Long-Term Outcome of Uterine Artery Embolization of Leiomyomata

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OBJECTIVE: To determine the long-term outcome from uterine artery embolization for leiomyomata.

METHODS: In a prospective study, 200 consecutive patients treated with uterine embolization were each followed for 5 years. Outcome, including symptom status compared with baseline, reinterventions, menstrual status, and satisfaction were recorded. Summary statistics were used to report baseline characteristics and outcome at each interval. Predictors of subsequent interventions, failure, and satisfaction with treatment were analyzed using logistic regression and Cox proportional hazards models. Failure was defined as subsequent hysterectomy, definitive myomectomy, repeat embolization, or failure of symptom improvement at the patient's final follow-up interval.

RESULTS: Of the 200 patients initially treated, 5-year follow-up was completed in 182 (91%), with 18 patients missing. At 5 years after treatment, 73% had continued symptom control, whereas 36 (20%) had failed or recurred. There had been 25 hysterectomies (13.7%), 8 myomectomies (4.4%), and 3 repeat embolizations (1.6%). Long-term failure was more likely in those not improved at 1 year (relative risk [RR] 5.73; 95% confidence interval [CI] 2.32–14.12, $P < .001$) and in those with baseline leiomyoma volumes greater than the median (RR 2.18; 95% CI 1.05–4.51, $P = .036$). After adjustment, patients in the first tertile of leiomyoma volume reduction (≤ 30.5%) were 3 times more likely to be dissatisfied with outcome compared with women in the third tertile (≥ 56.3% volume reduction) (RR 3.23; 95% CI 1 07–9.81, $P = .037$).

CONCLUSION: Uterine embolization provides durable symptom relief for most patients, with a 25% chance of failure of symptom control or recurrence over the course of a 5-year follow-up.

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LEVEL OF EVIDENCE: II-3

Uterine artery embolization first was reported for the treatment for leiomyomata in 1995.[1] Since that time, there has been rapid growth in the use of this treatment, and there has been considerable research into its outcome. Although it has become recognized as an effective therapeutic alternative to hysterectomy and myomectomy,[2] there are remaining questions regarding its long-term outcome. Most published studies have reported outcomes in the first 12 months,[3–5] but as of yet there are few long-term studies. The longest follow-up in a published study in the English literature to date was 3 years in a retrospective comparison of myomectomy and embolization by Broder et al.[6]

We began a study assessing the outcome from uterine embolization in 1997 and treated 200 consecutive patients, with outcome data collected prospectively. The initial results of this group of patients at 12 months after therapy have been reported previously.[7] In that report, 90% of patients had improved menstrual bleeding and 91% had improved pain and pressure (bulk symptoms) at 12 months. The follow-up interval in that initial report ranged from 12 minimum up to 21 months. During that interval, there was reintervention in 10.5% of patients. These patients have now completed 5 years follow-up, and their outcomes are presented here. The intent of this phase of the study is to estimate the durability of symptom control, the rate of reintervention, and the level of long-term patient satisfaction. In addition, we hoped to determine predictors of long-term satisfaction and, conversely, the predictors of failure.

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METHODS

Patients enrolled in this study were treated between July 1997 and December 1999 and represent the first 200 consecutive patients treated at our center. The institutional review board approved this protocol and each patient gave her informed consent.

All patients enrolled had uterine leiomyomata and symptoms associated with them. As defined in our previous report,[7] patients must have had 1 or more of the following symptoms: 1) Heavy menstrual bleeding with or without anemia; 2) Pelvic pain or pressure, or back, flank, or leg pain caused by leiomyomata; 3) Urinary frequency or other bladder symptoms caused by compression of the bladder by leiomyomata or compression of the ureters with hydronephrosis. All but heavy menstrual bleeding were grouped as pain and pressure symptoms. Exclusion criteria included current pregnancy or a suspicion of uterine, ovarian, or cervical cancer. In addition, patients must have failed, refused, or not been suitable candidates for medical therapy. In the initial 50 patients, our protocol for patients aged less than 35 years or those who wished to maintain their fertility required that all therapies had to have been exhausted short of hysterectomy or repeat myomectomy in those patients with prior myomectomy. After our 50th patient, we altered our protocol (with institutional review board approval) to treat patients who wished to maintain their fertility if 1) they had failed medical therapy and 2) if their only remaining option was extensive myomectomy (resection of large and deep intramural leiomyomata), repeat myomectomy, or hysterectomy. Anatomic exclusion criteria for all patients included those with pedunculated submucosal leiomyomata that were hysteroscopically resectable and those with greater than 24 weeks size uterus.

Each subject had either a pelvic ultrasound or magnetic resonance imaging (MRI) study of the pelvis, although after the 14th patient, only MRI studies were obtained. The imaging studies were used to confirm the diagnosis of leiomyomata and to provide dimensions for the uterus and the largest (dominant) leiomyoma, as well as its position in the uterus. The number of leiomyomata was estimated and grouped in the following categories: single, 2–5, 6–10, or more than 10. Follow-up MRI was obtained at 3 months after embolization, and the same dimensions were again obtained. Patients were also offered the option of an additional follow-up MRI at no charge 12 months after therapy. Volumes of the dominant leiomyoma and uterus both before and after treatment were calculated using the formula for a prolate ellipse ($L \times W \times D \times .5233$).

Bilateral embolization was performed in each case. Polyvinyl alcohol particles (500 to 710 m size) (Contour, Boston Scientific, Boston, MA; Ivalon, Cook Inc., Bloomington, IN; Trufill, Cordis, Miami, FL) were embolized into each uterine artery until the leiomyoma vasculature was occluded and there was slow flow or near stasis in the main uterine artery. No supplemental embolics were used. The patients received routine postoperative care. The recovery after embolization and any subsequent complications were reported in our earlier report.

Symptom change was recorded by self-administered questionnaire at 3, 12, 24, 36, 48, and 60 months after treatment. If there was no response after 2 mailings, the patient was contacted by phone and the questionnaire completed by interview by a research assistant. The questionnaire (which was not validated) inquired about the regularity of menstrual cycles, and the change in menstrual bleeding and pain and pressure symptoms. To rate the change in symptoms, the scale ranged form -5 (markedly worse) through -3 (moderately worse) to -1 (slightly worse) to 0 (no change) to $+1$ (slightly improved) to $+3$ (moderately improved) to $+5$ (markedly improved). For satisfaction, appropriate corresponding labels were used on the same scale -5 (very dissatisfied) to $+5$ (very satisfied).

At each follow-up interval, the patient was asked about intervening gynecologic interventions; specifically, had any of the following occurred: hysterectomy, myomectomy, dilatation and curettage, hysteroscopic resection of leiomyomata, endometrial ablation, repeat embolization, or other. Of these, major interventions were defined as a hysterectomy, a definitive myomectomy, or repeat embolization. A definitive myomectomy was either an abdominal myomectomy of the major leiomyoma or leiomyomata present or a hysteroscopic resection of a sole submucosal leiomyoma. Once a patient had a major intervention, they were censored from further follow-up in the study. A "failure" was any patient who had a major intervention or who was not improved at their final follow-up.

Data were analyzed using SPSS 11.0 software (SPSS Inc., Chicago, IL). All P values reflect the results of a 2-tailed test ($\alpha = 0.05$). Univariate analyses were performed to examine the distribution of each baseline and outcome measure. Continuous baseline factors were dichotomized into categories based upon median values. Logistic regression was used to examine the associations between baseline and imaging

factors and failure during the first year after embolization. The variables evaluated include age, race, number of leiomyomata, location of leiomyomata, uterine volume, leiomyoma volume, percent uterine volume reduction at 3 months, percent leiomyoma volume reduction at 3 months, bleeding and pain scores at 3 months and 1 year, and regularity of menstrual cycle at 3 months.

Cox proportional hazards regression was used to examine the relationship between interventions and longer-term failure (beyond 12 months) and baseline factors and imaging parameters. For these analyses, a subsequent intervention was hysterectomy, definitive myomectomy, or repeat embolization. Survival time was defined as days from the uterine artery embolization procedure until censorship or the mid point of the interval in which the failure was reported. The variables included were improvement at first year follow-up (yes/no), baseline leiomyoma volume (> median/≤ median), percent leiomyoma volume reduction (≤ median/> median), baseline leiomyoma volume (1 mL increase), bleed score year 1 (1 unit increase), pain score year 1 (1 unit increase), percent leiomyoma volume reduction (1st tertile /3rd tertile), and 2nd/3rd tertile). The proportional hazards assumption of constant hazard over time was assessed graphically, and all variables included in the final models satisfied the assumption. Cox proportional hazards regression was also used to assess the relationship between satisfaction with uterine leiomyoma embolization results over a 5-year period and independent factors. The outcome measure of interest, satisfaction, was defined as a score of 3 or higher (moderately to very satisfied) at each time of measurement. Hence, women meeting this criterion were consistently satisfied during their follow-up. Women were considered not to be satisfied with the procedure if any satisfaction score fell below 3. Survival time was defined as months from the uterine artery embolization procedure until censorship or time when the satisfaction score fell below 3 for the first time.

RESULTS

Of the 200 women enrolled in the study, follow-up data were obtained in the following numbers of patients: 3 months 193, 12 months 190, 24 months 161, 36 months 183, 48 months 180, and 182 at 60 months. Three patients died during follow-up: 1 of metastatic breast cancer, 1 of metastatic colon cancer, and 1 of preexisting cardiomyopathy. The mean age of the patients was 43.1 years (95% confidence interval [CI] 42.4–43.7). The mean baseline uterine volume was 717.0 mL (95% CI 648.8–785.2), and the mean dominant (largest) leiomyoma volume was 240.0 mL (95% CI 200.8–279.3). Additional baseline characteristics are provided in Table 1.

A summary of the clinical outcome is presented in Table 2. At the end of the first year, 87% (n = 166) were improved, 7% (n = 14) had failed, and an additional 5% (n = 10) were not improved. Over the course of the subsequent 4 years, there was progressive reduction in the proportion improved over each of the follow-up intervals. By 5 years after treatment, an additional 11% (n = 22) had a major intervention indicating failure and an additional 5% (n = 10) were not improved. Taken together, there were a total of 25% (n = 46) who had failed or recurred during follow-up and 73% (n = 133) with continued symptom relief. As noted above, 2% (n = 3) died during follow-up.

Among the 20% with subsequent major interventions, there had been a total of 25 hysterectomies, 8 myomectomies, and 3 repeat embolizations. Two of these myomectomies were hysteroscopic for sole submucosal leiomyomata. These procedures were included regardless of indication; although it is known that some had interventions for recurrent leiomyoma symptoms and others for indications other than leiomyomata, the indications for many interventions were unclear or unavailable, and thus, summary data by indication is not included. The mean change scores in bleeding and pain or pressure are presented at the bottom of Table 2. Although there is on average moderate or better improvement in these symptoms,

Table 1. Baseline Characteristics of Study Participants

Characteristic	n	%
Age at intervention (y)		
< 35	7	3.5
35–39	38	19.0
40–44	78	39.0
45–49	65	32.5
50–55	12	6.0
Race		
African American	101	50.5
White	90	45.0
Other	9	4.5
Number of leiomyomata		
1 dominant	28	14.8
2–5	138	73.0
> 5	23	12.2
Missing	11	
Location of leiomyomata		
Intramural	108	54.0
Submucosal	35	17.5
Subserosal	39	19.5
Missing	18	

Table 2. Subject Characteristics During Study by Annual Visit

	3 Month	Year 1	Year 2	Year 3	Year 4	Year 5
Symptoms						
Improved	180, 93 (89–96)	166, 87 (82–92)	136, 85 (78–90)	152, 83 (77–88)	143, 79 (73–85)	133, 73 (66–79)
Not improved	9, 5 (2–9)	10, 5 (3–9)	8, 5 (2–10)	7, 4 (2–8)	6, 3 (1–7)	10, 5 (3–10)
Major intervention*	4, 2 (1–5)	14, 7 (4–12)	17, 11 (6–16)	25, 14 (9–20)	30, 17 (12–23)	36, 20 (14–26)
Expired	0, 0	0, 0	0, 0	0, 0	2, 1 (0–4)	3, 2 (0–5)
Missing	7	10	39	17	20	18
Cycle						
Amenorrhea	14, 8 (4–12)	8, 4 (2–9)	9, 6 (3–11)	19, 12 (7–17)	26, 17 (11–24)	42, 29 (21–37)
Missing	8	19	49	36	47	53
Interventions						
Hyst/D&C	6, 3 (1–6)	4, 2 (1–5)	3, 2 (0–5)	2, 1 (0–4)	2, 1 (0–4)	2, 1 (0–4)
Hysterectomy	1, 1 (0–3)	8, 4 (2–8)	2, 1 (0–4)	5, 3 (1–6)	4, 2 (1–5)	5, 3 (1–6)
Redo UAE	0, 0	1, 1 (0–3)	1, 1 (0–3)	0, 0	0, 0	1, 1 (0–3)
Myomectomy	0, 0	2, 1 (0–4)	0, 0	4, 2 (1–5)	0, 0	0, 0
Mean change score† [mean (95% CI)]						
Bleeding	3.33 (3.04–3.61)	3.73 (3.47–4.00)	3.83 (3.54–4.13)	3.84 (3.54–4.15)	4.07 (3.77–4.37)	3.98 (3.67–4.28)
Pain	3.47 (3.17–3.78)	3.68 (3.38–3.98)	3.56 (3.23–3.90)	3.81 (3.49–4.14)	3.84 (3.49–4.20)	3/72 (3.34–4.10)

Hyst, hysterectomy; D&C, dilation and curettage; UAE, uterine artery embolization; CI, confidence interval.
Values are n, % (95% confidence interval) (where percentage is based on known values), except where otherwise specified.
* A major intervention is a hysterectomy, definitive myomectomy, or repeat embolization and resulted in the patient being censored for follow-up for the balance of the study.
† Based on change score range from –5 (markedly worse) to +5 (markedly improved); includes only those who are not failed as of that follow-up interval.

these scores are only from those patients not having had major intervention by that interval.

The 18 women who were missing at year 5 did not differ significantly from the remaining cohort on age, race, bleeding and pain scores at 3 months and 1 year, baseline uterine and leiomyoma volumes, number and location of leiomyomata, and volume reductions. To assess whether a learning curve was present, we compared outcomes from the first 100 patients treated with those of the second 100, and there were no differences.

Follow-up imaging was obtained on 175 patients at 3 months and 124 patients at 1 year. The mean percent volume reduction of the largest leiomyoma was 43.6% (95% CI 39.6–47.6) at 3 months and 57.8% (95% CI 52.7–62.8) at 12 months. The mean percent volume reduction for the uterus was 28.5% (95% CI 24.7–32.3) at 3 months and 39.4% (95% CI 34.6–44.2) at 12 months.

At 1 year after treatment, 4% of women were amenorrheic, but there was a progressive increase in this number throughout the duration of the study. By the conclusion of data gathering, 23% (42 of 181) were amenorrheic. The mean age of this group of patients at the time of embolization was 46.0 years, and the mean age of their first report of amenorrhea was 50.0 years (95% CI 48.9–51.2). Most of these patients developed amenorrhea late in the follow-up period, with the mean interval until onset of amenorrhea 4.1 years after embolization (95% CI 3.7–4.4). Two patients aged younger than 40 years became amenorrheic within 5 years, 1 at age 40 years and 1 at 39 years. Both had normal menstrual periods for 4 years after uterine artery embolization. One became amenorrheic spontaneously and 1 became so after a dilatation and curettage for blighted ovum at 4 years postembolization. Serum follicle-stimulating hormone levels are not available on these 2 patients.

Logistic regression was used to examine the association between baseline variables and early failure. Using a definition of early failure including women undergoing hysterectomy, definitive myomectomy, repeat embolization, or reporting no improvement in symptoms at the first year follow-up visit, 12% (24 of 200) of women met the criteria for early failure. Twenty-five patients were not included due to missing data points. In these logistic regression analyses, after adjusting for baseline leiomyoma volume, women with less than or equal to median percent reductions were 3 times more likely to fail during the first year than women with greater than median percent reductions (OR = 3.02; 95% CI: 1.02–8.93, $P = .046$). No other significant associations between baseline or imaging variables and failure at 12 months were identified.

Further analyses were conducted examining women who had not failed by 1 year after embolization. Cox proportional hazards regression was used to

examine the association between baseline variables and the risk of subsequent major intervention or no improvement among these women. There were 32 women meeting these criteria among the 174 women included in the model. Twenty-six women were eliminated from this analysis due to missing data points. In the final model, women reporting no improvement at their first-year follow-up visit were more than 5 times more likely to have subsequent interventions or no improvement in later follow-up than women reporting improvement (relative risk [RR] 5.73, 95% CI 2.32–14.12, $P < .001$), and women with baseline leiomyoma volumes greater than the median (151.5) were more than 2 times more likely to have subsequent interventions or no improvement during later follow-up than women with baseline leiomyoma volumes less than or equal to the median value (RR 2.18, 95% CI 1.05–4.51, $P = .036$). These associations were independent of percent leiomyoma volume reduction and other baseline variables.

Those with major interventions over the entire course of the study and those that had no improvement at their final follow-up interval were then combined and analyzed using Cox proportional hazards regression. Thirty-nine of the 175 women were included in the analysis, with 25 women excluded for missing data. After adjusting for baseline leiomyoma volume, women with a percent leiomyoma volume reduction less than or equal to the median were 2.1 times more likely to fail using this definition during the study period than women with percent leiomyoma volume reduction greater than the median after adjusting for baseline leiomyoma volume (RR 2.15, 95% CI 1.07–4.31, $P = .03$).

With regard to satisfaction with outcome, 45 patients (23.6%) reported at least 1 satisfaction score below 3, and 146 patients (76.4%) consistently reported satisfaction scores of 3 or higher during their follow-up. The association between important baseline variables and satisfaction was assessed using Cox proportional hazards regression. Dissatisfaction was defined as a score of less than 3 at any of the follow-up intervals. Poorer bleeding and pain or pressure scores at year 1 and less leiomyoma volume reduction at 3 months were found to be significantly associated with an increased risk of dissatisfaction during the 5-year follow-up period. After adjusting for pain score and leiomyoma volume reduction, every 1-point increase in bleeding score at year 1 was associated with a 26% reduction in risk of dissatisfaction (RR 0.74, 95% CI 0.60–0.91, $P = .001$). Similarly, after adjustment for bleeding score and leiomyoma volume reduction, every 1-point increase in pain or pressure score at year 1 was associated with a 27% reduction in risk of dissatisfied (RR 0.73, 95% CI 0.61–0.87, $P = .001$). Percent leiomyoma volume reduction at 3 months was entered into the model categorized into tertiles, because the association with dissatisfaction did not seem to be linear. After adjustment for bleeding and pain scores at 1 year, women with percent leiomyoma volume reduction in the first tertile ($\leq 30.5\%$) were more than 3 times as likely to be dissatisfied than women in the third tertile ($\geq 56.3\%$) (RR 3.23, 95% CI 1.07–9.81, $P = .037$). In multivariate models age, race, baseline leiomyoma volume, baseline uterine volume, and subsequent interventions were not significantly associated with satisfaction and did not seem to confound the association of satisfaction with variables in the final model.

DISCUSSION

In the present study, most patients had continued symptom improvement and satisfaction with outcome over the duration of follow-up. The hysterectomy rate for all indications was low (13.7%), and overall, 73% had continued symptom control for the 5 years. This study also identifies some factors that may be associated with failure or recurrence. Short-term failure (at 12 months) was 3 times more likely in those whose dominant leiomyoma shrank less than the median. When evaluating those that were not failed at 1 year, those not improved symptomatically at 12 months were 5 times more likely to fail long-term. Those with larger than median baseline leiomyoma volume were 3 times more likely to fail after 12 months than others, and those with dominant leiomyoma shrinkage less than the median were 2.4 times more likely to fail. Satisfaction was also more likely in those with greater volume reduction. Although not included in this article, our previous analysis on these data determined that larger baseline leiomyoma volume results in less shrinkage after embolization.[8] In that analysis, continuous variables such as uterine and leiomyoma volume reduction were analyzed on a per milliliter basis. For each milliliter increase in leiomyoma volume at baseline, there was a 0.02 decrease in the percentage leiomyoma volume reduction at 12 months, adjusted for other baseline variables. This suggests that the larger the dominant leiomyoma at baseline, the less the volume reduction that will occur and the greater the likelihood of dissatisfaction during follow-up.

There has been at least 1 other study that has reported on outcome based on baseline characteristics. MC Lucas and coworkers[9] noted that women with leiomyomata greater than 8.5 cm in diameter

were more likely to fail. However, the analytic measures used in that study were not described, and how that diameter was determined was not included in the article.

There have been numerous clinical case studies published reporting on the safety and effectiveness of uterine embolization for leiomyomata.[3,7,10–13] The published studies of this procedure have been limited in the duration of reported follow-up, with relatively few that have reported outcome beyond 12 to 24 months. Further, to date, there has been little exploration of factors that might predispose to recurrent symptoms or subsequent interventions.

In 1 study reporting long-term follow-up, Broder et al[6] compared small groups of embolization patients (n = 51) and myomectomy patients (n = 30) at a minimum of 3 years after therapy. Among those evaluated, 94% of embolization patients and 79% of myomectomy were at least somewhat satisfied with symptom control ($P = .06$), but there were much more frequent reinterventions in embolization patients (29% compared with 3%, $P = .004$). However, these groups were not comparable; embolization patients were on average older and more likely to have undergone prior leiomyoma therapies, suggesting they may have had more extensive disease. The reasons for interventions were not presented and factors predisposing to reintervention were not analyzed.

In a study reviewing recurrence after embolization, Marret and coworkers[14] found 8 recurrences among 85 patients at a median of 30 months after embolization. Among these, there was progressive leiomyoma growth in 1 and new leiomyomata in 7. Most of the recurrences in this study were new small submucosal leiomyomata. The study was small, and there were relatively few recurrences to evaluate. As a result, the authors were not able to perform an in-depth analysis to identify predictors of recurrence or failure.

The demographics of the patient group treated here is perhaps most comparable to patients undergoing hysterectomy. However, in order to assess for predictors of recurrence for other leiomyoma therapies, one needs to look to uterine-sparing therapies. For abdominal myomectomy, there are 2 recent studies that identify factors predisposing to recurrence. In a study by Stewart et al,[15] 2 factors predicted a greater likelihood of recurrence: patients who gained greater than 30 lb in weight since age 18 and those with less than a 12 weeks size uterus. In the more recent study by Hanafi,[16] recurrence was more likely in those with multiple myomas removed at the myomectomy and in those with intraoperative uterine size larger than 10 weeks size, a finding at odds with Stewart's study. In an analysis by Candiani and associates,[17] those having a pregnancy with delivery after myomectomy were less likely to recur than those who did not. With hysteroscopic resection of leiomyomata, multiple leiomyomata, larger uterine size, and incomplete resection of leiomyomata predicts greater likelihood of recurrence.[18]

Unfortunately, all these analyses (including our own) have limitations. The extent of disease for leiomyomata is quite varied, and there is no classification system of anatomic extent of disease for this condition. This makes the comparison of outcomes from different therapies or between different studies difficult, given that it is not known whether the patients are even similar in disease extent. There are also some procedures best suited for only a minority of patients, such as hysteroscopic or laparoscopic myomectomy. Thus, any analysis of predictors of recurrence may be influenced by the bias of patient selection factors imposed by the specific treatment. Comparisons of differing approaches to therapy must be made with extreme caution. Ideally, the various approaches to therapy would be compared in randomized clinical studies with long-term follow-up. However, the complexity and expense of such studies is an impediment to their initiation. The creation of an anatomic classification would be helpful to advance our analyses beyond basic comparisons and to begin to understand better those subgroups of patients that are best treated by one or another therapy. We believe this should be a research priority for this field.

The current study has additional limitations. First, the enrollment criteria were expanded after the 50th patient to include those who wanted to maintain their fertility if their only treatment alternatives were hysterectomy or extensive myomectomy. Thus, some patients in this circumstance would have been rejected if they presented early in the study and would have been included later in the study. However, all patients included were symptomatic and all met the same anatomic inclusion criteria. Another limitation is the variability in the method by which the follow-up data were collected. Some patients responded spontaneously to the questionnaires when sent by mail (self-administered), whereas others only responded after being telephoned several times–in most of these cases, the questionnaire was completed by telephone interview. We recognize that bias could be introduced into the data collection by this inconsistency, but the follow-up would have been much less complete without these efforts.

The current study begins to fill a gap for clinicians

and patients considering uterine embolization as a treatment option. This study provides evidence that in the long-term, embolization is an effective and durable therapy for most patients. Those with very large uteri and large dominant leiomyomata are among those that are more likely to have recurrence and subsequent intervention. The degree to which the volume of the dominant leiomyoma decreases seems to have a much larger role in patient outcome and satisfaction than we previously believed.

The causes of recurrence after embolization are not yet known and will require additional study. There are some data that suggest that incomplete leiomyoma infarction will allow recurrent growth of those leiomyomata, with symptom recurrence in time.[19] The degree to which this plays a part in early recurrence is unknown. We have theorized about possible causes of incomplete leiomyoma infarction, including embolic material used, presence of spasm in the uterine artery, short-term recanalization of the uterine artery, and collateral arterial supply to the uterus, usually from the ovarian arteries.[20] The patients treated in this study were among the first treated in the United States, and there has been considerable innovation since they were treated. Whether these changes in method would have any effect on long-term outcome is not yet known.

The data on incomplete leiomyoma infarction and uterine embolization are also likely applicable to other leiomyoma ablative therapies, including high-frequency ultrasound ablation, uterine artery ligation or occlusion, and myolysis. There are fewer studies of the outcome from these therapies compared with embolization, but much of what we are learning about recurrence after embolization may apply. Most of these therapies result in either ischemic infarction or coagulative necrosis of the leiomyomata. Regardless of the means of ablation, the recurrences that can be anticipated will likely be determined by the same factors that determine the outcome of embolization.

With the analysis that we have presented, we conclude that uterine embolization is an effective therapy in the long term, with a minority of recurrences at 5 years after treatment. Better outcome is more likely in those with smaller dominant leiomyomata and greater leiomyoma volume reduction.

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