Uterine Artery Embolization of Uterine Fibroids

A review of the current literature.

BY MICHAEL L. CENSULLO, MD; POLINA N. KYRIAKIDES, MD; LUCHO L. ROSSMAN, MD; AND ALAN M. COHEN, MD

The uterus is the most common site to develop smooth muscle tumors. Uterine fibroids (leiomyomas) contain benign smooth muscle and fibrous tissues. Twenty percent to 40% of reproductive age women develop uterine fibroids, with a higher incidence in African Americans. Although the decline in hormonal stimulation causes most fibroids to regress at menopause, 20% become symptomatic before then. Uterine artery embolization (UAE, alternatively uterine fibroid embolization or UFE) was accidentally discovered and reported in 1994 by the French physician, Dr. J.H. Ravina.[1] Ravina pretreated patients scheduled for myomectomy with pelvic embolization for the purpose of reducing operative blood loss. Subsequently, many patients canceled their myomectomy due to symptomatic improvements. Over the following years, it has been found that most uterine fibroids are amenable to UAE, and current estimates are that 13,000 to 14,000 UAEs are performed annually in the US alone.[2] The FDA has approved specific embolic materials for endovascular treatment of symptomatic uterine fibroids.[3]

TREATMENT OPTIONS FOR UTERINE FIBROIDS

There are many available uterine fibroid therapies. Oral contraceptives, gonadotropin-releasing hormone agonists (GnRH-a), myomectomy, hysterectomy, and UAE constitute the well-accepted management options, although other experimental techniques including myolysis and MRI-guided ultrasound ablation may eventually evolve into general use. Oral contraceptives cannot decrease uterine fibroid volume, but may make

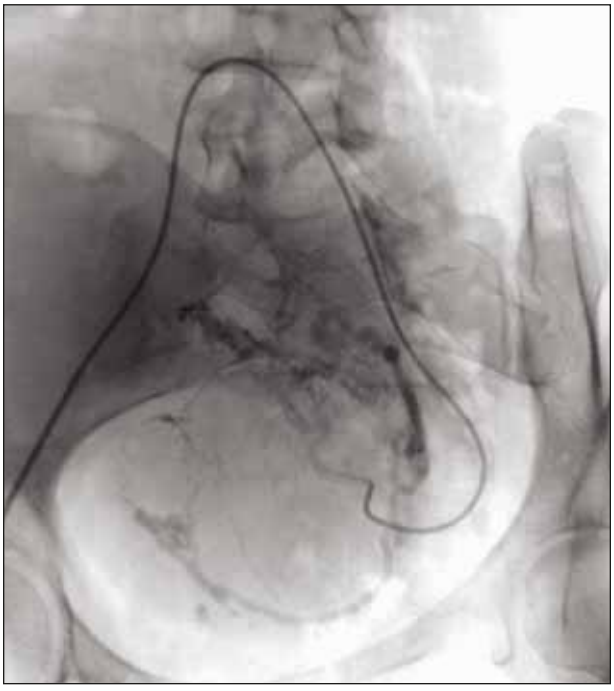

Figure 1. Uterine artery arteriogram in a patient with symptomatic uterine fibroids, before transcatheter embolization. Hypervascular arterial supply to the uterine fibroids is demonstrated.

menorrhagia symptoms tolerable. GnRH-a works by inhibiting pituitary release of GnRH, which ultimately leads to decreased estrogen production. GnRH-a therapy achieves 33% to 50% reduction in uterine fibroid volume.[4] During therapy, there are frequent menopausal-like side effects, and the potential for osteoporosis limits therapy to less than 6 months. Fibroids usually grow again after cessation of therapy, making this treatment option rarely definitive.

When conservative medical management fails to control hemorrhagic or pressure-related symptoms, surgical options are available. Hysterectomy can be considered when fertility preservation is not desired. Hysterectomy is the only definitive cure for uterine fibroids and is performed for this purpose approximately 177,000 to 366,000 times each year in the US.[5] Vaginal hysterectomy is preferred when the uterus is both mobile and less than 12 weeks gestational size, while laproscopic-assisted and abdominal hysterectomy is performed in all other cases.[6]

Hysterectomy is well known to improve or resolve symptoms in the majority of patients and has the secondary benefit of removing the rare (.13%-.29%) instances of leiomyosarcomas. Myomectomy is recommended when the patient desires fertility preservation, but is performed only one-tenth as frequently as hysterectomy.[7] Abdominal myomectomy is preferred to laproscopy when uterine size is greater than 17 weeks gestational size, when fibroids are greater than 8 cm in diameter, or when fibroids are within the myometrium. Pedunculated and small serosal fibroids are amenable to laproscopic removal, although there is a 2% to 11% conversion rate to open abdominal myomectomy, and the quality of laproscopic uterine suturing is controversial.[8-12]

Hysteroscopic myomectomy is reserved for submucosal fibroids. Sixty-seven percent to 100% of patients undergoing myomectomy have significant symptom reduction. However, both myomectomy and hysterectomy are major surgeries and usually require general anesthesia, result in hospital recoveries ranging from 1 to 3 days (vaginal hysterectomy) to 3 to 5 days (abdominal hysterectomy), and entail a long convalescence time (15-20 days for hysteroscopic myomectomy, 6-8 weeks or longer for abdominal hysterectomy).[12] The surgical options also have appreciable complication rates ranging from 17.1% to 42.8%.[13-14] Unreported in those studies are the effects on sexual function. Although hysterectomy may commonly result in sexual dysfunction,[15-16] only one case of anorgasmia has been reported after UAE.[17] These recovery times and morbidity rates have made UAE an attractive option in uterine fibroid therapy.

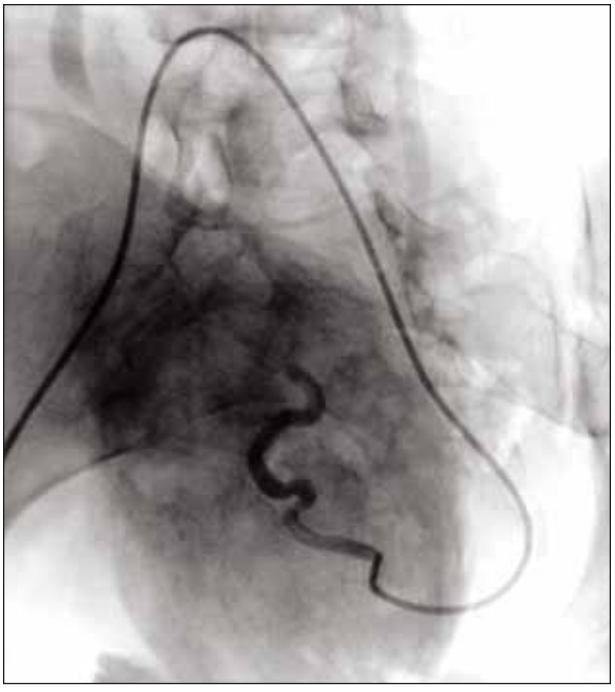

Figure 2. After embolization, the vascularity is markedly "pruned," and blood flow is nearly static.

DIAGNOSING UTERINE FIBROIDS AND THE UAE PATIENT EVALUATION

Many patients requesting UAE consultation do so by self-referral. This most probably is related to the position of the American College of Obstetricians and Gynecologists, which currently considers UAE experimental,[18] and most of its members do not refer patients for this reason. There have been media reports speculating that referrals for UAE do not occur because of "territory issues."[19] Another likely contribution is the World Wide Web. Women now have the resources to become independently knowledgeable about uterine fibroids and the treatment options. Regardless of reason, any practitioner offering UAE must be prepared to address problems related to nonreferral, including independent public education through seminars and Web sites, difficulties obtaining insurance approvals without referrals, and patients being told to never return to their ob/gyn physician if they seek UAE therapy. Sometimes this leaves the UAE practitioner isolated in diagnosing the patient's pelvic condition. The most successful UAE practices have a mutual alliance with a local ob/gyn practitioner. Some level of cooperation is essential for pap smears and endometrial biopsies during the patient's evaluation.

Uterine fibroid symptoms depend somewhat on the location of the fibroid, although multiple locations may

have fibroids and there is some nonspecific overlap in symptom presentations.[20] Submucosal fibroids classically present when smaller than fibroids at other locations with abnormally heavy cyclic menstrual bleeding (menorrhagia), anemia, and infertility. Intermenstrual bleeding (menometrorrhagia) is uncommon with uterine fibroids, and suggests a different etiology, possibly malignant. Subserosal and pedunculated fibroids become symptomatic when their size exerts regional mass effects such as urinary frequency, hydronephrosis, constipation, radiculopathy, and a palpable pelvic mass. Intramural fibroids may present with any of these symptoms as they grow larger. Pelvic pain and dyspareunia is variably reported at all fibroid locations. It is important to establish the diagnosis of uterine fibroids and exclude other pathologies that may present with similar symptoms. For instance, a differential diagnosis of abnormal vaginal bleeding includes uterine fibroids, adenomyosis (which debatably is also responsive to UAE), endometrial sarcoma, and polyps.[21]

The clinical suspicion of uterine fibroids can be confirmed with ultrasound, but MRI is essential to determine fibroid distribution and to exclude adenomyosis and is also useful in detecting stalks of pedunculated fibroids. MRI is predictive of UAE success through fibroid contrast enhancement.[22] MRI provides the most accurate assessment of fibroid size. While some practitioners do not embolize when an individual fibroid exceeds 8 cm to 10 cm in diameter, most will, and outcomes are favorable.[23] Multiple fibroids are associated with increased transfusion needs during myomectomy,[24] which makes UAE more attractive to women choosing to avoid blood transfusions.

Bleeding complaints (especially with menometrorrhagia) should prompt consideration of endometrial biopsy to exclude endometrial sarcoma. A benign up-to-date pap smear should be documented because early-stage cervical cancer and uterine fibroids may be cured concurrently with hysterectomy. A pap smear also presents the opportunity to exclude pelvic inflammatory disease, which is a contraindication to UAE.

Future fertility plans must be taken into consideration in the patient's evaluation. The Society of Interventional Radiology, whose members perform most UAEs in the US, currently does not recommend UAE for premenopausal patients who wish to preserve fertility. Post-UAE amenorrhea occurs in approximately 1% to 7% of patients, but mostly in patients over 45 years of age.[25] Many pregnancies following UAE have been reported, and one study has found the post-UAE pregnancy rate is comparable to myomectomy.[26] Although abnormal placentation, increased Caesarian rates, spontaneous abortions, ectopic pregnancies, and pre-term deliveries after UAE have been reported,[27-28] it is difficult to discern UAE's gestational effects from those attributable to the underlying fibroid condition. Obviously, patients desiring future pregnancy will consider UAE as well as myomectomy.

The pre-UAE evaluation should also include the usual components of any endovascular procedure, including a history and physical, lab values for renal function, bleeding profile, complete blood count, and review of possible contrast allergies. Bleeding diathesis, severe contrast allergies, prior pelvic irradiation, and a rapidly enlarging uterus with a single fibroid are contraindications to UAE. Finally, in our practice, we make clear that the embolic particles are permanent but have a long history without systemic complications, and that radiation is used for imaging during UAE. This helps avoid any misunderstandings about the procedure.

UAE PROCEDURE

The UAE procedure has some variability between practitioners along individual steps, but there is a common underlying approach. Moderate intravenous sedation is administered, and then endovascular access is achieved by percutaneous femoral artery approach. A 5-F sheath is placed, and through this, selective catheter angiography of an internal iliac artery is performed. A catheter is advanced into the anterior division of the internal iliac artery, and then subselectively into the uterine artery beyond the cervicovaginal (also known as cervicovulvar) branch (Figure 1). This helps prevent subsequent impairment of the sexual response,[21] though a cervicovaginal branch that arises directly from the internal iliac artery (9% of patients) should also be protective. Embolization particles are administered in a solution containing contrast, under fluoroscopic surveillance. A completion angiogram is performed (Figure 2). The process is repeated on the contralateral side.

In general, procedural variability has debatable impact on overall outcome, and includes:

• *Pain management.* Some practitioners (including these authors) arrange for epidural anesthesia prior to UAE.[29] There is no prospectively randomized evidence demonstrating its merits over intravenous analgesia; however, our experience has been highly favorable. As a pertinent aside, intra-arterial lidocaine injection in UAE is associated with arterial spasm, and unlike other (ie, malignant) tumor embolizations, it should be avoided.[30]

• *Prophylactic antibiotics.* Although post-UAE infections have been reported and should be treated with antibiotics, there is no consensus regarding the administration of prophylactic antibiotics in UAE. Cefazolin or

doxycycline (or related antibiotics) are used by many practitioners who employ prophylactic antibiotics.

• *Aortic angiography*. Aortography at the level of the renal arteries can be useful in identifying variant ovarian artery collaterals to the uterine fundus, which occurs in 10% to 25% of patients, and alters treatment in 6% of patients.[31] However, it entails more radiation and contrast exposure, and many practitioners will not attempt the technically difficult and higher-risk transovarian artery uterine embolization unless there is documented UAE failure at 3-month follow-up.

• *Unilateral versus bilateral femoral access.* Some practitioners advocate bilateral femoral artery access with crisscrossing catheters. The bilateral access allows easier arterial cannulization (no need to form a Waltman loop) and decreased radiation exposure if embolic material is administered simultaneously in both uterine arteries.[32] Many practitioners only perform unilateral access due to the cumulative risks associated with each arterial access, unless bilateral access is needed to complete the UAE.

• *Coaxial microcatheters versus direct catheterization.* Coaxial 3-F microcatheterization is believed to decrease the low risk of arterial spasm, although some practitioners will directly access the uterine artery with a 4- or 5-F catheter due to the technical challenges associated with coaxial microcatheter use. In our practice, we find catheter selection is somewhat dependent on practitioner training and experience, the tortuosity and size of the uterine artery encountered (large hypervascular fibroid volumes tend to hypertrophy the uterine artery), and whether spasm is encountered with initial attempts to cannulate using a nonmicrocatheter system.

• *Embolic material selection.* Most early UAE reports used polyvinyl alcohol (PVA) particles for embolization. PVA is inexpensive but can aggregate in the syringe or catheter, especially microcatheters. Tris-acryl gelatin microspheres (Biosphere Medical, Rockland, MA) are more expensive, but have more uniform spherical shape and a hydrophilic coating to prevent aggregation. PVA (Boston Scientific, Boston, MA), Biopspheres (Biosphere, Rockland, MA) and Contour SE (Boston Scientific Corporation, Natick, MA) are the particles approved by the FDA for UAE; however, Bead Block (Terumo Medical Corporation, Somerset, NJ) may also become approved.[3]

• *Particle size.* Most practitioners use either 355-µm to 500-µm or 500-µm to 700-µm-sized particles for UAE. There is scant randomized evidence regarding what size produces the best outcomes.

• *Embolization end point.* The embolization end point depends on the material selected. PVA particles typically occlude more proximally, and most regard a stagnant main uterine artery as the end point. Microspheres penetrate further into the microvasculature, and most use a "pruned-tree" vascular appearance as an end point. Other ubiquitous criteria include persistence of main uterine artery contrast at five or more cardiac pulsations and/or new opacification of collateral arteries. Mounting evidence suggests that re-evaluating blood flow 5 minutes after embolization will reveal the need to further embolize in 10% to 20% of patients,[33] but the impact on clinical outcome is unknown.

• *Arterial closure devices.* Many patients are uncomfortable keeping their leg(s) straight for hours after UAE. We use arterial closure for patients with minimal analgesic needs (facilitating earlier ambulation) and those with high analgesic needs (anticipating difficulties with leg immobilization). With epidural analgesia, the decision to use arterial closure requires coordination with the anesthesiology team. A single study has demonstrated arterial closure is safe in UAE patients.[34]

POSTPROCEDURE MANAGEMENT

The first 24 hours after UAE are characterized by pelvic cramping pain, nausea, and a low-grade fever. At our institution, oral nonsteroidal anti-inflammatory drugs (NSAIDS) and patient-controlled IV narcotics start immediately following the procedure. Zofran (ondansetron; GlaxoSmithKline, Philadelphia, PA) is prescribed for nausea as needed. Levaquin (levofloxacin; Ortho-McNeil, Inc., Raritan, NJ) is prescribed for prophylactic antibiotic coverage in some instances. The morning after the procedure, most patients have their epidural removed and then are transferred to oral narcotics for breakthrough pain and phenergan suppositories for nausea. Most patients are discharged home within 24 hours, and all continue NSAIDS and acetominaphen for 1 week.

Pelvic cramping pain typically subsides during this week. Most patients gradually resume normal activities within 7 to 10 days. Patients are instructed to call us for fevers >101.5ºF, purulent vaginal discharge, or increasing pain. Menstruation usually resumes after 2 months, and the first cycle may be heavy. As discussed above, a few patients (usually >45 years old) experience prolonged or permanent amenorrhea. Clinical follow-up occurs at 1 week, 1, 3, 6, and 12 months, and MRI re-imaging occurs at 6- and 12-month intervals.

OUTCOMES

The technical success rate of UAE ranges from 98% to 100%,[12] with most failures attributable to inability to

subselectively cannulate the uterine artery beyond the cervicovaginal branch, or uterine artery spasm. Uterine artery spasm may prevent cannulization or may cause early arterial thrombosis thereby preventing further administration of embolization particles. Technically successful UAEs that result in clinical failure may be due to continued fibroid perfusion through ovarian artery collaterals. As discussed previously, this occurs in 10% of patients. Transovarian artery fibroid embolization is a technically challenging procedure,[35] beyond the scope of this review, and has an increased risk of ovarian failure. There is recent evidence that recurrent fibroids exhibiting MRI contrast enhancement are amenable to re-embolization with high success rates.[36]

Post-UAE fibroid and uterine volume changes are easily quantified radiographically with subsequent MRI imaging. The consensus from multiple reports is that dominant fibroids decrease to 40% to 70% of original size, and uterine volume decreases to 40% to 60% of original size after 1 year.[21] There are reports that further volume decreases occur over a more extended follow-up time. Clinical outcomes are more important. Menorrhagia has an 81% to 100% clinical response rate, whereas regional mass-related symptoms have a 61% to 100% clinical response rate.[21] Menorrhagic response usually occurs within two mensus cycles, while mass-related symptoms may require 3 months or longer before clinical improvement becomes apparent. Most practitioners (including these authors) simplify the outcome numbers as 90% response for bleeding and 80% response for mass-related symptoms when consulting patients.

The UAE complication rate appears to be half that of myomectomy and hysterectomy. Short-term complications from arterial access and angiography are also encountered with UAE. The most common complications are access-site hematomas and contrast allergies, but pseudoaneurysms and dissections can occur infrequently. More unique to UAE is fibroid expulsion and uterine infection, related to devascularization of fibroid and uterine tissues. Fibroid expulsion occurs in 2.5% to 5% of patients and usually from a submucosal fibroid component.[37-38] It is imperative that the necrotic tissues are expelled from the endometrial cavity, which requires the assistance of a gynecologist in half of these patients. Necrotic tissues may become infected, resulting in endometritis and pyometria, which is the cause of most post-UAE hysterectomies. The overall hysterectomy rate within 3 months of UAE is approximately 1.5%.[39]

Amenorrhea has been previously discussed, and may occur when embolic particles affect the ovaries through collateral channels or by nontarget embolization. Women most susceptible to amenorrhea are over 40 to 45 years of age, leading some to speculate that this complication is due to an age-related decrease in "ovarian reserve."

There are four known fatalities after UAE. Two were from pulmonary-thromboembolic disease, which may have been the consequence of a tissue necrosis alteration of the coagulation cascade. The other two fatalities were related to infection. The overall UAE mortality rate is probably in the range of 1:5000.

CONCLUSION

With appropriate patient selection, UAE presents an effective and safe therapy for uterine fibroids. ■

Michael L. Censullo, MD, is from the Department of Diagnostic and Interventional Imaging at the University of Texas Health Center at Houston. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Censullo may be reached at (713) 704-6762; michael.l.censullo@uth.tmc.edu.

Polina N. Kyriakides, MD, is from the Department of Diagnostic and Interventional Imaging at the University of Texas Health Center at Houston. She has disclosed that she holds no financial interest in any product or manufacturer mentioned herein. Dr. Kyriakides may be reached at (713) 704-6762; polina.n.kyriakides@uth.tmc.edu.

Lucho L. Rossman, MD, is from the Department of Diagnostic and Interventional Imaging at the University of Texas Health Center at Houston. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Rossman may be reached at (713) 704-6762; lucho.l.rossman@uth.tmc.edu.

Alan M. Cohen, MD, is from the Department of Diagnostic and Interventional Imaging at the University of Texas Health Center at Houston. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Cohen may be reached at (713) 704-6762; alan.m.cohen@uth.tmc.edu.

1. Ravina JH, Merland JJ, Herbreteau D, et al. Preoperative embolization of uterine fibroma. Preliminary results (10 cases). Presse Med. 1994;23:1540.
2. Society of Interventional Radiology, http://www.sirweb.org/patPub/uterine.shtml. Accessed October 3, 2005.
3. Food and Drug Administration. http://www.fda.gov/bbs/topics/ANSWERS/2002/ANS01175.html. Accessed October 3, 2005.
4. Sutton CJ. Treatment of large uterine fibroids. Br J Obstet Gynaecol. 1996;103:494-496.
5. Broder MS, Harris K, Morton SC, et al. Uterine artery embolization: a systematic review of the literature and proposal for research. MR-1158-CIRREF, 1999.
6. Presis IV. An update in obstetrics and gynecology [CD-Rom]. Washington, DC: American College of Obstetricians and Gynecologists; 1989.
7. Lumsden MA., Embolization versus myomectomy versus hysterectomy: which is best, when? Hum Reprod. 2002;17:253-259.
8. Miller CE. Myomectomy: comparison of open and laparoscopic techniques. Obstet Gynecol Clin N Am. 2000;27:407-420.
9. Dubuisson JB, Fauconnier A, Fourchotte V, et al. Laparoscopic myomectomy: predicting the risk of conversion to an open procedure. Hum Reprod. 2001;16:1726-1731.

10. Nezhat C, Nezhat F, Silfen SL, et al. Laparoscopic myomectomy. Int J Fertil. 1991;36:275-280.
11. Seinera P, Arisio R, Decko A, et al. Laparoscopic myomectomy: indications, surgical technique and complications. Hum Reprod. 1997;12:1927-1930.
12. Wolanske KA, Gordon, RL. Uterine artery embolization: where does it stand in the management of uterine leiomyomas? Part 2. Applied Radiol. 2004:33:18-25.
13. Dicker RC, Greenspan JR, Strauss LT, et al. Complications of abdominal and vaginal hysterectomy among women of reproductive age in the United States. The collaborative review of sterilization. Am J Obstet Gynecol. 1982;144:841-848.
14. Makinen J, Johansson J, Tomas C, et al. Morbidity of 10 110 hysterectomies by type of approach. Hum Reprod. 2001;16:1473-1478.
15. Kilkku P, Gronroos M, Hirvonen T, et al. Supravaginal uterine amputation vs. hysterectomy. Effects on libido and orgasm. Acta Obstet Gynecol Scand. 1983;62:147-152.
16. Thakar R, Manyonda I, Stanton SL, et al. Bladder, bowel and sexual function after hysterectomy for benign conditions. Br J Obstet Gynaecol. 1997;104:983-987.
17. Lai AC, Goodwin SC, Bonilla SM, et al. Sexual dysfunction after uterine artery embolization. J Vasc Interv Radiol. 2000; 11:755-758.
18. http://www.acog.org/from_home/publications/press_releases/nr01-30-04-2.cfm. ACOG Issues opinion on uterine artery embolization for treatment of fibroids. Accessed January 30, 2004.
19. http://abcnews.go.com/2020/HealthyWoman/story?id=124229&page=1. Are most hysterectomies unnecessary? Accessed August 27, 2004 ▪
20. Stewart EA. Uterine fibroids. Lancet. 2001;357:293-298.
21. Itkin M, Shlanksky-Goldberg R. Uterine fibroid embolization for the treatment of symptomatic leiomyomata. Applied Radiol. 200231:9-17.
22. Jha RC, Ascher SM, Imaoka I, et al. Symptomatic fibroleiomyomata: MR imaging of the uterus before and after uterine arterial embolization. Radiology. 2000;217:228-235.
23. Katsumori T, Nakajima K, Mihara T. Is a large fibroid a high-risk factor for uterine artery embolization? AJR Am J Roentgenol. 2003;181:1309-1314.
24. AHRQ. Management of uterine fibroids. Evidence report. Technol Assess. 2001;1-173.
25. Lupattelli T, Basile A, Garaci FG, et al. Percutaneous uterine artery embolization for the treatment of symptomatic fibroids: current status. Eur J Radiol. 2005;54:136-147.
26. Maskova J. Endovascular treatment of uterine leiomyomata: Our first experience. Ceska Radiologie 2001;55:364-369.
27. Pron G, Mocarski E, Bennett J, et al. Pregnancy after uterine artery for leiomyomata: the Ontario multicenter trial. Obstet and Gynec. 2005;105:67-76.
28. Carpenter TT, Walker WJ. Pregnancy following uterine artery embolisation for symptomatic fibroids: a series of 26 completed pregnancies. BJOG. 2005;112:321-325.
29. Nagao T, Ohwada T, Kitazono M, et al. Thoracic epidural analgesia is effective in perioperative pain relief for uterine artery embolization. Masui. 2005;54:156-159.
30. Keyoung JA, Levy EB, Roth AR, et al. Intraarterial lidocaine for pain control after uterine artery embolization for leiomyomata. J Vasc Interv Radiol. 2001;12:1065-1069.
31. Binkert CA, Andrews RT, Kaufman JA. Utility of nonselective abdominal aortography in demonstrating ovarian artery collaterals in patients undergoing uterine artery embolization for fibroids. J Vasc Interv Radiol. 2001;12:841-845.
32. Nikolic B, Spies JB, Campbell L, et al. Uterine artery embolization: reduced radiation with refined technique. J Vasc Interv Radiol. 2001;12:39-44.
33. Spies JB. Failures and reoccurences: why they occur and how to manage them. Society of Interventional Radiology 28th Annual Scientific Meeting Program, Fairfax, VA: SIR; 2003:67-69.
34. Chrisman HB, Liu DM, Bui JT, et al. The safety and efficacy of a percutaneous closure device in patients undergoing uterine artery embolization. J Vasc Interv Radiol. 2005;16:347-350
35. Andrews RT, Bromley PJ, Pfister ME. Successful embolization of collaterals from the ovarian artery during uterine artery embolization for fibroids: a case report. J Vasc Interv Radiol. 2000;11:607-610.
36. Chrisman HB, West D, Corpuz B, et al. Primary failure of uterine artery embolization: use of magnetic resonance imaging to select patients for repeated embolization. J Vasc Interv Radiol. 2005;16:1143-1147.
37. Pelage JP, Le Dref O, Jacob D, et al. Selective arterial embolization of the uterine arteries in the management of intractable post-partum hemorrhage. Acta Obstet Gynecol Scand. 1999;78:698-703.
38. Andersen PE, Lund N, Justesen P et al. Uterine artery embolization of symptomatic uterine fibroida. Initial success and short-term results. Acta Radiol. 2001;42:234-238.
39. Pron G, Mocarski E, Cohen M, et al. Hysterectomy for complications after uterine artery embolization for leiomyoma: results of a Canadian multicenter clinical trial. J Am Assoc Gynecol Laparosc 2003;10(1):99-106.

Indications
The AneuRx Stent Graft System is indicated for the endovascular treatment of infrarenal abdominal aortic or aorto-iliac aneurysms having: • Adequate iliac/femoral access • Infrarenal nonaneurysmal neck length of greater than 1 cm at the proximal and distal ends of the aneurysm and an inner vessel diameter approximately 10–20% smaller than the labeled device diameter • Morphology suitable for endovascular repair • One of the following: (1) Aneurysm diameter of >5 cm (2) Aneurysm diameter of 4–5 cm which has also increased in size by 0.5 cm in the last 6 months (3) Aneurysm which is twice the diameter of the normal infrarenal aorta.

Contraindications
There are no known contraindications currently associated with this device.

Warnings and Precautions
The AneuRx Stent Graft is intended to prevent rupture of abdominal aortic aneurysms. However, this risk is not completely eliminated. Based on reports received for patients enrolled in all phases of the clinical study, through August 1, 2001, ruptures have occurred in 2/1193 patients (0.167%) during the operative period; in 3/1193 patients (0.251%) within 30 days of the treatment; and in 10/1193 patients (0.838%) greater than 30 days after treatment. The one-year freedom-from-rupture rate for patients enrolled in all phases of the clinical study is 99.5%; the two-year freedom-from-rupture rate is 98.6%; and the three-year freedom-from-rupture rate is 98.5%; and the four-year freedom-from-rupture rate is 98.5%.

The long-term safety and effectiveness of this implant have not been established. All patients with endovascular aneurysm repair must undergo periodic imaging to evaluate the stent graft, aneurysm size and occlusion of vessels in the treatment area. Significant aneurysm enlargement (>5 mm), the appearance of a new endoleak, evidence of perigraft flow, change in aneurysm pulsatility, or migration resulting in an inadequate seal zone should prompt further investigation and may indicate the need for additional intervention or surgical conversion.

Exercise care in the handling and delivery technique to aid in the prevention of vessel rupture. If an AneuRx Stent Graft is placed with less than one centimeter length of non-aneurysmal tissue at the proximal or distal end attachment sites, there is potential for leaking or migration due to inadequate apposition of the stent graft.

Inappropriate patient selection may contribute to poor device performance. Preliminary data indicate that patients with an aortic neck angle >45 degrees may have a higher likelihood of suboptimal outcomes compared to patients with an aortic neck angle <45 degrees. The same data indicate that patients with an aortic seal length of <15 mm and an iliac seal length of <25 mm may also have a higher likelihood of suboptimal outcomes.

This device should only be used by physicians and teams trained in vascular interventional techniques, including training in the use of the device.

Do not use the AneuRx Stent Graft in patients unable to undergo the necessary preoperative and postoperative imaging and implantation studies.

The results of the clinical studies indicated that patients who experience an unsuccessful endovascular repair attempt, and as a result undergo conversion to surgical abdominal aortic aneurysm (AAA) repair, are likely to have increased complications arising from both procedures (*i.e.*, cardiac complications, fever, infection, musculoskeletal complications, neurological complications, pulmonary complications, vascular disease, vessel dissection, wound healing issues and mortality).

The safety and effectiveness of the AneuRx Stent Graft System for the treatment of abdominal aortic aneurysms have not been evaluated in patients:
• With aneurysms pending rupture • With connective tissue disorder • With hypercoagulability • With mesenteric artery occlusive disease • With ilio-femoral, thoracic, or inflammatory aneurysms • With juxtarenal AAA • With pararenal AAA • With suprarenal or thoracoabdominal aneurysms • Who are morbidly obese • Pregnant or nursing • Less than 18 years old • With less than one-year life expectancy.

Always have a vascular surgery team available at institutions performing endovascular grafting in the event that conversion to open surgical repair is required.

Patient Selection, Treatment and Follow-up
Do not use this device in patients having an active systemic infection. Do not use this device in patients with sensitivities or allergies to the device materials. The materials include: polyethylene-terephthalete (PET), nickel, titanium, tantalum, stainless steel, polyetheresterblock-copolymer (Hytrel), polyetherblockamide (Pebax), polyetheretherketone (PEEK), platinum, ethyl cyanoacrylate, polymethylmethacrylate and hydroquinone.

The results of the clinical study indicate that women treated with this device may have a higher mortality rate as compared to their male counterparts.

The use of this device requires administration of radiographic agents. Patients with preexisting renal insufficiency may have an increased risk of renal failure postoperatively.

Proper use of this device requires accurate fluoroscopic imaging. This device is not recommended for patients whose weight exceeds 350 lbs (150 kg) or whose weight may impede accurate fluoroscopic imaging.

Regular follow-up including imaging of the device should be performed every 3 to 6 months for patients in the enhanced surveillance group and at least every 6 to 12 months for patients in the routine surveillance group (see IFU for patient follow-up recommendations). During the recommended follow-up imaging schedule, patients should be monitored for aneurysm size, occlusion of vessels, change in pulsatility, migration, leaks and device integrity.

Additional treatment including endovascular treatment or surgical conversion should be strongly considered in the following cases:
• Aneurysm growth >5 mm (with or without leak) since last follow-up • Change in aneurysm pulsatility (with or without growth or leak) • Persistent endoleak with or without aneurysm growth
• Stent graft migration resulting in an inadequate seal zone.

The results of the clinical study indicate that subjects experiencing reduced blood flow through the graft limbs and/or leaks may be required to undergo secondary interventions or minor surgical procedures.

MRI may be used on the stent graft only under the following conditions: • When used in shielded MRI systems with static magnetic fields of 1.5T or less • Spatial gradient of 450 gauss/cm or less, gradient magnetic fields of 10 Tesla/second or less • A maximum whole body averaged specific absorption rate (SAR) of 1.4 W/kg for 30 minutes of imaging.

Adverse Events
Death, AAA rupture, bleeding, cardiacfailure/infarction, edema, wound healing complications, impotence, pulmonary complications, renal failure, gastrointestinal complications, arterial vascular occlusion and venous vascular occlusion.

Potential adverse events include: arterial and venous occlusion (includes thrombosis and thromboembolism), arterial trauma/dissection/perforation, bleeding, cardiac failure/infarction, central or peripheral nervous system impairment, coagulopathy, death, edema, endoleak, erosion with fistula or pseudo-aneurysm, gastrointestinal complications, graft dilatation, graft migration, graft occlusion, impotence, infection, loss of device integrity (stent fractures, graft wear holes and suture breaks), pulmonary/respiratory complications, renal insufficiency/failure, ruptured vessel/aneurysm, and wound healing complications.

Please reference appropriate product *Instructions for Use* for a more detailed list of indications, warnings, precautions and potential adverse events.

CAUTION: Federal (USA) law restricts this device to sale by or on the order of a physician.

Medtronic
Alleviating Pain · Restoring Health · Extending Life

UC200601633EN 8/05