE, Morse SS, Denny DF. Obstetric and nonmalignant gynecologic bleeding: treatment with angiographic embolization. Radiology 1987; 164:155–159.
10. Rosenthal DM, Colapinto R. Angiographic arterial embolization in the management of postoperative vaginal hemorrhage. Am J Obstet Gynecol 1985; 151:227–231.
11. Pais SO, Glickman M, Schwartz PE, Pingoud E, Berkowitz R. Embolization of pelvic arteries for control of postpartum hemorrhage. Obstet Gynecol 1980; 55:754–758.
12. Frates MC, Benson CB, Doubilet PM, et al. Cervical ectopic pregnancy: results of conservative treatment. Radiology 1994; 191:773–775.
13. Vogelzang RL, Nemeck AA, Skrtic Z, Gorrell J, Lurain JR. Uterine arteriovenous malformations: primary treatment with therapeutic embolization. JVIR 1991; 2:517–522.
14. Higgins CB, Bookstein JJ, Davis GB, Galloway DC, Barr JW. Therapeutic embolization for intractable chronic bleeding. Radiology 1977; 122:473–478.
15. Yamashita Y, Harada M, Yamamoto H, et al. Transcatheter arterial embolization of obstetric and gynecological bleeding: efficacy and clinical outcome. Br J Radiol 67: 530–534.
16. Vujic I, Stanley JH, Gobien RP, Bruce RJ, Lutz MH. Embolic management of rare hemorrhagic gynecologic and obstetrical conditions. Cardiovasc Intervent Radiol 1986; 9:69–74.
17. Sampson JA. The blood supply of uterine myomata. Surg Gynecol Obstet 1912; XIV:215–234.
18. Matta WHM, Stabile I, Shaw RW, Campbell S. Doppler assessment of uterine blood flow changes in patients with fibroids receiving the gonadotropin-releasing hormone agonist Buserelin. Fert Steril 1988; 49:1083–1085.
19. Stancato-Pasik A, Mitty HA, Richard HM III, Eshkar NS. Obstetric embolotherapy: effect on menses and pregnancy. Radiology 1996; 201(P):179.
20. Martin JN, Ridgway LE, Connors JJ, Sessums JK, Markin RW, Morrison JC. Angiographic arterial embolization and computed tomography-directed drainage for the management of hemorrhage and infection with abdominal pregnancy. Obstet Gynecol 1990; 76:941–945.