Technical Results and Effects of Operator Experience on Uterine Artery Embolization for Fibroids: The Ontario Uterine Fibroid Embolization Trial

Gaylene Pron, PhD, John Bennett, MD, Andrew Common, MD, Kenneth Sniderman, MD, Murray Asch, MD, Stuart Bell, MD, Roman Kozak, MD, Leslie Vanderburgh, MD, Greg Garvin, MD, Martin Simons, MD, Cuong Tran, MD, and John Kachura, MD, for the Ontario UFE Collaborative Group

PURPOSE: To document the technical results and spectrum of practice of uterine artery embolization (UAE) for fibroids in the health care setting in Canada. The effects of interventional radiologist's (IR's) experience with UAE on procedure and fluoroscopy time were also investigated.

MATERIALS AND METHODS: The study involved a multicenter prospective single-arm clinical treatment trial and included the practices of 11 IRs at eight university-affiliated teaching and community hospitals. Vascular access with percutaneous femoral artery approach was followed by transcatheter delivery of polyvinyl alcohol (PVA) particles into uterine arteries with fluoroscopic guidance. Technical success, complications, procedural time, fluoroscopy time, and effects of operator experience were outcomes analyzed.

RESULTS: Between November 1998 and November 2000, 570 embolization procedures were performed in 555 patients. UAE was bilaterally successful in 97% (95% CI: 95%–98%). Variant anatomy was the most common reason for failure to embolize bilaterally. The procedural complication rate was 5.3% (95% CI: 3.6%–7.4%). Of the 30 events, three involved major complications (one seizure and two allergic reactions) that resulted in additional care or extended hospital stay. Procedure time and fluoroscopy time averaged 61 minutes (95% CI; 58–63 minutes) and 18.9 minutes (95% CI; 18–19.8) and varied significantly among IRs ($P < .001$; $P < .001$). The average 27% reduction in procedure time (20 minutes; $P < .001$) and 24% reduction in fluoroscopy time (5.1 minutes; $P < .001$) with increasing UAE experience were significant.

CONCLUSIONS: A high level of technical success with few complications was obtained with a variety of operators in diverse practice settings. Increased experience in UAE significantly reduced procedure and fluoroscopy time.

J Vasc Interv Radiol 2003; 14:545–554

Abbreviations: IR = interventional radiologist, PVA = polyvinyl alcohol, UAE = uterine artery embolization

UTERINE artery embolization (UAE) has increasingly been reported as an alternative treatment to hysterectomy for symptomatic fibroids. The results of UAE have been reported as clinical series in several countries including the United States (1–5), France (6–8), and England (9,10). However, these studies involved the experience of a single institution or individual interventional radiologist (IR) and have tended to be retrospective and involve small patient groups.

This study is the first multicenter prospective clinical study of embolization therapy to involve the practices of a large collaborative group of IRs. The overall objectives of this study were to evaluate technical success, tolerability, safety, effectiveness, and durability of this therapy for symptomatic fibroids. The purpose of this paper is to document the technical results and the

From the Department of Public Health Sciences (G.P.), University of Toronto, Toronto; Department of Radiology (J.B., R.K., G.G.), St Joseph's Health Care, London; Department of Medical Imaging (A.C), St Michael's Hospital, Toronto; Department of Medical Imaging (K.S, J.K), Toronto General Hospital, Toronto; Department of Medical Imaging (M.A), Mount Sinai Hospital, Toronto; Department of Diagnostic Imaging (S.B.), Rouge Valley Health System and the Scarborough Hospital, Scarborough; Department Radiology (L.V.), William Osler Health Center, Brampton; Department Medical Imaging (M.S.), Toronto Western Hospital, Toronto; Department Medical Imaging (C.T.), McMaster University Medical Center, Hamilton, Ontario, Canada. Received November 18, 2002; accepted January 15, 2003. The Ontario UFE Trial was funded in part by Boston Scientific Corporation. **Address correspondence to** G.P., Department Public Health Sciences, Faculty of Medicine University of Toronto, 100 College St, Rm 513 Banting Building, Toronto, Ontario, Canada M5G 1L5; E-mail: g.pron@utoronto.ca

None of the authors have identified a potential conflict of interest.

DOI: 10.1097/01.RVI.0000071099.76348.DF

Table 1
Background and Experience of Interventional Radiologists in the Ontario UFE Trial

Interventional Radiologist	Hospital	Fellowship Training (months)	Residency
1	1	12	Montreal, Quebec, Canada
2	2	24	Toronto, Ontario, Canada
3	3	6	Toronto, Ontario, Canada
4	4	24	United Kingdom
5	5	12	London, Ontario, Canada
6	5	12	London, Ontario, Canada
7	6	12	London, Ontario, Canada
8	5	3	London, Ontario, Canada
9	7	12	Vancouver, British Columbia, Canada
10	8	12	Montreal, Quebec, Canada
11	2	12	Toronto, Ontario, Canada

spectrum of practice with respect to fibroid UAE therapy in the health care setting in Canada. The details of practice spectrum that were evaluated include: the hospital setting; equipment; interventional team; and background and experience of the IR. The technical aspects that were studied include: technical success; procedural and fluoroscopic time; materials; procedural complications; and reasons for failure. The effects of IR experience with UAE on procedure and fluoroscopy time was also investigated because the therapy was being newly introduced at these hospitals. This report is based on the procedural details of fibroid UAE performed on 555 women in eight university-affiliated teaching and community hospitals.

MATERIALS AND METHODS

Study Design and Participating Centers

The Ontario UFE Trial was a multicenter clinical study that involved the prospective follow-up of a consecutive series of women undergoing UAE as an alternative to hysterectomy for symptomatic uterine fibroids between November 1998 and November 2000. Treatment was provided by 11 IRs at eight hospitals; seven hospitals were university-affiliated teaching hospitals and one was a community hospital. Approvals for the study were obtained from Institutional Review Boards at all institutions.

Patient Eligibility

The study group included women who were referred to IRs for treatment of symptomatic ultrasound (US)-documented uterine fibroid(s). Symptoms included, but were not restricted to: menorrhagia, pelvic pain, or bulk related symptoms (such as urinary urgency or frequency). Patient age or fibroid size, number, and location were not criteria for exclusion. Although women who wanted to have children were not excluded from the study, they were further informed of the uncertain effects of UAE on conception or carrying to full term. Women with active pelvic infection, undiagnosed pelvic mass, endometrial carcinoma, pregnancy, or renal insufficiency (creatinine levels > 150 μmol/L) were ineligible for the study.

Study Patient Characteristics

Patients were predominantly white (66%) and the mean age was 43 years (range, 18–59 years). More than half of the patients (56%) were married or with regular partners and 50% of patients had one or more children. Thirty-one percent of patients wished to retain their fertility. Fifty-seven percent of patients reported their general health to be very good or better. Heavy menstrual bleeding was reported by 80% of patients. Most patients (70%) had multiple fibroids and a minority of patients had undergone surgical treatment for their fibroids—myomectomy (14%) and endometrial ablation (3%). Pre-UAE uterine and fibroid average volumes were 680 cm^3 (95% CI: 626–734 cm^3) and 293 cm^3 (95% CI: 259–327 cm^3). Mean dominant fibroid length was 8 cm (range, 1–24 cm). The complete details on this cohort have been reported (11).

Interventional Teams

Embolization therapy was provided by 11 IRs in the Departments of Medical Imaging or Radiology. All were fellowship-trained in vascular and interventional radiology and had at least 3 years of experience in peripheral angiography and embolization techniques (**Table 1**). Only two IRs were 100% dedicated to interventional practice. Others had combined practices that included diagnostic imaging. At some teaching hospitals (numbers 3 and 4) fellows occasionally assisted with UAE. The standard personnel for UAE procedures consisted of one IR, at least one nurse, and at least one radiology technologist.

Preprocedural Investigations

All patients underwent a gynecological examination (performed by gynecologists) before UAE to rule out other causes for their symptoms. The procedure, risks, indications, and alternatives were explained to the patient in detail by the IR, after which informed consent was obtained from

Table 1
(Continued)

Fellowship Training (Location)	Years Performing Peripheral Angiography Embolization (Post-fellowship)	Time as Dedicated Interventionalist (%)	Admitting Privileges
Montreal, Quebec, Canada	15	90	No
Boston, MA; Cornell, New York, NY	26	100	Yes
Toronto, Ontario, Canada	11	60	No
Toronto, Ontario, Canada	7	50	No
Duke, Durham, NC; London, Ontario, Canada	11	75	No
London, Ontario; Montreal, Quebec, Canada	13	50	No
Toronto, Ontario, Canada; Detroit, MI	3	50	Yes
Detroit, MI	5	20	Yes
Toronto, Ontario, Canada	15	80	Yes
Montreal, Quebec, Canada	3	60	Yes
Boston, MA	3	100	No

all patients for the treatment and the study. Preadmission blood work and instruction were performed approximately 1 week before treatment. At some sites, patients viewed a video to orient them with the use of a patient-controlled analgesic pump for management of postprocedural pain. Investigations included prothrombin time and international normalized ratio, partial thromboplastin time, complete blood count with platelet count, and serum creatinine. Transabdominal and/or transvaginal US examinations were performed before embolization to document baseline characteristics of the uterus and fibroid(s). Uterine and fibroid (largest) volume measurements were estimated with the equation for an ellipsoid shape ($d1 \times d2 \times d3 \times 0.5233$).

Admission and Preparation

On the morning of the procedure, patients were generally admitted as inpatients, prepared, and brought to Interventional Suites in the Department of Medical Imaging. Antibiotic prophylaxis was routine at four hospitals (numbers 2, 3, 4, and 6) and reserved for patients at higher infection risk at four hospitals (numbers 1, 5, 7, and 8). Routine antibiotic coverage involved 1 g of cefazolin (Ancef; SmithKline Beecham Pharm, Oakville, Ontario) administered intravenously 1 hour before the procedure. Patients who were allergic to penicillin were administered 500 mg vancomycin intravenously (Vancocin; Eli Lilly Canada, Scarborough, Ontario, Canada). Foley catheters were placed by nurses before treatment.

Sedation and Analgesia

Preprocedural analgesics included 30 mg intramuscularly or intravenous Toradol (Ketorolac Tromethamine; Hoffman-LaRoche, Mississauga, Ontario, Canada), 30 mg ibuprofen intramuscularly (Motrin; McNeil Consumer Healthcare, Guelph, Ontario, Canada), 600 mg ibuprofen orally or 50 mg indomethacin (Indocid; Merck Frosst Canada, Kirkland, Quebec, Canada) suppository.

Patients were administered conscious sedation with use of benzodiazepines such as midazolam (Versed; Hoffman-LaRoche) or diazepam (Valium, Roche, Mississauga, Ontario, Canada). Narcotics such as fentanyl citrate (Sublimaze; Abbott Laboratories, St. Laurent, Quebec, Canada), meperidine hydrochloride (Demerol; Abbott Laboratories), or morphine sulfate were used as necessary for analgesia. Epidural anesthesia was administered to 13 patients at one center (number 8). In that protocol, epidural catheters were inserted in the medical imaging suites by anesthesiology and continuous epidural infusions were administered with bupivicaine hydrochloride 0.125% (Sanofi-Synthelab Canada, Markham, Ontario, Canada) and fentanyl citrate 5 μg/mL titrated per pain usually at 8 mL/h. Epidural catheters were removed several hours after the procedure.

Angiography and Arterial Access

Digital subtraction angiography was performed with a variety of C-arm equipped units capable of road mapping and pulsed fluoroscopy (except at institution number 3). Patient vital signs, including oxygen saturation, heart rate, and blood pressure, were monitored by pulse oximetry, electrocardiography (except at institution number 3), and a blood pressure cuff. During the procedure, patients were administered an intravenous solution of 5% dextrose solution or 0.45% saline running at 100–120 mL/h.

With local anesthetic and aseptic technique, hemostatic sheaths were placed in the common femoral artery through which a 4- or 5-F selective single-hole catheter was used for selective catheterization of the anterior division of the internal iliac and subsequently the left and right uterine arteries. Two IRs (numbers 3 and 11) did not routinely use a hemostatic sheath. The catheter was then advanced into the horizontal portion of the uterine artery and satisfactory position for safe embolization was confirmed with angiography. When required, pelvic flush arteriography with nonionic contrast material was performed to map the origin, size, and course of the uterine, ovarian (if abdominal aortography was performed), and other pelvic arteries. Microcatheters were not routinely used but were reserved for cases with difficult uterine artery access. In most cases, both uterine arteries were

catheterized from the right femoral approach. The ipsilateral uterine artery was catheterized with a variety of techniques, including direct catheterization and formation of a Waltman loop (12).

Embolization

The primary embolic agent was polyvinyl alcohol (PVA) particles 355–500 μm in size and packaged as 1 cc per vial (Contour; Target Therapeutics, Boston Scientific Corporation, Mississauga, Ontario, Canada or Ivalon; Cook, Stouffville, Ontario, Canada). One IR (number 4) routinely used a larger particle size (500–710 μm) for embolization. Embolic material was hand mixed in a syringe with saline and nonionic contrast material in a ratio dependent on contrast agent density. The slurry was then carefully injected to prevent reflux out of the uterine artery. Embolization proceeded until a standing column of contrast in the uterine artery was observed or contrast refluxed toward the uterine artery origin or into the internal iliac artery.

Four IRs (numbers 1, 5, 6, and 8) routinely used supplemental metal coils. Protocol for IR number 1 was to inject pledgets of absorbable gelatin sponge (Gelfoam; Pharmacia & Upjohn, Mississauga, Ontario, Canada) when endpoints with PVA particles had been established, followed by placement of a single metal coil per side (Tornado; Target Therapeutics, Boston Scientific). Protocol for the other three IRs (numbers 5, 6, and 8) was to place two metal coils per side (Gianturco; Cook, Stouffville, Ontario, Canada) with gelatin sponge pledgets sandwiched between. After embolization, the sheath and catheter were removed and hemostasis at the puncture site was obtained by direct compression.

After UAE, morphine sulfate was administered through a patient-controlled analgesic pump. The anesthesiology pain service programs in the hospitals were responsible for the patient-controlled analgesic pump. Patients allergic to morphine were switched to meperidine-based pumps. Nausea was managed by metoclopramide (Reglan; Wyeth-Ayerst, St. Laurent, Quebec, Canada), dimenhydrinate (Gravol; Carter Horner, Mississauga, Ontario, Canada), and/or ondansetron (Zofran; Glaxo Wellcome, Mississauga, Ontario, Canada). Patients recovered in the postanesthesia recovery room for 1 to 2 hours after UAE and were then transferred to the gynecology ward and admitted overnight.

At three hospitals (numbers 6, 7, and 8), patients were admitted to the sole supervision of the IR. Patients who underwent epidural anesthesia at one hospital (number 8) were discharged the same day, usually 4–5 hours after the epidural was stopped, if they were ambulatory, tolerating oral medications, and there were no complications. Foley catheters were removed 8 hours after the procedure and, on the following day, intravenous lines were removed when the patient was tolerating clear fluids. Patients were discharged the next morning if ambulatory and tolerating oral intake. At discharge, patients were given prescriptions for ibuprofen, codeine, or oxycodone with acetaminophen (Percocet; Du Pont Pharma, Mississauga, Ontario, Canada) and stool softeners.

Follow-up was performed by researchers through a central university coordinating site. Telephone interviews were performed by trained interviewers with prepared scripts at 2 weeks, 3 months, 6 months, and planned annually for 5 years. Pelvic US examinations were also scheduled after embolization therapy at intervals of 3 months, 6 months, and annually for 5 years.

Data Management and Analysis

Data forms on technical information were completed at the end of each procedure by the IR and forwarded to research staff at the central coordinating site. Information collected on the procedure included: operator; procedure date; procedure start and finish time; fluoroscopy time; material used, including contrast agent; catheters; embolic material(s); medications; and procedural complications. Procedure duration was defined as the start time from arterial puncture to the end time at puncture closure and catheter withdrawal. Fluoroscopy time was automatically generated by angiography units and was recorded by the technologist.

Technical success was defined as bilateral embolization, verified by fluoroscopy as stasis in the uterine artery trunk and nonfilling of the uterine artery on postembolization angiography. The effect of experience on technical performance was investigated by comparison of the outcomes in the early experience, defined as the first 20 consecutive procedures, with later experience, defined as the next 20 consecutive procedures. A cut-off point of 20 procedures was based on study results reported by Andrews et al (13), who reported that fluoroscopy time stabilized after 20 procedures. Complication events were classified based on criteria established by the Standards of Practice Committee for the Society of Cardiovascular and Interventional Radiology (SCVIR) (14). Minor complications included events that involved nominal therapy of no consequence such as hematomas that resolve spontaneously. Major complications included events that involved minor therapy with a short hospitalization, major therapy with an unplanned increase in care and prolonged hospitalization (48 hours), or permanent adverse sequelae or death.

Descriptive measures such as means, medians, and 95% CIs were used to detail variation in procedural technical details such as complication rates, procedure time, fluoroscopy time, and contrast volume. Complication rates included events that occurred during the first and second attempted procedures. Exact CIs for rates were based on the binomial distribution with use of StatXact software (Cytel Software, Cambridge, MA). Differences in procedure time and fluoroscopy time between two groups were evaluated by Student *t* test and between more than two groups by one-way analysis of variance. Statistical significance was determined by *P* values of 0.05 or less and all tests were two sided.

RESULTS

Technical Success

In total, 570 UAE procedures were performed on 555 women by 11 IRs (**Table 2**). The majority were elective procedures. Five procedures (0.9%) were performed because of urgent or emergent situations, including four procedures for fibroid related vaginal

Table 2
Technical Results of Embolization Therapy

Interventional Radiologist	Hospital	Bilateral Embolization		Unilateral Embolization	Bilateral Failure	Total Cases	Total Procedures
		At first procedure	At second procedure*				
1	1	190	6	5	2	203	209
2	2	64	1	—	—	65	66
3	3	49	1	1	—	51	52
4	4	43	3	1	—	47	50
5	5	40	—	—	—	40	40
6	5	38	1	2	—	41	42
7	6	38	—	2	—	40	40
8	5	31	3	2	1	37	40
9	7	13	—	—	—	13	13
10	8	12	—	1	—	13	13
11	2	5	—	—	—	5	5
Total		523	15	14	3	555	570

* Cases undergoing successful bilateral emoblization at the second procedure had an earlier first procedure.

hemorrhage and one procedure performed after an aborted hysterectomy (because of extensive adhesions from previous myomectomies). The total number of UAEs performed by individual IRs ranged from 5 to 203; with eight IRs performing more than 25. UAE was bilaterally successful in 97% of patients (538 of 555 patients; 95% CI: 95%–98%]. Bilateral success was achieved in 523 patients (94%) on the first attempt and 15 patients (3%) on the second attempt.

Failure of bilateral embolization at the first attempt occurred in 32 patients (5.8%) and resulted in three different outcomes (**Table 3**): successful second uterine artery embolization on the second attempt in 15 patients (group 1), unilateral embolization in 14 patients (group 2), and bilaterally unsuccessful embolization in three patients (group 3).

Table 3
Reasons for Unsuccessful Bilateral Embolization at First Procedure

	Group 1	Group 2	Group 3	
	Bilateral Embolization at Second Procedure	Unilateral Embolization	Bilateral Failure	Total
1. Unable to catheterize; small tortuous uterine artery, steep angles	13	2	3	18
2. Uterine artery absent or unable to locate	—	10	—	10
3. Allergic response	2	—	—	2
4. Perforation uterine artery	—	2	—	2
Total	15	14	3	32

The most common reason for failure to bilaterally embolize at the first attempt was for anatomical variation (n = 18). Uterine arteries were either too small or too tortuous to catheterize or the vessel origin angles were too tortuous or steep for access. However, most of these patients (13 of 18 patients) were successfully treated with a second procedure, usually with a contralateral approach. In one case, previous treatment with lupron depot (Leuprolite Acetate for Depot Suspension; Abbott Laboratories**)** resulted in reduced arterial diameter that prevented access and necessitated procedure termination. The patient was successfully embolized at the second attempt after a 2-month wait to allow for the uterine arteries to normalize. Allergic reactions occurred in two cases, one involved classic signs of anaphylaxis. In both cases, patients returned at a later date and were successfully embolized after premedication and use of alternate contrast agents.

Of the 14 patients with unilateral embolizations (group 2), the major cause was absence or nonidentification of the uterine artery (five right, five left). In three of these patients (one right, two left) a large ovarian artery was noted to be the dominant source of uterine vascularity. In the other four patients, perforations in the right uterine artery prevented embolization in two patients and vessel tortuosity prevented catheterization in two patients. Two other patients in this group had previously undergone myomectomy and the uterine artery may have been damaged or ligated during surgery.

Procedural Complications

The overall procedural complication rate was 5.3% (95% CI: 3.6%–7.4%). Complication events (n = 30) that occurred during embolization are outlined in **Table 4**. The most common complications were angiography related and included minor reactions to contrast material (n = 10) and hematomas (n = 4). Perforations occurred in four patients; three involved the uterine artery and one involved the obtu-

Table 4
UAE Procedural Complications

	N	(%)
Minor contrast reaction	10	1.8
Anaphylactoid response*	2	0.4
Hematoma	4	0.7
Vasovagal attacks, bradycardia	5	0.9
Pseudo aneurysm	1	0.2
Hypertension	1	0.2
Perforation uterine artery	3	0.5
Perforation obturator branch	1	0.2
Arthritic flare	1	0.2
*Seizure	1	0.2
Leg numbness	1	0.2
Total	30	5.3

* Complications were classified as major because of resultant extra care and extended length of hospital stay.

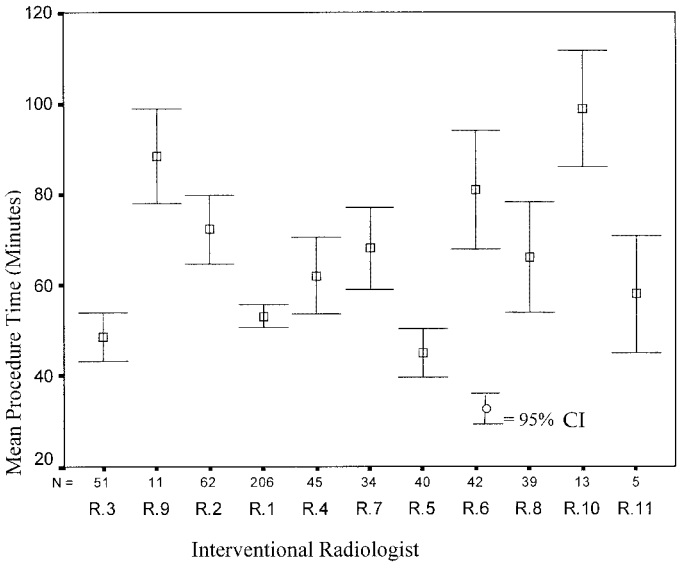

Figure 1. UAE procedure time by interventional radiologist.

rator artery (successfully treated with two platinum coils). Perforations in the uterine artery prevented complete embolization in two patients. Blood pressure decreased in five patients and increased in one patient. One patient experienced numbness in her leg after epidural anesthesia and was kept overnight for observation.

Of the 30 immediate complication events, three (0.5%; 95% CI: 0.1%–1.5%) were major complications that resulted in extra care or an extended hospital stay. One woman experienced multiple seizures approximately 10 hours after UAE and was further hospitalized for 3 days for treatment and observation. Her embolization had been uneventful, there had been no anaphylactoid signs or reactions during or just after the procedure. She did not have a history of seizures and her medical history was uneventful. Her seizures were controlled with phenytoin (Dilantin; Parke-Davis, Scarborough, Ontario, Canada) and she had no further neurologic sequelae at 3- and 6-month follow-up.

Allergic reactions were serious in two cases. The first case involved an anaphylactic response. After accessing the right internal iliac artery, 1.5 to 2 mL of iodixanol (Visipaque 270; Nycomed Amersham, Oakville, Ontario, Canada) was injected. The patient became flushed and developed itchiness in the throat and palms. Her pulse increased to 110 and blood pressure decreased to 93/54 mm Hg. She was given oxygen by mask, a 500 mL bolus of normal saline and 0.4 mL 1/1000 epinephrine subcutaneously. Symptoms resolved within 15 minutes. At 20 minutes, the patient developed confluent hives centered on the pelvis that became more scattered with increasing distance from the pelvis and other than pruritis was asymptomatic. Hives slowly faded after administration of 50 mg intravenous diphenhydramine HCI (Benadryl; Warner-Lambert, Scarborough, Ontario, Canada) and recovery was uneventful.

A second embolization was successfully performed 3 weeks later. The patient was given prophylaxis with three oral doses of prednisone 50 mg and one dose 50 mg intravenous diphenhydramine HCI before the procedure. Alternate contrast agents including 20 mL Gadopentetate dimeglumine (Magnevist, Princeton, NJ) and 40 mL CO_2 were used. In the recovery room, 30 minutes after the procedure, the patient developed nausea and mildly decreased blood pressure of 115/68 that responded to 0.6 mg intravenous atropine and 50 mg intravenous dimenhydrinate. Recovery was otherwise uneventful.

The second case involved an unusual allergic type reaction that occurred early after a small volume test injection of iohexol (Omnipaque 300; Nycomed Amersham, Oakville, Ontario, Canada). The patient became flushed "saw stars, felt light headed, had chest heaviness and had difficulty breathing. Pulse increased to 124 and blood pressure was 180/85. The patient was turned on her side and oxygen and a 250 mL bolus of normal saline was administered. Epinephrine was not administered because symptoms rapidly resolved. The patient did not have typical signs of contrast reaction—urticaria, lip or tongue swelling, or bronchospasm. Two weeks later the procedure was repeated with iodixanol contrast agent. Prophylaxis included three doses of 50 mg prednisone orally and 50 mg diphenhydramine HCL intravenously. Other than one hive, the procedure was uneventful and was successfully completed.

Procedure Time

Procedure time for the group averaged 61 minutes (95% CI: 58–63 minutes) and the median time was 55 minutes. The average procedure time for bilaterally successful cases at the first attempt was 59 minutes (95% CI: 57–61 minutes) and for unsuccessful cases was 88 minutes (95% CI: 75–100 minutes). The longer time for unsuccessful cases (mean, 29 minutes; 95% CI: 18–39 minutes) was statistically significant ($P < .001$). Procedure time also varied significantly ($P < .001$) among IRs from 45 minutes to 99 minutes (**Fig 1**).

Overall, the average time for procedures performed in early experience was 75 minutes (95% CI: 70–80 minutes) and in later experience was 55

Table 5
Effects of Interventional Radiologist's Experience on UAE Procedure Time

Interventional Radiologist	Early Experience* Time (Minutes)		Late Experience† Time (Minutes)		Change in Time (Minutes)		
	Mean	95% CI	Mean	95% CI	Mean	Change (%)	P‡
1	66	58–73	58	50–67	8	12	ns
2	100	87–112	59	51–67	41	41	<.001
3	53	43–63	43	35–50	10	19	ns
4	64	53–75	62	52–71	2	3	ns
5	50	42–59	40	33–46	10	20	.05
6	104	81–128	60	53–68	44	42	.001
7	67	50–83	70	61–78	3	4	ns
8	76	55–97	55	45–68	21	28	ns
9	88	78–99					
10	99	86–112					
11	58	45–71					
Group	75	70–80	55	52–59	20	25	<.001

* First twenty consecutive cases.
† Next twenty consecutive cases.
‡ Student t-test.
ns = not significant.

minutes (95% CI: 52–59 minutes). The average difference in procedure time, 20 minutes (95% CI: 13–26 minutes) representing a 25% reduction in procedure time, was significant ($P < .001$). Of the eight IRs who performed 40 or more procedures, average time decreased for six, ranging from 12% (8 minutes) to 42% (44 minutes) reduction. Procedure time was significantly reduced for two IRs (numbers 2 and 6) (**Table 5**).

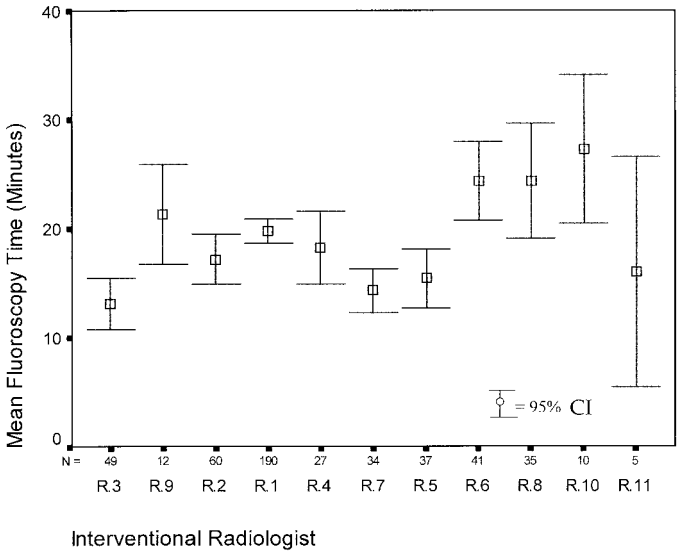

Figure 2. UAE fluoroscopy time by interventional radiologist.

Fluoroscopy Time

Fluoroscopy time for the group averaged 18.9 minutes (95% CI: 18.0–19.8 minutes). The average fluoroscopy time for cases that were bilaterally successful at the first attempt was 18.1 minutes (95% CI: 17.3–18.91 minutes) and for cases that were not successful at the first attempt was 31.5 minutes (95% CI: 24.3–38.6 minutes). The longer time for unsuccessful cases, on average 13.4 minutes (95% CI: 5.9–20.8 minutes), was significant ($P < .001$). Fluoroscopy time also varied significantly among IRs from 15 minutes (95% CI: 13–18 minutes) to 27 minutes (95% CI: 21–23 minutes) ($P < .001$) (**Fig 2**).

Overall, the average fluoroscopy time for procedures performed in early experience was 21.3 minutes (95% CI: 19.4–23.3 minutes) and in later experience was 16.2 minutes (95% CI: 14.8–17.5 minutes). The shorter fluoroscopy time with increased experience, 5.1 minutes (95% CI: 2.7–7.6 minutes) or 24% reduction in time, was significant ($P < .001$). Of the eight IRs who performed 40 or more procedures, average fluoroscopy time decreased with six IRs ranging from a 4% (2.7 minutes) to a 42% (8.1 minutes) reduction. Fluoroscopy time was significantly reduced for two IRs (numbers 2 and 6) (**Table 6**).

Procedural Materials

The majority of embolizations were performed with a variety of 4- and 5-F catheters in 42% and 53% of the procedures ($N = 570$), respectively. A right femoral approach was used in 535 procedures (94%). Microcatheters, usually the Fas Tracker 325 (Boston Scientific, Target Therapeutics), were used in 28 procedures (5%). Vasodilators, such as intraarterial nitroglycerin or sublingual nifedipine, were used to

Table 6
Effects of Interventional Radiologist's Experience on UAE Fluoroscopy Time

Interventional Radiologist	Early Experience* Time (Minutes)		Late Experience† Time (Minutes)		Change in Time (Minutes)		
	Mean	95% CI	Mean	95% CI	Mean	Change (%)	P‡
1	15.6	8.9–22.2	16.8	13.7–19.8	1.2	8	ns
2	24.9	19.5–30.4	14.1	11.6–16.7	10.3	42	<.001
3	12.9	9.0–17.0	12.4	9.6–15.3	0.5	4	ns
4	18.9	7.4–30.4	18.9	13.6–24.2	0.0	0	ns
5	17.7	14.1–21.4	13.0	8.9–17.2	4.7	26	ns
6	28.9	22.2–35.5	20.8	17.3–24.3	8.1	28	.03
7	15.6	12.5–18.7	12.9	10.2–15.7	2.7	17	ns
8	28.2	18.8–37.6	21.1	14.6–27.7	7.1	25	ns
9	21.3	16.8–25.9					
10	27.3	20.5–34.1					
11	16.0	5.4–26.6					
Group	21.3	19.1–23.3	16.2	14.8–17.6	5.1	26	<.001

control spasm in 23 procedures (4%), primarily by two IRs in their early cases. All IRs used nonionic contrast agents. The average volume injected per procedure was 147 mL (95% CI: 141–154 mL). Various contrast agents, including Omnipaque 300 (Nycomed Amersham), Visipaque 270 (Nycomed Amersham), Isovue 300 (Iopamidol, Bracco Diagnostics) and Omnipaque 240 (Nycomed Amersham), were used in 60%, 18%, 16%, and 6% of the procedures, respectively. PVA particles sized 355–500 μm were used in 501 procedures (88%). The average total number of vials used per case was 3.6 (median, 3.3; range, 1–10). PVA particles sized 500–710 μm were used in 50 procedures by one IR (number 4). The average total number of vials used per case was 7.4 (median, 6.5; range, 2–26). Supplemental metal coils were used in 308 procedures (54%).

DISCUSSION

The objectives of this report were to document the spectrum of practice and technical results for UAE therapy for symptomatic fibroids in a collaborative multicenter setting (Ontario UFE Trial). Examination of the procedural variation in a new and evolving therapy is a useful method to identify the parameters to be used to define the limits of practice. It is also a useful method to identify aspects of the technique that are contentious and based more on personal preference than objective evidence. This multicenter collaborative group included a diverse spectrum of interventional practice. Recruitment to the different centers did vary and was mostly attributable to the varied time of application submissions and approval processes from their Ethics Review Boards. Despite this, most IRs had performed 40 or more procedures during the study.

The high degree of technical success, 97% reported in this trial agrees with results reported in American (1–4) and European (7,8,10) studies and is also higher than the suggested 95% threshold of success for embolic therapies established by the SCVIR guidelines (15). The main reason for failure to bilaterally embolize at the first attempt (ie, difficulties in catheterizing small or tortuous arteries) has also been reported by others: Siskin et al (2) (2%; 1 of 49); Hutchins et al (5) (0.7%; 2 of 305); Ravina et al (6) (5%; 4 of 80); Braude et al (16) (2.5%; 6 of 200) and McLucas et al (17) (1.8%; 3 of 167). Although difficulty in accessing arteries was the most common reason for failure in this series, cases were usually successfully embolized at the second attempt. One case in this trial that involved previous treatment with Lupron was an avoidable failure. Use of hormones before UAE has also been reported by others (1,6,18) as a cause for embolization failure. Because of its effects on the uterine arteries, it is recommended that medical therapy should be discontinued several weeks before embolization therapy.

In some cases, variant anatomy with arteries that are congenitally absent or traumatically damaged made it impossible to complete bilateral embolization. In this study, single uterine arteries were identified in 10 of 555 cases (1.8%). Two of these had previous myomectomies. Absent uterine arteries have also been reported by Hutchins et al (5) (1.6%; 5 of 305) and by Kirsch et al (19) (1.6%; 12 of 746) in a review of experience of three IRs. However, damage to uterine arteries can also occur during embolization in some cases, resulting in incomplete embolizations. In this study, the rate of 0.5% (3 of 555 cases) was lower than that reported by others (5,8).

Vasospasm can also be a cause of technical failure. Spasm can result in restricted blood flow, limiting the flow of embolic material to distal regions of smaller vessels and potentially resulting in incomplete or less effective treatment. Spasm was not systematically reported in this study but Pelage at al (18) noted vasospasm in 26% of cases (97 of 197) that prevented embolization in 3% of cases (6). Brunereau et al (8) also reported vasospasm as a significant problem in 10% of cases (6 of 58). The majority (5 of 6) of those cases were treated with the use of microcatheters. Occurrence of vasospasm appears to be as variable as the approaches to prevent or treat it. Options include waiting until the spasm resolves, catheterizing past the spasm with a hydrophilic wire, use of a microcatheter, or treatment with vasodilators. Some IRs early in this trial used

vasodilators but, because of subsequent incidents of vasovagal attacks and hypotension, the practice was discontinued. Microcatheters were used infrequently (5%) in this series, in keeping with the low rates reported in European (Pelage et al (7), [6%; 5 of 80], Brunerau et al (8), [11%; 6 of 53]) trials. While this variability may be due to individual preference, institutional cost constraints may also play a role.

Nontarget embolization is an important risk consideration for those providing or undergoing UAE. In this trial, the ovarian artery was noted to be the major uterine vascularity supply in several cases. Vascular supply to other regions of the bladder, rectum, or vagina in association was also noted in some of these cases. Unilateral embolization was performed in these cases because of a concern with disrupting ovarian supply. Although the rich network of communicating vessels (20) in the pelvis offers some protection, judgment, experience and detailed knowledge of pelvic anatomy is required to ensure that inadvertent embolization of nontarget organs does not occur. These risks should be discussed with the patient before embolization as part of the informed consent.

Procedural complications during UAE were uncommon and in most cases minor. Only three were classified as major and, although each required additional care and increased hospital stay, none involved any subsequent clinical sequelae. Anaphylactic reactions to iodinated contrast materials occur infrequently (21). In this trial, two procedures were abandoned because of anaphylactic reactions. However, both cases were successfully managed at a later date by premedicating the patients and using alternate contrast agents. Gadolinium use to supplement CO_2 angiographic techniques, including UAE, has been reported (22,23). Previous contrast material reactions therefore, may not be an absolute contraindication for UAE, given the successful management of patients.

Although the training standards for competency in UAE has been established at 25 procedures for fibroids by the SCVIR (15), the authors believe that it was reasonable to explore the effects of experience based on 20 procedures. The decision was also based on study results by Andrews et al (13), who reported that fluoroscopic times during fibroid embolization had stabilized after 20 procedures. A cut point of 20 procedures also allowed the comparison of experiences of a greater number of IRs. Both procedure and fluoroscopic time are reflections of technical experience. Procedures times reported in this trial were lower that those reported by others, even though embolization was performed with a single access site. In a review of technical outcomes after UAE, median procedure times were higher for both European (87 minutes) and American (74 minutes) studies than for this Canadian trial (55 minutes) (24). The longer procedure time in the American studies can be explained to some extent by the greater use of microcatheters, 55% versus 5% in this study. However, the 14% microcatheter use in the European studies was closer to usage in this study but their procedure time was even greater than the American studies. Other factors, such as operator experience or case differences, may also explain some of these differences.

Experience was found to have a marked affect on procedure time in this trial. With experience, procedure times decreased significantly by 20 minutes. With some IRs, the learning curve was even steeper with procedure times decreasing by 44 minutes, which represented a 42% reduction. It would seem that IRs in this study, despite having several years of experience in angiographic and embolic techniques before UAE, continued to increase their knowledge of female pelvic vascular anatomy.

Fluoroscopy time during UAE procedures is an important consideration because the ovaries are in the fluoroscopic field during the procedure. In this study, the average fluoroscopy time (18.9 minutes) was also lower than those reported by others: Andrews et al (13) (30.6 minutes for 35 cases) and Nikolic et al (25) (21.9 minutes for 20 cases). Significant decrease in fluoroscopy time was also noted in this study with increased experience. The decrease in this trial (21.3–16.2 minutes) closely paralleled the decrease with experience reported by Andrews et al (13).

With UAE, as with any new and evolving therapy, there are technical aspects that are opinion or preference based. The use of different embolic agents, types, and sizes continues to be a matter of debate. There is no comparative evidence to suggest that outcomes of embolization therapy differ with embolic particle size. In general, the short-term results of studies (2,6–8,10) that used smaller embolic particles ($\leq$355–500 μm) are similar in terms of fibroid reduction and symptom relief to the studies (1,3,4) that used larger embolic particles (500–710 μm). There is some thought that smaller particle size may be associated with more ischemic pain, but there have been no studies that confirm this impression.

The use of secondary embolic agents, such as gelfoam and metal coils, is also a source of debate. Some IRs used metal coils routinely because of the ease in determining the technical endpoint. Although the angiographic endpoint used in this study was complete stasis in the uterine artery trunk, it is still not generally known how much or for how long a period vascular occlusion is needed to produce adequate fibroid ischemia and cell death. Use of coils increases the cost of the procedure and prevents reembolization at a later date if it becomes necessary. Therefore, their use is probably not supported unless they prove to be more effective or produce results that are more durable. Further follow-up of this trial cohort is planned to determine if the use of metal coils or embolic particle size influences the degree of fibroid reduction or symptom improvement.

Acknowledgments: The trial represents the collaborative efforts of members of the Ontario UFE Collaborative Group and consists of the following individuals and institutions: Dr. Gaylene Pron, Department Public Health Sciences, University of Toronto, Toronto, Ontario. Dr. Andrew Common, Dr. Jane Wall; Department Medical Imaging, St. Michael's Hospital, Toronto, Ontario. Dr. Anthony Cecutti, Dr. Jorzy Cupryn, Dr. Adolmo Martoglio, Dr. Paul McCleary, Dr. Eva Mocarski, Dr. Donna Steele, Dr. Karen Tessler, Department Obstetrics and Gynecology, St. Michael's Hospital, Toronto, Ontario. Dr. John Bennett, Dr. Roman Kozak, Dr. Greg Garvin, Department Radiology, St. Joseph's Health Care, London, Ontario. Dr. George Vilos, Department Obstetrics and Gynecology, St.

Joseph's Health Care, London, Ontario. Dr. Stuart Bell, Department Diagnostic Imaging, Rouge Valley Health Systems and the Scarborough Hospital, Scarborough, Ontario. Dr. Jennifer Blake, Dr. Deborah Butler, Dr. Rose Kung, Dr. Michael Shier, Department Obstetrics and Gynecology, Sunnybrook and Women's College Health Sciences Center, Toronto, Ontario. Dr. Marsha Cohen, Center for Research in Women's Health; Sunnybrook and Women's College Health Sciences Center, Toronto, Ontario. Dr. Murray Asch, Department Medical Imaging, Mount Sinai Hospital, Toronto, Ontario. Dr. Peter Hawrylyshyn, Dr. Nick Leyland, Dr. Michael Sved, Department Obstetrics and Gynecology, Mount Sinai Hospital, Toronto, Ontario. Dr. Terry Colgan, Pathology and Laboratory Medicine, Mount Sinai Hospital, Toronto, Ontario. Dr. Kenneth Sniderman, Dr. John Kachura, Department Medical Imaging, Toronto General Hospital, Toronto, Ontario. Dr. Martin Simons, Department Medical Imaging, Toronto Western Hospital, Toronto, Ontario. Dr. Leslie Vanderburgh, Department Radiology, William Osler Health Center, Brampton, Ontario. Dr. Cuong Tran, Department Medical Imaging, McMaster University Medical Center, Hamilton, Ontario.

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