Symptomatic Fibroids as Main Indication for Laparoscopic Hysterectomy and Their Handling

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Introduction

One of the multiple treatment possibilities for myomas considering all laparoscopic surgical, medical or interventional techniques is total laparoscopic hysterectomy (TLH) or subtotal laparoscopic hysterectomy (SLH). As SLH is a much less invasive procedure, a good number of patients with myomas can consider a subtotal approach. However, only a total laparoscopic hysterectomy (TLH) can offer 100 % protection from new fibroid formation, later sarcoma formation, uncontrolled bleedings, cervical and endometrial cancer or any other problems arising from the uterus.

In spite of numerous theories, the etiology of fibroid formation remains unclear. While a genetic disposition must be given, as Africans have a much higher frequency of multiple myomas than Caucasians certain up- and down-regulations in the genes of patients with and without myomas have been described. However, as yet no clear guidelines for the prevention of fibroids are available. Hereditary leioyomatosis and renal cell carcinoma syndrome is a rare syndrome involving fibroids. Individuals with the gene that leads to both fibroids and skin leiomyomas have an increased risk of developing a rare case of kidney cell cancer (papillary renal cell carcinoma).

Understanding which genes are involved in fibroids does not automatically tell us why fibroids develop or how to control them. From our understanding of fibroid behavior, we would guess that genes involved in estrogen or progesterone production, metabolism or action are involved. Unfortunately, science is seldom that straightforward. Most guesses regarding these "candidate genes" turn out to be wrong and much research is still required to find out how these genes lead to disease. There are also small variations, called polymorphisms, in genes that may play a role in influencing the risk of fibroids. Both polymorphisms and mutations are changes in the sequence of genes, but the difference is in the degree of change. A mutation makes a major change in the gene that leads to a change in the protein the gene is coding for. For example, it can change the amino acid from alanine to glycine or cause the protein to be prematurely cut off.

The Genetics of Fibroids, Genotype, Phenotype

The discovery of the structure of DNA (desoxyribonucleic acid) by Watson and Crick revolutionized biology and medicine. They discovered that DNA carries the code for life in a ladder-like structure. Today, it is known that the genes from a single person take up the space of 400,000 times the distance from the earth to the moon or 1000 times the distance from the earth to the sun = 150 billion kilometers [1–3].

Before going further, it is important to define the terms genotype and phenotype. The genotype is the pattern of genes that you inherit. For example, with eye color, brown is a dominant color and is represented by a "B". Blue is a recessive trait and represented by a "b". Therefore, a person can have "BB", "bb", or "Bb" as genotypes for eye color. Each person gets two copies of the gene, one originally from his or her mother and the other from his or her father. The dominant gene will always dominate; it has the power to trump a recessive trait. Phenotype is the physical manifestation, or end result, of the genotype. Although there are three different genotypes (BB, bb, or Bb), there are only two phenotypes: brown eyes and blue eyes. People with the "BB" or the "Bb" genotype have brown eyes because brown is the dominant trait; only the people with the "bb" genotype have blue eyes.

We believe that fibroids are a common phenotype that represents many different underlying genotypes. In other words, in our view, fibroids can arise through multiple

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different pathways. In this case, "Bb" might represent two different genes that code for the estrogen receptor beta which influences the action of estrogen on fibroid tissue. A "B" gene may make the fibroid more sensitive to this hormone and therefore more likely to grow. In addition, probably multiple genes influence fibroids so that in addition to "Bb" we may also have "Pp" for progesterone receptors, "Ff" for fibrotic factors, and so on. This information would be most helpful in advancing treatment as women who carry a high risk of recurrent fibroids and have completed their family planning might choose to have a hysterectomy because of the higher chance of their having an additional surgery. We currently have some clinical information (based on physicians' clinical experience with many patients) to predict prognosis for recurrence after myomectomy, but our clinical information for alternative forms of treatment options is limited.

Evidence for the Role of Genes in Fibroid Development and Growth

Studies of women with fibroids suggest several reasons to suspect that genes play a role in fibroid formation. The first is that both women in a pair of identical twins are twice as likely to have had a fibroid-related hysterectomy as both women in a pair of fraternal (non identical) twins. Identical twins share 100 % of their genes, while fraternal twins share only 50 % of their genes. This suggests that the genes that identical twins share make them more likely to form fibroids, since both are identical and non identical twins have equal exposure to environmental factors. This difference between identical and fraternal twins has been observed in a general population of women undergoing hysterectomy and a population of women with fibroids leading to hysterectomy [4, 5].

There is also evidence that women who have close relatives, such as a mother or sister, with fibroids are much more likely to have fibroids themselves [6, 7]. This propensity is called familial aggregation. Just as with breast cancer, if you have many relatives affected by fibroids, your risk of disease is likely to be increased.

Molecular Genetics and Genome-Wide Scan for Fibroid Genes

Finally, in the age of molecular genetics, we can scan markers across the complete sets of DNA, or genomes, of many people to find genetic variations associated with a particular disease. This process is called a genome-wide scan. This is a common approach to finding genes in complex diseases, such as diabetes, asthma and heart disease. With a genome-wide scan, women who are sisters and both have fibroids (an affected sibling pair) are recruited to participate in the study. Their DNA is studied for common genes. If hundreds of women are studied, each region of every chromosome can be examined, and it can be determined which genes are shared by the sisters who share the fibroid phenotype but are different in many other respects. This approach often produces novel genes that were not previously thought to be involved in the disease process [8–11].

Microscopic Facts and Fibroid Viability

Fibroids are composed primarily of smooth muscle cells. The uterus, stomach and bladder are all organs made of smooth muscle. Smooth muscles cells are arranged so that the organ can stretch, instead of being arranged in rigid units like the cells in skeletal muscle in arms and legs that are designed to "pull" in a particular direction. In women with fibroids, tissue from the endometrium typically looks normal under the microscope. Sometimes, however, in submucosal fibroids there is an unusual type of uterine lining that does not have the normal glandular structure. The presence of this abnormality, called aglandular functionalis (functional endometrium with no glands), in women having bleeding disorders is sometimes a clinical clue for their doctors to look more closely for a submucosal fibroid [12]. A second pattern of endometrium, termed chronic endometritis, can also suggest that there may be a submucosal fibroid, although this pattern can also be associated with other problems, such as retained products of conception and various infections of the uterus. Hysterectomy is not the only solution for treating fibroids; distinctions in size, position, and appearance have to be taken into account when deciding upon the best treatment option. If we understand these issues, we may be able to tell why some women have severe bleeding and other women with a similarly sized fibroid have no problem.

Costs of Fibroids

In fact, accurately capturing all the costs attributable to uterine fibroids will help us move toward more, and more effective, innovative therapies. When deciding whether or not to launch a new concept, companies typically look at the amount currently spent for other treatments. The economics of fibroids has chiefly been discussed in terms of the health care costs of hysterectomy. This in itself is a huge amount of money. According to a recent estimate, in the United States, more than $2 billion dollars are spent every year on hospitalization costs due to uterine fibroids alone [13]. Additionally, one study estimates that the health care costs due to uterine fibroids are more than $ 4600 per woman per year [14].

When you incorporate all the costs of fibroids, however, the way of treatment becomes even more significant. Let us consider what costs arise

- The costs of myomectomy, uterine artery embolization (UAE), and other minimally invasive therapies
- The costs of birth control pills and other hormonal treatments to control bleeding
- The costs of tampons, pads, and the adult diapers many women require to contain the bleeding
- The costs of alternative and complementary therapies
- The cost of doing nothing (for many women this means missing work or working less productively during their period).

Reasons for Hysterectomies in Fibroid Patients

Why should a patient have a hysterectomy today when so many alterative treatment possibilities are available? Firstly, up to a certain size of the enlarged uterus, laparoscopic subtotal hysterectomy completely solves the problem and if women want to eliminate every risk of recurrent fibroids, hysterectomy is their only choice. Hysterectomy also solves coexisting problems, such as adenomyosis, endometriosis and endometrial polyps or cervical dysplasia, and there is no danger of ever leaving a sarcoma or carcinoma behind.

Review of All Uterine-Preserving Treatment Possibilities for Fibroids

The surgical treatment of fibroids can be differentiated between less invasive and more invasive surgical techniques. Time and type of treatment have to be chosen individually and are dependent on the patient and the treating gynecologist (Tables 30.1 and 30.2).

Table 30.1 Uterine fibroids or myomatous uterus

Asymptomatic	Symptomatic
Conservative treatment	Operative treatment
No acute need for action	Acute need for action
Medical therapy	Primary operative treatment
Expectant management	Delayed operative treatment with medical pre-treatment

Expectant Management

Wait-and-see is a possibility if patients are asymptomatic, decline medical or surgical treatment or have contraindications to any kind of treatment. However, existing data describe the possibility that fibroids can shrink substantially either by optimizing endocrinological disorders, such as hypothyroidism, or during the postpartum period [15, 16].

To pursue the idea of expectant management, the pelvic mass must definitely be classified as a fibroid and differentiated from an ovarian mass. The complete blood count (CBC) should be normal, especially in patients with severe symptoms, such as menorrhagia or hypermenorrhea. The women must also be informed that the risk of miscarriage, premature labor and delivery, abnormal fetal position and placental abruption is increased during pregnancies with uterine fibroids [17].

Medical Therapy

The benefit of medical treatment in the management of women with symptomatic fibroids is still difficult to prove. Medical therapy can provide adequate symptom relief, especially in cases where hypermenorrhea is the leading problem. The benefit of symptom improvement decreases in long-term treatment periods so that more than 50 % undergo surgery within two years [18].

Nevertheless, there has been a shift in traditional thinking that medical treatment of fibroids is solely based on the manipulation of steroid hormones. A deeper analysis and understanding of specific genes or pathways associated with leiomyomatosis may open new possibilities for prevention and medical treatment [19].

Primarily as a preoperative treatment to decrease heavy bleedings in patients with fibroids, hormonal treatment with selective progesterone modulators, such as ulipristal acetate 5–10 mg daily, have become widely used over the last 2 years [20–22].

Alternative Treatment Methods

If the patient does not want to undergo surgery or there are contraindications to surgery, there are alternative procedures:

Table 30.2 Treatment options for uterine fibroids

Alternative	Surgical						
Uterine artery Embolization	Myomectomy				Hysterectomy		
High intensity focused ultrasound	Hysteroscopic	Laparoscopic	Abdomical	Robotic assisted	Vaginal	Laparoscopic	Abdominal
Miscellaneous methods (myoma coagulation, myolysis)						Supracervical	
						Total	

Uterine Artery Embolization (UAE): This minimally invasive therapeutical option allows an occlusion of the specific arteries supplying blood to the fibroids. A catheter is introduced via the femoral artery under local anesthesia and particles are injected to block the blood flow to the fibroid. This can be an effective treatment option if the uterus should not be removed, surgery is contraindicated and family planning is completed. It results in myoma shrinkage of up to 46 %. Nevertheless, there is still a significant rate of postinterventional complications [23, 24].

Magnetic Resonance-guided focused UltraSound (MgRf-US): This is a more recent treatment method for uterine fibroids in premenopausal women. Again, the patients should have completed their family planning. In this noninvasive thermo ablative technique multiple waves of ultrasound energy are converged on a small volume of tissue, resulting in maximal thermal destruction. The limiting factors are size, vascularity and access [25, 26].

Uterine-Preserving Surgical Treatment of Fibroids

The surgical removal of fibroids is still the main pillar in the treatment of leiomyomas. Hysterectomy is the only definitive solution and can be performed as supracervical or total hysterectomy. Myomectomy performed by hysteroscopy, conventional laparoscopy or laparoscopy with robotic assistance and by the open or vaginal approach are alternative surgical methods.

Indications for surgical therapy of uterine fibroids are:

1. Abnormal uterine bleeding disorders (hypermenorrhea, dysmenorrhea, menorrhagia- and metrorrhagia)
2. Bulk-related symptoms
3. Primary or secondary infertility and recurrent pregnancy loss.

Counseling and Informed Consent

Patients undergoing an operative procedure have to be informed of the risks and potential complications as well as alternative operating methods. Counseling before surgery should include discussion of the entry technique and the associated risks: injury of the bowel, urinary tract, blood vessels, omentum and other surrounding organs and, at a later date, wound infection, adhesion-associated pain and hernia formation.

Counseling needs to integrate the individual risk dependent on the BMI of the patient. Depending on the medical history, it is important to consider anatomical malformations, number of vaginal births, midline abdominal incisions, a history of peritonitis or inflammatory bowel disease [27].

Myomectomy

Myomectomy is a surgical treatment option for women who have not completed their family planning or who wish to retain their uterus for any other reasons. The enucleation of fibroids by any method is an effective therapy for bleeding disorders or displacement pressure in the pelvis. Nevertheless, the risk of recurrence remains after myomectomy. Furthermore, if any other pathologies might be causative or only co-causative for the symptoms (such as adenomyosis uteri), these problems will persist [28]. Complications arising at myoma enucleations and pregnancy-related complications have been investigated extensively. All operating possibilities, especially laparoscopic versus laparotomic, but recently also laparoscopic versus robotic-assisted myomectomy have been evaluated. Uterine rupture or uterine dehiscence is rare and occurs in less than 1 % of laparoscopic cases and even less seldom in robotic-assisted and laparotomic cases. Careful patient selection and preparation, as well as suture techniques, appear to be the most important variables for myomectomy in women of reproductive age [29, 30]. Uteri with multiple fibroids have an increased number of uterine arterioles and venules. Therefore, myomectomy can lead to a significant blood loss and corresponding arrangements should be made [31].

Hysteroscopic Myomectomy

Submucosal fibroids have their origin in myometrial cells underneath the endometrium and represent about 15–20 % of all fibroids. Before the establishment of hysteroscopy as a minimally invasive and effective treatment method, these myomas were removed by hysterotomy or even hysterectomy. Increased surgical training, improvement of technology and the widespread use of hysteroscopic myomectomy have made it a safe, fast, effective and cheap method of fibroid resection while preserving the uterus [32].

Patient selection concentrates on intracavitary submucous and some intramural fibroids. More than 50 % of the fibroid circumference needs to be protruding into the uterine cavity. Deep myometrial leiomyomas require advanced operative skills and have an increased risk for perioperative complications and incomplete resection. The depth of myometrial penetration correlates with the volume of distension fluid absorbed [33, 34]. Few data are available on the size of myoma that prevents the use of the hysteroscopic approach. The European Society of Hysteroscopy suggests to limit the myoma size to 4 cm but the few existing data report a significant increase of complications in fibroids that are >3 cm. Surgical skills determine the size and number of myomas that can be resected [35].

Prior to hysteroscopy, knowledge of the patient's medical history is important e.g. history of caesarean section or any other reason to expect an anatomical disorder. A vaginal ultrasound scan must be performed to precisely determine the uterus location, size and all cervical and uterine pathologies [36]. If available and feasible, fluid hystero-sonography should be performed to better differentiate the relationship of leiomyoma to the endometrial cavity and the myometrium. No prophylactic antibiotic is required to prevent surgical site infection.

The first step is the dilation of the cervical channel with Hegar dilators up to Hegar 9. The most commonly used instrument for fibroid resection is the monopolar or bipolar wire loop. Using a monopolar device the fluid medium must be non-electrolytic, using a bipolar device the fluid medium is isotonic [37]. A continuous flow allows the clearance of blood out of the uterine cavity to improve visualization. Furthermore, the resected pieces can be retracted. Nevertheless, the surface of the myoma and the time needed for resection increase the risk of excessive fluid absorption [38].

The resectoscope is inserted through the cervix into the uterine cavity and after distension with fluid the uterine cavity is carefully inspected. The monopolar resectoscope requires a cutting current of 60–120 W. Bipolar resectoscopes offer the possibility of simultaneous cut and coagulation. The wire loop passes easily through the tissue. The incision starts at the highest point of the myoma. Only in pedunculated fibroids might the incision cut the peduncle first. The loop is then moved towards the surgeon using the spring mechanism and simultaneously the entire resectoscope is gently pulled backwards. The wire loop must be in view of the surgeon during the whole procedure. This motion is repeated until the whole myoma has been resected and the surrounding myometrium (depth) and endometrium (side) can be differentiated. All resected specimen is sent to the pathologist. In cases of heavy bleeding and reduced vision the endometrium and the cutting surface have to be reinspected. These areas can be desiccated with the coagulating current.

The resected area will be recovered by the surrounding endometrium during the following weeks. The complication rate is low (0.8–2.6 %) [38, 39]. Complications that can occur, especially after extensive resection, are uterine perforation or excessive fluid absorption. Absorption of distension fluid might result in hyponatremia or volume overload [40]. The recurrence rate is about 20 % in a follow-up period of more than 3 years [35] .

Laparoscopic Myomectomy

With the improvement of laparoscopic techniques and skills myomectomy can be performed laparoscopically in most women. The laparoscopic approach is usually used for intramural or subserosal fibroids. The main advantage compared to abdominal myomectomy is decreased morbidity and a shorter recovery period. Nevertheless, laparoscopic myomectomy is limited by surgical expertise and especially laparoscopic suturing skills [41, 42]. Selection criteria for laparoscopic myomectomy are location, size and number of fibroids. Nevertheless, these characteristics are variable in relation to the surgical expertise. Preoperative imaging is performed by vaginal ultrasound to assess the precise features of the leiomyomas [31, 36, 43, 44].

Laparoscopic myomectomy starts with the usual placement of ports and trocars. After placement of the initial port in the umbilicus or higher up in the midline, depending on the size of the fibroids, 2–3 ancillary trocars are placed in the lower abdomen about 2 cm medial of each iliac crest and possibly in the midline [31, 45, 46]. Myomectomy can lead to severe bleeding that will complicate the procedure due to reduced vision. Vessel bleeding is controlled by bipolar electrosurgical power tools. Intraoperative bleeding can be reduced using vasopressin or other vasoconstrictors. Vasopressin is diluted (e.g. 20 units in 100 ml of saline) and injected into the planned uterine incision site. Vasopressin constricts the smooth muscle in the walls of capillaries, small arterioles and venules. Nevertheless, due to side effects the surgeon should pull back the plunger of the syringe before insertion to check that the needle is not inserted intravascularly [47–49]. Alternatively, misoprostol can be administered vaginally about one hour before surgery to reduce blood loss [50].

The uterine incision is preferably made vertically as this allows a more ergonomic suturing of the defect. The incision is performed with a monopolar hook directly over the fibroid and carried through deeply until the entire myoma tissue has been reached (Figs. 30.1, 30.2, 30.3, 30.4, 30.5 and 30.6).

After exposure of the myoma, it is grasped with a tenaculum or sharp forceps and traction and countertraction are applied. The removal of the myoma can easily be performed with blunt and sharp dissecting devices. Capsular vessels should be coagulated before complete removal of the myoma as coagulation becomes more difficult if traction is unsuccessful and bipolar coagulation occurs in the remaining myometrium wall. Subsequent to removal, the myoma is morcellated with an electromechanical device under direct vision and at a safe distance to all structures, such as the small bowel, to avoid inadvertent injury. The myoma tissue is removed and sent for pathologic evaluation. The uterine defect is closed with delayed absorbable sutures in one or two layers, depending upon the depth of the myometrial defect. It is important that the suture starts at the deepest point to avoid any cavity that might lead to a weak uterine wall. Furthermore, we tie the knot extracorporally so that the knot can be pushed into the deep layers with full strength (Fig. 30.7).

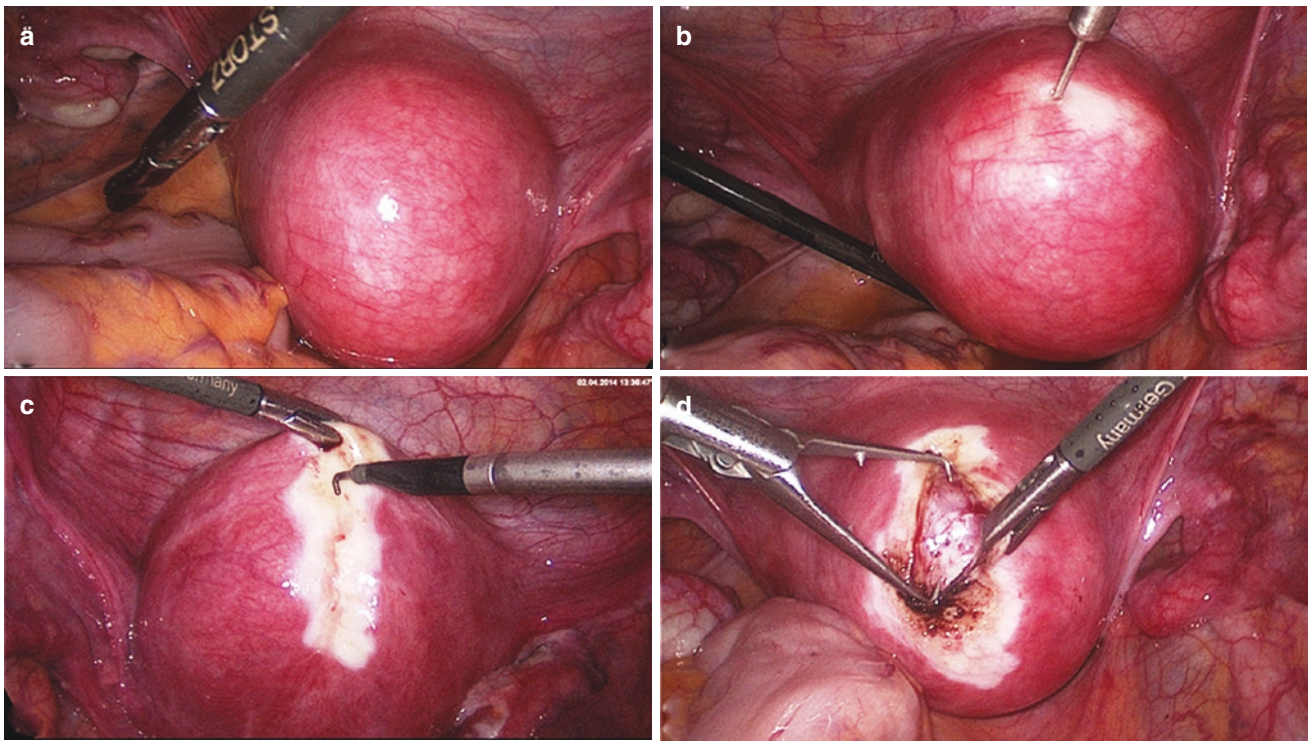

Fig. 30.1 Laparoscopic myoma enucleation. (**a**) Situs of a fundal/anterior wall fibroid. (**b**) Prophylactic hemostasis with 1:100 diluted vasopressin solution (Gylcilpressin) in separate wells. The injection intends to separate the pseudocapsule from the fibroid and reduces bleedings. (**c**) Bipolar superficial coagulation of the longitudinal incision strip and opening of the uterine wall with the monopolar hook or needle up to the fibroid surface. (**d**) Grasping of the fibroid and beginning of the enucleation. The pseudocapsule remains within the uterine wall and is pushed off bluntly

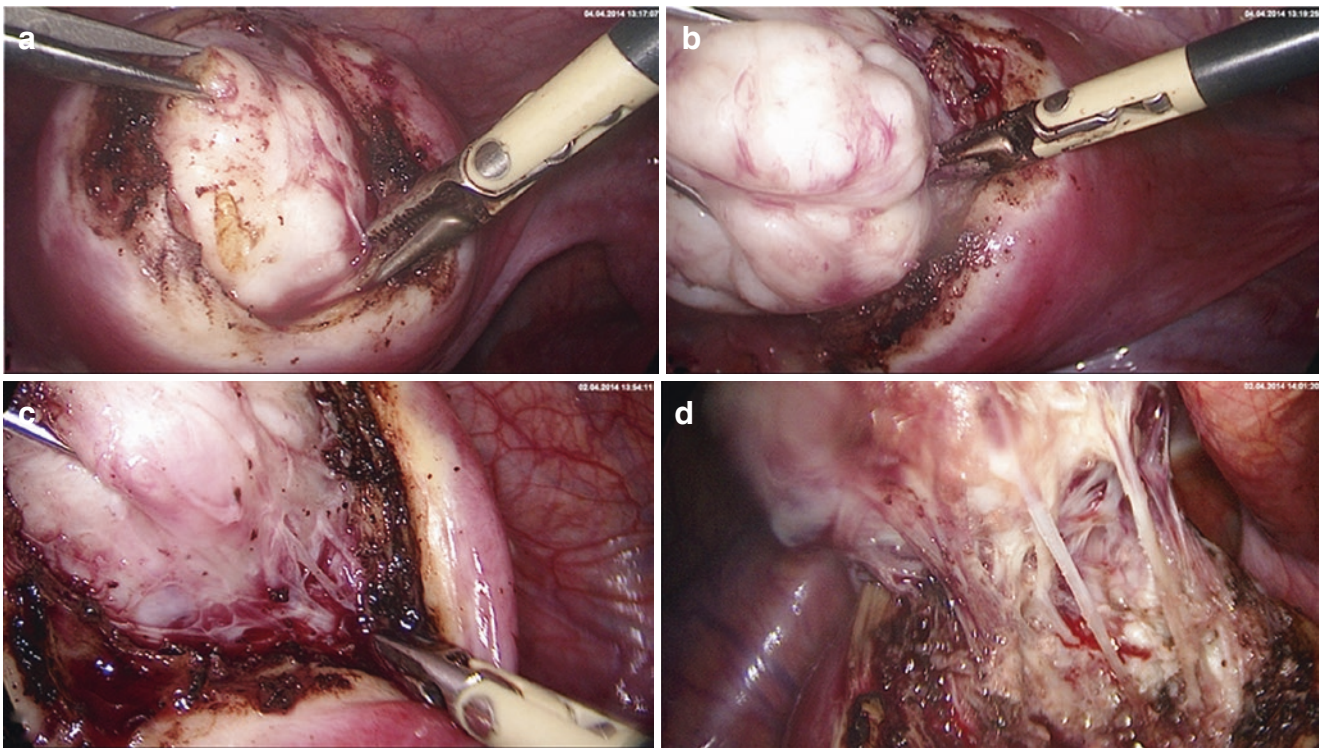

Fig. 30.2 Laparoscopic myoma enucleation. (**a**) Traction of the fibroid with a tenaculum and blunt delineation from the capsule. (**b**) Focal bipolar coagulation of basic vessels. (**c**) Continuous enucleation of the fibroid under traction and specific coagulation of capsule vessels containing fibers. (**d**) Magnification of remaining capsule fibers to be coagulated and cut

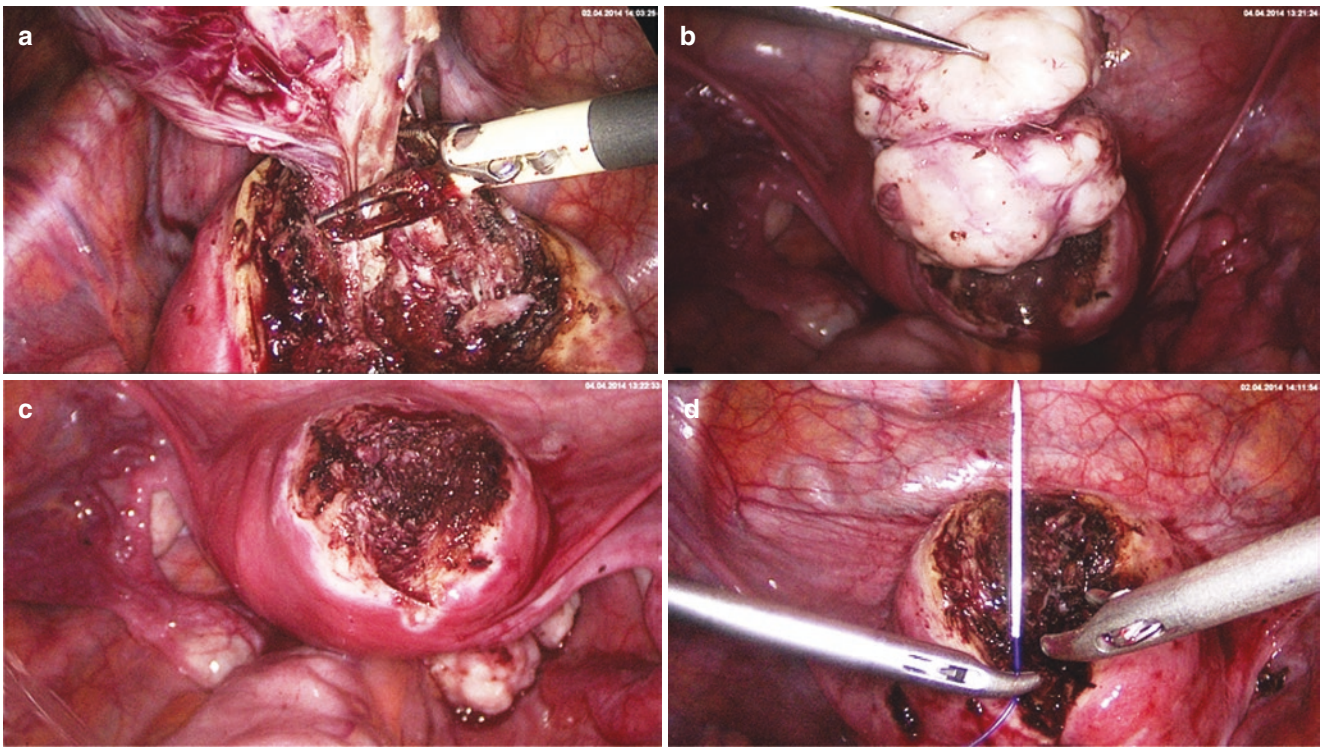

Fig. 30.3 Laparoscopic myoma enucleation. (**a**) Final coagulation of the capsule vessels. (**b**) Double belly fibroid after complete enucleation. (**c**) Minimal coagulation of bleeding vessels under suction and irrigation. (**d**) Approximation of wound edges with either straight or round, sharp needle and a monofilar late-absorbable suture

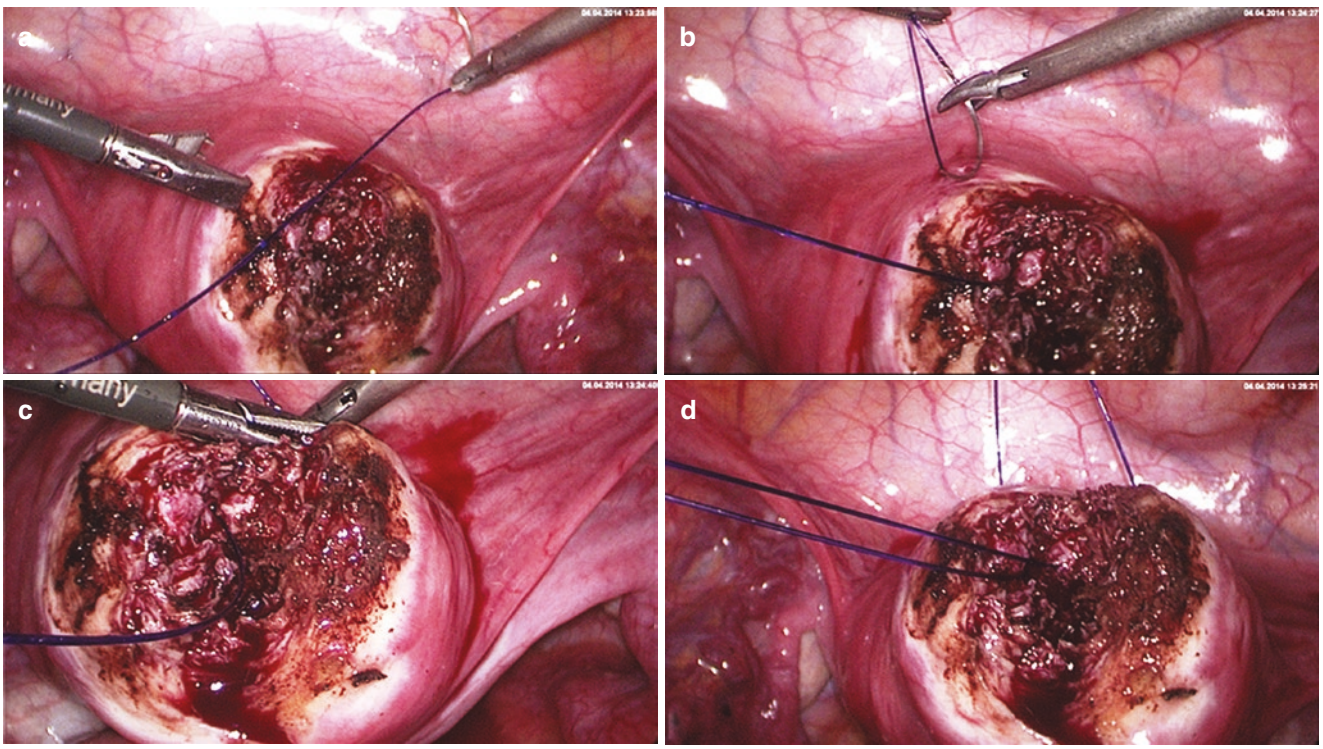

Fig. 30.4 Laparoscopic myoma enucleation. (**a**) Advantage of round needle stitch. The wound angle is elevated safely and completely by elevation with a Manhes forceps. Deeper layers of the myometrium can be grasped more easily using a round needle. (**b**) Needle exit and simplified regrasping with the right needle holder. (**c**) Final stitch to invert the knot. (**d**) Extirpation of the needle and completion of the extracorporeal knot and preparation to push down the extracorporeal knot

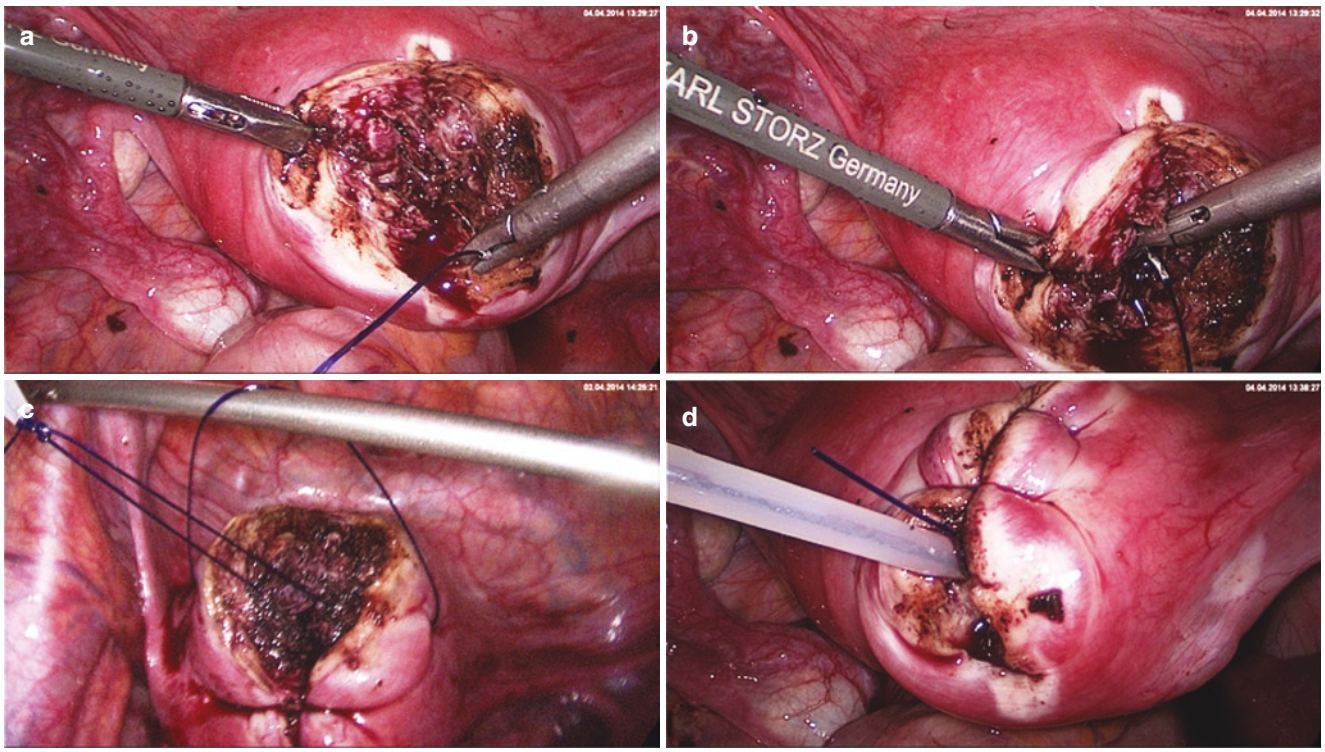

Fig. 30.5 Performance of the extracorporeal "von Leffern" knot. (**a**) Pulling out the suture, removing the needle, half hitch. (**b**) Holding the knot with the left hand and reaching over with the right hand. (**c**) Grasping the short end from below and leading it back, exiting before the half hitch. (**d**) Turning back the knot. Holding the straight suture and tightening the knot

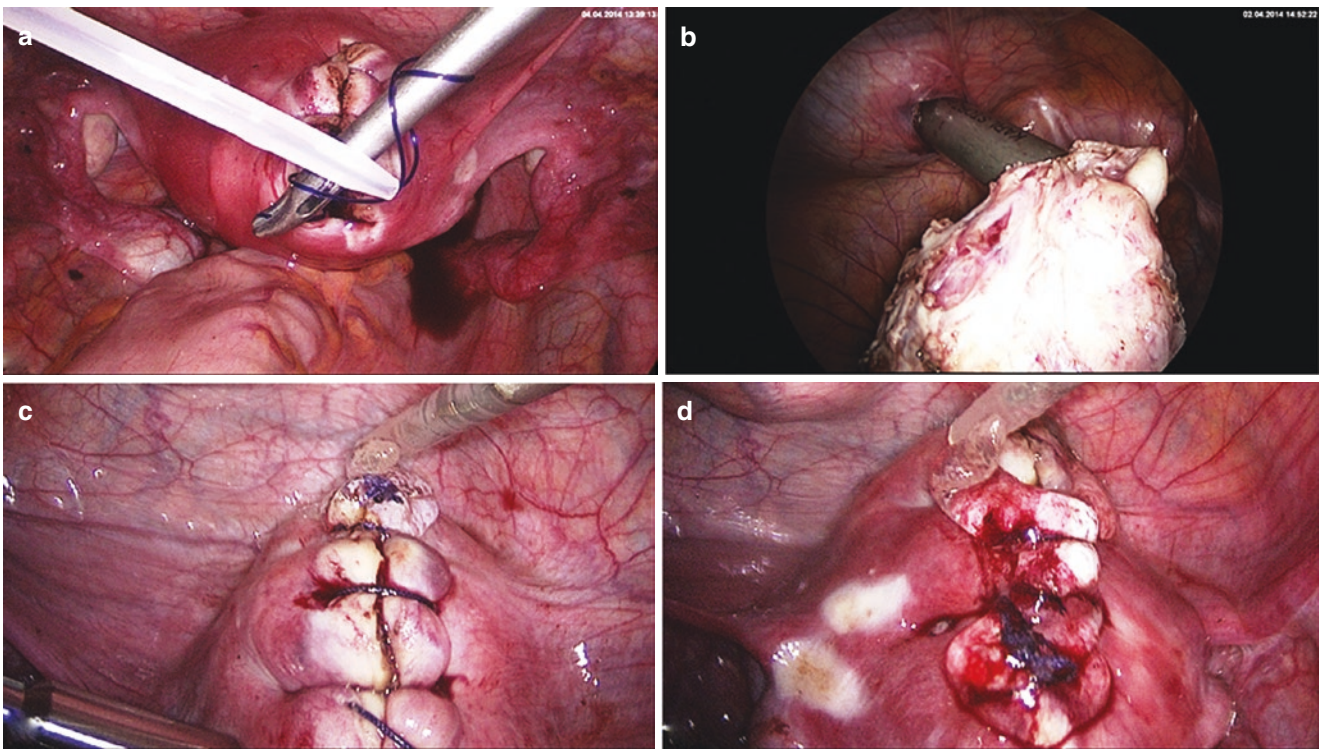

Fig. 30.6 Laparoscopic myoma enucleation. (**a**) Second single stitch starting as deep as possible in the uterine wound. (**b**) Exit of the needle on the left wound margin (just next to the Manhes forceps). (**c**) Completion of the stitch and preparation of the extracorporeal von Leffern knot. The needle holder elevates the thread to avoid tearing of the uterine wall while pulling through the monofilar thread (PDS). (**d**) The extracorporeal knot is pushed down with a plastic push-rod and deposited deep in the wound minimizing the external suture part

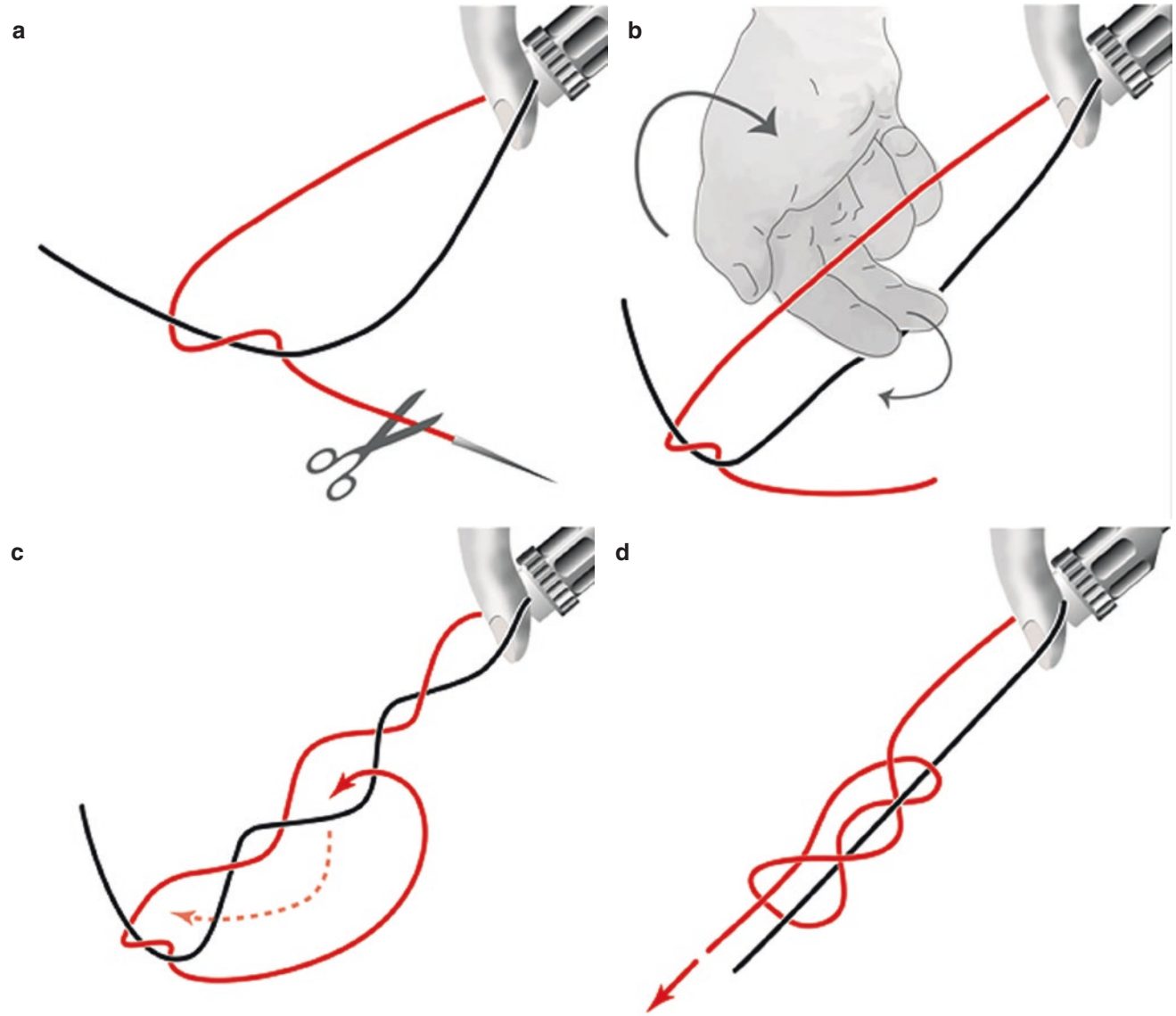

Fig. 30.7 Laparoscopic myoma enucleation. (**a**) Intracorporeal safety knot of the knot performed extracorporeally. (**b**) Morcellation of the fibroid with the Rotocut morcellator (Storz) in an apple-peeling manner. (**c**) Final situs showing the extracorporeal sutures to adapt the uterine wound edges. (**d**) Application of Hyalo Barrier (Nordic Pharma) for adhesion prevention

Alternatively, barbed sutures, such as V-lock, can be used to tighten the tissue or a third ancillary trocar can be inserted to hold the suture tight. The security of the uterine closure has bearing on the risk of uterine rupture in subsequent pregnancy. Different kinds of adhesion prevention barriers can be applied (Fig. 30.8) [51–53]. Women should wait at least 4–6 months before attempting to conceive [54].

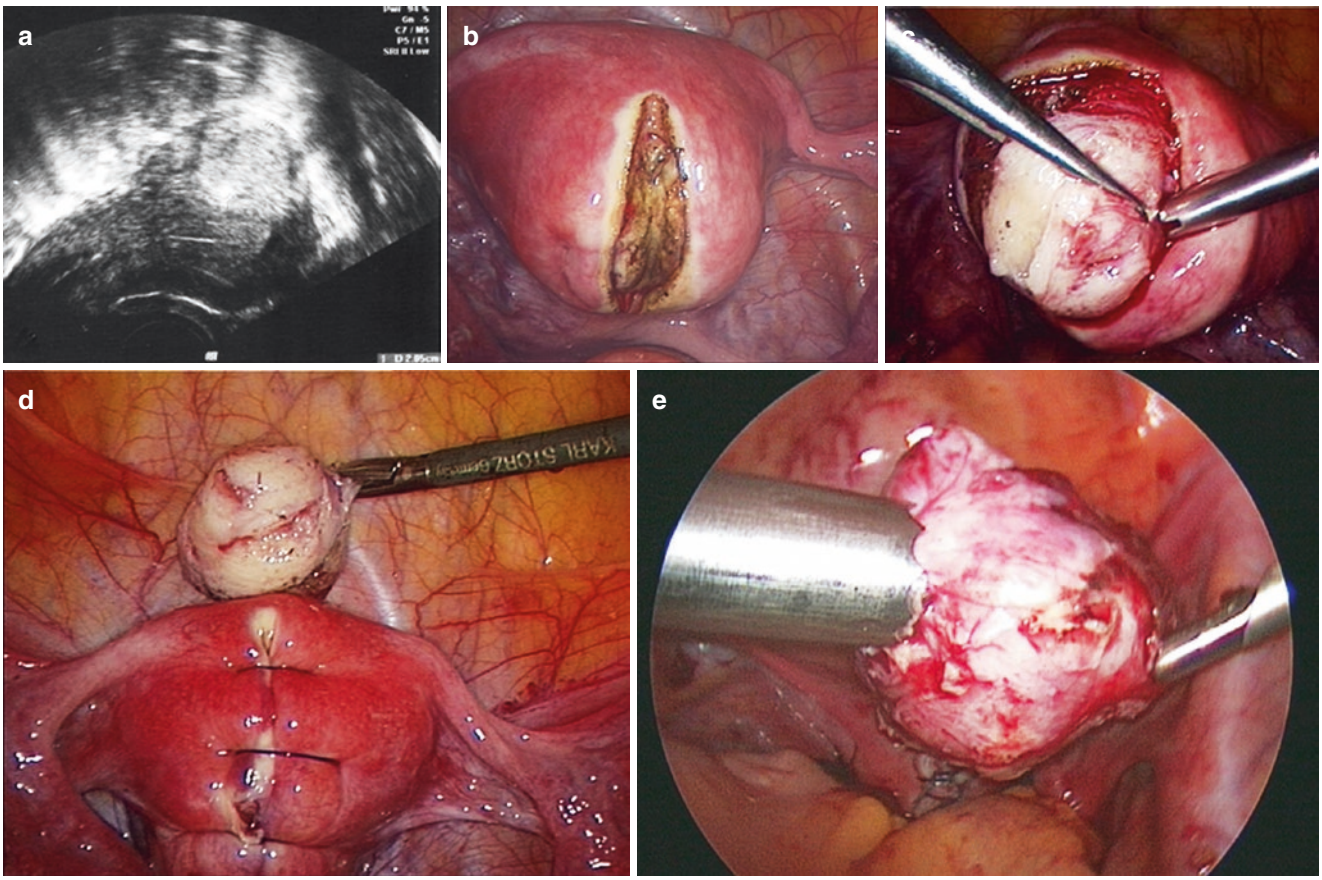

Fig. 30.8 (**a**) Transvaginal ultrasound shows a 3.5 cm intramural myoma in the back wall of the uterus. (**b**) Intraoperative uterotomy just above the myoma after injection of vasopressin. The uterotomy includes the myometrium and the myoma capsule and is done with a monopolar needle. All different tissue layers can be differentiated (**c**) Intraoperative sight of the myoma and its surrounding vascularized capsule. (**d**) Reconstruction of the uterine wall after excision of the tumor. (**e**) Removal of the myoma by morcellation

Abdominal Myomectomy

Abdominal or open myomectomy has its origin in the early 1900s as a uterus-preserving procedure. Today, it is mostly performed for women with intramural or subserosal myomas and less frequently for submucosal localization. Since the introduction of endoscopic procedures, the indication for abdominal myomectomy has become rare. It becomes an option if hysteroscopic or laparoscopic myomectomy is not feasible or if a laparotomy is required for any other reason. The indication to exclude uterine sarcomas has to be taken very strictly; however, uterine sarcoma is a very rare malignancy and the rate of sarcoma after clinical diagnosis of myoma is very low. The risk of severe complications in association with open surgery is higher than with hysteroscopic or laparoscopic moymectomy. Prophylactic antibiotics should be given for any abdominal fibroid operation [55, 56]. After the Pfannenstil incision either a vertical or transverse uterine incision is performed [57]. The myoma enucleation is performed by traction on the myometrial edges, e.g. with Allis clamps. After exposure of the fibroid it can be extirpated. The pseudocapsule is typically dissected bluntly. The uterine defects are closed with sutures in in several layers to reapproximate the tissue and achieve haemostasis without excessive bipolar coagulation.

Robotic Myomectomy

Robot-assisted laparoscopic myomectomy is a relatively new approach. The advantages of robotic surgery are three-dimensional imaging, mechanical improvement, including 7 ° of freedom for each instrument, stabilization of the instruments within the surgical field and improved ergonomics for the surgeon. Technical difficulties are decreased as suturing is easier than during conventional laparoscopy; however, there are few data comparing robot-assisted with conventional laparoscopic myomectomy [58–60]. The advantages compared to abdominal myomectomy are decreased blood loss and shorter recovery time. Nevertheless,

operation duration and operating costs are much higher than for conventional procedures. Furthermore, robotic devices are large and bulky. Robotic surgery is limited by the lack of tactile feedback and additional team training is necessary to minimize the risk of mechanical failure [61]. To date, no advantage compared to conventional laparoscopy could be demonstrated regarding blood loss or operative duration. A more secure myometrial closure has not yet been proven [59]. In obese patients robot-assisted surgery might be beneficial [62].

Hysterectomy as Treatment for Myomas

As fibroids are also the most common indication for hysterectomy (30 % of hysterectomies in white and 50 % of hysterectomies in black women), specific focus is given to hysterectomies within this chapter. The decision for a hysterectomy in a multifibroid uterus depends on the wish of the patient, her health status, whether childbearing has been completed and on the combined decision with the doctor. Only if the patient suffers from metrorrhagia does the disorder need to be examined pre-operatively in more detail as this may be a sign of endometrial cancer or sarcoma. Nevertheless, the combined evaluation of MRI and tumor makers pre-operatively leads to a more specific diagnosis of rapidly growing uterine masses or adnexas in the case of a leiomyomatous uterus or adnexal tumors. Only in cases where malignancy is not suspected is a simple TLH or SLH recommended, otherwise an oncological approach has to be selected. Hysterectomy as TLH or SLH is recommended for the following indications:

- Acute hemorrhage with non-response to other therapies
- Completion of family planning and current or increased future risk of other diseases, such as cervical intraepithelial neoplasia, endometrial hyperplasia or an increased risk of uterine or ovarian cancer. Precondition for the indication for hysterectomy is that these risks can be eliminated or decreased by hysterectomy.
- Failure of previous treatment.
- Completion of family planning and significant symptoms (e.g. multiple fibroids or adenomyosis) and the desire for a definitive solution.

The main advantage of hysterectomy over all other therapeutical possibilities is the definitive solution in eliminating all existing symptoms and the risk of recurrence. Nevertheless, the advantage of a definitive solution that allows freedom from future problems can be an obstacle if family planning has not been completed or the patient has a personal inhibition against the removal of the central genital female organ [63]. These issues must be discussed in advance with the patient before the decision for a hysterectomy is taken. Furthermore, for a solitary submucous, subserous, pedunculated or intramural myoma, the complication rate of a hysterectomy has to be compared with the complication rate of a myomectomy. The operational risks have to be compared to the operational risks of hysteroscopy, laparoscopic fibroid enucleation or conservative management. With the advances in cervical cancer screening the prevention of future cervical or uterine pathologies is no longer a relevant indication for hysterectomy. The decision must be tailored to meet the needs of each individual patient.

Laparoscopic hysterectomy was first introduced in 1989 with the aim of reducing the morbidity and mortality of abdominal hysterectomy to the level reached with vaginal hysterectomy. Laparoscopic assistance for vaginal hysterectomy can be of advantage if there is a need for adhesiolysis, a need to treat endometriosis simultaneously, a need to treat large leiomyomas and to ensure an easier and safer adnexectomy. If feasible, vaginal hysterectomy allows a more rapid and less painful recovery than open or laparoscopic surgery and is much cheaper [64].

Should Ovaries and/or Fallopian Tubes Be Removed or Left in Place at Hysterectomy?

Ovaries

Generally, the ovaries are not removed when a hysterectomy is performed for uterine fibroids. Removing the uterus alone will cure the bleeding and the size-related symptoms caused by the fibroids. When treating fibroids it is not necessary to remove the ovaries or fallopian tubes as is sometimes the case when treating other diseases, such as endometriosis or gynecologic cancers.

Many physicians were taught that at a set age (which varies between 35 and 50) women should be told that removal of the ovaries is recommended as part of the surgery, with the speculation of “while we are there, we may as well.” The general teaching has been that ovaries do not have any function after menopause and the risk of ovarian cancer increases with increasing age, so removing the ovaries near the time of menopause was a no-lose proposition. This was especially true if hormone replacement therapy could be used to help younger women transition to the time when they would naturally go through menopause.

However, more recent research suggests that although after menopause the ovaries produce little estradiol (the major estrogen in premenopausal women), they produce a tremendous amount of androgens (usually thought of as male hormones) [65]. It is thought that these androgens may be important in maintaining mood and sex drive [66–68]. In

addition, the risks of hormone replacement have become clearer, and many women choose to use hormones following menopause [69, 70]. Most women are aware of the research from the Women's Health Initiative demonstrating significant complications with postmenopausal hormone replacement therapy. However, it is not widely known that the risks are lower for women without a uterus, who are able to take estrogen alone [70]. Recently the association of premature loss of ovarian function and the increasing risk of heart disease has also been investigated [71].

Considering all these factors, there are good reasons to retain the ovaries if possible. The major reason to remove them at the time of fibroid surgery is if the woman has a high risk of ovarian cancer.

Fallopian Tubes

According to new research presented at the Annual Clinical Meeting of The American College of Obstetricians and Gynecologists in 2013, bilateral salpingectomy at hysterectomy, with preservation of the ovaries, is considered a safe way of potentially reducing the development of ovarian serous carcinoma, the most common type of ovarian cancer. Increasing evidence points toward the fallopian tubes as the origin of this type of cancer. Removing the fallopian tubes does not cause the onset of menopause, as does the removal of the ovaries.

Prophylactic removal of the fallopian tubes during hysterectomy or sterilization would rule out any subsequent tubal pathology, such as hydrosalpinx, which is observed in up to 30 % of women after hysterectomy. Moreover, this intervention is likely to offer considerable protection against later tumor development, even if the ovaries are retained. Thus, we recommend that any hysterectomy should be combined with salpingectomy. Women undergoing hysterectomy with retained fallopian tubes or sterilization have at least a doubled risk of subsequent salpingectomy. Removal of the fallopian tubes at hysterectomy should therefore be recommended [72, 73].

For this reason, once the reproductive function is completed the tubes of a female of reproductive age should be removed while the ovaries should remain to support the female wellbeing. Beyond the reproductive age, tubes should always be removed with the uterus while ovaries, as previously discussed, are routinely removed only above the age of 65 years.

Abdominal Hysterectomy

As the indication for abdominal hysterectomy in benign diseases has become very rare, it is not discussed in this article [74].

Vaginal Hysterectomy

Before beginning a vaginal hysterectomy, a bimanual pelvic examination is performed to assess uterine mobility and descent and to exclude unsuspected pathology of the adnexa. Only then can a final decision be made whether to proceed with a vaginal or abdominal approach. The operation starts with entry into the cul-de-sac or the vesico vaginal fold. Here we describe the posterior peritoneal opening. The uterosacral ligaments are identified and clamped, including the lower portion of the cardinal ligaments. In the next step the vesicovaginal space is opened and after identification of the peritoneal fold it is cut and the cardinal ligaments are ligated, including the uterine vessels. Most adnexa can be removed by grasping the ovary and clamping the infundibulopelvic ligament. The uterus can then be enucleated stepwise from the remaining peritoneal fold at a safe distance from the bladder. The peritoneum can either be closed or left open and the vaginal epithelium is reapproximated in either a vertical or a horizontal manner. A myomatous uterus has to be morcellated in a circular manner. Sometimes it is necessary to enucleate large solitary myomas or perform intramyometrial coring, especially in cases of diffusely enlarged uteri [75, 76].

Subtotal Laparoscopic Hysterectomy (SLH)

The supracervical (subtotal) hysterectomy was first described by Semm in 1990 and in another technique by Lyons. The operative technique is similar to the total laparoscopic hysterectomy. Only after occluding the ascending branch of the uterine artery is the uterine corpus resected as a reverse conus down to the endocervical canal [77]. For SLH and TLH the trocar placements are the same as for laparoscopic myomectomy and depend on the size of the uterus (see above). There is no need to perform ureterolysis at the beginning of the operation as the ureter is at a safe distance if the suturing line is kept strictly at the uterine wall. The infundibulopelvic ligament and the round ligament are divided from the pelvic side wall and, if the adnexa are to remain in situ, division of the adnexa from the uterus is performed. The broad ligament is then opened, dissected and each leaf separately coagulated. The bladder is separated from the uterus by opening the vesicouterine ligament and pushing the bladder downwards for about 1–2 cm. This is followed by presentation of the ramus ascendens of the uterine artery and division of the uterine pedicles with the same stepwise dissection of the left adnexa. A thorough inspection of the cervix then takes place. The cervix is separated from the uterus with the help of the electric cutting loop or any other cutting instrument. This is followed by coagulation of the cervical canal and closure of the peritoneum over the remaining cer-

vical stump for infection and adhesion prevention. However, the peritoneum can also be left open, according to surgeon preference. Afterwards, morcellation of the uterine body is performed and, if the adnexa are also resected, they should be put into an endo bag for extraction.

As morcellation techniques are described in detail in other chapters of the book, the importance of this technique is not dealt with here.

Total Laparoscopic Hysterectomy (TLH)

LSH should be avoided if adenomyosis uteri is suspected because part of the endometrial glands remain in the cervical and paracervical channel. These can cause an early recurrence or persistence of the symptoms although the few existing data offer no direct confirmation of this view [78, 79].

The surgical steps are identical to the LSH, the only difference being that a uterine manipulator is placed in the vagina before the operation. After separation of the bladder from the uterus, the bladder is pushed and dissected down 2–3 cm to clearly visualize the rim of the cervical cup. In cases of post-caesarean section, a gentle, blunt and intermediate sharp dissection has to be carried out. After the uterus has been lateralized by pushing up the manipulator, the uterine artery and vein with collateral vessels are completely coagulated near the cervix and dissected. The vagina is resected from the cervix with the monopolar hook by firmly stretching the manipulator cranially and carefully performing an intrafascial dissection leaving the sacrouterine ligaments almost completely in place. This is in accordance with the CISH technique introduced by Kurt Semm [80]. The uterus is then retracted through the vagina while still fixed to the manipulator. If the uterus is too large, it has to be morcellated either intraabdominally or transvaginally. The vagina is closed with 2 corner sutures and 1 or 2 sutures in between the corner sutures. The sacrouterine ligaments and the middle portion of the vagina are stitched and elevated by the corner sutures to prevent vaginal prolapse or enterocele formation at a later time. Peritonealization and drainage are not required.

With the improvement of endoscopic surgery and above all the improvement in endoscopic suturing laparoscopic-assisted vaginal hysterectomy has become obsolete, especially as this technique does not include a suspension of the cardinal and sacrouterine ligaments.

Conclusions

Treatment options for uterine leiomyomas vary. The choice of treatment should be made on an individual basis taking into account the following factors: the patient's level of suffering due to bleeding disorders or displacement-caused pain, the status of family planning and the patient's preferences regarding the different treatment options.

In *asymptomatic women* expectant management is suggested except for hydronephrosis caused by displacement or hysteroscopically resectable submucous fibroids in women who pursue pregnancy.

In *postmenopausal women* without hormonal therapy fibroids usually shrink and become asymptomatic. Therefore, expectant management is the method of choice. However, sarcoma should be excluded if a new or an enlarging pelvic mass occurs in a postmenopausal woman. Surgical treatment is the option of choice if the leiomyomas are symptomatic. If there are contraindications to operative procedures or hysterectomy is declined by the patient for personal reasons, any of the alternative treatment options can be considered (medical, embolization or guided ultrasound).

In *premenopausal women* appropriate submucosal leiomyomas should be resected hysteroscopically if the women wish to preserve their childbearing potential and/or they are symptomatic (e.g. bleeding, miscarriage). Intramural and subserosal leiomyomas in women who wish to preserve their fertility can be removed laparoscopically. Nevertheless, an appropriate surgical technique and advanced laparoscopic skills are necessary. If this cannot be guaranteed, abdominal myomectomy has to be recommended or referral to a laparoscopic center to maximize the possibility and safety of pregnancy after uterine reconstruction. The risk of uterine rupture in pregnancy following myomectomy needs to be discussed with the patient.

Robotic assistance makes laparoscopic suturing easier and offers surgery with 3 dimensional vision; however, costs are still high. Further developments in robotic assistance, including force feedback, will catch more of our attention in the future.

For *women who have completed their family planning,* hysterectomy is the definitive procedure for relief of symptoms and prevention of recurrence of fibroid-related problems. With increasing experience in laparoscopic hysterectomies, the risk of side effects has become manageable. In relation to the compliance and individuality of the patient, a suitable solution can be either laparoscopic supracervical or total laparoscopic hysterectomy.

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