Gynecology and Minimally Invasive Therapy 3 (2014) 31–38

Contents lists available at ScienceDirect

Gynecology and Minimally Invasive Therapy

journal homepage: www.e-gmit.com

Review article

Laparoscopic myomectomy—The gold standard

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ARTICLE INFO

Article history:
Received 9 October 2013
Received in revised form
23 January 2014
Accepted 24 January 2014
Available online 29 April 2014

Keywords:
Infertility
Laparoscopy
Minimally invasive surgery
Myomectomy
Uterine rupture

ABSTRACT

Uterine myomas are the main cause for gynecological disease in premenopausal women. If a myomectomy is indicated, abdominal myomectomy is still a frequently performed procedure although laparoscopic myomectomy should be the method of choice. Searches were conducted in PubMed and The Cochrane Library to identify relevant literature. Compared with myomectomy by laparotomy and minilaparotomy, laparoscopic myomectomy is associated with improved short-term outcomes. Laparoscopy is further associated with less adhesion formation. Pregnancy rates after myomectomy in symptomatic patients might be higher after laparoscopy than after laparotomy. Although uterine ruptures following laparoscopic myomectomy are described in the literature, it seems to be a rare event. Concerning the recurrence, there is evidence that rates are similar after laparoscopy and laparotomy. Myomectomy by laparoscopy has several advantages over abdominal myomectomy (by conventional laparotomy and minilaparotomy) and should be the standard procedure. Despite the advantages of laparoscopy, abdominal myomectomy is still a frequently performed procedure. Lack of training in advanced laparoscopic procedures hampers the widespread use of laparoscopic myomectomy. Due to the advantages of laparoscopic surgery, efforts should be made to implement this procedure into daily practice. To provide the best care, physicians should offer patients the opportunity of a laparoscopic treatment of myomas.
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Introduction

The most common benign tumor of the uterus in women of reproductive age is the uterine leiomyoma (uterine fibroid, fibroid, myoma).[1] In a large ultrasonographic study, the cumulative incidence of uterine myomas by age 50 years was over 80% for black women and nearly 70% for white women.[2] Although not all women with myomas develop symptoms, myomas have a great clinical impact.[3,4] The majority of hysterectomies are performed due to symptomatic uterine myomas.[5,6] Symptoms include abnormal uterine bleeding, pelvic pressure and pain, and reproductive dysfunction.[3] If a future pregnancy is desired or if women want to preserve their uterus for personal reasons, an appropriate alternative to hysterectomy has to be found for their treatment.

Abdominal myomectomy has been performed routinely for many decades, in recent years, various minimally invasive alternatives to laparotomy have been developed.[7] At present, a vast number of minimally invasive approaches for the treatment of myomas exist including abdominal myomectomy (by minilaparotomy[8] or ultraminilaparotomy[9]), vaginal myomectomy,[10] laparoscopic myomectomy (also gasless laparoscopy,[11] single access laparoscopy,[12] or robotic assisted laparoscopy[13]), uterine artery embolization (UAE),[14] uterine artery occlusion,[15] myolysis,[16] magnetic resonance imaging-guided focused ultrasound,[17] and medical treatment.[18] Only a few of the treatment options are investigated in randomized, controlled trials and some of them still need to be investigated for safety and efficacy. This article focuses on myomectomy as the most common plastic and reconstructive uterine procedure. Myomectomy by laparoscopy is compared to myomectomy by laparotomy, minilaparotomy and robotic assisted laparoscopic myomectomy. Moreover, frequent concerns associated with laparoscopic myomectomy are discussed.

Materials and methods

The PubMed database was searched using the search term “myomectomy” alone and in combination with “adhesions”, “infertility OR fertility outcome”, “uterus rupture”, “recurrence”, “costs”, and “surveys” with the limitation on articles published in

Conflicts of interest: The authors declare no conflicts of interest relevant to this article.

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http://dx.doi.org/10.1016/j.gmit.2014.02.001
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English and German. Additionally, the PubMed database was searched using the search term “laparoscopy and learning curve”. The Cochrane Library was also searched for the search term “myomectomy”. Articles were included in the review if the title indicated any relevance to the topic. Statements in the articles were scrutinized by searching the corresponding articles listed in the references sections. The reference lists were also searched for relevant literature.

Results and discussion

Myomectomy

Depending on the preference of the surgeon, different modifications of the technique are possible, concerning trocar placement, instruments used, methods to reduce bleeding, or suture material used. The following section provides a brief overview of the basic steps of myomectomy.[19,20]

During the procedure, the use of a uterus manipulator facilitates myomectomy and suturing as it enables the positioning of the uterus depending on the location of the myoma (Fig. 1). At the beginning of the procedure, diluted vasopressin is injected between the myoma capsule and the normal muscle layer which is an effective technique to reduce hemorrhage.[21] Although rare, some severe complications, associated with the use of vasopressin, were reported including pulmonary oedema, severe hypotension, and bradycardia with eventual cardiac arrest.[22] Therefore, the possible occurrence of these complications should be kept in mind when diluted vasopressin is used. After injection, the myometrium overlying the myoma become pale and the myometrium can be incised in a horizontal or vertical direction. A horizontal incision may facilitate the subsequent suturing of the myometrial defect.[23] To further reduce the risk of bleeding, the incision is made with a monopolar instrument (hook or scissors) or a harmonic scalpel.[1,23] Once the myoma pseudocapsule is reached, the myoma can be grasped with a forceps or a myoma screw, enabling traction and countertraction on the myoma which is necessary for the enucleation (Fig. 2). If the myoma is enucleated along the avascular cleavage plane, the enucleation should be easily possible. Attachments to the myometrium can be lysed with bipolar forceps or monopolar scissors.[19] The enucleated myoma is temporarily placed in the cul-de-sac and is removed at the end of the procedure by mechanical or electric morcellation. Suturing of the myometrial defect is of great importance for the strength of the uterine scar. Depending on the depth of the defect, a single or multilayer closure is necessary to minimize the risk of hematoma, postoperative bleeding, or uterine rupture in subsequent pregnancies (Fig. 3).[22,23]

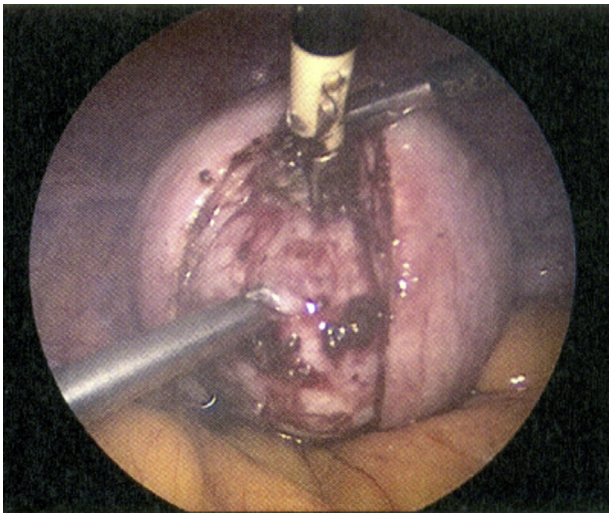

Fig. 2. The myometrium overlying the myoma is opened and the myoma is visible. A myomascrew is inserted into the myoma.

Laparoscopic myomectomy versus abdominal myomectomy by conventional laparotomy

The first reports of abdominal myomectomy as an alternative to hysterectomy were published over 100 years ago.[24,25] Back then, reasons for uterus preservation already included the woman’s desire for future childbearing as well as the woman’s wish for organ preservation in order to avoid emotional distress caused by the experience of an organ loss.[26,27] Despite these early advocacies for myomectomy, it took decades before abdominal myomectomy was generally accepted as a treatment option for uterine fibroids.[28,29] Additionally, in 1979, Semm[30] introduced the laparoscopic myomectomy as a promising new surgical approach for the treatment of uterine myomas. Since then, numerous articles have been published concerning the feasibility and safety of laparoscopic myomectomy.[31–33] However, only a few studies compared laparoscopic

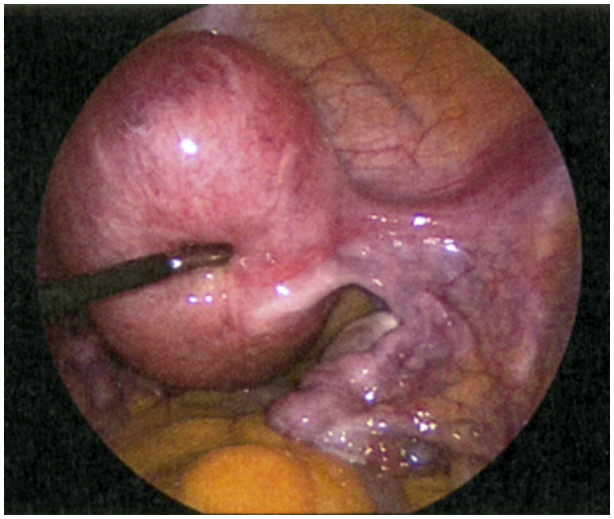

Fig. 1. Fundal myoma.

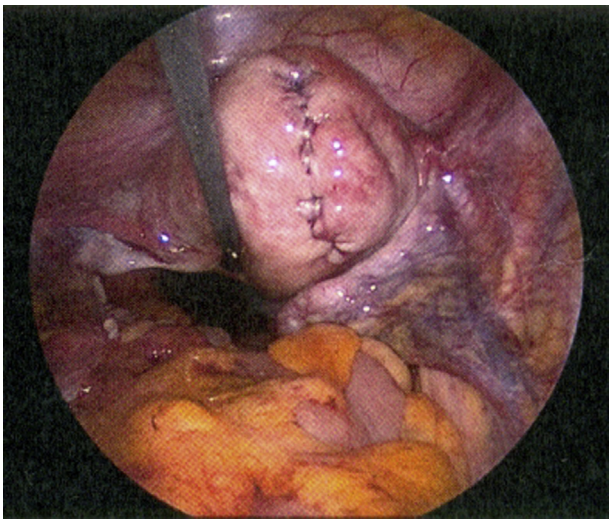

Fig. 3. Uterus after myomectomy with hysterectomy suture.

myomectomy with abdominal myomectomy and only some of them are prospective, randomized trials.[34–38] The retrospective trials revealed that laparoscopic myomectomy is associated with lower hemoglobin drop or less blood loss, respectively, lower morbidity, and a shorter hospital stay.[34,35] These findings are in line with the prospective, randomized studies (Table 1).[36–38] Moreover, Holzer et al[38] demonstrated in a double-blind study that laparoscopic myomectomy is associated with lower postoperative pain. In recent years, however, publications about myomectomy by minilaparotomy as a minimally invasive alternative to conventional laparotomy are increasing. Prospective, randomized studies exist, comparing myomectomy by laparoscopy and minilaparotomy. Therefore, the next section provides a more detailed comparison of these two minimally invasive fibroid treatments.

Laparoscopic myomectomy versus abdominal myomectomy by minilaparotomy

Minilaparotomy is a modification of laparotomy where the skin incision does not exceed 5–6 cm.[8,39] Although minilaparotomy was already described in the 1990s [40], only in the past decade, an increasing number of articles have been published concerning minilaparotomy as a minimally invasive treatment option for myomectomy.[8,41,42] Authors, who encourage myomectomy by minilaparotomy, state that this procedure has several advantages over laparoscopic myomectomy including the ability to palpate the uterus, the possibility to operate large myomas, and no need for extra equipment and/or advanced technical skills, especially in suturing the uterine incision.[8,43] In comparison with conventional laparotomy, minilaparotomy showed advantages of minimally invasive surgery such as a shorter hospital stay.[44,45] However, prospective, randomized trials comparing minilaparotomy and laparoscopy, confirmed that laparoscopy is associated with better short-term outcomes such as a significantly lower decline in hemoglobin concentrations, lower postoperative pain, lower analgesic requirements, and a shorter hospital stay (Table 2).[39,46,47]

Concerning complications associated with laparoscopic and abdominal myomectomy, Alessandri et al[46] reported in their study one laparoconversion due to difficulties of hemostasis and one case of diffuse peritonitis caused by ileal perforation in the laparoscopic group. Interestingly, in the study of Palomba et al[47] six laparoconversions occurred in the minilaparotomy group. These laparoconversions were due to posterior isthmic and infraligamentary location of the leiomyomas and the authors mentioned that in these cases the degree of surgical difficulty was similar to that of laparoscopy. In this study, location of the main myoma rather than the size of the myoma was the main factor that influenced the results. The authors stated that myomectomy of anterior, fundal, and lateral myomas was simpler and faster when minilaparotomy was conducted. However, there were five (7.4%) postoperative complications in the minilaparotomy group including one case of fever >38°C, two cases of wound infections, and one case of wound dehiscence. In the laparoscopic group, two (2.9%) postoperative complications occurred including one case of fever >38°C and one case of urinary tract infection.[47] Cicinelli et al[39] reported two intraoperative complications in the laparoscopic group. In one patient, moderate subcutaneous emphysema developed at pneumoperitoneum creation and in the other patient the procedure was converted to minilaparotomy due to difficulty in reconstructing the uterine wall. Postoperatively, five patients in the laparoscopy group (12.5%) and 10 patients in the minilaparotomy group (25%) developed fever.[39] Compared with myomectomy by minilaparotomy, laparoscopic myomectomy is associated with better short-term outcomes. Furthermore, laparoscopic myomectomy carries a low risk of minor and major complications.

Laparoscopic myomectomy versus robotic-assisted laparoscopic myomectomy

In the past decade, robotic surgery has been introduced in gynecology and is described as “an enhancement along the continuum of laparoscopic technological advances”.[13] Robotic surgery provides a 3-dimensional image, absence of tremor, superior instrument articulation, comfort for the surgeon, and a faster learning curve.[48] At present, only retrospective studies are available comparing robotic-assisted laparoscopic myomectomy (RALM) with laparotomy or laparoscopy. Compared with laparotomy, RALM is associated with a decrease in blood loss, fewer complications, and a shorter hospital stay.[49–51] Compared with laparoscopic myomectomy, RALM seems to have similar short-term outcomes.[51–53] Furthermore, Nezhat et al[53] stated that RALM does not offer any major advantages over laparoscopy when laparoscopy is performed by a skilled surgeon. However, removal of large, unfavorable localized myomas as well as suturing the uterine incision is

Table 1
Laparoscopic myomectomy versus abdominal myomectomy by conventional laparotomy.

LM versus AM	Mais et al 1996[36]	Seracchioli et al 2000[37]	Holzer et al 2006[38]
No. of patients	20 versus 20	66 versus 65	19 versus 21
No. of myomas	2.5 ± 1.1 versus 2.3 ± 0.8	2.94 ± 1.53 versus 2.75 ± 1.98	2 (1–4) versus 3 (1–7)
Diameter of the largest myoma (cm)	4.4 ± 0.8 versus 4.7 ± 1.3	7.07 ± 2.54 versus 7.47 ± 2.60	7 (4–10) versus 5 (3–11)
Operative time (min)	100 ± 31 versus 93 ± 27	100.23 ± 38.34 versus 88.85 ± 26.91	99 ± 37 versus 68 ± 22
Estimated blood loss (mL)	200 ± 50 versus 230 ± 44	—	71 ± 80 versus 115 ± 64
Decline in Hb concentration	—	1.33 ± 1.23 versus 2.17 ± 1.57	—
Complications/ postoperative outcome	Fever: 1/20 versus 1/20	Fever: 8 (12.1%) versus 17 (26.2%) Transfusions: 0/66 versus 3/65	None
Postoperative pain assessed by visual analog scale (VAS)	Significantly lower in the LM group (figures are represented in a chart)	—	2.28 ± 1.38 versus 4.30 ± 1.63 (mean overall VAS – score at 24 h, 48 h, and 72 h postoperatively)
Analgesic-free patients at Day 2 (%)	85 versus 15	—	—
Piritramid boli first 24 h	—	—	7 (0–23) versus 12 (2–90)
Time to discharge/length of hospital stay	90 versus 10 patients discharged by Day 3 (%)	75.61 ± 37.09 versus 142.80 ± 34.60 Length of hospital stay (h)	—
Recuperation/return to work	90 versus 5 patients fully recuperated by Day 15 (%)	—	2.9 ± 1.8 versus 3.7 ± 2.9 Return to work (wk)

Values are expressed as mean ± SD or median (range). First value = laparoscopic myomectomy (LM). Second value = myomectomy by conventional laparotomy (AM).

Table 2
Laparoscopic myomectomy versus abdominal myomectomy by minilaparotomy.

LM versus MLT	Alessandri et al 2006[46]	Palomba et al 2007[47]	Cicinelli et al 2009[39]
No. of patients	74 versus 74	68 versus 68	40 versus 40
No. of myomas	2.6 ± 1.0 versus 2.8 ± 1.0	1 (1–3) versus 1 (1–3)	2.1 ± 0.3 versus 2.0 ± 0.4
Diameter of the largest myoma (cm)	6.2 ± 0.7 versus 6.4 ± 0.5	7.6 (5.7–9.8) versus 7.8 (5.5–9.7)	5.2 ± 1 versus 4.8 ± 1.1
Operative time (min)	98 ± 13 versus 85 ± 14	108 (69–150) versus 95 (62–174)	80 ± 23 versus 71 ± 18
Estimated blood loss (mL)	—	130 (90–200) versus 160 (90–280)	133 ± 29 versus 186 ± 44
Decline in Hb concentration (g/dL)	1.1 ± 0.5 versus 2.2 ± 0.5	0.8 (0.2–2.1) versus 1.3 (0.2–2.5)	1.5 ± 0.4 versus 2.5 ± 0.3
Complications	2/74 versus 0/74	Laparoconversion: 0/68 versus 6/68 Postop. complications: 2/68 versus 5/68	Intraop. complications: 2/40 versus 0/40 Fever: 5/40 versus 10/40
Postoperative pain assessed by visual analog scale (VAS)	4.1 ± 1.5 versus 6.5 ± 1.5 (6 h after surgery)	—	—
Time of postoperative ileus (h)	28 ± 6 versus 45 ± 6	24 (24–72) versus 24 (24–72)	18 ± 7 versus 31 ± 6
Request for analgesic (%)	34 versus 73 (in the first 24 h after operation)	—	—
Vials of analgesic used (n)	—	3 (1–8) versus 7 (2–10)	—
Time to discharge/length of hospital stay	38 ± 12 versus 48 ± 12 Time to discharge (h)	2 (2–5) versus 3 (3–5) Length of hospital stay (d)	2.1 ± 0.6 versus 3.3 ± 0.5 Length of hospital stay (d)
Recuperation/return to work	90.3 versus 74.3 patients fully recuperated by Day 15 (%)	5 (3–11) versus 5 (3–12) Return to work (d)	—

Values are expressed as mean ± SD or as median (range). First value = laparoscopic myomectomy (LM). Second value = myomectomy by minilaparotomy (MLT).

challenging for many surgeons and hampers the widespread adoption of laparoscopy.[49,54] Although robotic surgery can overcome these difficulties,[51,55] the higher costs currently lead to an obvious drawback of this possible approach.[49,56] In case of persisting higher costs, robotic surgery is unlikely to be adopted by all hospitals in the near future. At present, therefore, laparoscopy remains the preferred approach if myomectomy should be conducted by a minimally invasive approach.

Postoperative adhesions

Adhesions are fibrin strands between two anatomical sites which are normally not attached to each other. After a previous laparotomy, adhesions were found in 93% of patients during a second procedure.[57] Complications associated with adhesions are small bowel obstruction (SBO),[58] chronic pelvic pain,[59] infertility,[60] and the risk of inadvertent bowel injuries in subsequent procedures.[61] A recent review of 2000 laparoscopies conducted for the treatment of acute SBO, declared that adhesions were accountable for 84.9% of the small bowel obstructions.[62] Although adhesions are described as an important cause of chronic pelvic pain, its real impact remains controversial.[59] One further major concern about adhesions is the unfavorable influence that they could have on future fertility. Adhesions can lead to an impaired interaction between the Fallopian tube and the ovary and it is assumed that adhesions cause 20–40% of female infertility.[63,64] It is known that some gynecological procedures carry a higher risk of adhesion development than others[65] whereas myomectomy is associated with a high risk for adhesion formation.[66] Bearing this in mind, it is important to find ways to reduce adhesion formation after myomectomy, as this procedure is often performed to restore childbearing potential.

Conflicting data exists when comparing laparoscopy and laparotomy in their adhesiogenic potential. Although laparoscopy was long regarded to be less adhesiogen, it was demonstrated that the laparoscopic environment itself functions as a cofactor in adhesion formation. The pressure used to maintain the pneumoperitoneum leads to tissue hypoxia and thereby to alterations in the fibrinolytic system which is a key factor in adhesion formation. Furthermore, the use of cold and dry insufflation gas could lead to peritoneal damage through tissue desiccation, although tissue desiccation is also a problem during open surgery.[67] Nevertheless, studies investigating adhesion formation after myomectomy by laparoscopy or laparotomy revealed that adhesions occur less often after laparoscopy. The published incidence of adhesions after myomectomy varies as shown by the following studies. In a prospective blinded observational study Tinelli et al[68] investigated the effect of an antiadhesion agent after both laparoscopic myomectomy and abdominal myomectomy. A large number of patients (n = 546) with comparable baseline characteristics and no difference in the dimension of the fibroid were assessed during a second procedure conducted for several reasons. The incidence of adhesions in the different groups was as follows: abdominal myomectomy (AM) without adhesion barrier (AB; 28.1%), laparoscopic myomectomy (LM) without AB (22.6%), AM with AB (22%), and LM with AB (15.9%). Kubinova et al[69] assessed adhesions during a second-look laparoscopy for adhesiolysis after abdominal or laparoscopic myomectomy. In their study, 96.65% of patients had adhesions after laparotomy (n = 28) compared with 71.43% of patients after laparoscopy (n = 68). If adhesions were present, patients after abdominal myomectomy had more dense adhesions than patients after laparoscopy. Furthermore, after abdominal myomectomy 89.29% of patients had *de novo* adnexal adhesions which might compromise fertility. In the laparoscopic group *de novo* adnexal adhesions were observed in 10.6% of patients. Another study also assessed the occurrence of adhesions after laparoscopic myomectomy during a second procedure and found adhesions in only 1.6% of patients (2/121).[70] Although the use of laparoscopy is not able to prevent adhesion formation completely, it can be shown that the occurrence of adhesions is reduced after laparoscopy.

Several factors associated with myomectomy influence the formation of adhesions. Some studies revealed that myomas of the posterior uterine site lead to more adhesions than fundal or anterior myomas.[71,72] Further influencing factors are the size and the number of removed myomas.[73] Suturing of the uterine surface can increase the risk of adhesion formation.[74–76] Furthermore, the skill of the surgeon may also have an impact on the development of adhesions.[73] Thus, following the principles of gentle tissue handling is important to avoid extensive trauma to the peritoneum which could result in adhesions. These principles include constant tissue moistening and reduced use of electrocautery.[77] In addition, in high risk procedures like myomectomy, the use of an antiadhesion agent should be considered.[78]

Myomectomy and fertility

The role of fibroids as a cause for infertility, is still controversial. There is agreement that large submucosal fibroids are associated with increased miscarriage rate and reduced fertility, and that removal of submucosal fibroids improve fertility outcomes. As submucosal myomas are mainly removed hysteroscopically, they are not included in this article.[79] Whereas subserosal fibroids seem to have no impact on fertility, there is conflicting evidence on the impact of intramural fibroids on fertility.[80] In a recent systematic review, the implantation rate and the ongoing pregnancy rate were found to be significantly lower in the presence of intramural fibroids, whereas the spontaneous abortion rate was significantly higher.[81] These data were obtained only during prospective trials. A further restriction to studies, which used a high-quality method to assess the uterine cavity, revealed that the implantation rate was still significantly impaired, but the other parameters do not reach significance. Moreover, advising infertile patients with intramural fibroids on surgery is controversial due to limited data on the impact of myomectomy on improving fertility.[81] Somigliana et al[82] proposed to make the decision for surgery based on: "(i) the age of the woman; (ii) the location, dimension and number of the fibroids; (iii) the concomitant presence of fibroid-related symptoms such as menorrhagia or hypermenorrhea; and (iv) the presence of other causes of infertility and whether or not there is an indication to IVF".

If surgery is recommended, the best approach has to be chosen for the patient not to further compromise fertility. Additionally, not all myomectomies conducted in women of childbearing age are performed in infertile patients. Because more and more women decide to postpone their childbearing to a later age, myomectomies are frequently performed in symptomatic patients with a desire for subsequent pregnancies.[83] Hence, it is important to decide which the best approach is, for both infertility and symptomatic patients, to improve fertility outcomes. At present, only two randomized controlled trials are available comparing fertility outcomes after laparoscopic and abdominal myomectomy.[37,47] Seracchioli et al[37] investigated 131 patients with otherwise unexplained infertility and found no significant differences in the pregnancy and abortion rate between the two groups. However, patients in the laparoscopic group showed better short-term outcomes (Table 1). A more recent study by Palomba et al[47] investigated the reproductive outcomes in both infertility and symptomatic patients ($n = 136$). In the case of infertility, no difference in the cumulative pregnancy rate, abortion rate, and live-birth rate between laparoscopy and minilaparotomy was found. The authors stated that the study was probably underpowered to demonstrate a significant difference. Comparing only patients with myomectomy for symptomatic myomas, however, cumulative pregnancy rate, pregnancy rate per cycle, and live-birth rate per cycle were significantly higher in the laparoscopic group. Furthermore, the time to first pregnancy and live-birth was significantly lower after laparoscopic myomectomy.[47] Thus, laparoscopy performed for the removal of symptomatic myomas may not only have advantages in short-term outcomes, but also in fertility outcomes. In the future, large-scaled, prospective, randomized studies are needed to confirm these findings.

Uterine rupture

The main concern after laparoscopic myomectomy in women of childbearing age regards the strength of the myomectomy scar during subsequent pregnancies. Although it seems to be a rare event, reports of uterine rupture after abdominal myomectomy also exist in the literature.[84–86] However, pregnancies after laparoscopic myomectomy have been a matter of concern because laparoscopic suturing is regarded as a demanding task. Several factors may contribute to the development of a weak scar with the subsequent risk for uterine rupture. The extensive use of electrocoagulation instead of sutures to achieve hemostasis can lead to tissue necrosis followed by an impaired wound healing.[87] Furthermore, the presence of infection or hematoma formation within the myometrium, the extent of local tissue destruction, and individual healing characteristics are also factors which could influence wound healing in the myometrium.[88] Another important contributing factor to the development of a weak scar may be an inadequate suturing of the myometrial defect. A recent review of 19 case reports of uterine rupture after laparoscopic myomectomy revealed that in seven cases the uterine defect was not repaired (3 subserosal myomas and 4 subserosal pedunculated myomas), in three cases it was repaired with a single suture (1 subserosal myoma and 2 intramural myomas), in four cases it was repaired in only one layer (intramural myomas), and in one case only the serosa was closed (subserosal myoma).[88] Depending on the depth of the myometrial defect, a multilayer closure may be necessary to eliminate dead space and to achieve an adequate wound closure.[87,89]

Considering several studies on fertility outcome after laparoscopic myomectomy, uterine rupture seems to be also a rare event after laparoscopy.[23] A large review including 626 pregnancies after laparoscopic myomectomy found only one case of uterine rupture.[23] In the above-mentioned review of case reports, time of uterine rupture range from 17 weeks to 40 weeks of gestation.[88] Thus, the possibility of uterine rupture should already be taken into consideration prior to the start of labor and patients should be appropriately counseled. Additionally, the mode of delivery, vaginally or by cesarean section, must be discussed with the patients. Kumakiri et al[89] prospectively investigated the safety of vaginal birth after laparoscopic myomectomy by using the criteria for a vaginal birth after cesarean section. The authors concluded that in selected patients vaginal delivery could be successfully accomplished if the myomectomy wound is appropriately sutured. Therefore, pregnancies after laparoscopic myomectomy carry a low risk of uterine rupture if laparoscopy is conducted by a surgeon who has sufficient expertise.

Myoma recurrence

The risk for myoma recurrence after laparoscopic myomectomy compared with abdominal myomectomy is still a matter of debate. It is assumed that the inability to palpate the uterus during laparoscopy leads to a higher recurrence rate due to small intramural myomas which are left behind in the uterus. These myomas could grow and could be responsible for the recurrence of symptoms.[90] The 5-year cumulative recurrence rate after laparotomy varies from 5.7% to 11.1% if the recurrence rate is not assessed through systematic ultrasound investigations [90].[90] If transvaginal ultrasonography is used, the recurrence rate after abdominal myomectomy is much higher and varies from 15.4% to 62%.[90–92]In their study, Nezhat et al revealed a 5-year cumulative recurrence rate after laparoscopic myomectomy of 51.4% evaluated through chart reviews, returned questionnaires, and telephone interviews. The authors concluded that the recurrence rate after laparoscopy may be higher than reported after laparotomy.[93,94] In a prospective, randomized study, the recurrence rate between abdominal and laparoscopic myomectomy was compared in 81 patients. Transvaginal ultrasonography was used for assessment and after a study period of 40 months, the recurrence rates were similar in both groups (27% laparoscopy and 23% laparotomy, respectively). Furthermore, in this study, none of the women with myoma recurrence required additional surgery during the study period.[95] In another large study, investigating 512 patients who underwent

laparoscopic myomectomy, the cumulative recurrence rate at 5 years and at 8 years was 52.9% and 84.4%, respectively, whereas the cumulative probability of reoperation for recurrent myoma was 6.7% at 5 years and 16% at 8 years, respectively.[96] Factors influencing myoma recurrence may be age, number of myomas, uterine size, and childbirth after myomectomy,[90,91,96] although other authors did not find a relationship between these factors and myoma recurrence.[95] However, further longerm, prospective, randomized studies are needed to compare the recurrence rate after laparoscopic and abdominal myomectomy including skill factors. Moreover, it is important to evaluate the clinical impact of myoma recurrence, measured through the need for subsequent treatment, as well as the influencing factors. Thus, patients should be appropriately counselled about probability and risk factors for myoma recurrence.

Training and uptake of laparoscopic myomectomy

Despite the above-mentioned advantages of laparoscopic myomectomy, abdominal myomectomy is still a frequently performed procedure. In France, 37,787 patients required an intervention for uterine myomas in 2005. The study data were obtained through analysis of a national hospital activity database. Treatment of myomas included 22,540 (59.7%) hysterectomies, 6291 hysteroscopic resections, and 571 UAEs. A total of 8385 myomectomies were conducted including 2277 laparoscopic and 6108 abdominal myomectomies.[97] In Germany, hospital admissions due to interventions for uterine myomas were identified through DRG (diagnosis-related group) codes. In 2005, 64,299 patients were admitted for uterine myomas. 54,577 (84.9%) patients were treated with hysterectomy and in 1527 patients the myoma were removed through hysteroscopic resection. A total of 8195 myomectomies were conducted including 315 vaginal myomectomies, 4692 laparoscopic myomectomies, and 3188 abdominal myomectomies (including 504 laparoconversions). In Germany, more laparoscopic than abdominal myomectomies were performed, although the number of conducted laparotomies was still high.[97] Because acquiring laparoscopic skills is more challenging than acquiring skills needed for conduction of open surgery, not all surgeons are able to perform advanced laparoscopic procedures such as myomectomy.[98] A UK survey, published in 2006, revealed that only 11% of the respondents perform laparoscopic myomectomy (response rate 59%).[99] In a recent Canadian survey, 24.5% of the respondents perform laparoscopic myomectomy and 3.1% stated that more than 50% of their myomectomies are conducted laparoscopically. These rates might be overestimated as the response rate was only 41.4% and it is likely that the questionnaires were answered by gynecologists who were interested in the topic or perform laparoscopic myomectomy. According to this survey, the main obstacle to performing laparoscopic myomectomy was the lack of training in the procedure (70.7% of respondents).[100] During residency, only a few residents have the opportunity to gain practical experience in advanced laparoscopic procedures such as myomectomy.[101] However, for the implementation of laparoscopy, training of basic laparoscopic skills during residency is also important, as laparoscopies are performed by surgeons who received explicit training during residency.[102] It was shown that simulator training can be an effective tool to enhance basic laparoscopic skills leading to a better performance during future procedures.[103] After finishing residency, acquirement of advanced laparoscopic skills can be difficult if there is no opportunity for appropriate teaching and training. Hiring an experienced laparoscopic surgeon who is interested in teaching other surgeons, in combination with surgeons who are interested in learning advanced laparoscopic procedures, has proven to be an effective method to implement advanced laparoscopic procedures into daily practice.[102,104] Although not all surgeons are similarly skilled,[105] personal efforts should be made by every surgeon who performs laparoscopy to continuously enhance personal laparoscopic skills, and thereby enhance the safety of patients. As Sami Walid[106] recently mentioned: “gynecologists need to improve their laparoscopic skills, as minimally invasive surgery is becoming the *sine qua non* of a modern surgeon”. In the future, it is likely that there will be a steadily increasing demand for minimally invasive procedures by patients.[100] Thus, if the patient is a candidate for laparoscopic myomectomy, the procedure should be offered to the patient, either performed personally or through referral to an experienced colleague, for providing the best care.

Cost considerations

One frequently mentioned concern about laparoscopic myomectomy is the expected higher costs associated with laparoscopic procedures. A review of studies comparing abdominal and laparoscopic hysterectomies demonstrated that although laparoscopy was associated with higher direct costs, the indirect costs were lower and might compensate the higher direct costs.[107] At present, studies comparing the costs of abdominal and laparoscopic myomectomy are sparse. In a recent study, abdominal myomectomy was the least expensive approach compared with robotic-assisted laparoscopic myomectomy.[56] Contrarily, in another study, no significant difference in the average costs of abdominal and laparoscopic myomectomy was found.[34] Thus, further studies are needed to compare costs of the procedures, including indirect costs as well as long-term costs if additional treatment is required.

Conclusion

Laparoscopic myomectomy has several advantages over abdominal myomectomy and even over myomectomy by minilaparotomy, given that minilaparotomy is suggested as a minimally invasive alternative to laparotomy. These advantages include a lower decline in hemoglobin concentrations, lower postoperative pain, lower analgesic requirements, a shorter hospital stay, and a faster postoperative recovery (Tables 1 and 2). Moreover, myomectomy by laparoscopy decreases the risk of adhesion formation which could potentially lead to serious complications. Compared with abdominal myomectomy, fertility outcomes in infertile patients seem to be similar after laparoscopy, whereas in symptomatic patients, laparoscopy may lead to higher pregnancy rates. Furthermore, if the procedures are performed by a surgeon who is skilled in laparoscopic surgery, uterine ruptures after laparoscopic myomectomies are rare events. Therefore, laparoscopy should be the standard approach for myomectomy. Nevertheless, further prospective, randomized studies are needed to compare long-term outcomes between different invasive and noninvasive treatment options in uterine myomas including skill evaluation.

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