



# Review of nonsurgical/minimally invasive treatments for uterine fibroids

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## Purpose of review

Many nonsurgical and minimally invasive therapies for symptomatic uterine fibroids have been introduced. The purpose of this review is to summarize the recent evidence on these techniques, and their effect on fibroid volume, menorrhagia, health related quality of life (HRQOL), fertility and their risk of complications.

## Recent findings

Laparoscopic or hysteroscopic myomectomy and uterine artery embolization (UAE) have been the most widely studied and all show significantly beneficial effects on menorrhagia and HRQOL, with a low incidence of complications. Magnetic resonance-guided high-intensity focused ultrasound (MRgFUS), myolysis/radiofrequency ablation (RFA) and laparoscopic or vaginal occlusion of uterine vessels (L/V-OUA) are newer interventions, with a smaller body of evidence.

For women wishing to retain their childbearing possibilities, myomectomy is the best-studied intervention. Hysteroscopic myomectomy is specifically indicated in submucosal fibroids with subsequently beneficial effects on fertility. The use of UAE in fertile women has not been studied extensively, but evidence points toward an increase in adverse pregnancy outcomes after UAE compared with myomectomy. For MRgFUS, myolysis/RFA and L/V-OUA more evidence is needed.

## Summary

Laparoscopic/hysteroscopic myomectomy and UAE are evidence-based beneficial alternative therapies for symptomatic uterine fibroids. Until more evidence is available, myomectomy stays the option of choice for women who wish to conceive in the future.

## Keywords

laparoscopic/hysteroscopic myomectomy, laparoscopic/vaginal occlusion of uterine vessels, MRgFUS, myolysis/radiofrequency ablation, uterine artery embolization

## INTRODUCTION

Symptomatic uterine fibroids are very common. Recent longitudinal studies have estimated the lifetime risk for developing fibroids in a woman over the age of 45 years to be more than 60% [1]. Although many fibroids are asymptomatic, some may cause seriously deteriorating complaints, such as menorrhagia and subfertility. Hysterectomy offers a definite solution, but for many women this is not an option. The effect of fibroids on clinical signs and symptoms and on fertility is largely determined by their location. Subserosal fibroids do not appear to have impact on menstrual bleeding or fertility outcomes. Intramural fibroids may be associated with heavy menstrual bleeding, reduced fertility, and an increased miscarriage rate. However, there is insufficient evidence to substantiate the exact impact of intramural fibroids on fertility and pregnancy, as randomized intervention studies are lacking altogether. Finally, submucosal fibroids

are associated with heavy uterine bleeding, reduced fertility, and an increased risk of miscarriage rate [2].

Even women without a desire for future pregnancies might not wish to lose their uterus for various reasons. In the past years, several nonsurgical and minimally invasive treatment options have been introduced and studied, which not only preserve the uterus and – possibly – fertility, but also reduce morbidity and recovery time in comparison with hysterectomy. Uterine artery embolization (UAE),

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**Curr Opin Obstet Gynecol** 2012, 24:368–375

DOI:10.1097/GCO.0b013e328359f10a

## KEY POINTS

- Laparoscopic/hysteroscopic myomectomy and UAE are the best-studied minimally invasive therapies for symptomatic fibroids, with significant improvement in menorrhagia and HRQOL, and infrequent complications.
- For subfertile women or women with the wish to conceive, myomectomy is still the treatment of choice.
- MRgFUS, myolysis/radiofrequency ablation, and laparoscopic or vaginal occlusion of uterine arteries are not widely studied and more evidence is needed before these interventions can be implemented in the therapeutic arsenal for symptomatic uterine fibroids in daily practice.

magnetic resonance-guided focused ultrasound (MRgFUS), laparoscopic/hysteroscopic myomectomy, and several less known therapies such as (laparoscopic) myolysis and vaginal/laparoscopic occlusion of the uterine arteries (V/L-OUA), have been explored.

This article reviews and discusses recent evidence on these treatments for symptomatic fibroids, thereby focusing on health related quality of life (HRQOL), cessation of menorrhagia, requirement for reinterventions, fertility prospects, and complications.

## UTERINE ARTERY EMBOLIZATION

UAE as a treatment for symptomatic uterine fibroids was first described in 1995 [3]. With accumulating evidence of its good clinical results, UAE is increasingly being applied. As UAE is painful, the procedure can be performed with patient controlled intravenous analgesia, or epidural analgesia. During the first 24 h after the intervention, the median visual analogue scale (VAS 1–10) for pain was 3.0 under analgesia, as described in a meta-analysis [4<sup>•</sup>]. A recently published Cochrane review summarized the results of five RCTs comparing UAE versus surgery (hysterectomy/myomectomy), with a 5-year follow-up [5<sup>••</sup>]. Satisfaction with treatment was the primary outcome measure and the pooled results showed no difference in satisfaction between the UAE and the surgery group, neither at 12–24 months, nor at 5 years of follow-up. Several secondary outcome measures were described: major complications were rare and reported not to differ between both groups at varying time points. However, there were significantly more minor complications in the UAE group than the surgery group within 1 year, that is, nausea, pain, and vaginal discharge. Reinterventions were needed more often in the UAE group after 5 years and fibroid recurrence rate was not different (Table 1) [2,5<sup>••</sup>,6,7<sup>•</sup>,8–11,12<sup>••</sup>,13,14<sup>••</sup>,15–18]. HRQOL 5 years after UAE

was reported from the randomized Embolization versus hysterectomy (EMMY) trial (Table 1) [6], showing that patients in both treatment groups had equal HRQOL, which was significantly higher than at baseline. Data from the Randomised comparison of uterine artery Embolisation with Surgical Treatment in patients with symptomatic uterine fibroids (REST) trial were similar (Table 1) [7<sup>•</sup>]. The EMMY trial showed symptomatic relief of menorrhagia complaints to persist after 5 years in 82.7% of patients primarily treated by UAE. The REST trial showed that because of the high reintervention rate over the period from baseline to 5-year follow-up, the initial financial advances of UAE over surgery gradually faded to £524 after 5 years (Table 1) [7<sup>•</sup>]. The effect of UAE on ovarian reserve and pregnancy outcome is less well established. Follicle-stimulating hormone levels as an indicator of ovarian failure after 2 years were not significantly different between UAE and surgery [5<sup>••</sup>]. Homer and Saridogan [8] stated in a systematic review that miscarriage rates were higher in post-UAE pregnancies (35.2%) compared with pregnant women with a nontreated fibroid uterus, matched for age, and fibroid location (16.5%). The UAE pregnancies were more likely to be delivered by cesarean section and to experience postpartum haemorrhage. Rates of preterm delivery, intrauterine growth restriction and malpresentation were similar in UAE pregnancies and in control pregnancies with fibroids (Table 1) [8]. In the Cochrane review, the other primary outcome measure was live birth rate. This was calculated from the limited cohort of participants who tried to conceive in the study of UAE versus myomectomy. There was no significant difference between the groups in live birth rate (Table 1) [5<sup>••</sup>].

## MAGNETIC RESONANCE-GUIDED HIGH-INTENSITY FOCUSED ULTRASOUND

MRgFUS is a relatively new technique for the treatment of symptomatic uterine fibroids, which uses heat generated by high-intensity focused ultrasound. The advantages of MRgFUS are its completely noninvasive character and continuous imaging of fibroids and adjacent structures, which optimizes fibroid ablation and prevents injury to adjacent tissues [19]. The disadvantage is that relatively few patients are eligible, that is, only those with fibroids located immediately beneath the anterior abdominal wall without bowel interposition or scars in the region of interest, and that average treatment time is long [9]. In a prospective study with 33 patients with intravenous fentanyl the reported average pain score (VAS 1–10) was  $1.8 \pm 2.6$  during treatment, with a statistically not significant

**Table 1. Evidence and statistics on minimally invasive alternatives to hysterectomy used in the text**

Study	Comparison	Study type	Outcome measure/intervention	Efficacy
Uterine artery embolization				
Gupta <i>et al.</i> [5**]	UAE versus surgery <i>n</i> = 452	Cochrane review	Satisfaction 12–24 months	OR 0.69, 95% CI 0.40–1.21
			Satisfaction 5 years	OR 0.90, 95% CI 0.45–1.80
			Reinterventions	OR 5.79, 95% CI 2.65–12.65
			Fibroid recurrence rate after UAE/myomectomy	OR 1.32, 95% CI 0.38–4.57
			Minor complications	OR 2.75, 95% CI 1.59–4.76
	<i>n</i> = 297		FSH levels over 40 IU/l within 2 years	OR 1.01, 95% CI 0.53–1.94
	<i>n</i> = 66		Live birth rate	OR 0.33, 95% CI 0.11–1.00
EMMY [6]	UAE versus hysterectomy <i>n</i> = 177	RCT	SF-36 at 5 years	OR 1.02, 95% CI –3.08–1.03
REST [7*]	UAE versus best surgical option <i>n</i> = 157	RCT	EuroQoL at 5 years	UAE: mean 85, SD 13
			Surgery: mean 80, SD 20	
			95% CI –9–3, <i>P</i> = 0.29	
			SF-36 at 5 years	No significant differences between groups in any of the eight components of the SF-36 scores at 5 years, minimum <i>P</i> = 0.45
			Mean costs	UAE: 2467 (2076–2857)
				Surgery: 2961 (2509–3413)
				Difference: –524 (–1149–58)
Homer and Saridogan [8]	UAE versus no intervention (all women with fibroids) <i>n</i> = 227	Meta-analysis	Miscarriages	OR 2.8; 95% CI 2.0–3.8
			Delivered by cesarean section	66 versus 48.5%; OR 2.1; 95% CI 1.4–2.9
			Postpartum hemorrhage	13.9 versus 2.5%; OR 6.4; 95% CI 3.5–11.7
			Rate of preterm delivery	14 versus 16%; OR 0.9; 95% CI 0.5–1.5
			Intrauterine growth restriction	7.3 versus 11.7%; OR 0.6; 95% CI 0.3–1.3
			Malpresentation	10.4 versus 13%; OR 0.8; 95% CI 0.4–1.5
MRgFUS				
Voogt <i>et al.</i> [9]	MRgFUS with fentanyl <i>n</i> = 33	Uncontrolled Prospective (cohort) study	Baseline reported pain score VAS 1–10	1.8 + –2.6
			Pain increase 24 h post treatment	2.4 + –2.6, <i>P</i> = 0.343

Kim <i>et al.</i> [10]	MRgFUS <i>n</i> = 40	Uncontrolled Prospective (cohort) study	Mean baseline SSS (1-100)	64.8, 95% CI 60.8–68.8
			Mean SSS at 3-year follow-up	17.0, 95% CI 8.9–25.1
			Mean baseline UFS QOL (1-100)	44.1, 95% CI 37.7–50.6
			Mean UFS QOL at the 3-year follow-up	83.9, 95% CI 74.5–93.3
			Mean baseline volume of the treated leiomyoma	336.9 ml, 95% CI 295.2–378.6
			Mean baseline volume of the uterus	978.7 ml, 95% CI 925.1–1032.3
			Mean volume of the treated leiomyoma at 3 years	228.4 ml, 95% CI 171.9–284.8
			Mean volume of the uterus at 3 years	707.3 ml, 95% CI 622.2–792.4
<b>Myomectomy</b>				
Manyonda <i>et al.</i> [11]	UAE versus myomectomy <i>n</i> = 163	RCT	Increase HRQOL	UAE 39.9 ± 27.3 versus myomectomy 32.3 ± 28.8, <i>P</i> = 0.14
Kongnyuy and Wiyosong [12**]	Interventions to reduce haemorrhage during myomectomy for fibroids <i>n</i> = 12 RCTs, 674 patients:	Cochrane review	Misoprostol	MD -149.00 ml, 95% CI -229.24 to -68.76
			Vasopressin	MD -298.72 ml, 95% CI -593.10 to -4.34
			Bupivacaine–epinephrine	MD -68.60 ml, 95% CI -93.69 to -43.51
			Tranexamic acid	MD -243 ml, 95% CI -460 to -25.98
			Pericervical tourniquet	MD -289.44, 95% CI -406.55 to -172.32
			Gelatin–thrombin matrix	MD -545.00 ml, 95% CI -593.26 to -496.74
Pritts <i>et al.</i> [2]	Women with intramural fibroids; removal versus no removal <i>n</i> = 2 studies	Meta-analysis	Clinical pregnancy rate	RR 3.765 95% CI 0.470–30.136 not significant
	<i>n</i> = 1 study		Spontaneous abortion rate	RR 0.758 95% CI 0.296–1.943 not significant
	<i>n</i> = 1 study		Ongoing pregnancy/live birth rate	RR 1.671 95% CI 0.750–3.723 not significant
<b>Hysteroscopic myomectomy</b>				
Mavrelou <i>et al.</i> [13]	GnRH versus placebo before hysteroscopic resection <i>n</i> = 74	RCT	Complete fibroid resections	RR 0.84, 95% CI 0.54–1.29; <i>P</i> = 0.43
Pritts <i>et al.</i> [2]	Women with submucosal fibroids versus infertile women without fibroids <i>n</i> = 18 studies	Meta-analysis	Clinical pregnancy rate	RR 0.36, 95% CI 0.18–0.74
	<i>n</i> = 14 studies		Implantation rate	RR 0.28, 95% CI 0.12–0.65
Mais <i>et al.</i> [14**]	Hyaluron gel versus no intervention <i>n</i> = 5 RCTs, 335 patients	Meta-analysis	Adhesions laparoscopy	OR 0.25, 95% CI 0.10 - 0.63
			Adhesions hysteroscopy	OR 0.41, 95% CI 0.22–0.77
<b>Radiofrequency ablation/myolysis</b>				

(Continued)

**Table 1 (Continued)**

Study	Comparison	Study type	Outcome measure/intervention	Efficacy
Garza <i>et al.</i> [15]	Laparoscopic, ultrasound guided RFA n = 31	Prospective cohort study	SSS 3 months	95% CI 44.8–74.7, P < 0.05
			SSS 6 months	95% CI 55.7–87.7, P < 0.05
			SSS 12 months	95% CI 70.9–93.1, P < 0.05
			HRQOL baseline	95% CI 51.6–68.7
			HRQOL 12 months	95% CI 96.2–99.4, P < 0.001
Kim <i>et al.</i> [16]	Transvaginal ultrasound-guided radiofrequency myolysis n = 69	Prospective cohort study	SSS improvement	95% CI –57.7 to –37.9, P < 0.001
			UFS QOL improvement	95% CI 28.3–51.2, P < 0.001
			Volume decrease fibroids in ml	95% CI 171.9–284.8, P < 0.001
			Volume decrease uterus in ml	95% CI 622.2–792.4, P < 0.001
Laparoscopic uterine artery occlusion				
Helal <i>et al.</i> [17]	LUAU versus UAE n = 90	RCT	Satisfaction	36 patients versus 39 patients satisfied, P = 0.23
			Bleeding reduction	39 patients versus 40 patients bleeding reduction, P = 0.69
Marra <i>et al.</i> [18]	LUAO versus UAE n = 200	Prospective comparative study	Mean shrinkage of fibroid volume (MRI)	53% after UAE and 39% after LUAO, P = 0.063
			Complete fibroid infarction	82% of women after UAE, 23% after LUAO, P = 0.001

Euro QoL, Euro Quality of Life; FSH, follicle-stimulating hormone; HRQOL, health related quality of life; LUAO, laparoscopic uterine artery occlusion; RFA, radiofrequency ablation; SF-36, Short Form 36; SSS, Symptom Severity Scale; UAE, uterine artery embolization; UFS-QOL, Uterine Fibroid Symptom and Quality of Life.

increase in pain scores to  $2.4 \pm 2.6$ , 24 h posttreatment (Table 1) [9]. No RCTs have been published yet. A prospective study with 40 patients showed mean improvement scores for symptom severity scale (SSS 1–100) of  $-47.8$  and for Uterine Fibroid Symptom and Quality of Life questionnaires (UFS-QOL, scale 1–100) of 39.8 at 3 years. The mean volume decrease in treated fibroids was 32.0%, and the volume decrease of the whole uterus was 27.7% at 3 years (Table 1) [10]. Although MRgFUS is a complex technology and the initial set-up is expensive, there is such an improvement in quality of life, that it rapidly becomes cost-effective over a relatively short period; in a model, the incremental cost of an MRgFUS treatment strategy compared with current treatment, results in a cost saving of £295 per patient [20]. Among 130 patients treated with MRgFUS, complications were observed in a retrospective analysis. One major complication that occurred was a deep vein thrombosis. Minor complications were more common: abdominal edema/erythema (11 patients) and lower back discomfort (five patients) [21<sup>■</sup>]. A prospective registry of all known pregnancies occurring after MRgFUS reported on 51 women with uterine fibroids [22]. The mean age of the women at the time of treatment was  $37.2 \pm 4.6$  years. The spontaneous miscarriage rate was 26%, which is comparable with the rate in women of similar age without fibroids [23]. Live births occurred in 41% of pregnancies, with an 11% rate of elective pregnancy termination, and 20% ongoing pregnancies beyond 20 gestational weeks the moment the study ended. The vaginal delivery rate was 64%.

At present, only a minority of women with uterine fibroids seems to meet the inclusion criteria for this new technique. In the lack of randomized data, MRgFUS should still be regarded as an experimental treatment.

## LAPAROSCOPIC MYOMECTOMY

Laparoscopic myomectomy has long been the minimally invasive therapy of choice for symptomatic uterine fibroids, before the introduction of UAE and other minimally invasive therapies. It is still widely used for symptomatic subserosal fibroids and can be even used for intramural fibroids, depending on the position of the fibroid and the skills of the surgeon. A prospective study with 235 patients undergoing laparoscopic myomectomy for symptomatic fibroids showed no conversions to laparotomy and in 3 years only 1.2% of patients had a second laparoscopic myomectomy for recurrent fibroids. By 48 h after surgery, 86.3% of the patients were discharged [24]. In a RCT comparing UAE and myomectomy in 160 patients, 1 year after

myomectomy HRQOL was significantly better than at baseline for both the UAE and the myomectomy group (Table 1) [11]. As UAE and MRgFUS have not been widely studied for effect on pregnancies, myomectomy is the gold standard in this patient group. A systematic review compared women with subserosal fibroids to women without fibroids, and found no difference for fertility outcomes. In contrast, women with intramural fibroids had significantly lower clinical pregnancy rates and ongoing pregnancy/live birth rates and significantly higher spontaneous abortion rates compared with women without fibroids (Table 1) [2,25]. The same review could not identify a significant effect of the removal of intramural fibroids on fertility outcomes, as compared between women with intramural fibroids and women that underwent removal of their intramural fibroids.

Blood loss is an important clinical problem during myomectomy. Many interventions to reduce blood loss have been described. A Cochrane review summarized RCTs studying the effectiveness of various measures to reduce blood loss during surgery (Table 1) [12<sup>■</sup>]. They found significant reductions in blood loss with misoprostol, vasopressin, bupivacaine and epinephrine, tranexamic acid, pericervical tourniquet, and gelatin–thrombin matrix. There was no evidence of an effect on blood loss with oxytocin.

## HYSTEROSCOPIC MYOMECTOMY

Submucosal fibroids can often be removed by hysteroscopic myomectomy. This can be performed under general or regional analgesia, and in some centers it is performed as an office procedure, depending on the type and the size of the fibroid(s).

Although it is widely applied and its effect on bleeding complaints is well known, there is surprisingly little randomized evidence to support this. A recent retrospective analysis of 105 patients that underwent hysteroscopic myomectomy for submucosal fibroids, showed disappearance of bleeding symptoms in 90% of cases after a mean follow-up of 17 months [26]. In an RCT GnRH pretreatment was found not to increase the number of complete resections (Table 1) [13]. To measure the beneficial effects of misoprostol on the outcomes of hysteroscopic myomectomy, a systematic review and meta-analysis was carried out of patients undergoing operative hysteroscopy that used misoprostol compared with placebo. Misoprostol was not found to be beneficial for cervix dilation or complication rates. There was an increase in side effects [27<sup>■</sup>]. The most common perioperative complications associated with hysteroscopic myomectomy are hemorrhage (2.4%), uterine perforation (1.5%), and cervical laceration (1–11%) [28].

Surprisingly, a common problem in hysteroscopic myomectomy is lacking altogether in this list, that is, fluid overload by intravasation of distension fluid. This might be explained by a lack of definition, or by the fact that procedures are simply stopped in time before the occurrence of this complication. Only recently the problem of gaseous embolism during myoma resection has been recognized as another realistic threat to the patient's wellbeing. The anesthesia records and operation files of 234 patients were screened for physiological changes that indicate embolism, as measured with standard intraoperative monitoring. Physiological changes in terms of end tidal CO<sub>2</sub> changes and decreased peripheral oxygen saturation attributable to gaseous embolism, were observed in 33–43% of patients with 1000–2500 ml fluid intravasation during transcervical myoma resection. Almost half of these patients had clinical cardiovascular manifestations that indicated the formation of emboli [29]. Delayed complications from hysteroscopic surgery may include intrauterine adhesions and infertility. Hysteroscopic myomectomy can cause adhesions as a result of surgical trauma to the endometrium. The average reported incidence is around 10% at second-look hysteroscopy, but it seems to be higher in certain conditions, for instance in the resection of multiple, opposing fibroids [30]. A systematic review comparing adhesion formation after laparoscopic or hysteroscopic myomectomy using autocross-linked hyaluronan gel to standard surgery showed that the incidence of postoperative adhesions in patients who received autocross-linked hyaluronan gel was significantly lower than in patients who underwent standard surgery (Table 1) [14\*\*].

A systematic review summarizing the effects of surgery on fertility showed that submucous fibroids or intramural fibroids with a submucosal component decreased clinical pregnancy and implantation rates, and removal of submucous fibroids led to a significant increase in pregnancy rate (from 27.2 to 43.3%) and a decrease in miscarriage rate (from 50 to 38.5%) (Table 1) [2].

### MYOLYSIS/RADIOFREQUENCY ABLATION

Myolysis/RFA was introduced in the late 1980s in Europe as a conservative treatment of uterine fibroids [31]. Myolysis/RFA refers to the destruction of uterine fibroids by focused energy with electric current through a bipolar electrode or a monopolar electrode, by radiofrequency or by a cryoprobe used as energy sources. These techniques can be performed laparoscopically or transvaginally under sonographic guidance. No RCTs have been published yet. Garza Leal *et al.* [15] reported a prospective study

with 31 patients that underwent laparoscopic ultrasound-guided RFA of symptomatic fibroids, wherein fibroid symptoms and volumes were successfully reduced. At 3, 6, and 12 months, mean SSS improved significantly compared with baseline, by 59.7, 71.7, and 82.0%. The increase in mean HRQOL scores over time was statistically significant ( $P < 0.001$ ): 60.15 at baseline and 97.8 at 12 months. Mean (SD) uterine volume decreased from 194.4 (105.9 ml) at baseline to 113.2 (53.5 ml) at 12 months ( $P = 0.006$ ) (Table 1). Recently, a prospective cohort study using transvaginal ultrasound-guided RFA was performed in 69 premenopausal women with symptomatic uterine fibroids as an outpatient procedure (Table 1) [16]. Mean baseline volume of the dominant fibroids was 304.6 + 229.1 ml and its volume at 3 months following radiofrequency myolysis decreased significantly ( $P = 0.002$ ). An improvement of menorrhagia occurred 1, 3, 6 and 12 months after operation (all  $P < 0.001$  versus baseline). No major complications were observed or reported. After 12 months, three patients had successfully conceived and delivered and there were no complications during labor or delivery. Pregnancy outcomes after myolysis/RFA have only been described anecdotally in case-reports.

### LAPAROSCOPIC OR VAGINAL OCCLUSION OF UTERINE VESSELS FOR TREATMENT OF SYMPTOMATIC FIBROIDS

Another way to treat fibroids by obstructing the blood flow is laparoscopic or vaginal uterine artery occlusion (L/V-UAO). A RCT with 90 patients allocated UAE or LUAO showed that satisfaction with treatment was comparable between the two groups (86.7% after LUAO versus 88.8% after UAE, no significant difference). After 12 months, more patients resumed heavy periods in the LUAO group [four of 45 patients (8.8%), compared with three of 45 (6.6%) in the UAE group,  $P = 0.044$ ] (Table 1) [17]. A recently published prospective, nonrandomized clinical trial comparing UAE (100 patients) and LUAO (100 patients) showed that after 6 months mean shrinkage of fibroid volume was 53% after UAE and 39% after LUAO ( $P = 0.063$ ); 82% of women after UAE, but only 23% after LUAO had complete fibroid infarction ( $P = 0.001$ ) (Table 1) [18]. Nevertheless, this technique is difficult and the surgeon needs advanced laparoscopic skills.

The uterine arteries are located less than 2 cm from the vaginal fornices and can be reached and clamped vaginally via doppler-guidance, to temporarily occlude both uterine arteries (VUAO). In a prospective nonrandomized study, 30 women were treated by VUAO. Six months after treatment, the dominant fibroid volume decreased by an average

of 24%, uterine volume decreased by 12%, and menorrhagia symptoms were reduced by up to 42%. Three women experienced hydronephrosis. Two women with hydronephrosis required ureteral stenting. One of these cases resolved after 6 weeks, whereas the other required ureteroscopy and laser endoureterotomy [32]. A pilot study to evaluate the VUAO was stopped prematurely because of a high incidence of major complications, mainly ureteral damage (<http://clinicaltrials.gov/ct2/show/NCT01140555>). Considering this, vaginal clamping of the uterine artery seems to be obsolete.

## CONCLUSION

Although hysterectomy is the only definitive solution for menorrhagia complaints, many women and doctors seek the possibility of minimally invasive uterus-sparing alternatives for the treatment of uterine fibroids. With the current evidence, laparoscopic/hysteroscopic myomectomy and UAE are the best-studied minimally invasive treatments for symptomatic fibroids, with significant improvement in menorrhagia and HRQOL, and infrequent complications. For women who wish to conceive, myomectomy is still the treatment of choice. MRgFUS, myolysis/RFA, and L/V-LUAO are not widely studied and more evidence is needed before these interventions can be implemented in the therapeutic arsenal for symptomatic uterine fibroids in daily practice.

## Acknowledgements

None.

## Conflicts of interest

No funding has been received for this review.

There are no conflicts of interest or sources of funding.

## REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 470).

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