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Uterine artery embolisation for symptomatic fibroids: clinical results in 400 women with imaging follow up

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Objective To evaluate the mid-term efficacy and complications of uterine artery embolisation in women with symptomatic fibroids. To assess reduction in uterine and dominant fibroid volumes using ultrasound and magnetic resonance imaging.

Design Prospective observational single-centre study.

Setting A district general hospital in Surrey and a private hospital in London.

Methods Four hundred consecutive women were treated between December 1996 and February 2001. Indications for treatment were menorrhagia, menstrual pain, abdominal swelling or bloating and other pressure effects. Uterine artery embolisation was performed using polyvinyl alcohol particles and platinum coils.

Main outcome measures Imaging was performed before embolisation and at regular intervals thereafter. Clinical evaluation was made at regular intervals after embolisation to assess patient outcome.

Results Bilateral uterine artery embolisation was achieved in 395 women, while 5 women had a unilateral procedure. With a mean clinical follow up of 16.7 months, menstrual bleeding was improved in 84% of women and menstrual pain was improved in 79%. Using ultrasound, the median uterine and dominant fibroid volumes before embolisation were 608 and 112 cc, respectively, and after embolisation 255 and 19 cc, respectively ($P = .0001$). Three (1%) infective complications requiring emergency hysterectomy occurred. Twenty-three (6%) patients had clinical failure or recurrence. Of these, nine (2%) had a hysterectomy. Twenty-six (7%) women had permanent amenorrhoea after embolisation including four patients under the age of 45 (2%). Of these, amenorrhea started between 4 and 18 months after embolisation, and only three had elevated follicle stimulating hormone levels when amenorrhea developed. Thirteen (4%) women had chronic vaginal discharge considered as a major irritant. Thirteen pregnancies occurred in 12 patients. Ninety-seven percent of women were pleased with the outcome and would recommend this treatment to others.

Conclusions Uterine artery embolisation is associated with a high clinical success rate and good fibroid volume reduction. Infective complications requiring hysterectomy, amenorrhoea under the age of 45 and chronic vaginal discharge may complicate the procedure.

INTRODUCTIONS

Arterial embolisation is a long established technique in the treatment of abdominal and pelvic haemorrhage but has only recently been used to treat uterine fibroids[1–5]. Until recently, surgery has been the only effective treatment for fibroids. It was not until 1995 that the first series of bilateral uterine artery embolisation for fibroids was published[5]. Since then several groups have reported their experience[6–12]. These reports indicate that uterine fibroid embolisation appears to be effective in controlling the symptoms in 80–94% of women[6–14]. However, the true incidence of complications is not known because of the small number of patients enrolled in published studies. Moreover, the longest clinical follow up reported is only 24 months in 80 patients[12]. Finally, no long term imaging follow up has yet been published. In December 1996, a prospective observational study was commenced to evaluate the value of uterine artery embolisation in the management of symptomatic uterine fibroids. This reports our experience of long term safety and efficacy of the procedure.

METHODS

Approval for this study was obtained from the Hospital Ethics Committee and all women gave written informed consent. All women had prior evaluation by a gynaecologist as well as an interventional radiologist (W.J.W.).

The indication for treatment was symptomatic fibroids such that the woman had been advised surgery. For entry into the study, women had to have experienced either heavy menstrual bleeding or pressure symptoms such as bloating

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or swelling of the abdomen, urinary frequency, back pain or sciatica ascribed to the fibroids. The clinical indication was determined by experienced gynaecologists based on patient history and clinical examination.

The management of women who wanted to maintain their fertility after embolisation was discussed with the gynaecologist. Embolisation was performed if the only surgical options were multiple/difficult myomectomy or hysterectomy. The risks of pelvic infection or amenorrhoea associated with embolisation were discussed with the patient. Infertility related to asymptomatic fibroids was not an indication for treatment. Five (1%) women were postmenopausal at the time of embolisation but had severe fibroid-related menorrhagia while using hormone replacement therapy and refused to be treated by hysterectomy (four women) or in whom surgery was considered risky (one woman).

Following prior assessment by a gynaecologist including a recent pelvic examination, all patients had a pre-embolisation consultation and ultrasound examination with the interventional radiologist (W.J.W.) who also carried out the procedure. The radiologist explained the procedure, its risks, benefits and complications. After embolisation, follow up was overseen by the interventional radiologist.

The women had ultrasound scans (trans-abdominal and/or endovaginal imaging) prior to embolisation and at regular intervals thereafter. When funding was available, magnetic resonance imaging was performed before and after embolisation (6 to 12 months after embolisation). Magnetic resonance imaging included transverse and sagittal T1- and T2-weighted images. Both examinations were performed to confirm the diagnosis of fibroids and to exclude associated pelvic pathology. The measurements obtained were of the fibroid mass if a single or dominant fibroid was present or of the uterus if there were multiple fibroids producing a complex mass. Measurements were taken in three dimensions and the uterine and fibroid volumes were estimated using the prolate ellipse equation ($d1 \times d2 \times d3 \times 0.52$). Special attention was given to the detection of associated pelvic malignancy, adenomyosis or other adnexal pathology.

After embolisation, all women were evaluated using the same imaging modality. The latest ultrasound and/or magnetic resonance imaging evaluation was used for the purpose of this study and for the statistical analysis. Only one magnetic resonance imaging was performed for each woman between 6 and 12 months after embolisation. Shrinkage was calculated using the ratio of the volume at the latest evaluation to the baseline volume.

Blood was taken before and after embolisation for serum follicle stimulating hormone, luteinising hormone and oestradiol (17-beta-estradiol) to detect ovarian failure. For the purpose of this study, blood tests were analysed only in women with menstrual abnormalities and always considered in combination with symptoms commonly associated with the perimenopause. These symptoms included amenorrhoea or irregular menstrual bleeding, hot flashes, vaginal dryness, mood swings and weight gain as previously reported[15,16]. Women were defined as having ovarian failure if they were amenorrhoeal, had at least one clinical symptom suggestive of menopause and had elevated follicle stimulating hormone (>30 iu/L) and luteinising hormone (>25 iu/L) levels and low oestradiol level (<150 pmol/L).

Prior to the procedure, women were given an anti-inflammatory suppository diclofenac sodium 100 mg and 1 mg of the anti-emetic granisetron. The procedure was carried out under local anaesthesia (xylocaine). Intravenous sedation consisting of a mixture of 100 mcg fentanyl, 10 mg midazolam and 10 mg metoclopramide in saline was given only as required. In all cases, antibiotics (120 mg gentamicin, 500 mg ampicillin and 500 mg metronidazole) were administered intravenously pretreatment. A Foley catheter was inserted in the bladder.

All procedures were carried out by an experienced interventional radiologist (W.J.W.). A unilateral right groin approach was used for most cases. Following a flush pelvic arteriogram, a 4-French Cobra 2 catheter was passed into the contralateral internal iliac artery and then into the origin of the uterine artery. Coaxially, a 3-French microcatheter (Tracker 325, Boston Scientific Watertown, Massachusetts, USA) was then inserted into the uterine artery. The microcatheter was usually placed approximately halfway along the artery distally to the cervicovaginal branches if possible[17]. Particles of polyvinyl alcohol were injected until flow in the uterine artery ceased. If spasm developed in the uterine artery, anti-spasmodics (300 mcg glyceryl trinitrate boluses intra-arterially) were administered. The first 66 women were treated using 150–250 and 355–500 μm polyvinyl alcohol particles (Contour, Boston Scientific). From February 1998, all patients were treated using 355–500 μm polyvinyl alcohol particles because of complications related to the use of small particles (described in the Results section). Particle embolisation was followed by platinum coil occlusion using 2- to 5-mm platinum coils as previously reported[7,10]. The objective was to avoid early recanalisation of the uterine arteries in order to ensure a durable fibroid ischaemia. The ipsilateral uterine artery was catheterised and embolised using the same catheter after forming a Waltman's loop[18,19]. At the time of the procedure, the total fluoroscopy time and the evaluation of the radiation exposure (cGy cm^2) were recorded.

All women were kept one to two nights in the hospital for pain control using a patient-controlled analgesia pump containing 60 mg morphine with 6 mg droperidol. Anti-inflammatory and analgesic drugs were also administered as required after embolisation.

Clinical improvement was evaluated at regular intervals after embolisation. With the six-week questionnaires, the women were asked to describe the procedure and the pain following the procedure as: (a) procedure and pain considered as better than expected, (b) as expected, or (c) worse

Table 1. Summary of patient demographic information. Values are given as *n* (%).

	n (%)
Age	
20–29	9 (2)
30–39	111 (28)
40–44	118 (30)
45–49	106 (26)
>50	56 (14)
Total	400 (100)
Mean age (years)	43.2
Race	
Caucasian	324 (81)
Afro-Caribbean	47 (12)
Indian	3 (1)
Chinese	6 (1)
Other	20 (5)

than expected. The intensity of pain was described on an eight-level scale from no pain, through like period pain or labour pain if applicable, to worse pain ever felt. The women were also asked to evaluate the recovery from the procedure with special emphasis on the number of days until there is no more pain, normal daily activities and back to work.

From three months onwards, questions were directed towards the women's symptoms and the response to the treatment using a three-grade scale: improvement, unchanged or worsening of symptoms. Most questions were asked directly during consultations. The women living away or those who failed to respond were systematically sent a repeat questionnaire and then telephoned to try to obtain their replies.

Complications were also recorded prospectively and recorded by the same questionnaires, phone calls and through direct contact with the women at regular intervals after embolisation. All women were told that they could contact the interventional radiologist at any time after the embolisation on a 24 hour basis especially in case of increasing pelvic pain, fever (>38°5), vaginal discharge of pus, heavy bleeding or expulsion of fibroid debris.

Summary descriptive statistics were used for procedure parameters, uterine and fibroid volumes pre- and post-embolisation and questionnaire replies. All values are reported as the mean and standard deviations (SD). The median and range (minimum–maximum) are also given. Uterine and dominant fibroid volumes before and after embolisation were compared using non-parametric tests (Mann–Whitney or Kruskal–Wallis). We used the Spearman rank correlation test to determine whether the fluoroscopy time was related to the experience of the interventional radiologist and if there was a correlation between volumes obtained with ultrasound and magnetic resonance imaging. Statistical analysis was carried out using Statview 512 software (Abacus Concept, California, USA).

RESULTS

During the study period (24 December 1996 to 15 February 2001), 403 women were evaluated by angiographies but three of them were not embolised because of absence of both uterine arteries or absence of vascularisation consistent with fibroids. The average age of the women was 43.2 (6.6) years. Eighty-one percent of women were Caucasian and 12% were of African descent. The most common presenting symptom was abdominal bloating or swelling (98% of patients). Seventy-eight percent of patients had menorrhagia and 59% had menstrual pain. Pressure symptoms, urinary frequency and sciatica were encountered in 82%, 35% and 32% of the women, respectively. The average number of symptoms reported was 2.4 [range 1–3]. Complete demographic data and presenting symptoms are summarised in Tables 1 and 2.

Forty-six percent of women had suffered period-induced anaemia (Hb < 12.0 g/dL) and 12% had required blood transfusion.

Bilateral selective uterine artery catheterisation and embolisation was performed in 395 (99%) women in one (378 women) or two sessions (17 women) (Fig. 1). Five women had unilateral embolisation. Catheterisation failed in three of these women who then refused a second procedure. One woman with a bi-cornuate uterus and a single large fibroid located on the left hemi-uterus was only treated unilaterally. Another patient with prior pelvic surgery (left ovariectomy and endometriosis) was also embolised unilaterally because of the absence of the left uterine artery. Two women had additional embolisation of the right ovarian artery, which was the main blood supply to large fundal fibroids.

The radiation dosage and screening times were available in 342 cases. These figures were not available 58 women treated with other but similar angiographic equipment. The mean fluoroscopy time was 25.9 (11.8) and 44.6 (17.4) minutes in women treated with one and two procedures, respectively. The mean radiation dose was 7954.4 and 14631.3 cGy cm^2 in the same two groups of women. The

Table 2. Summary of presenting symptoms. Values are given as *n* (%).

	Number of women who responded*	Number of patients with symptoms, *n* (%)
Period symptoms		
Heavy	400	310 (78)
Painful	400	234 (59)
Previous anaemia	281	138 (49)
Previous blood transfusion	255	29 (11)
Pressure symptoms	267	220 (82)
Swelling/bloating	329	323 (98)
Urinary symptoms	367	127 (35)
Sciatica	260	84 (32)

* Number of patients who definitively answered yes or no to the question. The remainder either left blank or gave unclear answer.

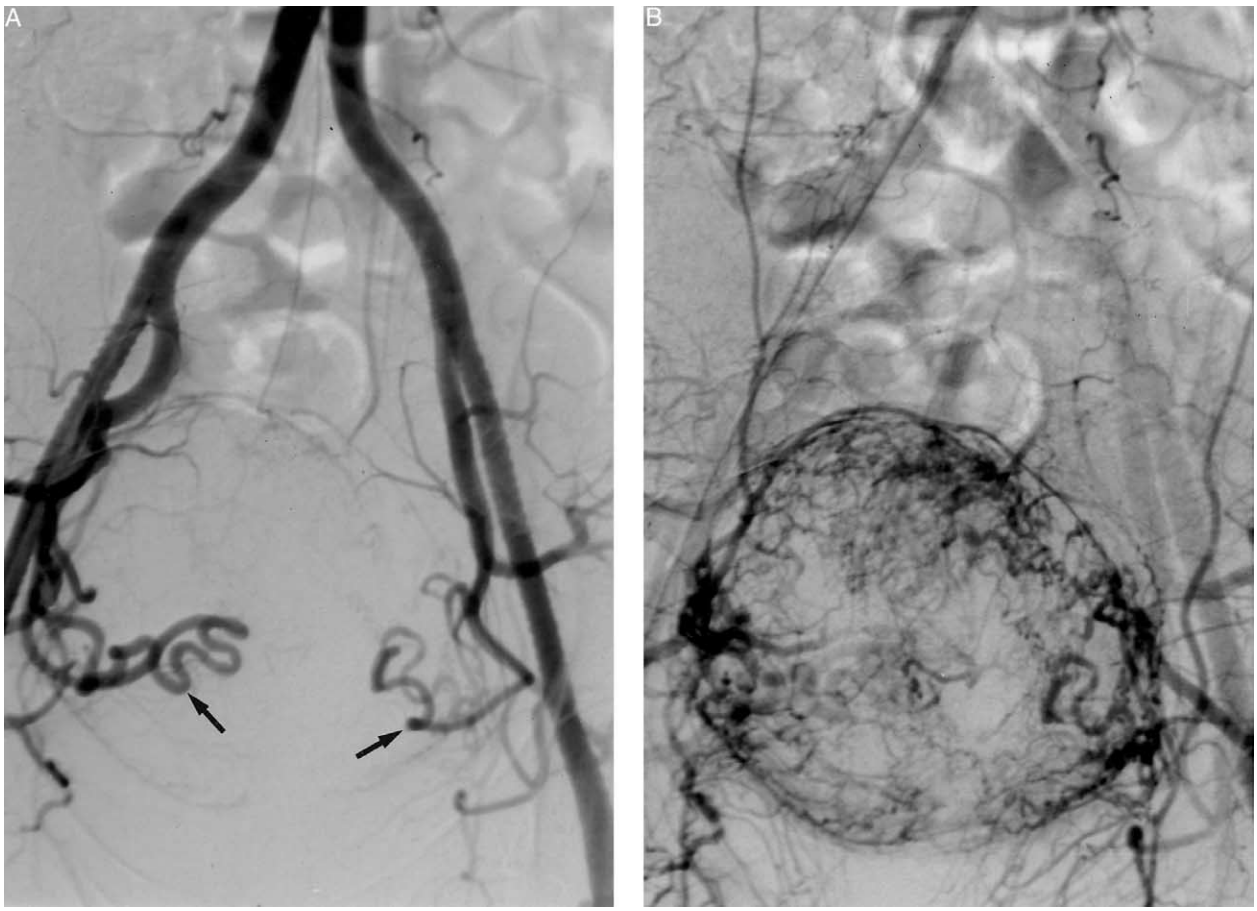

Fig. 1. (A) Pre-embolisation pelvic flush aortogram demonstrates two enlarged uterine arteries (arrows). (B) Late arterial phase demonstrates a large hypervascularised mass.

fluoroscopy time was statistically correlated with the experience of the interventional radiologist.

The evaluation of postprocedure pain is presented in Table 3. Sixty-eight percent of women felt pain that was greater than normal period-type pain (Table 3). Pain lasted on average 17 days after embolisation (Table 4). Most women returned to normal daily activity within 14 days after embolisation and back to work after 17 days (Table 4).

Of the 400 women who were treated, questionnaire follow up was available for 383 patients. Thirteen women were lost to follow up and four women refused to answer the questionnaires. One additional woman who was asymptomatic after six months died in a car accident. Mean duration of clinical follow up was 16.7 (10.4) months.

Two hundred and sixty-two women (66%) replied to the six-week questionnaire. Two hundred and fifty-five women (67%) had a follow up longer than one year and 131 (34%) longer than two years. The most recent follow up in each woman is presented.

Eighty-four percent of women noted improvement in their menorrhagia. Seventy-nine percent of women with menstrual pain were improved. Eighty-two percent of women with abdominal bloating or swelling were improved with complete resolution in 25%. The results are shown in Fig. 2 as percentages of all those who replied. The three women treated unilaterally are currently symptom-free after two years.

Ninety-seven percent of women were satisfied with the procedure and its outcome and would choose embolisation again. Ninety-seven percent of women would also recommend this treatment to others.

Table 3. Procedure evaluation. Values are given as *n* (%).

	Number of women who responded	Number of patients with pain, *n* (%)
Postprocedure pain		
Better	290	72 (25)
As expected	290	98 (34)
Worse	290	120 (41)
Pain		
Less than period pain	296	26 (9)
Like period pain	296	69 (23)
More than period pain	296	101 (34)
Like labour pain	296	40 (14)
More than labour pain	296	10 (3)
Worst ever	296	50 (17)

Table 4. Recovery from procedure (number of days after embolisation). Values are given as *n*, mean [SD] and median (range).

	Number of women who responded*	Mean [SD]	Median (range)
Days till no pain	117	17.2 [14.0]	14.0 (1–90)
Days till returned to normal daily activities	259	13.6 [9.8]	14.0 (0–90)
Days till back to work	237	16.6 [10.8]	14.1 (1–90)

Thirteen pregnancies have occurred in 12 women. Ten pregnancies occurred in 24 women actively trying to become pregnant after embolisation and three additional pregnancies were unexpected. Nine women have delivered successfully including eight term pregnancies so far. One woman was delivered by caesarean section at 27 weeks for pre-eclampsia. Two miscarriages, one ectopic pregnancy and one induced abortion were also observed.

Twelve (3%) women had severe symptoms that failed to respond to the embolisation. Eleven (3%) women had temporary improvement of their symptoms after embolisation and then recurrence within the first year. Of these 23 women with failure or recurrence, three women chose a second embolisation, four had myomectomy, two required hysteroscopies and one required a transcervical endometrial ablation for the control of their symptoms. Nine women were treated with hysterectomy for failure or recurrence of symptoms. In the group with recurrent menorrhagic symptoms, the onset of recurrence varied from 6 to 18 months. Histology reports available in six cases demonstrated that all fibroids were infarcted in four cases, fibroids were not infarcted in two women and adenomyosis was associated with fibroids in three women. One additional woman with clinical failure had associated adenomyosis proven by a transvaginal biopsy. None of these women had uterine sarcoma.

There have been three infective complications leading to hysterectomy. The first occurred in a 39 year old woman following the embolisation of an 11 × 13 × 11 cm fibroid with a mixture of 150–200 and 355–500 μm polyvinyl alcohol particles. She presented 10 days post-embolisation with sudden onset of pyrexia and rigors. Following failure to respond to intravenous antibiotics, the woman underwent a total hysterectomy and bilateral salpingo-oophorectomy 14 days after embolisation and made a full recovery. Histology showed a large tubo-ovarian abscess with some evidence of endometriosis affecting the tube and evidence of polyvinyl alcohol particles in the ovarian vessels (Table 5).

The second woman aged 34, with a 14 × 11 × 8 cm fibroid underwent embolisation with a mixture of 150–250 and 355–500 μm particles. After embolisation, she suffered increasing bouts of pain, intermittent vaginal discharge and a low grade pyrexia. The white count was slightly elevated. Blood cultures and a uterine biopsy revealed the presence of *Escherichia coli*. This appeared to respond to intravenous antibiotics and she was discharged but readmitted with

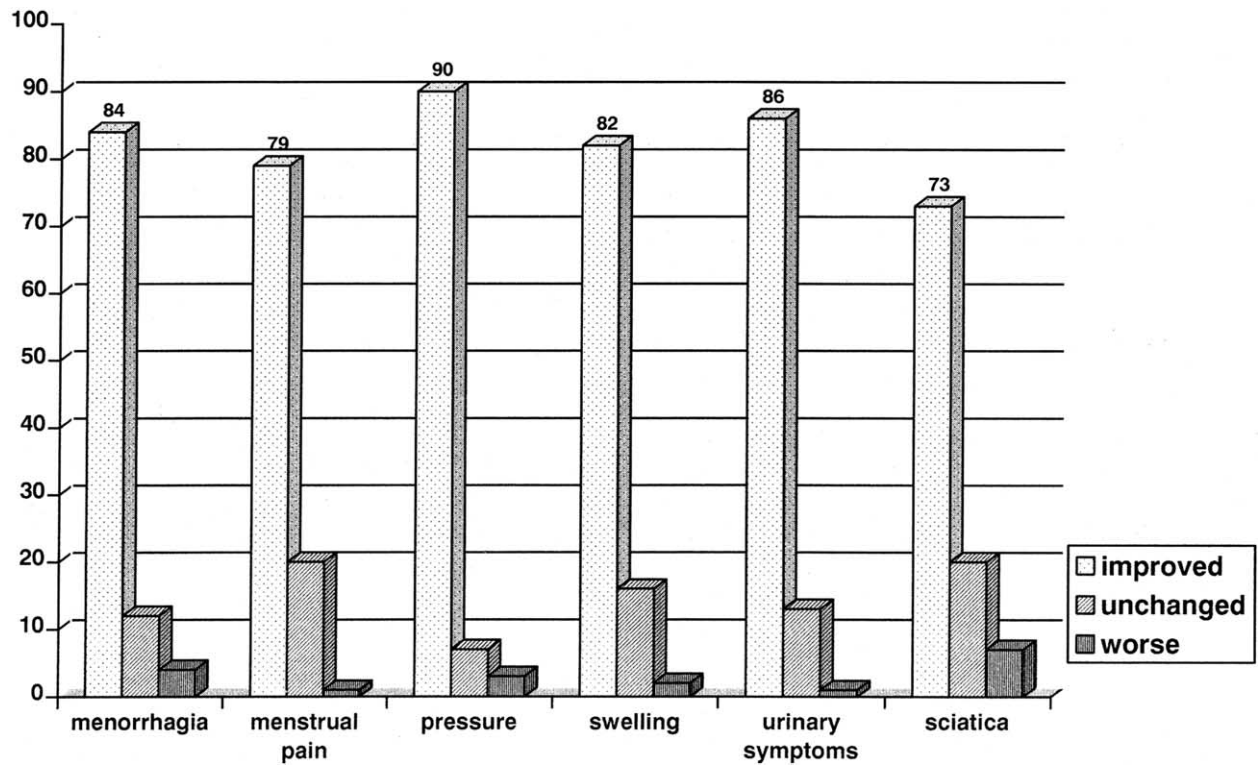

Fig. 2. For each symptom, the percentage of women reporting improvement (first column), unchanged (second column) or worsening of symptoms (third column) are given.

Table 5. Emergency hysterectomy for infection (three patients). Values are given as *n* (%).

Patient	Age	Interval*	Presurgical evaluation	Reason for hysterectomy	Histopathology
1	39	14 days	*E. coli* septicaemia (blood cultures)	Infectious complication unresponsive to antibiotics	Right tubo-ovarian abscess with embolic particles Myometrial abscess Endometritis
2	30	3 months	*E. Coli* septicaemia (blood cultures and uterine biopsy) Fibroid prolapsing through cervix	Infectious complication unresponsive to antibiotics Fundal perforation	Infarcted fibroids Fundal perforation Endometrial atrophy Myometrial ischemia
3	48	10 days	*Streptococcus* septicaemia (vaginal and blood cultures)	Infectious complication unresponsive to antibiotics	Infected fibroids Degenerative endometrium Endometritis

* From embolisation to surgery.

increasing pain and pyrexia three months after embolisation. A magnetic resonance imaging scan showed an infarcted fibroid prolapsing through the cervix and with pus in the endometrial cavity and a fundal perforation. The woman had a hysterectomy with conservation of the ovaries 90 days after embolisation and made a full recovery (Table 5).

The third woman aged 48, with a large, full-thickness fibroid measuring 11 × 11 × 8 cm was embolised using 355–500 μm polyvinyl alcohol particles. She presented with sudden onset of pyrexia and pelvic pain five days after embolisation, consistent with septicaemia. Blood tests and vaginal cultures revealed the presence of streptococcus. Since the woman did not respond to antibiotics, she had a hysterectomy performed 10 days after embolisation and made a full recovery (Table 5).

Nine women passed fibroids spontaneously and five additional women required hysteroscopic resection for infection and pain due to infarcted fibroids (Fig. 3). One of these at subsequent hysteroscopy and hysterosalpingography was found to have developed Asherman's syndrome. The diameter of the expelled fibroids ranged between 1 and 10 cm. Expulsion or resection occurred between two weeks and two years after embolisation.

Data were available on 321 women. One hundred and eighty seven (58%) women presented vaginal discharge after embolisation. Of those, in 54 women (28%) the discharge started almost immediately after embolisation and lasted less than four weeks. Thirty-seven women (20%) had a discharge for between four and eight weeks, and 30 women (16%) had a discharge for more than eight weeks, which then permanently ceased. Forty-three women (23% of those who had a discharge) had a persisting discharge. Of these, 13 (4%) regarded their discharge as a major irritant or very troublesome. In all cases, the discharge was discontinuous during the cycle. Three women in this group said they would have preferred a hysterectomy. One of these had adenomyosis and had a hysterectomy for persisting menorrhagia and the second also felt that the procedure 'prolapsed her bladder'. Currently, women with a chronic discharge who consent are undergoing hysteroscopy and resection fibroid debris and treatment of endometritis.

Three hundred ninety-five women menstruated regularly before embolisation. A total of 42 (11%) women

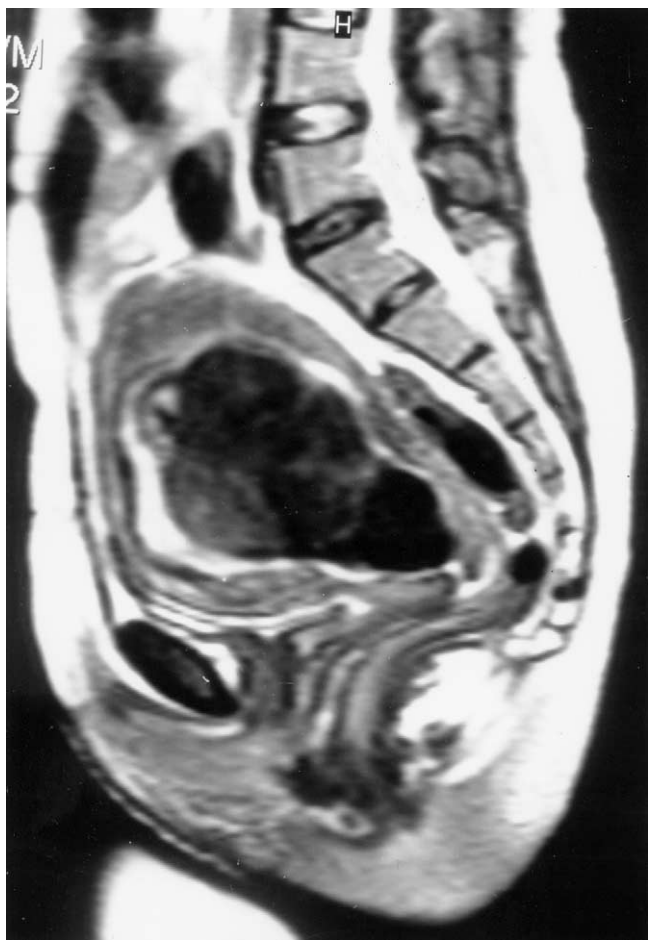

Fig. 3. T2-weighted sagittal magnetic resonance imaging performed two months after embolisation demonstrates a large submucous fibroid about to be expelled through the cervix.

Table 6. Reduction in fibroid/uterine volumes (cc) before and after embolisation by ultrasound and magnetic resonance imaging measurements. Values are given as *n* and mean [SD] and median (range) of volume.

	Ultrasound			Magnetic resonance imaging		
	Number of patients	Volume (cc)		Number of patients	Volume (cc)	
		Mean [SD]	Median (range)		Mean [SD]	Median (range)
Before	379			170		
Uterus	284	787 [648]	608 (103–5627)	110	949 [533]	829 (250–3123)
Fibroid	95	248 [354]	112 (1–2120)	60	403 [517]	267 (8–3566)
After	353			155		
Uterus	265	326 [246]	255 (17–1323)	99	432 [269]	356 (63–1265)
Fibroid	88	79 [158]	19 (0–1142)	56	155 [231]	57 (0–972)

complained of irregular menses or amenorrhoea after embolisation. Thirty-four women were amenorrhoeic after embolisation. Eight (2%) women had transient amenorrhoea and eight (2%) had irregular periods after embolisation. Twenty-six (7%) women had permanent amenorrhoea starting immediately or up to 18 months after embolisation. The mean age of these women was 48.4 (range, 36–56). Seventeen (4%) amenorrhoeic women had at least one clinical symptom suggestive of menopause. Of the 238 patients under the age of 45, four (2%) women were amenorrhoeic with symptoms consistent with menopause and three had biologic ovarian failure. The onset of amenorrhea was delayed four months in two women and 12 and 18 months in the other. One patient had had irregular periods before embolisation and had had a previous unilateral oopherectomy. Of the 162 women over the age of 45, 13 (8%) were amenorrhoeic with symptoms consistent with menopause and 10 had biologic ovarian failure.

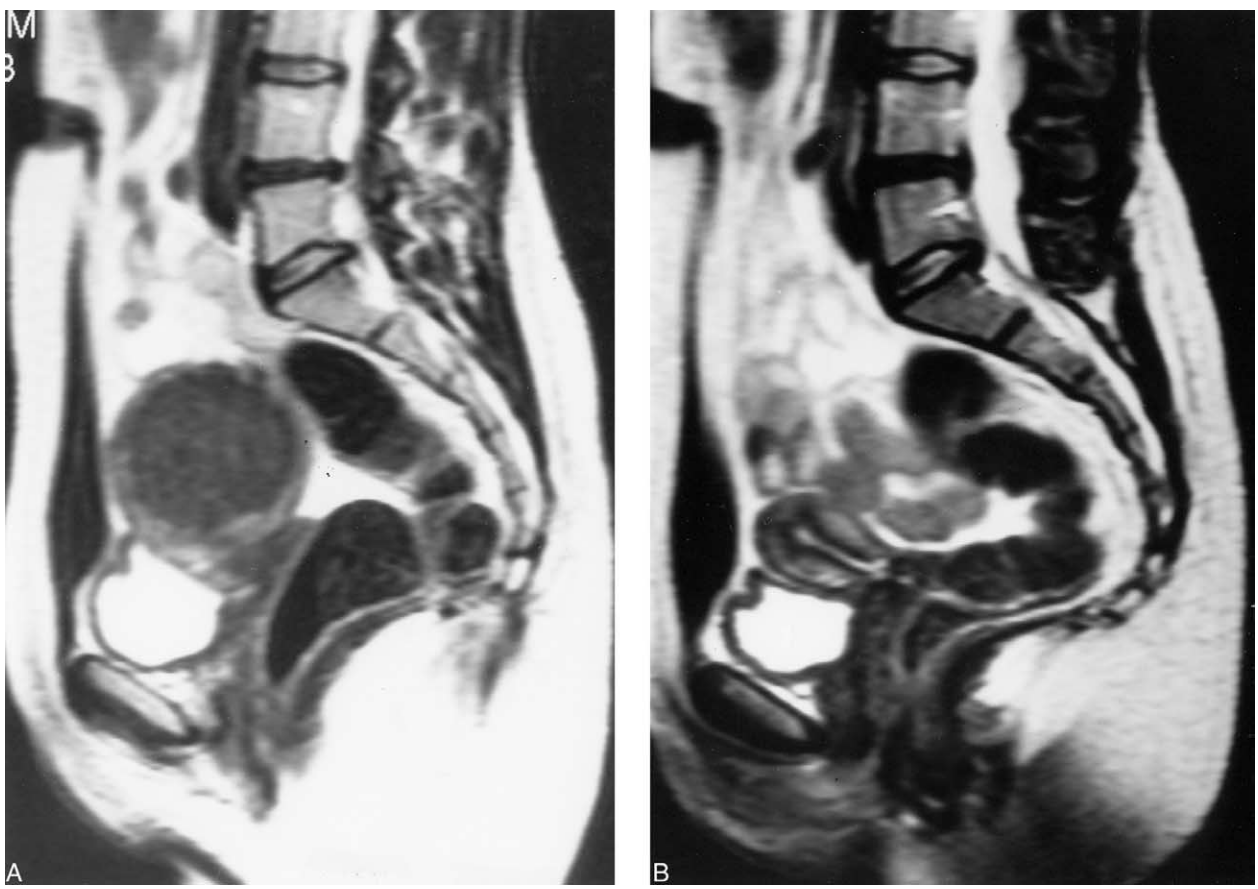

Fig. 4. T2-weighted sagittal magnetic resonance imaging. (A) Pre-embolisation examination shows a large fundal fibroid. (B) Nine months post-embolisation examination demonstrates a virtually normal uterus.

At baseline, 227 (57%) women were examined with ultrasound only, 19 (5%) women were evaluated using magnetic resonance imaging only and 151 (38%) women had both ultrasound and magnetic resonance imaging. In three women, the measurements obtained in the initial ultrasound reports did not permit accurate volume calculation. (Table 6) displays the uterine and fibroid volumes at baseline and for the latest follow up (ultrasound and magnetic resonance imaging). Associated adenomyosis was diagnosed in five women prior to embolisation. Endometrioma was found in three women, ovarian cyst in two women and dermoid cyst in one woman before embolisation.

At least one post-embolisation ultrasound evaluation was obtained on 353/378 women at an average of 9.7 months (range 1.5–42 months) after the procedure. No ultrasound follow up was available in the other women because they refused to be evaluated after embolisation or have been treated by emergency hysterectomy (three women). Table 7 displays the percent reduction in volume. The mean and median final volumes of the uterus were 326 cc (−55% on pre-embolisation figures) and 255 cc (−57%), respectively (Table 6). The mean and median final volumes of the dominant fibroid were 79 cc (−73%) and 19 cc (−77%), respectively (Table 6). No correlation between shrinkage and age of patient at the time of embolisation was found.

Magnetic resonance imaging follow up was performed on 155/170 women at an average of 6.4 months (range 6–12 months) after the procedure (Fig. 4A,B). Ten women were treated less than six months before the study was terminated and five women refused to be evaluated after embolisation. Table 7 displays the percent reduction in volume. The mean and median final volumes of the uterus were 432 cc (−53% on pre-embolisation figures) and 356 cc (−54%), respectively. The mean and median final volumes of the dominant fibroid were 155 cc (−64%) and 57 cc (−67%), respectively. No correlation between shrinkage and age of woman at the time of embolisation was found.

Table 7. Fibroid and uterine shrinkage in percentage of reduction after embolisation, ultrasound and magnetic resonance imaging evaluation. Values are given as *P* and mean [SD] and median (range) of volume reduction.

	P	Volume reduction (%)	
		Mean [SD]	Median (range)
Ultrasound			
Uterus	.0001	55 [18]	57 (0 to 96)
Fibroid	.0001	73 [25]	77 (−65 to 100)*
Magnetic resonance imaging			
Uterus	.0001	53 [17]	54 (0.4 to 90)
Fibroid	.0001	64 [38]	67 (−89 to 100)*

* In two patients, dominant fibroid volume has increased during the follow up.

Comparison between baseline uterine and fibroid volumes and between uterine and fibroid shrinkage rates was obtained in 151 women.

There was a close correlation between the baseline uterine volumes (Rho = .83) and fibroid volumes (Rho = .94) with magnetic resonance imaging and ultrasound. There was also a close correlation between the percentage change by ultrasound and by magnetic resonance imaging.

DISCUSSION

Pre-operative diagnosis is of vital importance before carrying out embolisation. Every woman being considered for this technique should be assessed by both the radiologist and the gynaecologist to exclude pelvic pathology, which may increase the risks of the procedure (e.g. infection or adenomyosis), or to know if it is inappropriate. Magnetic resonance imaging is probably the best imaging modality for the pelvis[20–22].

Elimination of the symptoms is the main objective of embolisation with fibroid shrinkage as an additional advantage. As reported in other studies, our data show that there is a durable improvement in the patients' presenting symptoms. There is also a very high degree of satisfaction with the treatment and the treatment is well tolerated. The procedure is painful but recovery is rapid with most women being back to work within 17 days.

We have shown significant reduction in fibroid volume assessed by both ultrasound and magnetic resonance imaging measurements average shrinkages of 73% and 64%, respectively. This is higher than that achieved in other series[7–10,12,13]. The different results may be due to the fact that we have used 355–500 μm particles and in a small number of cases even smaller particles. It may be that the smaller the particles, the more comprehensive the infarction and the greater the shrinkage[12,24]. The end-point of embolisation is also of crucial importance to reduce post-operative pain and myometrial infarction. Encouraging results following less extensive embolisation of the uterine artery have been recently presented[25].

The success of the procedure is also predicated on an adequate installation of particles. If spasm develops, this could reduce the amount of particles injected before stasis supervenes, giving rise to a false end point of embolisation. The use of microcatheters is important in obviating spasm, and our technique of slow injection of dilute particles also differs from some others in this regard[7,10,12,13]. This technique increases the fluoroscopy time compared with other studies but the risks of untargeted embolisation related to flow redistribution are reduced[26]. The mean radiation exposure in this series is approximately the quoted pelvic radiation dose of 6000 cGy cm^2 for a barium enema in the UK[27,28].

The exclusion of adenomyosis is important, some groups reporting poor response with one group reporting short

term efficacy[8,11,29,30]. The vascularity of fibroids is very different from that of adenomyosis with peripheral hypervascularity allowing infarction of the fibroid followed by hyalinisation, fibrosis and reduction in volume. In this study, five women with clinical failure were found to have adenomyosis. The risk of hysterectomy from dissatisfaction with the procedure in our study was 3% (9/400).

With regard to the indications for fibroid embolisation, attempts have been made to determine the types of fibroid that respond best based on size or magnetic resonance imaging characteristics[31,32]. An analysis of magnetic resonance imaging characteristics and size on 114 patients, who are also a part of this series, has already been published[33]. This demonstrated that size of fibroids, signal characteristics and site do not affect outcome with the proviso that too small a number of pedunculated subserous fibroids were treated to comment on that specific group.

In our series, we have had three (<1%) infective complications, two at the beginning of our experience leading to hysterectomy despite prophylactic antibiotics (ampicillin, gentamycin and metronidazole). None of the patients required intensive care unit admission, developed septic shock or coagulopathy. In one case, polyvinyl alcohol particles were demonstrated in the ovarian vessels. It may be that the use of small particles could facilitate passage of polyvinyl alcohol material via the uterine arteries into the ovarian vessels through collateral circulation[17]. Pre-existing infection should be excluded as far as this is possible. However, a low rate of infection leading to hysterectomy may be an unavoidable consequence of embolisation. It has been said that infection after embolisation is more common in women with large or pedunculated subserous fibroids[12]. Early recognition of infective complications is crucial in order to avoid potentially fatal septic shock[34]. If a patient develops a temperature >38 °C more than four days after the procedure and if she has increasing pain, she should be admitted to hospital and have blood cultures, midstream urine, full blood count, vaginal swabs, magnetic resonance imaging and put on antibiotics.

Persisting cyclically discontinuous vaginal discharge was observed in 13% of our patients and considered as a major irritant in 4% of cases. Ovarian failure is a recognised complication of uterine artery embolisation and developed in 2% of women under the age of 45[12,35]. It would seem that premature menopause occurs in approximately 1% of the normal population under the age of 40 and in 4% under the age of 45[36,37]. In a recent publication, the rate of amenorrhoea after embolisation reached 12% in women over 45[38]. Ovarian ischaemia following embolisation probably accounts for post-hysterectomy ovarian failure[36,39]. However, there does not seem to be an increased rate of ovarian failure in this study.

The number of hysterectomies carried out for fibroids in England and in the United States is approximately 30,000 and 150,000 per annum, respectively[40–42]. The mortality and morbidity of hysterectomy previously documented is slightly higher than the rate of complications associated with embolisation[43,44] and the cost of the hysterectomy to the National Health Service in the UK is approximately £70 million per year[42]. Uterine artery embolisation is a valuable alternative to hysterectomy, and possibly myomectomy in some cases. There seem to be fewer complications, a reduced hospital stay and convalescence and reduced cost[45].

The effect of fibroid embolisation on fertility is unknown. There is no evidence that previously fertile women have become infertile following pelvic embolisations for other causes[46]. However, some women who have had fibroid embolisation have become pregnant and had successful deliveries[6,10,12,14,47]. Encouragingly, ultrasound and magnetic resonance imaging examinations following embolisation demonstrate rapid revascularisation of the normal myometrium and an essentially normal appearance of the endometrium at six months. The rapid revascularisation is due to the rich collateral supply in the pelvis that compensates for the complete occlusion of the uterine vessels used in our study. In view of the lack of data about the effect on fertility, we perform this procedure on women who desire to retain fertility only if they are not thought to be suitable for myomectomy.

To the best of our knowledge, this is the largest reported prospective study to date. It is often said that a randomised controlled study between uterine fibroid embolisation and surgery should be done[23]. It would be nearly impossible to compare outcomes after surgery or embolisation. Various attempts to include women in comparative studies failed because the women randomised in the hysterectomy arm refused to be treated surgically. Comparing embolisation to myomectomy would mean very careful randomisation of the women in order to compare the same population in terms of number, location and size of fibroids. In addition, there is no accepted surgical gold standard for the treatment of uterine fibroids. With a large number of treated women in the present study and a mean clinical follow up of 17 months, the true frequency of complications, failures and success can be meaningfully assessed.

CONCLUSION

Our data would suggest that fibroid embolisation is an effective treatment for fibroids with a low complication and failure rate. Major complications (i.e. ovarian failure and pelvic infection are usually seen early after embolisation). Careful pre-embolisation evaluation both clinically and with imaging together with appropriate technical expertise in embolisation is important to effectively treat patients. Formal training of radiologists is thus a priority consideration. So far, there is no evidence of regrowth of fibroids after a mean follow up of 9.7 months with ultrasound. Long term evaluation of women treated by fibroid embolisation is needed to confirm these encouraging mid-term results.

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