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GENERAL GYNECOLOGY

Perioperative complications in conventional and microsurgical abdominal myomectomy

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Abstract
Purpose It has become evident that laparoscopic myomectomy is limited by size, number and location of fibroids. Myomectomy performed by laparotomy can be technically challenging and the surgical benefits have to be weighed against associated risks and impairing fertile potential, especially in multiple and large fibroids that may be positioned close to the cavity. Our aim was to evaluate the effect of microsurgical myomectomy technique on perioperative morbidity in premenopausal women.
Methods This retrospective study included 228 patients with symptomatic uterine fibroids and/or infertility undergoing myomectomy by laparotomy. As much as 156 patients were treated by standardized microsurgical technique and 72 patients by conventional myomectomy. The following data were recorded and analysed: postoperative haemoglobin, haemoglobin decrease, rate of blood transfusion, and number, size and location of myomas.
Results In 228 patients, seven complications occurred (abdominal wall haematoma, bowel and colon injury, transient ileus). The transfusion rate was 1.3%. Microsurgical technique was associated with a smaller haemoglobin decrease compared to conventional myomectomy (1.77 vs. 2.38 g/dl; $P = 0.007$). Microsurgical technique correlated inversely with haemoglobin decrease ($P < 0.001$). Haemoglobin decrease correlated positively with myoma number ($P < 0.001$), size of myoma ($P < 0.001$) and the opening of the cavum uteri ($P = 0.014$).
Conclusions In this large series of abdominal myomectomies, procedure-related morbidity, mainly perioperative blood loss, was amongst the lowest reported when microsurgical techniques were used. In patients with multiple, large or deep intramural fibroids who desire future pregnancies, the use of microsurgical techniques may decrease intraoperative blood loss and perioperative morbidity.

Keywords Abdominal myomectomy · Infertility · Microsurgical technique · Morbidity · Blood loss

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Introduction

Myomectomy as an organ-preserving procedure has become an established alternative to hysterectomy. An increasing number of women in their fourth or even fifth decade of life request conservative surgery to preserve their reproductive potential [1]. Because myomas can interfere with sperm migration, ovum transport and implantation, there is an additional role of myomectomy in promoting fertility, especially in selected patients with myomas positioned close to the uterine cavity [2–5].

However, techniques of myomectomy differ remarkably from surgeon to surgeon. The benefits of the operation and the type of surgical procedure have to be weighed against the associated risks possibly endangering fertility potential after myomectomy. Amongst different outcome parameters of morbidity in myomectomies, blood loss is of special interest as it can be related to two major risks for fertility, demanding attention during the surgical procedure: First, in the presence of tissue damage, intraoperative blood loss can lead to pelvic adhesions giving rise to a tubal infertility factor [6, 7]. Second, bleeding into an insufficiently adapted enucleation wound can impair the integrity of the uterine wall, potentially causing uterine ruptures with serious consequences in future pregnancies [8].

The aim to decrease myomectomy-related morbidity has not only led to technical variations of the procedure, but also stimulated the development of therapeutic alternatives to laparotomy [9–11]. Undoubtedly, laparoscopic myomectomy, established since the 1990s, offers obvious advantages over laparotomy such as short hospitalization and convalescence, as well as reduced postoperative pain [12]. Whilst the efficacy and the safety of laparoscopic myomectomy of fibroids of high mean diameter as well as of large myomas >10 cm have been demonstrated by some authors [13–15], laparoscopic myomectomy is reputed to be technically difficult and time consuming. It involves a high risk of conversion to laparotomy in complex situations [16, 17] and it has become evident that the laparoscopic procedure can be limited by size, number and location of fibroids [17].

It is therefore evident that abdominal myomectomy still plays a major role in the treatment of symptomatic fibroids in younger women: there are no limitations on size and number of fibroids, which should be removed, and the surgeon may palpate exactly the uterine wall to diagnose adenomyosis uteri. Furthermore, it is possible to perform reconstructive, microsurgical surgery of tubal damages as well as to remove severe endometriosis. Abdominal myomectomy using microsurgical technique allows for operating under the best possible technical conditions, which includes the prevention of tissue damage, the reduction of blood loss to a minimum, a precise, anatomical preparation and functional reconstruction of the uterine wall.

Our own experiences in microsurgical, reconstructive surgery in tubal infertility [18] and the relevance of surgical trauma and blood loss during myomectomy for fertility outcome led us to analyse perioperative morbidity in microsurgical, abdominal myomectomies in women with symptomatic myomas. The aim of this retrospective study including a high number of patients was to assess perioperative morbidity in women undergoing multiple myomectomy, to identify associated risk factors for blood loss and to evaluate the influence of microsurgical technique in myomectomy.

Materials and methods

Our retrospective study included 228 myomectomies in premenopausal, symptomatic patients performed by laparotomy in a 6-year time interval. The median age was 32.6 years (20.6–50.0). Surgical procedures were performed in a university teaching hospital (Medical University of Hannover, Germany), which has a long tradition in microsurgical, reconstructive and organ-preserving fertility surgery, e.g. reconstruction of the fallopian tubes. Only operations with the enucleation of at least three myomas or of one myoma measuring at least 3 cm in diameter were included in the analysis. At least one of the myomas had to be located deeply in the uterine wall. The main clinical symptoms leading to admission were severe menstrual disorders such as dysmenorrhoea and hypermenorrhoea, menorrhagia and/or primary or secondary infertility. The following data were recorded and analysed: patients' characteristics including history of symptoms, previous pregnancies and miscarriages, previous myomectomy and co-morbidities, number and location of myomas, mean diameter of the largest fibroid on ultrasound scan, preoperative and postoperative haemoglobin, taken on the day before and on the day after myomectomy, haemoglobin decrease, rate of blood transfusion, preoperative use of GnRH-agonists, operation time and intraoperative and postoperative complications. The standard clinical examination on admission in all patients included a gynaecological examination involving bimanual palpation of the uterus and ovaries and transvaginal ultrasound. Patients were excluded if myomectomy was performed as part of a more extensive operation such as severe endometriosis, extensive intraabdominal adhesions or tubal infertility. Patients who had pathologic results of coagulation factors, known bleeding disorders, severe hypertension or diabetes mellitus also were excluded from this study. Patients did not take any aspirin 10 days before surgery. In this retrospective study, we compared two cohorts of patients undergoing myomectomy by laparotomy. One group was treated according to microsurgical principles by the two main surgeons of the Department of Reproductive Medicine, G.G. and H.W.S. The other patients underwent myomectomy performed by conventional surgical technique by experienced surgeons of the Department of Obstetrics and Gynaecology, who were F.D., J.S., K.M., O.B. and S.N. Patients were allocated to the respective department by the referring gynaecologists in practice. Patients of both groups were equally distributed based on their anthropometric variables and myoma characteristics (Table 1).

Microsurgical technique versus conventional surgery

A total of 156 patients (68.4%) were treated according to strictly standardized microsurgical principles by two main surgeons of the Department of Reproductive Medicine, in which fertility surgery constitutes a clinical focus, e.g. reconstructive microsurgery of the fallopian tubes. Microsurgical techniques, which are also used in reconstructive

Table 1 Myomectomy: microsurgical techniques versus conventional surgery

	Microsurgical[a]	Conventional[a]	*P*
Patient characteristics			
Age (years)	33.8 ± 3.6	31.9 ± 5.4	0.004
Body mass index (kg/m^2)	23.2 ± 3.9	23.3 ± 4.1	NS
Myoma number	3.8 ± 3.7	2.7 ± 2.2	NS
Maximum myoma size (cm)	6.5 ± 2.6	6.9 ± 3.2	NS
GnRHa treatment, *n* (%)	55 (35.3)	21 (29.2)	NS
Re-laparotomy, *n* (%)	23 (14.7)	9 (12.5)	NS
Regressive myoma, *n* (%)	40 (25.6)	14 (19.4)	NS
Opened uterine cavity, *n* (%)	21 (13.5)	11 (15.3)	NS
Perioperative outcome and complications			
Operation time (min)	149.9 ± 51.5	124.4 ± 54.0	<0.001
Hb decrease (g/dl)[b]	1.77 ± 1.13	2.38 ± 1.67	0.007
Hb postoperative (g/dl)[b]	11.39 ± 1.55	11.16 ± 1.60	NS
Fever (≥38°C), *n* (%)	7 (4.5)	8 (11.1)	NS
Colon injury, *n* (%)	1 (0.6)	0 (0.0)	NS
Revision by laparotomy, *n* (%)	1 (0.6)	0 (0.0)	NS
Ileus, *n* (%)	0 (0.0)	1 (1.4)	NS
Adnexitis or endometritis, *n* (%)	2 (1.3)	1 (1.4)	NS
Abdominal wall haematoma, *n* (%)	2 (1.3)	3 (4.2)	NS
Transfusions intraoperative, *n* (%)	1 (0.6)	1 (1.4)	NS
Transfusions postoperative, *n* (%)	1 (0.6)	0 (0.0)	NS
Small Hb decrease[b,c], *n* (%)	101 (66.0)	32 (47.1)	0.008
Large Hb decrease[b,c], *n* (%)	5 (3.3)	10 (14.7)	0.003
Hb postoperative <7.0 g/dl[b], *n* (%)	1 (0.7)	2 (2.9)	NS

[a] Data are given as mean ± SD

[b] Analysis of haemoglobin values refers to 221 myomectomies. Patients with intraoperative transfusions ($n = 2$) or abdominal wall haematomas ($n = 5$) were excluded to avoid bias on the assessed intraoperative blood loss

[c] Small Hb decrease was defined as <2.0 g/dl, and large Hb decrease as >4.0 g/dl

surgery of the fallopian tubes and which may conserve fertility, should consider the following principles [18]: Atraumatic surgical technique with minimal traumatization of tissue, complete removal of diseased tissue by exact preparation technique, careful and subtle haemostasis, preparation layer by layer and exact adaptation of the tissue structures for an optimal reconstruction of the myometrium, complete peritonealization and continuous irrigation of exposed peritoneal tissue surfaces to avoid postoperative adhesions. No tourniquets, clamps, Foley catheter or vasoconstrictive agents were used to achieve haemostasis. Surgeons felt that the transient closure of vessels could mask potential bleeding sites, making precise and definite haemostasis more difficult.

In detail, standardized microsurgical technique of myomectomy included the following:

1. Atraumatic handling of the bowel with moist surgical packs, continuous rinsing of the site with Ringer-heparin to prevent tissue drying, fibrin accumulation and adhesion formation.
2. Preparation of the myoma was performed as follows: bipolar coagulation of the serosa above the myoma and monopolar cutting of the uterine wall until identification of the node (Fig. 1).
3. The myoma was then flexibly positioned with a clamp to facilitate preparation, performed with a bipolar device under exact adherence to the plane of cleavage between myoma and myometrium (Fig. 2). To avoid necrotic defects and undesired scar formation in the myometrium, bipolar coagulation was restricted to a minimum.
4. One of the primary goals was to avoid opening the uterine cavity (Fig. 3).
5. Definite haemostasis and restoration of uterine anatomy was achieved by thorough closure of the enucleation wound with a multilayer, interrupted suture of descending diameter (Vicryl 0, 2 × 0, 4 × 0, Ethicon, Norderstedt, Germany). In Fig. 4 the uterine wound is presented.
6. The visceral serosa was adapted to restore smooth organ surfaces preventing adhesion formation (Vicryl 6 × 0) (Fig. 5).
7. Finally, the pelvis was rinsed repeatedly with sterile saline solution until the fluid remained free of blood and tissue debris, and clear saline solution was left intra-abdominally as adhesion prophylaxis.

In 72 patients, abdominal myomectomy was performed by experienced surgeons of the Department of Obstetrics and Gynaecology not applying the special microsurgical

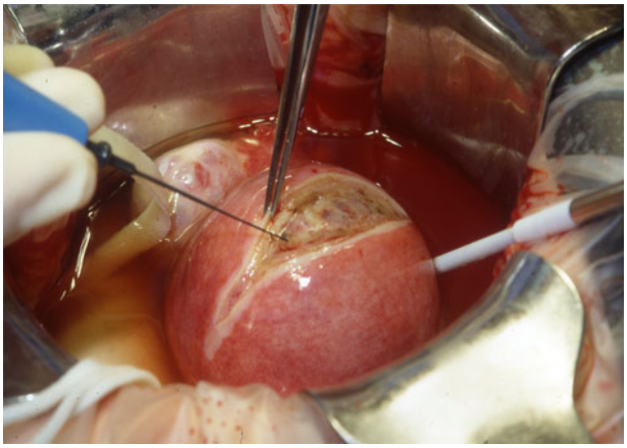

Fig. 1 Preparation of the myoma: bipolar coagulation of the serosa above the myoma and monopolar cutting of the uterine wall until identification of the node

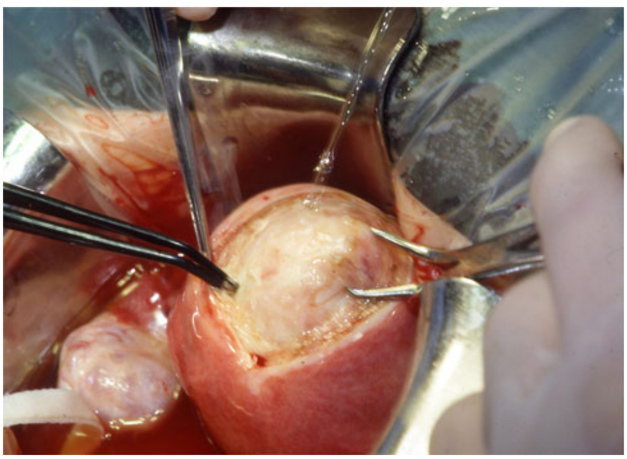

Fig. 2 Second step of preparation using a bipolar device. There is exact adherence to the plane of cleavage between myoma and myometrium and continuous rinsing of the site with Ringer-heparin to prevent tissue drying

techniques described above. The techniques of myoma preparation, haemostasis and adhesion prophylaxis in the conventional surgical procedure were subject to variation: In general, scissors or scalpels were used for a sharp myoma preparation, impairing a precise, anatomical but atraumatic separation of the fibroid from the uterine wall. A meticulous haemostasis fulfilling microsurgical standards was not achieved. The adaptation of intramural enucleation wounds was predominantly carried out only by a single or a double layer suture. Adhesion prophylaxis by rinsing the operation site with saline solution was not a standard.

Outcome measures

Perioperative complications impairing the clinical course until discharge from hospital were extracted from the

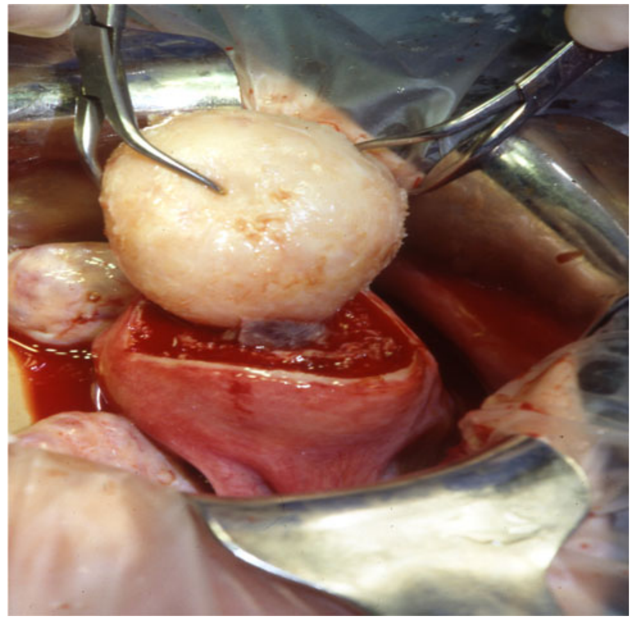

Fig. 3 Removal of myoma without opening the uterine cavity

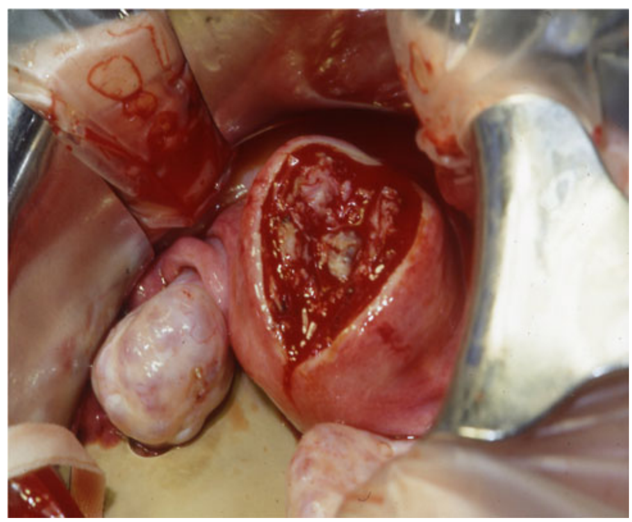

Fig. 4 The uterine wound is presented. Next step is the closure of the enucleation wound with a multilayer, interrupted suture of descending diameter (Vicryl 0, 2 × 0, 4 × 0, Ethicon, Norderstedt, Germany)

surgeon's and the anaesthetist's report and from the documentation of the postoperative course in the patient's file. Fever was defined as a body temperature of ≥38°C, excluding the day of surgery. Intraoperative and postoperative blood transfusions were recorded. The difference between the preoperative and the postoperative haemoglobin at the first day after myomectomy was calculated. The following additional data were analysed: number of myomas, size of the largest myoma, histology of myoma, opening of the cavum uteri, pretreatment with GnRH analogues and the operation time of myomectomy.

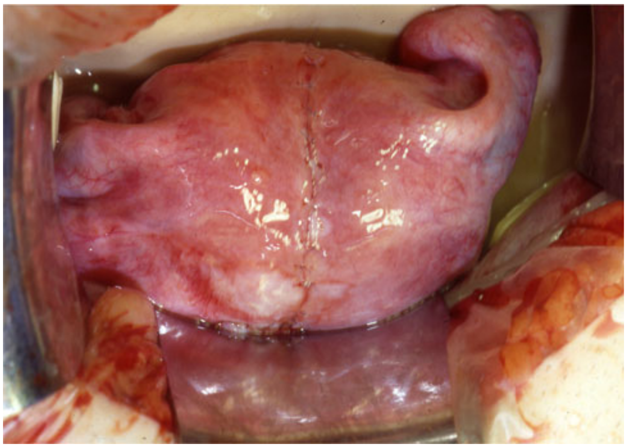

Fig. 5 The visceral serosa is adapted to restore smooth organ surfaces preventing adhesion formation (Vicryl 6 × 0)

Statistics

The primary outcome of this study was the incidence of perioperative morbidity, particularly the extent of blood loss in patients undergoing abdominal myomectomy and the corresponding differences between the use of microsurgical techniques versus conventional surgery. Statistical data analysis was performed with SPSS Vers. 13.0. The Chi-square test, Fisher's exact test and Mann–Whitney *U* test were used in bivariate data analysis. As a secondary objective, we investigated whether anatomical factors and surgical technique independently influenced blood loss in a multivariate analysis using stepwise linear regression. A value of $P < 0.05$ was considered to be statistically significant.

Results

The main clinical symptoms leading to admission were dysmenorrhagia and hypermenorrhagia (66.7%), primary or secondary infertility (22.8%), myoma growth (11.8%) and abdominal mass (7.9%). Patients in both groups were equally distributed regarding clinical characteristics and possible risk factors affecting perioperative morbidity (Table 1). In the microsurgery group, the mean number of myomas removed was 3.8 compared to 2.7 in the conventional group. The maximum myoma size was 6.5 cm in the microsurgery group and 6.9 cm in the conventional group. The uterine cavity was opened in 21 cases (13.5%) (microsurgery group) and in 11 cases (15.3%) (conventional surgery group), respectively. These differences were not significant. The mean operation time was significantly longer when microsurgical technique was used (149.9 vs. 124.4 min; $P < 0.001$).

Perioperative complications

Postoperative fever was the most frequent complication, occurring in 4.5% of patients of the microsurgical group and in 11.1% the conventional group, respectively (Table 1). Intraoperative complications of the microsurgical group included one bowel injury in the presence of pre-existing adhesions (0.6%). In the conventional group one transient ileus was observed, which was treated conservatively (1.4%). Five haematomas of the abdominal wall were observed in the postoperative course of all patients (2.2%), two in the microsurgical group (1.3%) and three in the conventional group (4.2%). One of the haematomas in the microsurgical group had to be revised by secondary laparotomy because of an infection (Table 1). An inflammatory condition of the pelvis, adnexitis or endometritis, was diagnosed in the postoperative course of two patients in the microsurgical group (1.3%) and of one patient in the conventional group (1.4%). None of the patients required a hysterectomy because of a perioperative complication. Because of a low overall incidence of the above complications, there was no statistically significant difference between groups. However, two complications perceived as typical in myomectomies occurred in the conventional group: an ileus and a higher incidence of fever.

Blood loss and transfusions

Besides postoperative fever, increased intraoperative blood loss was defined as Hb decrease >4.0 g/dl as a relatively frequent complication. However, in the microsurgical group a loss of haemoglobin >4.0 g/dl occurred less often and small decreases of haemoglobin <2.0 g/dl were significantly more frequent compared to the conventional group (3.3 vs. 14.7%; $P = 0.003$ and 66.0 vs. 47.1%; $P = 0.008$; respectively; Table 1). Congruently, patients treated under microsurgical conditions showed a significantly lower decrease of haemoglobin compared to the conventional surgery group (1.77 vs. 2.38 g/dl; $P = 0.007$). Two intraoperative and one postoperative transfusions were recorded, two in the microsurgical group (1.2%) and one in the conventional group (1.4%). The postoperative transfusion in the microsurgical group was an autologous transfusion, which was given without a strict clinical indication.

Factors influencing blood loss

As a secondary objective, we analysed potential risk factors influencing blood loss, because this complication is well recognized in myomectomies and can reflect atraumatic techniques and surgical precision. Furthermore, blood loss is hypothesized to influence fertility outcome by causing adhesions or intramural haematomas impairing uterine integrity. In a multivariate analysis using stepwise logistic regression, independent factors influencing blood loss during myomectomy were identified (Table 2). The maximum myoma diameter, the number of myomas removed and the opening of the uterine cavity in cases where the myoma was located deeply in the myometrium correlated positively with blood loss as measured by haemoglobin decrease ($P < 0.001$, $P < 0.001$ and $P = 0.014$, respectively). Besides this correlation of anatomical factors, the application of microsurgical techniques during myomectomy was correlated inversely with haemoglobin decrease ($P < 0.001$).

Discussion

To our knowledge, this study constitutes the largest series analysing morbidity in myomectomy by laparotomy, evaluating the differences of microsurgical technique versus conventional myomectomy. We find that perioperative complications, transfusion rate and blood loss are amongst the lowest reported when microsurgical techniques are used.

Perioperative complications

In literature, serious perioperative complications of myomectomy such as uterine haematoma, haemoperitoneum and myometrial abscess, and hysterectomy due to postoperative bleeding range from 1.7 to 2.8% [10, 19–21]. In a recent study, 3 out of 206 patients needed hysterectomy [1]. In a large retrospective series, Vercellini had to reoperate in nine cases (1.9%) during the postoperative course [21]. Besides six subfascial haematomas, three cases were related to the procedure of myomectomy itself (0.6%): one patient showed a uterine haematoma and another developed a haemoperitoneum. A third patient had to be hysterectomized because of a myometrial abscess (0.2%). In a group of 58 laparotomies for recurring myomas, Frederick hysterectomized one patient (1.7%) because of postoperative bleeding and hypovolemic shock [7]. A complication described as typical for myomectomy in literature is a postoperative ileus, with its rate ranging from 0.7 to 10.2% [19, 20, 22–24]. Postoperative ileus after myomectomy has been reported since the procedure is performed and has repeatedly stimulated the operative technique [25]. It is mostly caused by bleeding or dehiscence of the uterine wound during the postoperative course, typically following the enucleation of a myoma of the posterior uterine wall [25].

The two complications in our study requiring surgical treatment, intraoperative bowel injury related to abdominal wall adhesions and subfascial haematoma, were not caused by the procedure of myomectomy itself. Because of a low overall incidence, there was no statistically significant difference between the two groups regarding perioperative complications. However, the complications perceived as typical in myomectomies occurred in the conventional group: an ileus and a higher incidence of fever. Postoperative fever, a complication often associated with myomectomy caused by tissue trauma and prostaglandin-mediated resorption processes, was more frequent in the conventional group [1].

Table 2 Factors correlating with blood loss in a multivariate analysis

Factor	Correlation	*P*
Myoma size	Positive	<0.001
Number of myomas	Positive	<0.001
Re-laparotomy (earlier surgery)	Positive	0.002
Soft, regressive myoma	Positive	0.009
Opening of the uterine cavity	Positive	0.014
Microsurgical techniques	Negative	<0.001

Stepwise linear regression

Blood loss and transfusions

Blood loss is another well-recognized complication of myomectomy. Although infrequently critical in the acute situation, blood loss in myomectomy can be associated with the development of pelvic adhesions or uterine haematoma, possibly impairing future fertility potential [6, 7]. A low blood loss can be conceived as an indicator of a myomectomy with minimal traumatization. In our study, the haemoglobin decrease in the conventional group was 2.38 ± 1.67 g/dl, which is similar to reported values in literature between 2.14 and 3.07 g/dl [15, 22, 26, 27]. In contrast, the haemoglobin decrease in the microsurgical group was 1.77 ± 1.13 g/dl, which was significantly lower compared to the conventional group and which constitutes the lowest decrease in blood loss reported in literature. In literature, estimated blood loss in abdominal myomectomies ranges from 150 to 840 ml [1, 24, 26, 28–30], reaching the highest values in multiple myomectomy [1]. Although some smaller studies observed no transfusions in myomectomies [31–33], the rate of transfusion is often around 20%, ranging from 4.2 to 52.4% [15, 22–24, 26, 34–36], compared to a very low rate of 1.3% in this study. Whilst high transfusion rates could be partially explained by a broad patient selection, after correcting for unnecessary transfusions the rates remained considerable [17]. As a consequence for clinical practice, the low transfusion rate observed in this study does not justify a routine preparation of red blood cell units prior to abdominal myomectomy.

Recently, mechanical or pharmaceutical agents temporarily reducing uterine blood flow during myomectomy were reviewed in a Cochrane analysis [37]. Surgeons in this study did not apply vasoconstrictive agents to avoid a temporary masking of a bleeding site, complicating exact and definite haemostasis. We conclude that avoiding trauma by a precise preparation and anatomical reconstruction is effective in avoiding bleeding complications and transfusions in myomectomy as demonstrated by the results in the microsurgical group. We evaluated blood loss by assessing the difference in the preoperative and postoperative haemoglobin concentrations. Congruently, a limited bias, caused by dilution with intraoperative or postoperative infusions, cannot be completely excluded, although infusion regimes did not differ between both groups. Some studies refer to estimated blood loss observed by the surgeon; however, it has been shown that estimation is imprecise and often too low. In this context, calculating the difference between preoperative and postoperative haemoglobin can be conceived as an appropriate means to quantitatively approach intraoperative blood loss.

Factors influencing blood loss

As a secondary objective, we identified independent factors influencing intraoperative blood loss in a multivariate analysis (Table 2). Supporting a former study, reporting uterine size as a major determinant for blood loss, number and size of myomas in this study independently correlated with haemoglobin decrease [36]. Furthermore, the opening of the uterine cavity acted as an independent risk factor for blood loss, reflecting the location of a myoma deeply in the myometrium. Notably, softened, regressive myomas were positively associated with intraoperative blood loss in this study. In addition to the above pre-existing anatomic variables, the use of microsurgical technique independently determined intraoperative blood loss and exerted a beneficial effect on procedure-related morbidity. Blood loss can be conceived as an indicator for a traumatic operation and/or insufficient adoption of enucleation wounds. In this respect, the preparation and reconstruction of the uterine wall should be performed exactly layer by layer for an optimal and functional adaptation of the myometrium to allow a regular nidation and to prevent rupture of the uterine wall in future pregnancies.

Conclusion

The above findings clarify the significance of a meticulous anatomic preparation precisely along the myoma's plane of cleavage, preferably by the described microsurgical techniques. In premenopausal women desiring future pregnancy, complications during myomectomy demand special consideration, as they can give rise to effects impairing fertility. Uterine ruptures in pregnancies after myomectomy were caused by dehiscences of the uterine wall, constituting serious sequelae of an insufficiently reconstructed myometrium. These incidences have been reported for laparotomy [8] and for laparoscopy [38]. In conclusion, we hypothesize that a microsurgical removal of multiple and/or large myomas, especially in the case of deep intramural type in contact with the uterine cavum, may lead to an exact adaptation of the uterine wall layers. When intended as a fertility-preserving procedure, myomectomy should be conducted under ideal technical conditions, allowing for low morbidity. Data of this study support the hypothesis that the ambitious conception of myomectomy as "cure without deformity or loss of function" [25] can be achieved by microsurgical techniques, encouraging their application especially in complex cases. In evaluations of laparoscopic myomectomy, implemented to reduce morbidity, a comparison with the results of microsurgical myomectomy is of interest.

Conflict of interest The authors declare that they have no conflict of interest.

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