

Outcomes After Unilateral Uterine Artery Embolization: A Retrospective Review

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Abstract

Purpose Bilateral uterine artery embolization (UAE) is considered necessary to provide effective treatment for symptomatic uterine fibroids. Occasionally, only unilateral embolization is performed, and this study evaluates these outcomes.

Materials and Methods As part of a prospective observational study of more than 1600 patients treated with UAE since 1996, there have been 48 patients in whom unilateral embolization has been performed. This study retrospectively reviews clinical response as assessed by our standard questionnaire and radiological response assessed by either magnetic resonance imaging or ultrasound.

Results Two principal groups emerged: the largest, where only the dominant unilateral arterial supply was electively embolized (30 patients); and the second, where there was technical failure to catheterize the second uterine artery as a result of anatomical constraints (12 patients). Favorable clinical response with a reduction in menorrhagia at 1 year was seen in 85.7% (18/21) of those patients with a dominant arterial supply to the fibroid(s). In contrast, in those patients where there was technical failure to embolize one uterine artery, there was a high rate of clinical failure requiring further intervention in 58.3% (7/12). Comparison of the technical failure group with the dominant uterine artery group

demonstrated a statistically significant (Fisher's exact test) difference in the proportion of patients with evidence of persistent fibroid vascularity ($p < 0.001$) and requiring repeat intervention ($p < 0.01$).

Conclusion We conclude that unilateral UAE can achieve a positive clinical result in the group of patients where there is a dominant unilateral artery supplying the fibroid(s), in contrast to the poor results seen following technical failure.

Keywords Uterine artery · Embolization · Magnetic resonance imaging · Fibroids

The radiological treatment of uterine leiomyomata by uterine artery embolization (UAE) is a recognized and effective minimally invasive technique [1–4]. Current opinion is that the technique requires embolization of both uterine arteries. Embolization of ovarian arteries may also be carried out where these provide significant collateral blood supply to the fibroids [5–7].

There are a number of possible reasons for unilateral UAE. These include elective unilateral embolization when one of the uterine arteries is the sole dominant supply to the fibroid, with the contralateral uterine artery appearing on arteriography to supply only normal myometrium. There may be technical failure due to tortuosity of the uterine artery or procedural spasm precluding selective catheterization. Congenital absence, multiple uterine arteries, or previous surgical ligation of one uterine artery may also be encountered.

This study presents a retrospective review of the clinical and radiological outcome of 48 patients treated with unilateral UAE.

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Materials and Methods

Patients

Since 1996 more than 1600 patients have undergone UAE as part of a prospective observational study at the Royal Surrey County Hospital or the London Clinic. Approval for the study was obtained from the Hospital Ethics Committees, and all patients gave informed consent. Forty-eight women (mean age, 42.2 years; SD = 5.8 years) underwent unilateral UAE between October 1998 and May 2006.

All patients referred for UAE attended a pretreatment consultation with the radiologist to allow a discussion of treatment options and to provide patient information regarding UAE. At this time a transvaginal ultrasound (TVUS) was also performed to assess uterine volume and type and number of fibroids. Magnetic resonance imaging (MRI) was also performed pre-embolization if there was local funding and was specifically requested if ultrasound suggested alternative pathology such as adenomyosis.

Embolization Procedure

The intention in all cases had been to embolize both uterine arteries, but in this series there have been 48 patients (3.0%) in whom only unilateral embolization was performed. All procedures were performed by an experienced interventional radiologist (W.J.W.). A flush pelvic angiogram was initially performed in all cases with a 4-Fr pigtail catheter just above the level of the origin of the ovarian arteries. If possible, a 4-Fr Cobra 2 catheter was used to cannulate the uterine artery. Alternatively, a coaxial 3-Fr microcatheter (Tracker 325; Boston Scientific Ltd., St. Albans, UK) was used to selectively catheterize the uterine artery. Particles (Contour; Boston Scientific, Cork, Eire) of nonspherical polyvinyl alcohol (355–500 μm) were injected until stasis was achieved within the uterine artery. The ipsilateral uterine artery was then catheterized and embolized after forming a Waltman's loop [8].

In the largest group in this series ($n = 30$), one uterine artery was judged to supply normal myometrium (Figs. 1a–1c). This was based on angiographic features of small size and reduced tortuosity of vessels in comparison to those supplying fibroid tissue. Importantly, further correlation of this vessel to an area of normal myometrium on pre-embolization imaging was also required. An elective decision was then taken to perform unilateral embolization of the uterine artery supplying the fibroid(s) without subsequently embolizing the contralateral uterine artery.

Of those patients where the procedure was deemed to be a technical failure ($n = 12$), there was bilateral arterial supply of the uterus and fibroid(s). Selective catheterization of one of the uterine arteries was unsuccessful as a result of

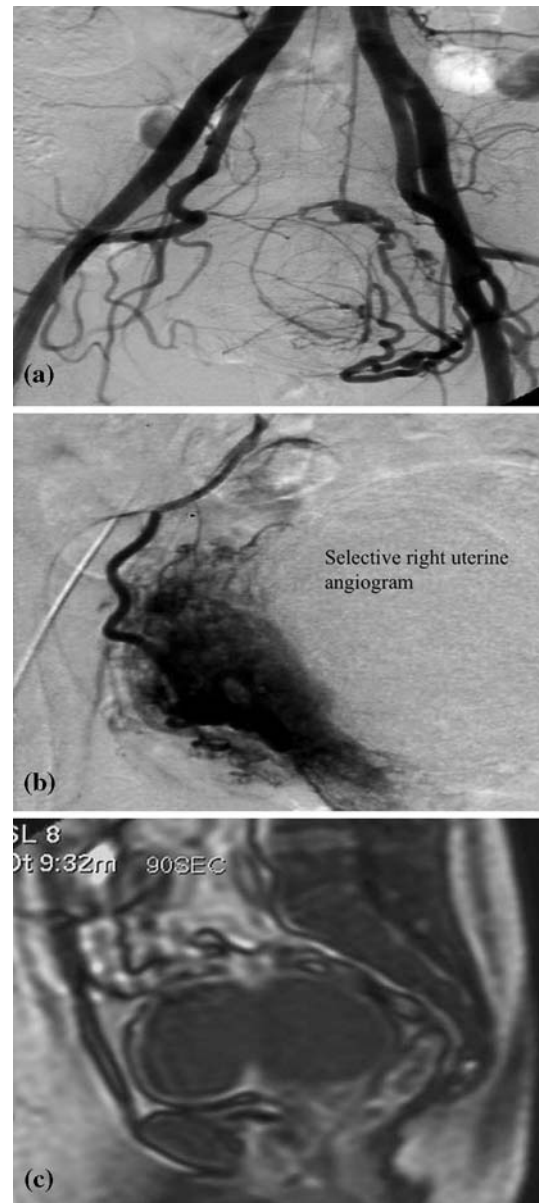


Fig. 1 **a** Pelvic flush angiogram demonstrating dominant left uterine artery supplying fibroid. **b** Selective right uterine artery angiogram demonstrating features judged to show this vessel is supplying only normal myometrium. **c** Sagittal T1-weighted contrast-enhanced MR images demonstrating absence of enhancement following unilateral embolization of the dominant uterine artery

anatomical constraints, despite the use of microcatheters and bilateral common femoral arterial punctures.

Completion embolization was attempted when there was a poor clinical response and continued fibroid enhancement on MRI.

Data Collection

Clinical response was assessed by the use of self-completed questionnaires at 6 and 12 months and yearly thereafter.

Table 1 Summary of main outcome measures

	Dominant uterine artery (<i>n</i> = 30)	Technical failure (<i>n</i> = 12)	Surgical ligation of one uterine artery (<i>n</i> = 4)	Congenital absence of one uterine artery (<i>n</i> = 2)
Positive clinical response (resolution/improvement in menorrhagia) at 1 year	85.7% (18/21)	16.7% (2/12)	25.0% (1/4)	100% (2/2)
Vascularity post-UAE (MRI/ultra-sound)	17.4% (4/23)	88.9% (8/9)	50.0% (2/4)	0% (0/2)
Repeat intervention (hysterectomy, myomectomy, UAE)	10.0% (3/30)	58.3% (7/12)	75.0% (3/4)	0%

This assessed symptoms of menorrhagia, dysmenorrhea, and bulk symptoms on a 4-point scale of complete improvement, partial improvement, no change, and a worsening in symptoms.

Standard imaging follow-up was by TVUS at 8 weeks, 6 and 12 months, and yearly thereafter. In addition to assessment in uterine/fibroid size, color Doppler ultrasound was also used to assess fibroid vascularity. MR images were all reported by an experienced radiologist (W.J.W.), and follow-up ultrasound examinations were performed mainly by experienced ultrasonographers under the supervision of W.J.W. or by W.J.W. directly.

Uterine/dominant fibroid volume was approximated using the formula for a prolate ellipse ($\text{vol} = d1 \times d2 \times d3 \times 0.52$) and this provided a reproducible measure of change in volume following embolization. Where performed, dynamic MRI at 24–72 h postembolization can immediately ascertain any evidence of continued vascularity as assessed by gadolinium enhancement within the fibroid(s). MRI at 4–8 weeks postprocedure can further assess any changes in uterine/fibroid volume.

Statistical Analysis

Summary descriptive statistics were used for demographic parameters and uterine/ dominant fibroid volume prior to embolization. Fisher's exact test was used to compare re-intervention rates and vascularity between those patients with unilateral UAE due to dominant uterine artery and those with technical failure. Statistical significance was defined as $p < 0.05$. Analysis was by Prism software (GraphPad Software, Inc).

Results

Dominant Uterine Artery Group

Those patients with a unilateral dominant arterial supply to the fibroid(s) represent the largest group in this series ($n = 30$). The dominant artery was the right uterine artery in 55% (16/30). Initial uterine/dominant fibroid volume in

this group was 733.2 cm^3 ($\text{SD} = 476 \text{ cm}^3$). A mean uterine/dominant fibroid volume reduction of 48.6% ($\text{SD} = 21.8\%$) was achieved at a mean follow-up time of 9.8 months (range, 1–42 months).

Clinical response data were available for 28 of 30 patients. Mean follow-up time was 19.5 months (range, 6–84 months). One year following UAE, 85.7% (18/21) reported improvement or resolution of menorrhagia (Table 1). There was a similar improvement/resolution in dysmenorrhea and bulk-related symptoms in 85.7% (18/21) and 76.2% (16/21), respectively, at 1 year. Twenty-four months following UAE 85.7% (6/7) of patients reported a sustained improvement/resolution of menorrhagia.

Persistent vascularity was seen in 17.4% (4/23) of patients in the dominant uterine artery group. Twelve patients underwent MRI investigation, with five undergoing MRI within 24 h of UAE. Of those patients undergoing MRI the fibroid(s) were devascularized in 83.3% (10/12). Of those two patients with persistent vascularity on MRI, one underwent a hysterectomy at 1 year due to worsening symptoms. The other patient declined repeat UAE and underwent laparoscopic myomectomy, with complete resolution of symptoms at 4-year follow-up.

Persistent vascularity was reported in 18.2% (2/11) patients on ultrasound. This correlated with persisting clinical symptoms. Repeat UAE was performed in one of those patients, and the left ovarian artery was found to be supplying the fibroid and was not embolized. The other patient was recommended for repeat UAE, although this has not yet been performed.

One patient reported recurrent symptoms after 1 year, and the fibroid was demonstrated on MRI to be devascularized, but an island of adenomyosis was now seen to account for the symptoms. There have been three pregnancies in this group of patients with a dominant uterine artery, with one live birth.

Technical Failure Group

There were 12 patients for whom unilateral embolization was a result of technical failure. Initial uterine volume was 872 cm^3 ($\text{SD} = 1023 \text{ cm}^3$) and there was a uterine/dominant fibroid volume reduction of 46.9% ($\text{SD} = 36.0\%$).

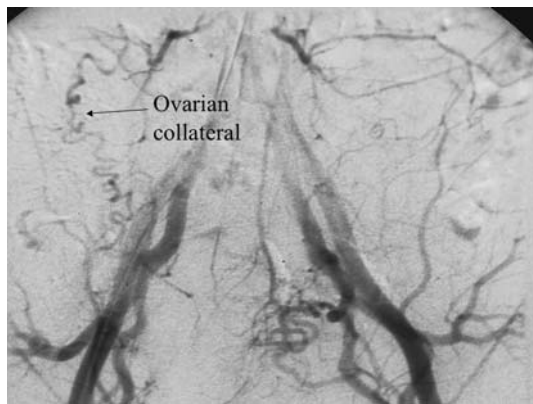


Fig. 2 Pelvic flush angiogram demonstrating well-developed collateral supply from the ovarian artery in a patient with previous surgical ligation of the uterine artery on this side

Persistent vascularity within the fibroid(s) was seen in 89% (8/9) of women where an assessment was made with MRI or ultrasound. In five of five patients MRI demonstrated persistent enhancement (Fig. 2), and vascularity was identified in four of five patients on ultrasound. Of those with persistent vascularity of the fibroid(s), one woman had a hysterectomy, as adenomyosis was also identified and she suffered ongoing menorrhagia.

Five patients underwent repeat attempted embolization, which remained unsuccessful in three patients due to anatomical constraints. In those two patients with successful repeat UAE, angiography demonstrated recanalization of the previously embolized uterine artery. Both uterine arteries were subsequently embolized, and in one of these patients there was further embolization of a large lumbar collateral to the fibroid. Both patients reported complete resolution of menorrhagia following repeat UAE.

Three patients with ongoing symptoms required hysteroscopic resection. In two further patients there were persistent symptoms that required hormonal therapy in one and were resolved with the onset of menopause in the other. Only two patients reported an improvement in symptoms, with devascularization of the fibroid demonstrated in one of those patients when assessed by ultrasound.

There was a statistically significant difference in the proportion of patients with persistent vascularity following unilateral UAE due to technical failure versus those patients with a dominant uterine artery ($p < 0.001$). The overall reintervention rate (hysterectomy, UAE, myomectomy) in those patients where there was unilateral UAE due to technical failure was 58% (7/12), compared to 10% (3/30) in those with a dominant uterine artery ($p < 0.01$).

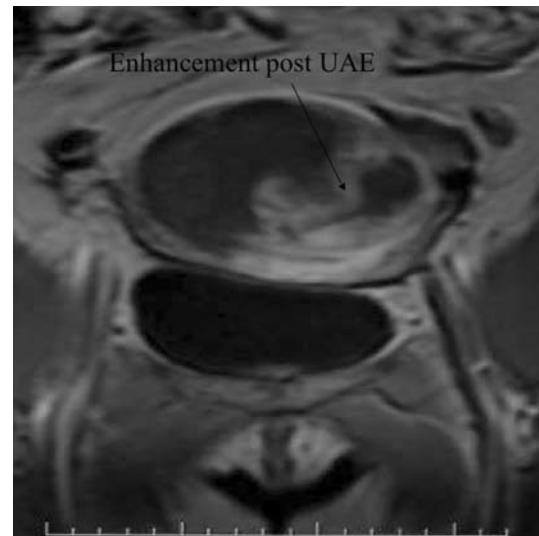


Fig. 3 Coronal T1-weighted contrast-enhanced MR images demonstrating an area of persistent enhancement following unilateral UAE due to technical failure

Congenital Absence/Surgical Ligation of One Uterine Artery

All four of the patients with a previous ligation of a uterine artery had developed collaterals from the ovarian artery (Fig. 3), and one patient developed an additional collateral from a lumbar artery. The ovarian artery and other collateral vessels were not embolized in any of these cases. There was some reduction in uterine/fibroid volume in two women (48% and 26%, respectively) and reduced fibroid vascularity in two others postembolization. However, two women had hysterectomies due to ongoing symptoms. One woman had hysteroscopic resection of a small submucous fibroid that was producing persistent vaginal discharge, despite overall devascularization and reduction in size of fibroids on MRI.

The two patients with congenital absence of a uterine artery demonstrated complete devascularization of the fibroid(s), and both reported a symptomatic improvement following UAE.

Discussion

It is assumed that UAE achieves its effect through infarction of fibroids [9, 10] followed by hyalinization and shrinkage, with sparing of the normal myometrium. Ravina et al. [11] first postulated that unilateral embolization would be unsuccessful in controlling symptoms due to collateral supply from the contralateral uterine artery. There are, however, humoral factors implicated in fibroid growth/shrinkage and DNA expression, for example, platelet-derived growth factor and monocyte chemotactic

protein-1 production [12–14]. Furthermore, although fibroid-related menorrhagia may be related to distortion of the uterine cavity, prostaglandins secreted by smooth muscle cells may also be important in the etiology of menorrhagia [15]. Therefore partial ischemia following UAE might hypothetically be sufficient to improve symptoms through modulation of one or more of these factors, although any effect would be unlikely to be sustained.

There have been two small series [16, 17] of outcomes following unilateral UAE. Nicholson reported a positive clinical outcome following unilateral UAE due to technical failure in five patients and advocated an initial conservative approach with an attempt at sequential embolization of the remaining uterine artery for those patients with a poor clinical response. McLucas et al., however, reported that in seven patients with unilateral UAE due to technical failure, four of five patients with a repeat early embolization (within 2 months) of the remaining uterine artery showed a positive clinical outcome, compared to one of two of those patients treated conservatively.

There was a positive clinical response (85.7% resolution/improvement in menorrhagia at 1 year) seen in those patients in our study with a dominant uterine artery, which is a similar order of response as seen in larger series of bilateral UAE [1–4]. The positive clinical response and low rate of fibroid vascularity (17.4%) do appear to justify elective unilateral embolization where one artery is judged to supply normal myometrium. There does remain the potential for blood supply to small fibroids from the non-embolized artery, and this vessel has the potential to provide a collateral supply to the embolized fibroid. This does not, however, appear to be significant given the results of this, albeit small, study.

These results contrast with the need for repeat intervention (58.3%) and poor clinical response in those patients where there was technical failure to embolize one uterine artery. There was a significant difference ($p < 0.01$) in the persistence of vascularity within the fibroid(s) following unilateral UAE due to technical failure (88.9%), compared to those with a dominant uterine artery (17.4%). These results support the theory that all of the vessels supplying the fibroid(s) must be embolized to achieve a satisfactory clinical result. As such, following true technical failure early reintervention with UAE is an appropriate strategy, and contrast-enhanced MRI can aid in the selection of suitable patients.

Despite the high rate of persistent vascularity and poor clinical outcome following technical failure to embolize one uterine artery, there was a 46.9% overall reduction in uterine/dominant volume. Overall volume reduction may mask growing viable fibroid tissue, and volume reduction alone has been shown to be a poor predictor of clinical outcome [18, 19].

Repeat embolization yielded mixed results, with a second attempt at embolization unable to overcome the challenging anatomy in three cases. Adverse factors included tortuosity and small caliber of the uterine artery and unfavorable anatomy such as the origin of the uterine artery arising close to the division of the anterior and posterior divisions of the internal iliac artery. However, on a second procedure there can be technical success due to a number of factors including preplanning of approach, preselection of suitable catheters, and possible hypertrophy of the remaining vessel. In our series recanalization of the previously embolized vessel was encountered, a well-documented cause of treatment failure following bilateral UAE [20].

McLucas et al. reported three patients with congenital absence of the uterine artery and one patient with previous ligation of the uterine artery. Although, again, only small numbers ($n = 6$) are seen in our study, a similar result was seen, with a positive response in the two patients with congenital absence of the uterine artery and a poor response in those with previous ligation ($n = 4$). In all patients in our series with previous surgical ligation of one uterine artery there was collateral ovarian supply to the fibroid(s), and in one case a lumbar artery collateral. None underwent embolization of the ovarian collateral, although this may have been a suitable management strategy.

There is evidence to support the use of contrast-enhanced MRI as a predictor of fibroid regrowth and likely symptomatic recurrence [18, 21]. Doppler ultrasound has been described for the assessment of fibroid vascularity [22]. There are, however, no reports comparing contrast-enhanced MRI to Doppler ultrasound to identify persistent vascularity of fibroids. In our experience, MRI is the modality of choice, especially where there are smaller areas of persistent fibroid vascularity. An interesting development is the potential application of contrast-enhanced ultrasound [23].

There are a number of limitations of this study, which include the small sample size and the use of different imaging methods. A nonvalidated questionnaire was used for assessing clinical outcomes, although we have used the same standard questionnaire with clear end points throughout our series of 1600 patients. Increasing length of follow-up also negates any placebo effect of the procedure. Reporting of posttreatment contrast-enhanced MRI was performed by the same radiologist who performed the embolization and therefore was not blinded to the previous embolization procedure.

In conclusion, those patients with a dominant uterine artery showed a good clinical response to unilateral UAE, compared to a poor response in those with a technical failure. The results of this study do appear to support elective unilateral embolization as an appropriate treatment

strategy when one artery is judged to be supplying normal myometrium only. Poor clinical outcome correlates with persistence of vascularity on imaging.

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