

Spontaneous Pregnancy with a Live Birth after Conventional and Partial Uterine Fibroid Embolization¹

João M. Pisco, MD, PhD
 Marisa Duarte, MD
 Tiago Bilhim, MD, PhD
 Jorge Branco, MD, PhD
 Fernando Cirurgião, MD
 Marcela Forjaz, MD
 Lúcia Fernandes, MD
 José Pereira, MD
 Nuno Costa, MD
 Joana B. M. Pisco, MD
 António G. Oliveira, MD, PhD

¹From the Department of Interventional Radiology, Saint-Louis Hospital, Lisbon, Portugal (J.M.P., M.D., T.B., L.F., J.P., N.C., J.B.M.P.); University Department of Radiology (T.B., L.F., J.P., N.C.) and Department of Obstetrics and Gynecology (J.B.), Faculty of Medical Sciences, Universidade Nova de Lisboa, Lisbon, Portugal; Department of Obstetrics and Gynecology, S. Francisco Xavier Hospital, Lisbon, Portugal (F.C.); Department of Obstetrics and Gynecology, Clínica de Santo António, Amadora, Portugal (M.F.); and Department of Pharmacy, Universidade Federal do Rio Grande do Norte, Rua General Gustavo Cordeiro de Farias s/n, Petrópolis 29012-570, Natal-RN, Brazil (A.G.O.). Received June 28, 2016; revision requested September 6; revision received November 14; accepted December 21; final version accepted February 22, 2017. **Address correspondence to** A.G.O. (e-mail: oliveira.amg@gmail.com).

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Purpose:

To determine pregnancy rates after conventional and partial uterine fibroid embolization (UFE).

Materials and Methods:

The study received institutional review board approval and all patients gave written informed consent. A retrospective analysis of data collected prospectively was performed between June 2004 and June 2014 in a cohort of 359 women (mean age, 35.9 years \pm 4.8) with uterine fibroids and/or adenomyosis who were unable to conceive. The median follow-up period was 69 months (range, 6–126 months). Under local anesthesia, both uterine arteries were embolized. In 160 patients, partial embolization was intentionally performed to preserve fertility, which may be decreased after conventional UFE. In partial UFE, only the small arterial vessels to the fibroids were embolized, leaving the large vessels of the fibroids patent. The Kaplan-Meier method and Cox regression were used for the statistical analysis.

Results:

During follow-up, 149 women became pregnant, 131 women had live births, and 16 women had several pregnancies, resulting in a total of 150 live newborns. It was the first pregnancy for 85.5% (112 of 131) of women. Spontaneous pregnancy rates at 1 year and 2 years after UFE were 29.5% and 40.1%, respectively. The probability of successful pregnancy with live birth at 1 year and 2 years was 24.4% and 36.7%, respectively. Clinical success for fibroid-related symptoms was 78.6% (282 of 359). A dominant submucosal fibroid and ischemia greater than or equal to 90% had greater likelihood of spontaneous pregnancy. Complication rates in patients treated with partial UFE (14.6%) were not greater than rates in patients treated with conventional UFE (23.1%, $P = .04$).

Conclusion:

Conventional and partial UFE may be safe and effective outpatient procedures for women with uterine fibroids who want to conceive.

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Uterine fibroids are considered one of the most common causes of infertility and complications related to pregnancy. In one study, Buttram and Reiter calculated that 27% of women with fibroids had problems related to fertility (1). The standard treatment option for such women is myomectomy via hysteroscopy, laparoscopy, or laparotomy. Myomectomy is considered the only treatment recommended for patients believed to have fibroid-associated infertility.

The use of uterine fibroid embolization (UFE) in women with fertility plans remains controversial (2). However, Ravina et al reported the first

12 pregnancies after UFE in 2000 (3). Since then, several clinical studies have reported on pregnancy outcomes after UFE (4–9). Spies et al suggested that UFE does not affect the ovarian function in most women younger than 45 years (10). Therefore, they concluded that UFE is a safe and effective treatment for symptomatic fibroids in selected women who wish to retain their uteri (11). However, concerns exist about the effects of UFE on fertility and the likelihood of pregnancy after the procedure. To preserve uterine fertility, partial UFE was performed in patients from this study, in whom only the small vessels to the uterine fibroids were embolized and the corresponding larger vessels were left patent. In the other patients, conventional UFE was performed and all uterine artery branches were embolized.

The purpose of the study was to determine pregnancy rates after conventional and partial UFE.

Advances in Knowledge

- Conventional and partial uterine fibroid embolization (UFE) was performed in 359 women with infertility who wished to conceive, with a pregnancy rate of 41.5% (149 of 359) after a median follow-up period of 69 months.
- The live newborn rate among women who became pregnant was 71.9% (131 of 182) and for 85.5% (112 of 131) of these women, it was their first pregnancy.
- The cumulative probabilities of spontaneous pregnancy at 12 and 24 months were 29.5% (95% confidence interval [CI]: 25.1%, 34.5%) and 40.1% (95% CI: 35.3%, 45.4%); cumulative probabilities of a successful spontaneous pregnancy with a live birth at 12 and 24 months were 24.4% (95% CI: 20.3%, 29.3%) and 36.7% (95% CI: 31.9%, 42.0%).
- In multivariate analysis, the factors associated independently with increased probability of pregnancy were submucosal location of the fibroid (hazard ratio: 4.58; 95% CI: 2.61, 8.01; $P < .01$) and degree of ischemia greater than or equal to 90% (hazard ratio: 2.003; 95% CI: 1.02, 4.03; $P = .04$).

Materials and Methods

Study Cohort

In a previous publication, the obstetric outcomes of 74 patients included in this cohort were presented (12). This study is based on a much larger series and presents more detailed results and a longer follow-up period. Our study was approved by the institutional review board, and written informed consent was obtained from each patient. From June 2004 to June 2014, UFE was performed in 1547 patients in a single medical center by interventional radiologists with 12 years (J.M.P., M.D., T.B.) and 4 years (L.F., J.P., N.C.) of experience with conventional UFE. Partial UFE was performed by the same interventional radiologists after training on the technique and the embolization end points of the procedure.

Implication for Patient Care

- UFE may be recommended as a fertility restoring procedure in women with uterine fibroids.

All women of fertile age (age 18 years or older) with uterine fibroids and/or adenomyosis who wanted to conceive, but could not after at least 1 year of unprotected sexual activity, were invited to participate in this observational cohort study. Three hundred fifty-nine women (mean age, 35.9 years \pm 4.8 [standard deviation]; range, 22–52 years) were included in the study and observed for up to 10 years after UFE. Conventional UFE is the standard interventional treatment for uterine fibroids. In the beginning of our experience, we performed conventional UFE in 199 women between June 2004 and June 2009. Because some patients could not become pregnant in spite of evidence of a decrease in volume and complete ischemia of the fibroids, we hypothesized that a partial embolization, by inducing a lower degree of ischemia to the endometrium, could improve the pregnancy rate. Consequently, we performed partial UFE in the next 160 patients from June 2009 to June 2014. The patients were advised about the uncertain effect of the procedure on future pregnancies and to wait at least 6 months after UFE before trying to conceive. The patients were counseled about the potential complications of UFE and were also informed about the eventuality of a

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Abbreviations:

CI = confidence interval

UFE = uterine fibroid embolization

Author contributions:

Guarantors of integrity of entire study, J.M.P., M.D., J.B., F.C., M.F., J.P.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; approval of final version of submitted manuscript, all authors; agrees to ensure any questions related to the work are appropriately resolved, all authors; literature research, J.M.P., M.D., T.B., F.C., M.F., L.F., J.P.; clinical studies, J.M.P., M.D., J.B., F.C., M.F., L.F., N.C., J.B.M.P.; experimental studies, M.F.; statistical analysis, M.D., F.C., M.F., L.F., A.G.O.; and manuscript editing, J.M.P., M.D., T.B., F.C., M.F., L.F., J.P., N.C., J.B.M.P., A.G.O.

Conflicts of interest are listed at the end of this article.

repeated UFE, because not all uterine artery branches were completely embolized and the results of partial UFE regarding fibroid volume reduction might be inferior to those of conventional UFE. Myomectomy was offered as an alternative. Patients with gynecologic malignancy or with current uterine or adnexal infection were excluded. All patients were asked about the number of previous pregnancies, live births, spontaneous abortions, myomectomies, and attempts at fertility-enhancing techniques, namely in vitro fertilization.

A baseline contrast material-enhanced magnetic resonance (MR) imaging study was performed before the UFE procedure (T.B., with 12 years of experience). Three dimensions and volume of the uterus and of the largest leiomyoma were evaluated, as well as the number of fibroids, their location, and whether adenomyosis was present. All patients were medicated with an acid-suppressing drug once daily (20 mg of omeprazole; Bluepharma, Coimbra, Portugal) and an anti-inflammatory drug once daily (1000 mg of naproxen, Naprosyn; Roche, Basel, Switzerland) 2 days before UFE. The patients were admitted to the hospital 2 hours before the procedure, at which time they were administered other medications such as antihistamines (hydroxyzine, Atarax; Union Chimique Belge, Brussels, Belgium), analgesics (metamizole, Noltil; Boehringer Ingelheim, Ingelheim am Rhein, Germany), and antiemetics (metoclopramide, Primperan; Sanofi-Aventis, Paris, France) (13–15). During the procedure, analgesics (2 g of metamizole and 100 mg of tramadol, Tramal; Grünenthal, Aachen, Germany) and an anti-inflammatory drug (30 mg of ketorolac tromethamine, Toradol; Roche, Paris, France) were given intravenously. If necessary, 1 mg of midazolam (Versed; Roche, Basel, Switzerland) was given intravenously (15).

UFE Technique

Under local anesthesia, both uterine arteries were embolized by a single femoral approach with a 5-F Roberts uterine catheter (Cook Medical, Bloomington, Ind). In partial UFE, the catheter tip was

placed distally in the uterine artery, but in a location where all small branches to the fibroid could be opacified. From there, all small fibroid arteries were embolized, leaving the corresponding larger vessels patent. The end point for embolization was absence of opacification of the majority of the small arterial branches to the fibroids, with the large vessels left patent, to avoid excessive embolization (Fig 1). Complete embolization of the uterine artery was avoided because it might cause ischemia of the normal endometrium and ovaries. In conventional UFE, the catheter tip was placed more proximally in the uterine artery, but in a point where all uterine artery branches could be opacified. Then, the embolization was started and the end point was nonopacification of all uterine artery branches, both small and large. Nonspherical polyvinyl alcohol particles 300–500 μm (Cook Medical) or 500–700- μm microspheres composed of a hydrogel core and an exterior shell of poly(bis[trifluoroethoxy]phosphazene) (Embozene; CeloNova BioSciences, San Antonio, Tex) were given in the beginning of the embolization, following with larger particles if necessary (13). For the patients with adenomyosis, the embolization was started with polyvinyl alcohol 100 μm and continued with polyvinyl alcohol 200–300 μm . Procedure and fluoroscopy times were recorded. Procedure time was defined as the time from entrance of the catheter into the femoral artery until the moment it was removed.

The women were treated as outpatients and were discharged when they were free of symptoms, usually 4–8 hours after the procedure, depending on the severity of the postembolization syndrome. MR imaging was repeated 6 months after the procedure to evaluate changes in fibroid and uterus volumes, and the degree of ischemia of the fibroids. The latter was evaluated by the percentage of perfused tissue after intravenous injection of gadolinium-based contrast agent. Ischemia over 90% was considered when the fibroid did not enhance with gadolinium. Patients whose fibroids showed an ischemia under 90% were advised to undergo repeated UFE.

Outcome Measures

MR imaging was performed 6 months after UFE. At that time, the patients underwent a clinical evaluation to identify complications of UFE, including vaginal examination, degree of pain, dyspareunia, regularity and duration of menstruation, and degree of vaginal flux. Changes on MR images were recorded, particularly the amount of volume change of the uterus and the dominant fibroid, and the degree of ischemia. Patient follow-up was performed by telephone interview yearly thereafter, or personally if a patient had symptoms of uterine fibroids. MR imaging was performed only if a patient had symptoms of uterine fibroids. Patients were asked about symptom changes, whether they became pregnant and the pregnancy outcome, or if they underwent subsequent uterine procedures or operations. Relevant study outcomes were spontaneous pregnancy and successful pregnancy with a live birth. For women with successful pregnancy, data were collected on gestational time, type of delivery, sex and weight of the newborn, and complications (preterm delivery and low birth weight). For women with unsuccessful pregnancy, information was obtained on the cause of the early termination.

Statistical Analysis

Results are presented as absolute and relative frequencies or as mean \pm standard deviation, median, and range. Cumulative probabilities of both spontaneous and successful pregnancy over time were estimated with the Kaplan-Meier method to account for varying follow-up times. For the analysis of factors associated with pregnancy after UFE, we used Cox proportional-hazards model. Variables significantly associated with the event of spontaneous pregnancy in univariate analysis were included in a multivariate model by using a stepwise backward selection method to obtain a final set of independent predictors ($P < .10$). The log-rank test was used to test whether study outcomes were significantly different between the first 199 women included in the cohort (who were treated with conventional UFE) and the last 160 women (who were

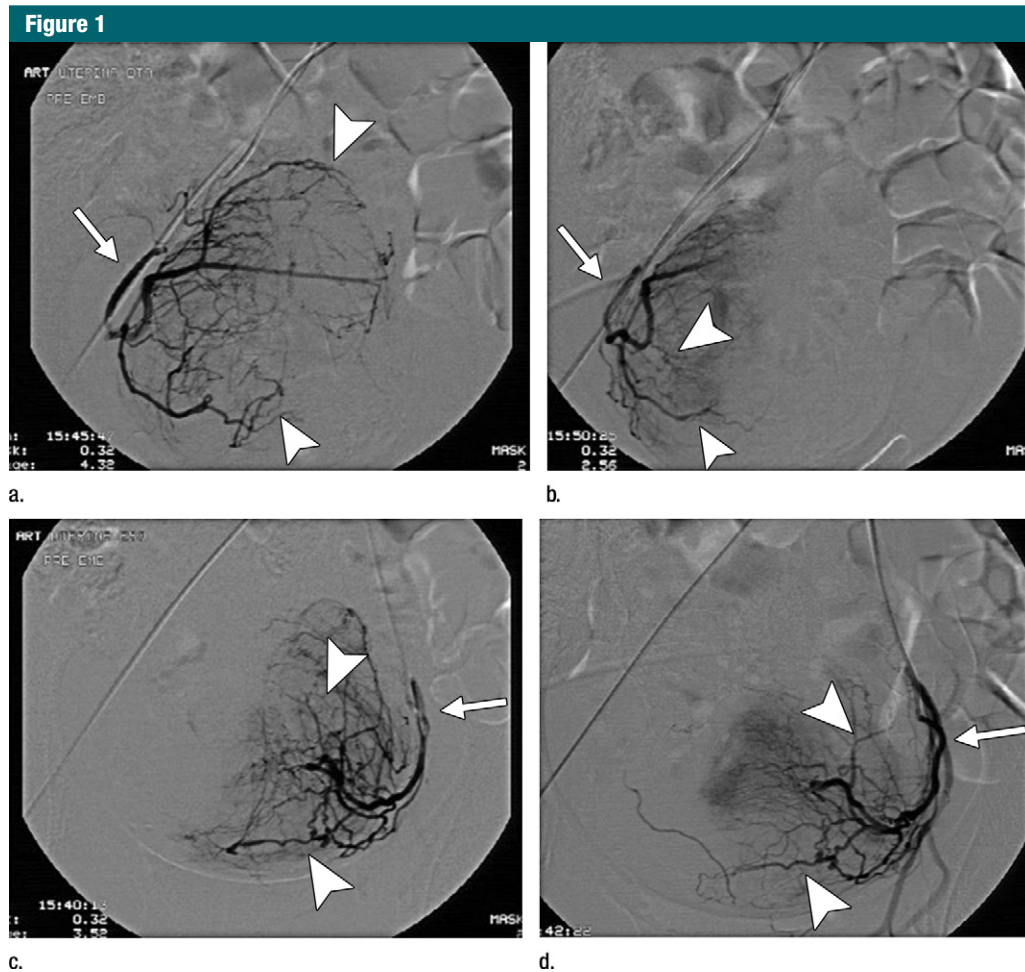


Figure 1: Digital subtraction angiography images show partial UFE. **(a)** Catheter is placed into right internal iliac artery with catheter tip in initial part of uterine artery (arrow); hypervascularization of fibroid is shown (arrowheads). **(b)** After partial UFE, uterine artery (arrow) is patent and there is some reduction of fibroid vessels, although some vessels are still shown (arrowheads). **(c)** Catheter is placed into left internal iliac artery with catheter tip in initial part of uterine artery (arrow); hypervascularization of fibroid is shown (arrowheads). **(d)** After partial UFE, uterine artery (arrow) is patent and there is some reduction of small fibroid vessels, although some vessels are still shown (arrowheads).

treated with partial UFE). The log-rank test was also used to test whether outcomes were different in women over age 40 years. Statistical analyses were performed with Stata 11 software (Stata, College Station, Tex).

Results

The study population consisted of 359 patients with uterine fibroids or adenomyosis who wanted to conceive. Seventy patients (19.5%) were over age 40 years. The median follow-up period was 69 months (mean, 67.5 months \pm 25.4; range,

6–126 months). Twenty-seven patients (7.5%) were lost to follow-up. Baseline characteristics of the patient cohort are presented in Table 1. The embolic material used was polyvinyl alcohol particles in all but in five patients, in whom microspheres composed of a hydrogel core and an exterior shell of poly(bis[trifluoroethoxy] phosphazene) were used. Details of the procedure and of the results on the uterus and fibroid volume at 6 months after the procedure are shown in Table 2.

Clinical success for UFE on fibroid-related symptoms (menorrhagia, pelvic

pain, and pelvic pressure) was 78.6% (282 of 359). The average volume reduction of the uterus and dominant fibroid was 33.4% \pm 26.6 and 54.8% \pm 30.6%, respectively, and the average degree of ischemia was 88.5% \pm 6.59.

Kaplan-Meier estimates (Fig 2) of the cumulative probability of spontaneous pregnancy at 12 months and 24 months were 29.5% (95% confidence interval [CI]: 25.1%, 34.5%) and 40.1% (95% CI: 35.3%, 45.4%), respectively. The estimates of the cumulative probability of a successful spontaneous pregnancy with a live birth at 12 months and 24 months were 24.4%

Table 1

Baseline Patient Characteristics

Variable	Value
Age ≥40 y	70 (19.5)
Previous pregnancy	114 (31.8)
Previous live birth	73 (20.3)
Previous abortion	63 (17.6)
Previous myomectomy	30 (8.4)
Previous in vitro fertilization	3 (0.8)
Location of dominant fibroids	
Intramural	216 (58.5)
Subserous	115 (31.2)
Submucosal	21 (5.7)
Pure adenomyosis	5 (1.4)
Adenomyosis plus fibroid	2 (0.6)

Note.—Data are number of patients, with percentages in parentheses.

Table 2

Results of UFE

Variable	Mean	SD	Median	Range
Procedure time (min)	36.7	19.6	30	10–125
Fluoroscopy time (min)	8.5	7.4	5.8	1.4–60
Uterus volume before UFE (cm ³)	413.5	384.0	297	33–2870
Uterus volume 6 months after UFE (cm ³)	260.3	296.8	178	16–2869
Uterus volume change (%)	−33.4	26.6	−32.9	−93.6 to 125.8
Dominant fibroid volume before UFE (cm ³)	176.0	294.6	83	1–2677
Dominant fibroid volume 6 months after UFE (cm ³)	90.7	206.2	31	0–2377
Dominant fibroid volume reduction (%)	54.8	30.4	56	−125.5 to 100.0
Degree of ischemia (%)	88.5	6.7	90	40–100

Note.—SD = standard deviation.

(95% CI: 20.3%, 29.3%) and 36.7% (95% CI: 31.9%, 42.0%), respectively.

The estimates of the cumulative probability of spontaneous pregnancy at 24 months were 45.0% (95% CI: 37.7%, 53.0%) after partial UFE and 36.2% (95% CI: 29.9%, 43.3%) after conventional UFE (hazard ratio, 1.27; 95% CI: 0.92, 1.75; *P* = .14). For successful pregnancy, the estimates at 24 months were 37.8% (95% CI: 30.6%, 46.1%) after partial UFE and 30.7% (95% CI: 24.6%, 37.8%) after conventional UFE (hazard ratio, 1.25; 95% CI: 0.87, 1.80; *P* = .21). Table 3 presents the distribution of pregnancy outcomes by UFE type.

Table 4 shows the hazard ratios of spontaneous pregnancy after UFE associated with each patient variable. In multivariate analysis, the factors associated independently with increased probability of pregnancy were submucosal location of the fibroid (hazard ratio, 4.58; 95% CI: 2.61, 8.01; *P* = .01) and degree of ischemia greater than or equal to 90% (hazard ratio, 2.03; 95% CI: 1.02, 4.03; *P* = .04). The average volume reduction of submucosal fibroids was 71% ± 34, significantly larger than the volume reduction of 54% ± 30 observed in fibroids in other locations (*P* = .016).

Table 5 shows the pregnancy data of women age 40 years or older compared

with women younger than 40 years. The cumulative probability of spontaneous pregnancy at 24 months was 31.5% for women age 40 years or older and 39.2% for women younger than 40 years (hazard ratio, 0.82; 95% CI: 0.53, 1.26; *P* = .35). The cumulative probability of successful pregnancy at 24 months was 32.6% for women age 40 years or older and 35.7% for women younger than 40 years (hazard ratio, 0.91; 95% CI: 0.55, 1.42; *P* = .67).

There were 182 spontaneous pregnancies in 149 of 359 patients (41.5%), and 131 of 149 patients (87.9%) with spontaneous pregnancy later had live births, for a total of 148 successful pregnancies with 150 live births. Of the 131 patients with successful pregnancy, seven patients (5.3%) also had adenomyosis, 14 patients (10.7%) had undergone 21 previous myomectomies, and three patients (2.3%) had undergone six unsuccessful in vitro fertilization procedures. For 112 patients (85.5%), it was the first live birth. These women tried but failed to become pregnant from 3–24 years (median, 8 years; mean, 8.8 years ± 4.2; 95% CI: 7.9 years, 9.6 years). Contrast-enhanced MR imaging was repeated at 6 months in 310 of 359 patients (86.4%). In 262 of these patients (84.5%), the dominant uterine fibroid showed an ischemia over 90%. UFE was repeated in 28 patients with incomplete fibroid ischemia, as shown by using MR imaging, and 11 of these patients subsequently had their first

pregnancy with a live birth. Thirty-six of 131 patients (27.5%) with a successful live birth have had a previous pregnancy, 19 patients (14.5%) have had one to three live births (total of 24 newborns), and 23 patients (17.6%) have had one to four spontaneous abortions (total of 38 spontaneous abortions). Two patients who did not become pregnant later underwent unsuccessful in vitro fertilization.

Among the 131 patients with live births, 115 patients (87.8%) had one successful pregnancy (two patients with twin births), 15 patients (11.5%) had two pregnancies, and one patient (0.8%) had three successful pregnancies. Therefore, there were 150 live births. The median time lag from UFE to first conception in those patients was 12 months (range, 1.5 months to 26 years). The average duration of gestation was 38.4 weeks ± 1.5 (range, 30–41 weeks), and the type of delivery was vaginal in 38.7% of patients (58 of 150) and cesarean in 61.3% of patients (92 of 150). Among the newborns, 43.3% (65 of 150) were girls and 56.7% (85 of 150) were boys, and the average birth weight was 3300 g ± 550 (range, 1700–4910 g). All newborns at term presented no significant neonatal problems.

Of the 31 unsuccessful pregnancies, 23 (74.2%) were due to spontaneous abortion, five (16.1%) were due to induced abortion, two (6.5%) were due to ectopic pregnancy, and one (3.2%) was due to stillbirth. The reasons for

Figure 2

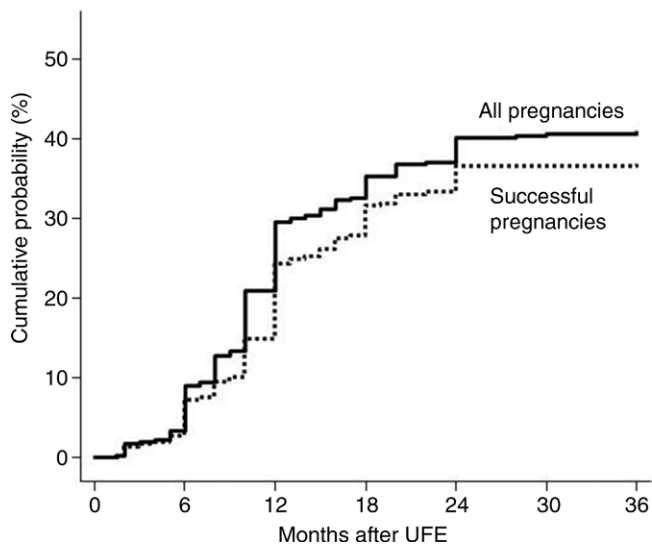


Figure 2: Graph shows cumulative probabilities of spontaneous pregnancy (solid line) and of live birth after spontaneous pregnancy (dotted line) after partial UFE in patients who wish to conceive.

induced abortion were administration of isotretinoin ($n = 1$), trisomy 21 ($n = 2$), trisomy 18 ($n = 1$), and cytomegalovirus infection ($n = 1$). Neither the two patients with ectopic pregnancy after UFE nor the five patients with induced abortion subsequently had a successful pregnancy.

Twenty-three of 182 patients (12.6%) had spontaneous abortions after UFE. Of these, 13 patients (56.5%) had one to three previous spontaneous abortions before UFE; therefore, we did not assume that the spontaneous abortions were a result of UFE. Only four of these women were able to conceive with one or two live births before UFE, whereas after UFE 12 women had successful pregnancies with a live birth (three who underwent conventional UFE and nine who underwent partial UFE). One woman had twin births, and one woman has an ongoing pregnancy.

At the time of writing this article, 182 spontaneous pregnancies have occurred in 149 patients, with one ongoing pregnancy. Of these, twenty patients (13.3%) underwent 24 previous unsuccessful myomectomies and three patients (2.0%) underwent six

unsuccessful in vitro fertilization procedures. Since the time of writing, there were 12 additional pregnancies resulting in eight live births, two abortions, and two ongoing pregnancies.

The complications observed in the 182 pregnancies were 23 of 182 (12.6%) spontaneous abortions; 10 of 150 (6.7%) cases of low birth weight; 10 of 150 (6.7%) cases of preterm delivery; eight of 150 (5.3%) cases of fetal malpresentation; five of 150 (3.3%) cases of postpartum hemorrhage, with one patient needing hysterectomy; two of 150 (1.3%) cases of placenta previa; one of 150 (0.7%) cases of placenta accrete; two of 150 (1.3%) cases of premature rupture of membranes; two of 150 (1.3%) cases of predelivery hypertension; two of 150 (1.3%) ectopic pregnancies; and one of 150 (0.7%) stillbirth. Two of the preterm newborns were conceived just 1.5 months after UFE. The procedure-related complications were as follows: (a) readmission for pain in two patients, (b) spontaneous expulsion of intracavitary submucosal fibroids in eight patients (two of them had the fibroids removed by hysteroscopic myomectomy), (c) premature

Table 3

Distribution of Pregnancy Outcomes by UFE Type

Pregnancy Outcome	Type of UFE	
	Conventional ($n = 199$)	Partial ($n = 160$)
Spontaneous	75 (37.7)	74 (46.3)
Successful	60 (30.8)	58 (38.4)
Unsuccessful	15 (7.5)	16 (10.0)
No pregnancy	124 (62.3)	86 (53.8)

Note.—Data are number of patients, with percentages in parentheses.

menopause in two patients, and (d) postembolization infection in one patient. Two patients who did not become pregnant later underwent unsuccessful in vitro fertilization.

Discussion

The treatment of uterine fibroids in patients who want to conceive has traditionally been myomectomy via hysteroscopy for submucosal fibroids and either laparoscopy or laparotomy for fibroids in other locations. UFE is considered controversial for women with symptomatic fibroids who wish to conceive. Myomectomy is performed under general anesthesia and requires hospitalization and recovery for many days. Moreover, myomectomy may result in complications such as bleeding and need of blood transfusion, a high recurrence rate of myomas, regrowth of new myomas, fragility of myometrium with locus of minor resistance that can cause uterus rupture and result in hysterectomy, a high rate of abnormal placentation, and/or adhesion formation and conversion to hysterectomy (5). Although myomectomy is the standard treatment procedure for women with uterine fibroids who desire future pregnancy, myomectomy may be difficult if numerous or very large intramural and/or submucosal fibroids are present, and the recurrence rate may be higher than 60% (16–19).

The role of UFE in patients with fertility plans remains unclear, in spite

Table 4

Factors Associated with the Likelihood of Spontaneous Pregnancy after UFE

Variable	Univariate Analysis		Multivariate Analysis	
	Hazard Ratio	P Value	Hazard Ratio	P Value
Age (y)	1.003 (0.969, 1.038)	.85	...	...
Age ≥40 y	0.873 (0.567, 1.343)	.54	...	...
Submitted to previous myomectomy	1.211 (0.698, 2.100)	.50	...	...
Presence of submucosal fibroid	4.784 (2.908, 7.837)	.01	4.575 (2.613, 8.008)	.01
Uterus volume before UFE (per 10 cm ³)	0.993 (0.987, 0.998)	.01	...	...
Uterus volume after UFE (per 10 cm ³)	0.986 (0.975, 0.997)	.01	...	...
Uterus reduction (%)	0.998 (0.992, 1.005)	.61	...	...
Dominant fibroid volume before UFE (per 10 cm ³)	0.991 (0.982, 0.999)	.04	0.993 (0.984, 1.002)	.09
Dominant fibroid after UFE (per 10 cm ³)	0.978 (0.959, 0.999)	.04	...	...
Dominant fibroid reduction (%)	1.002 (0.996, 1.008)	.56	...	...
Degree of ischemia ≥90%	2.273 (1.149, 4.498)	.02	2.029 (1.022, 4.026)	.04
Submitted to repeated UFE	1.135 (0.597, 2.157)	.70	...	...

Note.—Data in parentheses are 95% CIs.

of some small series showing its utility. UFE has been used to reduce fibroid and uterus volume and has the potential to treat all uterine fibroids in a single session. After embolization, the fibroids may either shrink or be expelled vaginally if they are submucosal. Embolized myomas with ischemia over 90% do not grow and continue to shrink during pregnancy (20). UFE causes complete embolization of uterine fibroid vessels and may cause non-target embolization of the ovarian and endometrium vessels with consequent compromise of future pregnancies.

To avoid compromising future pregnancies, partial UFE was performed in 160 patients of this cohort study. With this procedure, occlusion of only the small arterial branches to the fibroids was performed. The corresponding large vessels were left patent because embolization of large vessels may cause ischemia of the normal endometrium and ovaries that may compromise fertility. Partial embolization of uterine arteries may allow reduction of the vascular supply to the uterine fibroids without severely restricting blood supply to the uterus and ovarian arteries, possibly allowing a greater pregnancy rate, as well as lower complication rate. In spite of partial embolization of the uterine

Table 5

Comparison of Obstetric History and Outcomes after UFE

Variable	<40 Years (n = 289)	≥40 Years (n = 70)	P Value
Past history			
Pregnancy	81 (28.0)	33 (47.1)	.002
Abortion	47 (16.3)	16 (22.9)	.19
Live birth	48 (16.6)	25 (35.7)	<.001
Myomectomy	23 (8.0)	7 (10.0)	.58
Outcomes after UFE			
Spontaneous pregnancy	123 (42.6)	26 (37.1)	.41
Live birth	107 (37.0)	24 (34.3)	.67

Note.—Data are number of patients, with percentages in parentheses.

arteries in 262 of 310 patients (84.5%) in our study, the dominant fibroid showed an ischemia over 90%, similar to the results reported by Kroencke et al using conventional UFE (21). These authors reported complete infarction in 52% and almost complete infarction in 28% of all leiomyoma tissue after UFE. Therefore, partial UFE was not associated with lower rates of complete fibroid infarction or with higher rates of repeated UFE in our study. Partial UFE and conventional UFE did not seem to affect fertility. Therefore, the desire for a future pregnancy should not be a contraindication to fibroid embolization.

The low rate of obstetric complications in our study may be due to the

lower degree of embolization of the fibroids in most of the patients and to the relatively low mean age of the patients (35.9 years). The complication rates observed in our overall cohort of UFE patients are comparable with the rates of the general population.

The overall pregnancy rate of 50.7% observed in our study is comparable with the reported rates from a few published case series with smaller numbers of patients, although our series had a lower complication rate (22–24). These results may be due to the partial UFE that was performed. Ravina et al reported a complication rate of 42% (five of 12 cases) for spontaneous abortions and a rate of 25% (three of 12 cases) for premature deliveries (3). Walker et

al (20) reported the first large number of pregnancies, 33 pregnancies in 108 women (30.5%). However, there were 17 abortions (30.4%) and six preterm deliveries (18.2%) in their series. In a study of 26 pregnancies, Carpenter and Walker evaluated the abortion rate and found it was 26% following UFE and only 15% after laparoscopic myomectomy (8). Pron et al reported pregnancies in 21 women after UFE (9); however, there were four abortions (17%) and four premature deliveries (17%). Mohan et al performed a systematic review of the literature analyzing fertility following UFE (25) and concluded low level evidence suggests that pregnancy rates after UFE are similar to the corresponding rates of the general population. In a meta-analysis, Goldberg et al reported the findings on 32 pregnancies following UFE and 139 pregnancies after laparoscopic myomectomy (26). They found that pregnancies following UFE had higher complication rates, namely, preterm delivery, low birth weight, malpresentation, postpartum hemorrhage, cesarean delivery, and spontaneous abortion. However, those women who underwent UFE were older and had larger fibroids.

In 2008, Mara et al reported the only published prospective, randomized controlled trial on the impact of UFE and myomectomy on pregnancy (27). Twenty-six women following UFE and 40 women following myomectomy had tried to conceive. There were more pregnancies ($n = 33$), more successful deliveries ($n = 19$), and fewer abortions ($n = 18$) after myomectomy than after UFE. The rate of abortions after UFE was 64% in contrast with 23% after myomectomy. Furthermore, there were 22 (58%) preterm deliveries after UFE. The reason for the myomectomy group performing better than the UFE group might be due to the longer and larger experience of the authors in treating patients with myomectomy. In addition, many patients who had UFE had multiple large fibroids, for which hysterectomy is indicated. Mara et al also compared UFE and laparoscopic uterine artery occlusion in another study (28). The pregnancy rate after

UFE was 69% (29 of 42) versus 67% (32 of 48) after laparoscopic uterine artery occlusion, indicating that distal occlusion is not superior to proximal occlusion. The abortion and delivery rates after UFE were not statistically different between groups.

In our series, partial UFE had similar clinical results, a lower complication rate, a higher pregnancy rate with live births, and fewer obstetric complications than conventional UFE when compared with the literature mentioned previously. In addition, partial UFE and conventional UFE did not differ regarding fertility outcomes in our study cohort. The Royal College of Obstetrics and Gynecology refers to a 10%–15% risk of spontaneous abortion in the general population, but the risk of abortion increases by two- to threefold in patients over age 40 years (29). Therefore, our results are similar to those of the general population. In our patients, the spontaneous and successful pregnancy rates of partial UFE were better than those of conventional UFE; however, the differences were not statistically significant.

Two of the cases of low birth weight in our study occurred in patients with only 1.5 months between UFE and conception. These patients had large fibroids: one fibroid was 10 cm and another was 12 cm in the largest diameter. Therefore, there was not enough time for complete involution of the fibroids that had shrunk only partially until conception. Despite that, the fibroids continued to decrease in size during pregnancy. Four of the patients who had spontaneous abortions after UFE had previous spontaneous abortion before UFE. The stillbirth occurred at 36 weeks of gestation in a 37-year-old patient who had several previous myomectomies and one in vitro fertilization procedure.

The limitations of our study included that it was performed at a single center. Partial UFE was performed by different interventional radiologists using a subjective, nonstandardized technique. The study was a retrospective analysis, although it was conducted on prospectively collected data. Future studies to standardize and validate partial UFE and compare it to standard UFE are

therefore needed, as well as adequately powered prospective randomized trials to compare fertility and pregnancy rates after UFE and myomectomy. A randomized controlled trial comparing partial UFE, which we performed in our study, with conventional UFE is equally necessary. UFE, particularly partial UFE, may become a possible indication for women with future fertility plans.

In conclusion, the results of our study show that conventional and partial UFE are minimally invasive treatments and potentially feasible options for women with fibroids who wish to conceive, even if they had undergone previous failed myomectomies or in vitro fertilization. These findings show that pregnancy following UFE appears to be safe, with low rates of morbidity. Partial UFE has the potential advantages of avoiding ischemia of the normal endometrium and ovaries, in contrast with conventional UFE, which may cause embolization of these organs with consequent compromise of fertility.

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