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# Uterine artery embolization for fibroids: Procedure, results, and complications

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Uterine fibroid embolization (UAE) is a promising new application of a technique generally well known to trained interventional radiologists. Uterine fibroids may be the most common tumor found anywhere in the body. Many uterine fibroids are symptomatic, leading most commonly to abnormal uterine bleeding, a sensation of pelvic pressure, and the effects of compression of adjacent organs by an enlarged uterus. Selective UAE devascularizes uterine fibroids, leading to shrinkage of the fibroids and, more importantly, significant amelioration of symptoms. Early results of this minimally invasive therapy have been impressive, with resolution or significant reduction of symptoms achieved generally in the range of 90% to 95% out as long as 2 years. The low rate of serious complications has also been impressive to this point. Due to strong media and public interest driven by the desire of many otherwise healthy, relatively young women to avoid

major surgery, there are new studies dealing with results, technical considerations, and complications of uterine fibroid embolization appearing monthly. The purpose of this paper is to provide interventional radiologists with a review of the body of literature regarding this exciting new application of embolotherapy.

**U**terine leiomyomata are the most common benign tumors of the female genital tract and may be the most common benign tumors found anywhere in the body.<sup>1</sup> Leiomyomata are the result of clonal expansion of individual smooth muscle cells of the myometrium. The histology of the leiomyoma is almost indistinguishable from the normal myometrium.<sup>1</sup> Epidemiologic evidence strongly suggests a relationship between growth and regression of leiomyomata based on the patient's hormonal milieu.<sup>2</sup> A particular area of interest is the relationship between leiomyomata and estrogen/estrogen receptors.<sup>3</sup> Although there are forms of leiomyomata that metastasize, these are rare and still considered benign.<sup>3</sup> Rarely, a leiomyoma may

undergo malignant degeneration. The overall frequency of malignant degeneration is 0.7%, a number that would not in itself justify hysterectomy for all leiomyomata.<sup>4</sup> The main detrimental effects of leiomyomata stem not from malignant degeneration, but rather from disruption of the endometrium causing bleeding or symptoms from local pressure effects.

Most leiomyomata are asymptomatic.<sup>4</sup> When myomas manifest symptoms, the symptoms include excessive uterine bleeding with or without anemia, dysmenorrhea, pelvic pain, pressure effects on adjacent organs, infertility, loss of otherwise viable pregnancies, and increasing abdominal girth.<sup>1</sup> In particular, submucosal fibroids lead to degeneration of the mucosal surface, which results in abnormal uterine bleeding. The endometrial glands covering the myoma grow in parallel to the surface of the myoma rather than perpendicular to the surface, as in the normal uterus. This leads to a denuded surface that must be re-epithelialized from the periphery rather than from remaining glandular tissue, which at least partially accounts for the prolonged menstrual flow. Increased uterine cavity surface area due to fibroids

may be another cause of menorrhagia.<sup>4</sup> Intermenstrual flow can also result from uterine fibroids.<sup>3</sup> Pelvic pain may also result, although this is less common. Patients may experience pelvic pressure, which is similar to that experienced by women during pregnancy due to enlargement of the uterus.<sup>5</sup> The uterine musculature can contract in an attempt to expel the myoma, leading to further peduculation of the tumor.<sup>3</sup> These contractions of the uterus cause repeated episodes of pelvic cramping.<sup>3</sup> Mass effect on adjacent structures may result in difficulties with urination or defecation, dyspareunia, and low-back pain.<sup>5</sup>

In the United States, 33% of all hysterectomies are the direct result of symptoms from uterine fibroids.<sup>2</sup> This translates into approximately 200,000 hysterectomies per year, in addition to the 20,000 myomectomies performed for uterine fibroids annually.<sup>1</sup> The overall cost of hysterectomies in the United States is approximately \$2 billion.<sup>6</sup> Uterine artery embolization (UAE) is a promising new technique as a minimally invasive therapy to treat the widespread problem of symptomatic uterine fibroids. Over the last few years, information and interest regarding embolization as a treatment for uterine fibroids has exploded, fueled by promising initial results, strong media interest, and the desire of otherwise healthy, relatively young women to avoid undergoing a major surgical procedure. Due to the recent application of this technique to this indication and the strong aforementioned interest, new information regarding UAE is appearing monthly. The purpose of this article is to review the latest information regarding procedural techniques, results, and complications of uterine fibroid embolization. In addition, uterine fibroid embolization will be compared in several key areas with hysterectomy and myomectomy in an attempt to develop a basic understanding of the positive and negative aspects of each procedure.

## Uterine artery embolization technique

### Pre-procedure evaluation

The most common complaints for patients presenting with uterine fibroid embolization are abnormal uterine bleeding, the sensation of pelvic pressure, and pressure-related effects.<sup>5,7-9</sup> Unfortunately, none of these symptoms are pathognomonic of uterine fibroids. Therefore, the first step in the work-up of a patient presenting for embolization is to determine that leiomyomata are the source of her problems. In particular, the most common symptom found in patients with symptomatic fibroids, abnormal uterine bleeding, has a large and varied number of etiologies. These etiologies can be broadly categorized into organic (Table 1) and ovulatory dysfunction.<sup>10</sup>

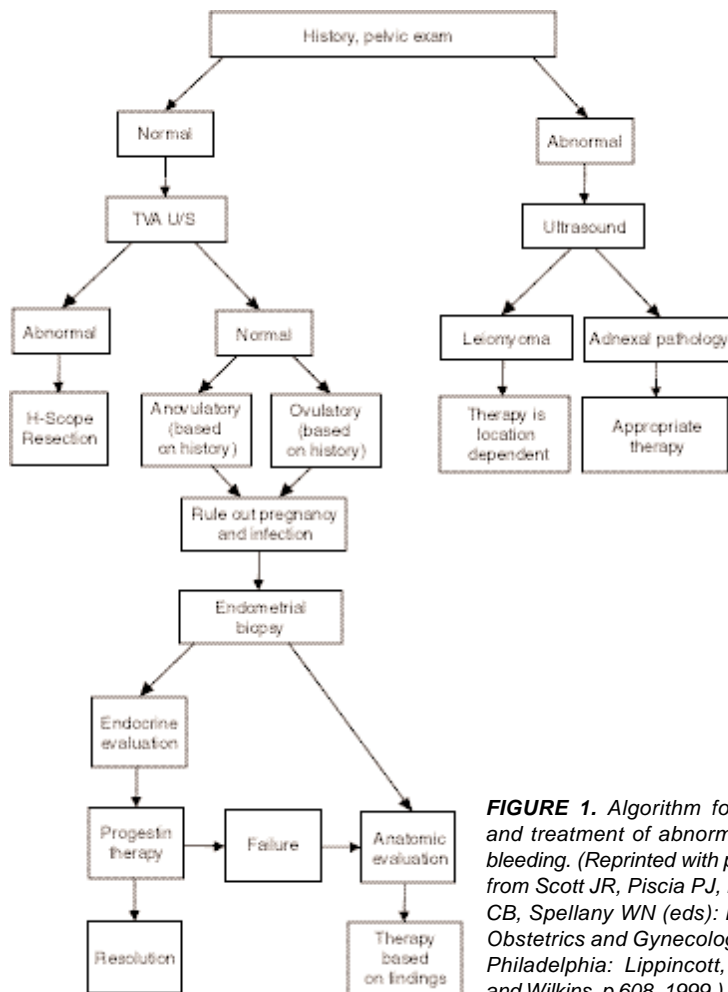
The initial clinical work-up begins with a thorough history and physical examination. The possibility of pregnancy must be excluded, and the results of a peroxidase-antiperoxidase (PAP) smear must be normal. Diagnostic imaging, including ultrasound and/or magnetic resonance imaging (MRI), is a useful adjunct to the physical exam. Ultrasound and MRI can identify uterine leiomyomata as well as other etiologies (such as endometrial hyperplasia, polyps, or endometrial carcinoma), which may present with similar symptoms. Although more expensive, MRI is more sensitive and less operator-dependent. MRI is also useful in the more precise localization of fibroids, particularly in identifying pedunculated fibroids. Other nonfibroid uterine abnormalities, such as adenomyosis, may be discovered. Either one of these findings has the potential to alter treatment strategies. MRI may help determine which patients may have a more complete response to embolization. Patients with hypervascular and submucosal fibroids on MRI have shown a greater reduction in vascularity and

**Table 1. Organic causes of abnormal uterine bleeding**

Pregnancy-related events
Spontaneous miscarriage
Incomplete, threatened, or missed abortion
Ectopic pregnancy
Gestational trophoblastic disease
Genital tract infection
Cervicitis
Vaginitis
Endometritis
Oophoritis
Neoplasm
Cervix
Dysplasia
Carcinoma
Polyps
Endometrium
Hyperplasia
Polyps
Carcinoma
Leiomyomas
Submucous
Intramural
Ovarian
Estrogen-producing tumors
Uterine
Adenomyosis
Systemic
Coagulation disorders
Thyroid disease
Liver disease
Sepsis
Iatrogenic
Oral contraceptives
Progestin-only contraceptives
Intrauterine devices
Hormone replacement therapy
Tamoxifen therapy
Steroids

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size, respectively.<sup>11</sup> Patients with large uteri prior to embolization have had less of a reduction in myoma size post-embolization.<sup>11</sup> However, the exact application of these findings is in doubt as a screening method, as the reduction in volume or vascularity did not correlate with reduction in symp-



**FIGURE 1.** Algorithm for work-up and treatment of abnormal uterine bleeding. (Reprinted with permission from Scott JR, Piscia PJ, Hammond CB, Spellany WN (eds): *Danforth's Obstetrics and Gynecology*. 8th ed. Philadelphia: Lippincott, Williams, and Wilkins. p 608, 1999.)

toms, as many patients even with suboptimal objective responses had relief of symptoms.<sup>11</sup> Additional work-up prior to treatment may include an endometrial biopsy to exclude carcinoma, particularly in women over 40 years old.<sup>9,12</sup> The full clinical/laboratory work-up for fibroid-type symptoms is beyond the scope of this article, but a simple flow chart is provided in figure 1.

Once it is determined that leiomyomata are truly the cause of the patient's symptomatology, certain patients may be excluded on the basis of other criteria. Contraindications to uterine fibroid embolization include pregnancy, acute or chronic pelvic infection, severe contrast allergy that cannot be controlled with premedication, severe renal insufficiency,

arteriovenous malformations, uncontrollable coagulopathy, active vasculitis, prior pelvic irradiation, and patients requiring pelvic surgery for concomitant conditions.<sup>7,12,13</sup>

The issue of pelvic infection as a contraindication has arisen as the result of a case report of fatal septicemia occurring after UAE,<sup>14</sup> where the patient developed a urinary tract infection 3 days after the procedure, was treated with appropriate antibiotics, and was subsequently discharged. The patient returned to the hospital in a state of sepsis and subsequently died. The authors questioned whether the fatal septicemia was the result of a pelvic infection with a concomitant necrosing fibroid in the

vicinity. Goodwin et al<sup>13</sup> describe one patient who needed a hysterectomy on a delayed basis due to acute endometritis. Although the patient did not demonstrate clinical signs of infection, the pathology specimen did demonstrate signs of chronic salpingitis, leading the authors to speculate whether an occult infection was present that predisposed the patient to acute endometritis after embolization.

One author expressed concern about embolizing pedunculated fibroids, as there is a theoretical risk of subsequent torsion with massive necrosis.<sup>7</sup> The subserosal fibroid on a small stalk also has the potential to disengage from the uterus and fall into the peritoneal cavity, necessitating surgery. In patients with a pedunculated subserosal fibroid found in conjunction with submucosal and/or intramural fibroids, a combined approach could include presurgical UAE followed by myomectomy of the pedunculated fibroid. Not only would this treat the entire uterus but it would also decrease intra-operative blood loss. Adenomyosis is considered by some to be a cause of treatment failure to spite an otherwise successful embolization.<sup>11,15</sup> This may be due to a differing vascular supply to the adenomyosis versus uterine fibroids.<sup>15</sup> However, other authors have reported symptomatic relief in patients with adenomyosis.<sup>15,16</sup> Therefore, the possible increased risk of failure in these patients should be communicated prior to embarking on the procedure, but this is not an absolute contraindication.

The issue of patients desiring future fertility remains a controversial subject. The main concerns regarding this subject are ovarian dysfunction after UAE, the promotion of an unfavorable environment for placental growth due to lack of sufficient blood flow, and the risk of uterine rupture.<sup>13</sup> Permanent ovarian failure has been a relatively uncommon event in published studies. When it has occurred, it has been overwhelmingly in perimenopausal women.<sup>13,15-18</sup> This is

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likely the result of an early menopause and occurs in women least inclined to desire pregnancy. No confirmed reports of an increased risk of placental insufficiency among post-embolization pregnancies have been published.<sup>13</sup> There have not been reports of uterine rupture post-embolization either. Degenerating fibroids are common in non-embolized patients as well. To the best of our knowledge, there have not been documented reports of uterine rupture with degenerating fibroids as a cause, which would be analogous to a post-embolization uterus.<sup>13</sup> In addition, although it is an unusual complication, there is clinical concern of uterine rupture in postmyomectomy patients, which has been described in case reports.<sup>5</sup> There have been reports of pregnancy after UAE for both pelvic hemorrhage and fibroids.<sup>15,19</sup> However, not enough data exists at this point to prove or disprove a negative long-term effect on fertility. Although current reports are encouraging, patients should be apprised of the lack of complete data on this subject prior to undergoing UAE.

It is important for patients taking gonadotropin-releasing hormone (GnRH) agonists for fibroid-associated symptoms that the medications are discontinued for at least 8 to 12 weeks prior to UAE, since they may lead to uterine artery constriction.<sup>20</sup> Embolization can be difficult and unsafe in a patient with constricted uterine arteries. The most commonly used GnRH analog for treatment of uterine fibroids is Lupron (TAP pharmaceuticals, Deerfield, IL). Other GnRH analogs include Syneral (G.D. Searle and Co., Chicago, IL) and Zoladex (Zeneca Pharmaceuticals, Wilmington, DE).

### Procedure

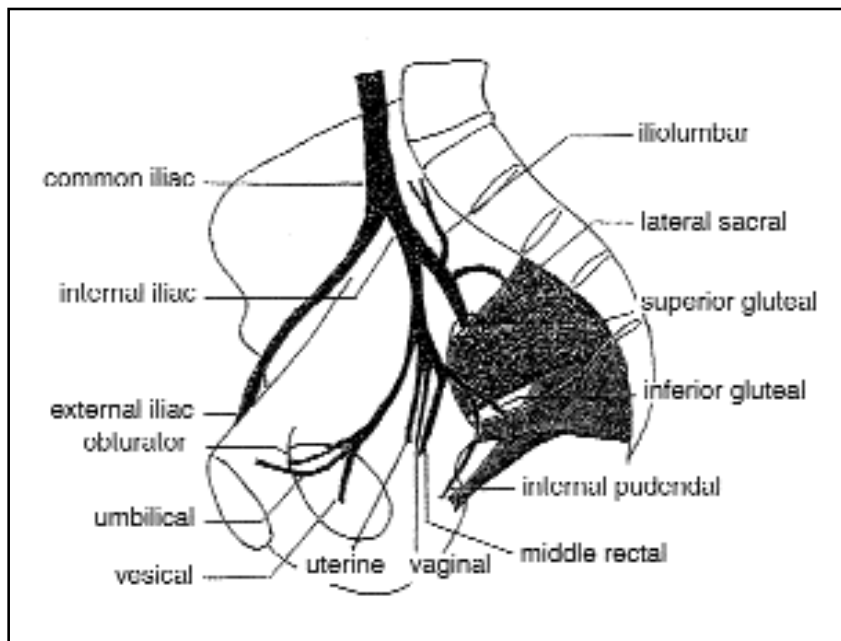
At our institution, after a patient is referred or self-referred for UAE, an initial phone or direct consultation is arranged with an interventional radiologist. During this time, the benefits

and risks of the procedure are described. If not already evaluated by a gynecologist, a consultation is arranged to evaluate the patient's clinical problem as described above. A packet of information including appropriate scientific articles and patient information, such as that available through the Society for Cardiovascular and Interventional Radiology (SCVIR), is sent to the patient. Once the interventional radiologist, clinician, and patient all agree that the procedure is appropriate for her, the procedure is scheduled.

On the day of the procedure, informed written consent is obtained. Preprocedural medications include a prophylactic antibiotic and a non-steroidal anti-inflammatory drug (NSAID). Cefazolin (Ancef, Smith Kline Beecham, Pittsburgh, PA) is our chosen prophylactic antibiotic with vancomycin usually given in penicillin-allergic patients. The typical Ancef dose is 1 g. Other authors also choose cefazolin as the primary prophylactic medication.<sup>8,17,21</sup> However, there are others who would encourage using antibiotics with a greater gram-negative coverage for solid organ embolization, such as ceftriaxone.<sup>22</sup> A loading dose of 30 mg of ketorolac (Toradol, Roche Labs, Nutley, NJ) is given. The hope is to have the effects of the NSAID already peaking at the time of the conclusion of the procedure in an attempt to both decrease opioid requirements and to achieve overall improved pain control. The simultaneous use of two analgesics that each use different mechanisms has been shown to improve pain control.<sup>8</sup> A patient-controlled analgesia (PCA) pump is arranged for in advance, to avoid any unnecessary delays in obtaining adequate pain control following the procedure. Many interventionalists will place a Foley catheter preprocedure, as a full bladder can impair visualization of the pelvic vasculature as the procedure progresses.

Conscious sedation is achieved with midazolam (Roche Labs, Nutley, NJ) and fentanyl (Elkins-Sinn, Cherry Hill, NJ) once the patient is in the angiography suite. Droperidol (Inapsine, Astra Pharmaceuticals, Wayne PA) is also administered for its anti-anxiety and anti-nausea effects. Since many of these patients are apprehensive, enough time is given for these medications to take effect prior to puncture. Once the patient is comfortable and has been prepped, a single access site is obtained via the right common femoral artery, and a 5F or 6F sheath is placed. A 5F pigtail catheter is advanced above the level of the bifurcation, and pelvic arteriography is performed. This confirms the presence of dilated uterine arteries and the approximate location of the hypogastric arteries. Another way to obtain similar information for the pelvic arteriogram is to perform a limited pelvic MRA at the time of a preliminary MRI, providing much the same information with no additional radiation (oral communication, David Hovsepian, MD, SCVIR Gynecologic Interventions workshop, March 2001).

It is important to have a firm understanding of the pelvic arterial anatomy to achieve a successful and safe procedure (figure 2). Most women suffering from significant uterine fibroid symptoms are young and relatively healthy. Therefore, the problems associated with abnormal malignant vasculature are not encountered while performing these procedures. The internal iliac artery divides and terminates into two main divisions, anterior and posterior, approximately 77% of the time, with other variations, in order of frequency, include three main branches, one main branch, and four or more branches.<sup>23</sup> The main arterial branches of the anterior division include the umbilical and superior vesicle, uterine/vaginal, middle rectal, obturator, internal pudendal, and inferior gluteal arteries.<sup>24</sup> Three main types of anatomoses



**FIGURE 2.** Normal pelvic arterial anatomy. (Reprinted with permission from Pelage et al<sup>23</sup>: Arterial anatomy of the female genital tract: Variation and relevance to transcatheter embolization of the uterus. *AJR Am J Roentgenol* 172:989-994, 1999.)

with the uterine artery have been reported, including anastomoses between the right and left uterine arteries, the ovarian and uterine artery, and the round ligament artery (a branch of the inferior epigastric artery) and the uterine artery.<sup>23</sup> The vaginal artery and/or the vesicle artery may arise from a common trunk with the uterine artery.<sup>23</sup> Care should be taken when ovarian-uterine artery anastomoses are detected, as the inadvertent embolization of the ovarian artery anastomotic branches has been postulated to be the cause of post-UAE ovarian failure.<sup>18</sup> At times, the primary arterial supply to a portion of the uterus may be via ovarian artery collateral branches (figure 3). One should also be careful to embolize distal to the cervicovaginal branch of the uterine artery as well, as this may be a source of post-UAE sexual dysfunction.<sup>25</sup>

Once the pelvic arteriogram is completed, access to the left common iliac is achieved with the pigtail or a reversed curve catheter, and that catheter is exchanged for a 5F Cobra

catheter (Angiodynamics, Queensbury, NY). The left hypogastric artery is cannulated over a guidewire. The image intensifier is obliqued. The best projection is often the contralateral anterior oblique with approximately 30 degrees of angulation, but the ipsilateral oblique may be of benefit, particularly when the uterine artery originates from an anterior division of the hypogastric that divides into more than one stem.<sup>23</sup> A road map is performed to assist with cannulation of the uterine artery. Although some authors describe the initial attempt at cannulation via a 4F or 5F catheter in the majority of their patients,<sup>9,12,17,26</sup> our experience with vasospasm has been such that we attempt primarily to cannulate the uterine arteries using a microcatheter coaxial system and try to avoid directly cannulating the uterine artery with standard 4F or 5F catheters. Other authors have described failures to embolize both uterine arteries due to significant vasospasm.<sup>7,26</sup> A microcatheter with a relatively large lumen, such as a Mass

Transit (Cordis, Miami, FL), is chosen to ease the administration of particles.

Once the catheter is positioned in the transverse segment of the uterine artery beyond the cervicovaginal branches at a safe distance from the orifice of the uterine artery, embolization can begin. The choice and size of the embolization agent to be used has been a source of discussion and refinement since UAE has become a widespread procedure. Most authors have used polyvinyl alcohol (PVA) alone as their embolization agent of choice.<sup>8,9,12,16,17,21,26</sup> One author used both PVA and gelfoam.<sup>7</sup> Following the embolization agent with coils is not recommended. Occasionally, patients may need to return for repeat embolization, and the placement of a coil in the uterine artery makes re-embolization difficult.

Polyvinyl alcohol is a substance used in many domestic and industrial products, including sponges.<sup>27</sup> The particles are shaved or punched out from a compressed block and passed through sieves to separate the requisite sizes.<sup>27</sup> The difficulty in defining the exact sizes present in the mixture and the tendency for these particles to clump could result in either a more distal or more proximal embolization than the one intended. Although measures have been taken to lessen the admixture of tiny unintended particles that may pass too distally and cause infarction of tissue, clumping cannot be controlled easily and the possibility of a less "true" embolization exists resulting from larger clumps of particles lodging more proximally than intended.<sup>27</sup> Nonetheless, excellent results have been achieved with this product, as will be discussed later. Another well-known problem with PVA is the tendency for this embolic agent to clog small catheters. Although PVA generally is believed to provide a permanent embolization, recanalization has been reported in vessels embolized with PVA and there has been a variable reported length of



**FIGURE 3.** (A) Early phase of a preliminary pelvic arteriogram demonstrates typical tortuous and dilated left uterine artery in this patient with a known multiple leiomyomas. There is no opacification of a right uterine artery or of the rightward portion of the uterus initially. (B) Late phase of the same pelvic arteriogram as (A) demonstrates late opacification of arteries supplying the right side of the uterus filling from ovarian arterial collaterals. No distinct right uterine artery was detected despite subselective arteriography.

occlusion with PVA use.<sup>27</sup> These findings may account for the occasional failure of an otherwise uneventful UAE. There are those that take care to use heparinized saline in their PVA mixture in the hope of delaying the onset of clot formation in the stagnant vessel and thus enabling more true embolization with PVA particles as opposed to thrombus formation.<sup>28</sup>

A recently developed embolization product is the Embosphere Microsphere (Biosphere Medical, Inc., Rockland, MD). Embospheres are produced from acrylic polymer impregnated with porcine gelatin. The spheres are reportedly precisely calibrated, do not aggregate significantly, and remain in suspension longer than other embolization agents.<sup>29</sup> The soft, deformable nature of the particles is supposed to decrease the incidence of catheter occlusion.<sup>29</sup> There have been anecdotal reports of decreased pain with the use of these particles in UAE, although no peer-reviewed studies defining the difference in tolerance or the long-term efficacy of these particles have been published. Trials are reportedly under way. The main clinical trials to date have been in neuroembolization procedures.<sup>30-32</sup> The manufacturer recom-

mends that a 2-cc vial, which is already diluted in 6 cc of saline, be mixed in a 1:1 ratio with Omnipaque contrast (Nycomed Amersham, Princeton, NJ) to achieve the best suspension of Embosphere particles.

Although gelfoam pledgets have been widely utilized in pelvic embolization procedures for other indications, they have not been the method of choice for UAE for the vast majority of authors. The level of vascular occlusion by gelfoam pledgets is somewhat variable. Gelfoam powder measures 40 to 60  $\mu\text{m}$  and causes a very distal embolization. Therefore, organs embolized with gelfoam powder are more prone to suffer from ischemia. Gelfoam powder should not be used for uterine artery embolization. Gelfoam generally causes vascular occlusion lasting 2 days to 6 weeks. Some small studies have been presented supporting the efficacy of gelfoam in UAE when compared with PVA.<sup>27</sup> Two abstracts were presented at the SCVIR meeting this year, each demonstrating excellent results with gelfoam pledgets.<sup>33,34</sup> However, due to the limited length of occlusion achieved by gelfoam pledgets, larger studies would be necessary to offset

the suspicion that long-term results may not bear out the effectiveness of gelfoam. Further study would also be necessary to prove that gelfoam would lead to a higher rate of fertility than PVA, as pregnancies have been reported with PVA embolization as described above. Some operators currently do use gelfoam in women desiring future fertility undergoing UAE.

Although some authors began using PVA particles in the 150 to 300  $\mu\text{m}$  range, the consensus is now generally that PVA particles in the 300 to 500  $\mu\text{m}$  range or 500 to 700  $\mu\text{m}$  range provide an effective embolization with a good margin of safety.<sup>35</sup> The radial arteries of the perfibroid plexus are the targets of UAE, and these have been estimated to be 500 to 600  $\mu\text{m}$  in size.<sup>36</sup> It is generally felt that whatever size PVA one might use, using one size greater Embospheres should be considered, as the clumped PVA particles of the smaller size are likely equivalent to the larger size Embospheres.

In general, we have begun using Embospheres in our patients due to the advantages listed above. We begin with 500 to 700  $\mu\text{m}$  particles in an attempt to embolize the radial arterial

branches of the uterine artery at that level. Once a significant number of embolization particles have been introduced, we may follow this with 700 to 900  $\mu\text{m}$  particles to further fill the lumen with particles as opposed to thrombus, which may recanalize.

The endpoint of Embospheres is different as well. Although it would not be wrong to continue to embolize to stasis, it is generally felt that the "pruned tree" appearance to the vessel may be enough (figure 4). This represents the blockage of peripheral fibroid branches with the hope of preservation of flow to more normal uterine tissue. Dr. Pelage and colleagues report that they have changed their endpoint of fibroid embolization with PVA as well, with their current strategy being an end-point of disappearance of fibroid hypervascularity and reduction of distal uterine artery flow.<sup>35</sup> The reasoning relates to greater sensitivity of fibroids to hypoxia than normal uterine tissue.

The embolization procedure is then repeated in the ipsilateral uterine artery. After formation of a Waltman's loop or exchange for a reverse curve catheter, the ipsilateral hypogastric

artery is cannulated. The road map is performed, the uterine artery is cannulated with a microcatheter, and embolization is performed in a similar fashion as the contralateral side.

Once the embolization is completed, we utilize a closure device, such as Perclose (Abbott Labs, Redwood City, CA), in patients with appropriate anatomy. Since some of these patients experience significant post-procedural pain, it is difficult for them to keep their leg straight for 6 to 8 hours after manual compression. Although we are currently recommending, as a precaution, 2 hours of bed rest after Perclose placement, these patients could probably stress the arteriotomy site immediately after closure without adverse effect if it became necessary.

We admit all of our patients overnight for pain management. However, some authors describe a high degree of success of discharging patients the same day.<sup>8,16</sup> As described earlier, a PCA pump is ready to be used immediately post-procedure. Ketorolac is given at a dose of 15 mg every 6 hours. An anti-nausea medication is also prescribed to be used as needed. The patient is admit-

ted to the interventional radiology service with overnight calls taken by the interventional service.

The next morning, the intravenous pain medication is stopped and changed to oral pain medications, including a narcotic analgesic such as hydrocodone bitartrate with acetaminophen (Vicodin, Knoll Laboratories, Mount Olive, NJ) or oxycodone with acetaminophen (Percocet, Dupont, Manate, PA), as well as an NSAID, usually Naprosyn (Naproxen, Wyeth-Ayerst Laboratories, Philadelphia, PA). If the patient is doing well on these medications, she is discharged home on these medications along with an anti-nausea suppository and a stool softener. Prior to discharge, the attending physician and fellow both see the patient, and a full range of instructions is given, including instructions to watch for signs of infection and information about what to expect regarding possible post-embolization syndrome. For post-procedural follow-up, the interventional radiologist keeps in close phone contact with the patient on multiple occasions, and a follow-up appointment is made with the gynecologist 1 week post-procedure for baseline post-embolization evaluation.



**FIGURE 4.** (A) Subselective injection of the left uterine artery demonstrates the typical appearance of the ascending segment and intramural (arcuate) branches of the uterine artery. (B) After embolization of the left uterine artery with 500 to 700  $\mu\text{m}$  and 700 to 900  $\mu\text{m}$  Embospheres as well as 500 to 710  $\mu\text{m}$  polyvinyl alcohol, the typical "pruned tree" appearance is obtained. This represents the occlusion of dilated arcuate arteries supplying predominantly leiomyomata with the preservation of a greater portion of arterial supply to normal uterus.

**Table 2. Results of uterine fibroid embolization**

Study, year	Follow-up	No. of patients	Technical success	Symptomatic relief	Mean uterine size by imaging	Hospital stay
Pelage et al, <sup>26</sup> 2000	24 m	80	Bilateral 95% Unilateral 5%	Menorrhagia • Resolution 90% • Improved 4% • Failed 6%	52% shrinkage at 6 months	N/A
Brunereau et al, <sup>7</sup> 2000	3 m – 2 y	58	Bilateral 98% Unilateral 2%	1 year • Resolved 80% • Improved 11% • Unchanged 7% 2 years • Resolved 100%	23% shrinkage at 2 months	Average: 2.3 days
Siskin et al, <sup>8</sup> 2000	3–6 m	49	Bilateral 98%	Resolved or decreased 88.5%	N/A	Discharge • Same day 96% • Next day 4%
Young et al, <sup>37</sup> 2000 (abstract)	1 y	20	N/A	Mass effect • Improved 100% Menorrhagia • Resolved 100%	39%–69% shrinkage at 1 year	N/A
Goodwin et al, <sup>16</sup> 1999	mean 16.3 m	60	Bilateral 98.3% Unilateral 1.7%	At least moderate improvement 81%	43% shrinkage	Discharge • Same day 53% • Next day 37% • Longer 10%
Spies et al, <sup>9</sup> 1999	mean 8.7 m	61	Bilateral 97% Unilateral 1.5%	Menorrhagia • Improved 89% • Moderate to marked 81% Mass effect • Improved 96% • Moderate to marked 79%	mean shrinkage at 1 year 48%	Discharge • Same day 15% • Next day 77% • 2 nights 8%
Hutchins et al, <sup>38</sup> 1999	mean 12 m	305	N/A	Menorrhagia • 92% improved at 1 year Mass effect • 92% improved at 1 year	N/A	N/A
Worthington- Kirsch, 1998 <sup>17</sup>	3 m	53	Bilateral 98% Unilateral 2%	Menorrhagia • Marked 88% Mass effect 94%	46% shrinkage	Overnight 92% Longer 8%

## Results

As mentioned earlier, UAE is a procedure demonstrating great promise; however, no real long-term data regarding efficacy is yet available. At this time, midterm data out to 2 years is just becoming available, and most data is regarding follow-up of 1 year or less. A table describing the most recent

large data sets from the last 2 years is presented in Table 2. Technical success rates of bilateral uterine artery embolization have been quite good, with bilateral embolization achieved in 97% to 98% of cases in most studies.<sup>7-9,16,17,35</sup> Most failures to cannulize a uterine artery have been due to uterine artery spasm, anomalous uterine artery

anatomy, or unintentional uterine artery dissection.<sup>7,9,16,17,26</sup> The use of microcatheters on a more consistent basis to directly cannulize the uterine artery may eliminate some of these technical failures. Data regarding symptomatic improvement of menorrhagia and pelvic pressure, the two main symptoms of uterine fibroid

**Table 3. Complications of uterine artery embolization**

Study	Total patients	Puncture site	Infection	Ovarian failure	Expelled fibroid	Uterine artery injury	Other
Pelage et al <sup>26</sup>	80	0	1 (required hysterectomy)	2 transient 4 permanent	4	1	0
Brunereau et al <sup>7</sup>	58	0	1 (pyelonephritis)	0	0	2	2
Siskin et al <sup>8</sup>	49	0	0	0	0	0	2
Young et al <sup>37</sup>	20	N/A	1 urinary tract 1 colitis (due to antibiotics)	N/A	N/A	N/A	N/A
Goodwin et al <sup>16</sup>	60	1	1 (required hysterectomy)	1 permanent	4	0	0
Spies et al <sup>9</sup>	61	0	1 (required dilatation ) and curettage	3 transient 1 permanent	1	2	0
Hutchins et al <sup>38</sup>	305	N/A	2	N/A	13	N/A	N/A
Worthington-Kirsch <sup>17</sup>	53	0	0	0	0	1	2

disease, have been quite similar among studies. Most authors quote a symptomatic resolution or improvement rate of 90% to 95%.<sup>7-9,17,22,26,39</sup> Overall decrease in uterine size has also been fairly consistent, with the size decreasing at a rate of 40% to 50% in most studies.<sup>9,17,26,37</sup> Although numbers have been small, studies with more midterm results have not demonstrated late failures to this point.<sup>7,16,26</sup> Hospital stay has been consistently short, with 87% to 100% of patients discharged by the next day in most reports.<sup>8,9,16,17</sup>

Although reasons for clinical failure of uterine artery embolization despite a technically successful procedure have not been discerned clearly, a few possible explanations have been postulated. Due to the communication of uterine arteries from different sides of the pelvis, it is considered imperative to embolize both uterine arteries. Pelage et al<sup>26</sup> describe that 3 of 4 patients in whom it was not possible to embolize bilaterally due to technical factors were clinical failures. Goodwin et al<sup>16</sup> also propose unilateral embolization as a source of treatment failure. Adenomyosis has also been forwarded as a possible source of failure.<sup>40</sup> Although Goodwin et al<sup>16</sup> report clinical success in 3 patients with adenomyosis who were known to

have this condition prior to embolization, they also report that 3 of 6 patients requiring hysterectomies after treatment failure demonstrated histologic findings of adenomyosis at pathology. In addition, ovarian collateral supply to the uterine arteries has also been described as a source of treatment failure.<sup>41,42</sup> This finding may not be evident initially angiographically, but may appear after slowing of uterine artery flow. Embolization of a distal right ovarian artery, which provided dominant blood supply to uterine fibroids, has been described.<sup>43</sup>

### Complications of UAE

Overall, complication rates of uterine artery embolization have been quite low. Table 3 summarizes the complications occurring in relationship to uterine artery embolization in recent studies. In addition, most complications have been of little consequence.

One of the most significant complications has been uterine infection. Of all recent studies reviewed, a total of 3 patients were identified as having uterine infection requiring treatment.<sup>9,16,26</sup> Two of these patients required hysterectomy and one required dilatation and curettage. Two urinary tract infections were found in women who had recently undergone UAE.<sup>7,37</sup> The rela-

tionship between the procedure and these infections is debatable. One patient developed pseudomembranous colitis, likely as a result of prophylactic antibiotics.<sup>37</sup>

Permanent ovarian failure is a relatively uncommon event.<sup>7-9,16,17,26,37</sup> Most women described as having permanent ovarian failure are actually perimenopausal and do not desire pregnancy.

Transcervical expulsion of fibroid tissue occurs occasionally with UAE.<sup>9,16,26</sup> This is not considered to have any long-term consequences. In fact, some authors consider this to be a positive event, as patients may experience a large decrease in their bulk symptoms after passing the fibroid tissue.<sup>44</sup>

Puncture site complications and uterine artery injury, either dissection or rupture, are infrequent. Uterine artery injury did not have significant consequences in the literature reviewed.<sup>7,9,17,26</sup> Lai et al<sup>25</sup> describe a single patient in whom sexual dysfunction occurred after UAE, possibly as a result of disruption of uterine artery flow via its cervico-vaginal branch, which nourishes the uterovaginal plexus, or via ischemic changes of the cervix itself.

An unusual complication that has occurred at our institution, which to our knowledge has not been previ-

ously described, was the development of urinary retention. After UAE, a patient developed urinary retention requiring admission that did not resolve until the passage of a large submucosal cervical fibroid. Other potential complications, which were not encountered in the review of current literature, are nontarget embolization, allergic reaction to contrast, and renal toxicity from contrast agents.

### **Uterine artery embolization versus hysterectomy/myomectomy**

#### ***Emotional/psychosexual issues***

For most relatively young, healthy women, there is a strong desire to avoid surgery of any kind. In particular, there have been emotional difficulties associated with hysterectomy, with some women feeling “de-sexed” or like “half a woman” after the procedure.<sup>25</sup> In addition, the uterus is an integral part of the normal female sexual response, and impaired sexual function has been well documented in patients who have had a hysterectomy.<sup>25</sup> One study demonstrated a feeling of loss, emptiness, and diminished femininity after hysterectomy in 16% of patients.<sup>6</sup> Although a single case report exists regarding decreased sexual response post-UAE, this has not been demonstrated to be a common occurrence to this point.<sup>25</sup> Myomectomy and UAE are both options for patients desiring to avoid such complications.

### **Results**

The main advantage of hysterectomy is that the risks for further symptomatic fibroids are nonexistent. However, the obvious negative to this procedure is that it excludes the patient from carrying future pregnancies. As far as abdominal myomectomy is concerned, the pooled results of multiple small studies demonstrate an approximate overall resolution of menorrhagia symptoms and pelvic pressure symptoms of 81%.<sup>5</sup> However, studies utilizing transvaginal sonography have

demonstrated a leiomyoma recurrence rate of approximately 51% at 5 years.<sup>5</sup> Patients undergoing laparoscopic myomectomy may be at higher risk for recurrent myomas, with a 33% recurrence rate at 27 months.<sup>5</sup> There is also a 2% to 8% conversion rate to a more invasive procedure.<sup>5</sup>

Hysteroscopic myomectomy for submucosal fibroids has been somewhat more successful, with 16% of patients requiring a second procedure with a follow-up of 9 years.<sup>5</sup> Uterine artery embolization has had similar if not better results up to this point in most studies, as described earlier, and with the exception of hysterectomy, is the only global treatment for uterine fibroids. However, the follow-up has not been as long as described earlier. There is a strong commitment by the interventional radiology community to document long-term results, particularly via the SCVIR.<sup>45</sup> The SCVIR fibroid registry is an example of such a commitment.

### **Fertility**

In general, leiomyomas have been found to decrease both clinical pregnancies and delivery rates.<sup>5</sup> In addition, there are risks of carrying a pregnancy in a leiomatous uterus, including occasional acute hemorrhagic degeneration, placental abruption, and lower uterine segment myomas leading to malpresentation of the fetus.<sup>4</sup> A placenta implanted over a  $\geq 5$ -cm submucosal fibroid has a 50% chance of an abruption.<sup>4</sup> Pregnancy rates in patients with no other infertility factor after myomectomy have ranged from 40% to 60% at 1 to 2 years.<sup>5</sup> As described above, patients undergoing UAE have been reported to conceive and deliver after the procedure,<sup>15,19</sup> and many concerns regarding ovarian failure and other hindrances to pregnancy have not come to fruition.<sup>13</sup> However, since no study documenting the number of patients undergoing UAE who desire fertility versus the number of patients who have actu-

ally given birth has been performed, many interventional radiologists still counsel women desiring fertility that other options should be considered at this point in time. No blanket rule regarding UAE and women desiring pregnancy is available at this time, and decisions regarding this issue should be made on a case-by-case basis.

### **Complications**

Hysterectomy is a major surgical procedure with the associated risks of damage/dysfunction of nearby structures, infection, and risks of convalescence. The most common complication of radical hysterectomy is partial denervation of the detrussor muscle, leading to urinary dysfunction.<sup>46</sup> Another common complication involves deterioration of bowel function, which has been described to occur in as many as 41% of post-hysterectomy patients.<sup>6</sup> Weakening of the pelvic floor may occur, leading to vaginal vault prolapse or enterocele.<sup>6</sup> A ureterovaginal or vesicovaginal fistula occurs in approximately 3% of patients.<sup>46</sup> Operative mortality is now approximately 0.6%. The risk of pulmonary embolus in patients after radical hysterectomy is 1% to 2%.<sup>46</sup>

There are a few risks particularly related to myomectomy. One major concern is hemostasis.<sup>47</sup> Post-myomectomy bleeding can be so severe as to require a hysterectomy.<sup>4</sup> In particular, laparoscopic myomectomy engenders a 2% to 8% conversion rate to a more invasive procedure.<sup>5</sup> Adhesion formation is also a problem, which may inhibit some women desiring fertility from becoming pregnant.<sup>47</sup> There is also a risk of obstetric-related uterine rupture, which has been confirmed by some investigators but denied by others.<sup>47</sup>

As described above, the risks of uterine fibroid embolization, particularly of major complications, have been quite small. There have been a few cases of infection requiring hysterectomy or dilatation and curettage.<sup>9,16,26</sup> Many patients experience a

post-embolization syndrome consisting of pain, nausea, malaise, and sometimes fever. This is almost always self-limited. Other complications described regarding uterine artery embolization are listed earlier.

### Convalescence

Decreasing the period of post-procedural convalescence is a significant advantage of UAE. The average inpatient hospital stay for total abdominal hysterectomy has ranged in studies between 3.0 and 4.8 days, for vaginal hysterectomy from 2.0 to 3.3 days, and for laparoscopically assisted vaginal hysterectomy from 1.5 to 3.0 days.<sup>6</sup> The average period of return to normal function has ranged from 35 to 41 days for total abdominal hysterectomy, 28 to 29 days for vaginal hysterectomy, and 21 to 25 days for laparoscopically assisted vaginal hysterectomy.<sup>6</sup> In a study comparing open versus laparoscopic myomectomy, 1 in 20 patients had completely recovered by postoperative day 15 after an open myomectomy, while 18 of 20 patients had completely recovered by postoperative day 15 in the laparoscopic myomectomy patients.<sup>6</sup>

In most studies addressing recovery from UAE, the vast majority of patients are discharged by the day after the procedure, if not the same day.<sup>8,9,16,17</sup> The mean number of post-procedure days before a patient was able to return to work ranged from 7.7 to 8.9.<sup>8,9</sup> This not only significantly reduces hospital costs when compared with other procedures, but also significantly decreases the days of productivity lost post-procedure.

### Radiation exposure

One concern that affects only the performance of UAE is radiation exposure. Nikolic et al<sup>48</sup> measured skin and vaginal radiation exposures to determine the approximate mean superficial and deep radiation exposures for UAE in 20 patients using

standard techniques. The mean absorbed ovarian dose was 22 cGy<sup>36</sup> and the mean absorbed skin dose was 162.34 cGy.<sup>48</sup> The ovarian absorbed dose for fallopian tube recanalization has been estimated between 0.2 and 2.75 cGy and between 0.1 and 1.9 cGy for computed tomography of the trunk. Pelvic irradiation for Hodgkin's disease has been reported to range from 263 to 3500 cGy.<sup>48</sup> The radiation dose is not likely to have significant deterministic effects, with the lowest level of threshold for deterministic effect ranging from 200 to 2000 cGy for skin erythema.<sup>48</sup> Although ovarian dysfunction has been seen in patients undergoing much larger doses of radiation for Hodgkin's treatment, the amount of radiation is at least 10 times that used in UAE.

Patients studied after irradiation for lymphoma treatment have not been shown to have significant increase in genetic defects in their offspring nor a decreased fertility rate.<sup>49</sup> The same group also studied the effect of changing parameters of the procedure on approximate absorbed ovarian dose.<sup>50</sup> They discovered that by using pulsed fluoroscopy, by avoiding magnification and oblique fluoroscopy, and by simultaneous bilateral embolization and arteriography, a substantial decrease in radiation exposure could be achieved. They were able to decrease the radiation exposures by approximately 50% by changing these parameters.<sup>50</sup>

### Conclusion

In conclusion, uterine artery embolization is a very promising new treatment based on classic interventional techniques familiar to trained interventionalists. As collective experience has grown, the process of patient selection and fine points of technique have progressed. Both early and new midterm results have shown the procedure to compare well with, if not exceed, the efficacy of established

treatments for symptomatic uterine fibroids while decreasing complication rates and convalescent periods. Although these early findings are quite favorable, further study is necessary to better assess the long-term durability of this procedure and its effects on fertility. The interventional radiology community as a whole is taking steps to ensure this information will be available in the future so the procedure can be performed on the patient population who will most benefit, while minimizing its potential negative effects. □

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