Spontaneous Uterine Rupture During Pregnancy

31

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Introduction

Uterine rupture is a life-threatening obstetric complication, an obstetric catastrophe associated with high maternal and perinatal morbidity and mortality [1].

Spontaneous rupture of the uterus, as well as a very rare event, is an unpredictable event, requiring a high index of suspicion for diagnosis [2].

In developed countries, uterine rupture is rare and is most commonly a complication of previous cesarean section (CS); in low-resource poor countries, it is commonly associated with prolonged obstructed labor due to fetopelvic disproportion, fetal malpresentation or malposition (such as neglected transverse lie), and injudicious or inappropriate use of uterine stimulants [3].

Hofmeyr et al. [4], in a research published over a decade ago, showed that uterine rupture was reported to be lower in a community-based study (median 0.053%, range 0.016–0.030%) compared to facility-based study (0.031, 0.012–2.9%). This prevalence was also higher in less developed countries (sub-Saharan Africa particularly) than in the developed countries [4].

Uterine rupture may be incomplete when uterine serosa remains intact or complete in cases of

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C. H. Nezhat (ed.), *Non-Obstetric Surgery During Pregnancy*,
https://doi.org/10.1007/978-3-319-90752-9_31

disruption of the full thickness of uterine wall including uterine serosa, thus resulting in a direct connection between the peritoneal space and the uterine cavity with or without protrusion or expulsion of the fetus and/or placenta into the peritoneal cavity (Fig. 31.1).

Incomplete uterine rupture is almost always the result of a dehiscence of a previous cesarean delivery scar and is often asymptomatic, only discovered at the time of repeated cesarean delivery or during manual exploration of the uterus after a successful vaginal delivery after previous cesarean delivery [5].

It is a rare peripartum complication that occurs in around 7/10,000 women, but this rate increases to 20–80/10,000 in those with uterine scars, mostly as a result of previous cesarean section [6].

Rupture of the unscarred pregnant uterus is a rare event, estimated to occur in one in 5700 to one in 20,000 pregnancies [7].

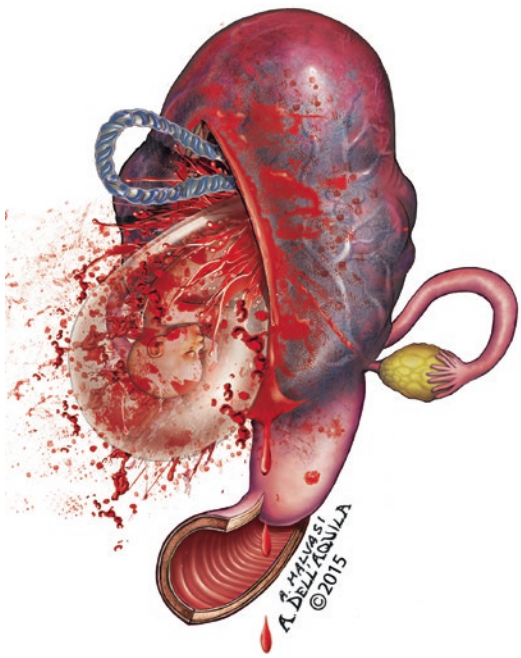

Fig. 31.1 A description of a complete uterine rupture, with the sudden pregnancy extrusion outside uterine cavity (Reprinted from Management and therapy of early pregnancy complications: first and second trimesters, edited by Malvasi A, Tinelli A, Di Renzo GC, Spontaneous uterine rupture prior to twenty weeks of gestation, 2016, Guseh SH, Carusi DA, Tinelli A, Gargiulo AR. With permission of Springer)

Definition of Uterine Rupture

Uterine rupture is divided into two main categories: rupture in a scarred uterus and rupture in an intact uterus. The term "scarred uterus" is referred to the uterus of a woman that has previously undergone gynecological operations, predominantly CS, which constitutes the principal cause of overall uterine ruptures.

Ruptures of the gravid uterus are generally described as "spontaneous" or "traumatic." Most authors who use the term "spontaneous rupture" mean that the uterus has ruptured during labor without other precipitating traumas [8].

Generally, labor involves vigorous, sustained myometrial contractions occurring for a prolonged period; thus, to call intrapartum uterine rupture "spontaneous" is misleading. An additional factor(s) is almost always present when a uterus ruptures. Very rare cases of uterine rupture in nonlaboring, nulliparous (or primigravid) women with unscarred uterus have been reported [9].

Trends of Uterine Rupture

Uterine rupture prevalence is estimated at 1% in patients with uterine scar [1]. Uterine rupture in a previously unscarred uterus is a rare event, estimated at 1:17,000–20,000 [10].

A study of Al-Zirqi et al. [6] evaluated women giving birth in 21 maternity units in Norway during the period 1967–2008. They identified 359 uterine ruptures among a total on 1,441,712 maternities, with an incidence of 2.5/10,000. Cited authors documented a sharply growing trend of uterine rupture. The increase was largely a result of the increasing percentages of scarred uteri (mainly from previous cesarean section) and augmentation of labor with oxytocin. Although the increase was observed among both intact and scarred uteri, scarred uteri showed a considerably higher incidence, with an increase from 14.2 to 66.8 in 10,000 maternities from the second to the fourth decade, respectively. Among scarred uteri, induction of labor with prostaglandins and combined prostaglandins and oxytocin played an important role. The authors concluded that uterine rupture is rare

in Norway, but there has been a sharp increase in recent years. This increase was partly linked to increases in scarred uteri (as a result of increasing rates of cesarean section), induced labor with prostaglandins or combined prostaglandins and oxytocin, and augmented labor with oxytocin.

Another study of Berhe and Wall [3] reviewed the clinical experience with uterine rupture in resource-poor countries. By their analysis, authors detected that in industrialized, high-resource countries, uterine rupture occurs most often in women who have had a previous cesarean delivery, whereas in resource-poor nations, uterine rupture is more commonly associated with obstructed labor, injudicious obstetric interventions/manipulations (often performed by untrained birth attendants), lack of antenatal care, grand multiparity, and poor access to emergency obstetric care. In resource-poor settings, uterine rupture is a reflection of ill-equipped, badly managed, and under-resourced healthcare systems that seem largely indifferent to the reproductive health needs of women [3].

The ultimate success (or failure) of these countries depends in large part upon their commitment to maintaining a healthy and productive female population.

With the advent of misoprostol, a prostaglandin E1 analog is cheap and accessible to most health facilities in Cameroon and most other countries in sub-Saharan Africa; the rates of uterine rupture have increased noticeably. Although much attention is paid to scar rupture associated with uterotonic agents, 13% of ruptures occurred in unscarred uteri, and 72% occurred during spontaneous labor [11].

Moreover, the low rates of partogram use in most countries in sub-Saharan Africa could have obstetric consequences, especially given the high likelihood that, under such circumstances, parturients are administered oxytocin or prostaglandins and are not properly followed up by hourly or 2-hourly examinations [12].

Reports from the study in Mali show that uterine rupture occurred in 87.4% (415/475) of cases in unscarred uterus vs. 12.6% (60/475) in a scarred uterus. Observed risk factors for primary uterine rupture included contracted pelvis, 12.0% (57/475); fetal macrosomia, 9.7% (46/475); and contracted pelvis associated with macrosomia, 3.4% (16/475). Malpresentation was recorded in 12.4% (59/475). Dystocia associated with oxytocin and/or traditional medicines labor augmentation has been observed in 12.6% of cases (60/475). Grand multiparity (≥7 deliveries in obstetric history) accounted for 12.4% (59/475) of all uterine ruptures, while short inter-pregnancy interval has been observed in 12.0% of all uterine ruptures (57/475) [13].

Risk Factors of Spontaneous Uterine Rupture

Risk factors for third-trimester uterine rupture in labor are well known; nevertheless, data on spontaneous second- and early third-trimester uterine rupture before labor remain very limited [11].

Unscarred uterine rupture is a rare event that usually occurs in late pregnancy or during labor. Risk factors for this condition include high parity, placental abnormalities (Fig. 31.2), and uterine anomaly [14]. Women with a classical incision that run vertically on the corpus uteri run a higher risk of uterine rupture than those with a low uterine segment transverse incision [15].

Nevertheless, there is still no consensus on the best gestational age in which to perform an iterative cesarean section, to prevent uterine rupture [16].

Surico et al. [17] evaluated the main risk factors for uterine rupture in a case series. It was previous cesarean section (5/10, 50%), but three of the ten cases of uterine rupture had no demonstrable risk factors. Thus, uterine rupture also occurred in the absence of risk factors in three cases (30%).

The major common predisposing factors of uterine rupture are poverty, ignorance, illiteracy, traditional practices, high parity, poor infrastructure, cephalopelvic disproportion, previous uterine scars, and poor obstetric care. Obviously such etiological factors are more present in low-resource countries. For example, in Nigeria, uterine rupture is a frequent obstetric complication, and reported incidence rates vary from 1 in 81 to 1 in 426 deliveries; these rates are largely similar to rates from sub-Saharan African countries [18].

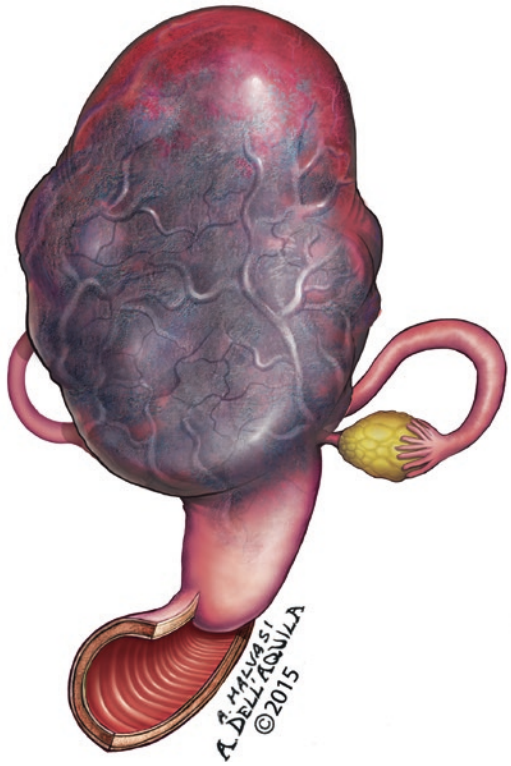

Fig. 31.2 A description of a placenta accreta at the site of prior cesarean sections could be a possible risk factor for uterine rupture (Reprinted from Management and therapy of early pregnancy complications: first and second trimesters, edited by Malvasi A, Tinelli A, Di Renzo GC, Spontaneous uterine rupture prior to twenty weeks of gestation, 2016, Guseh SH, Carusi DA, Tinelli A, Gargiulo AR. With permission of Springer)

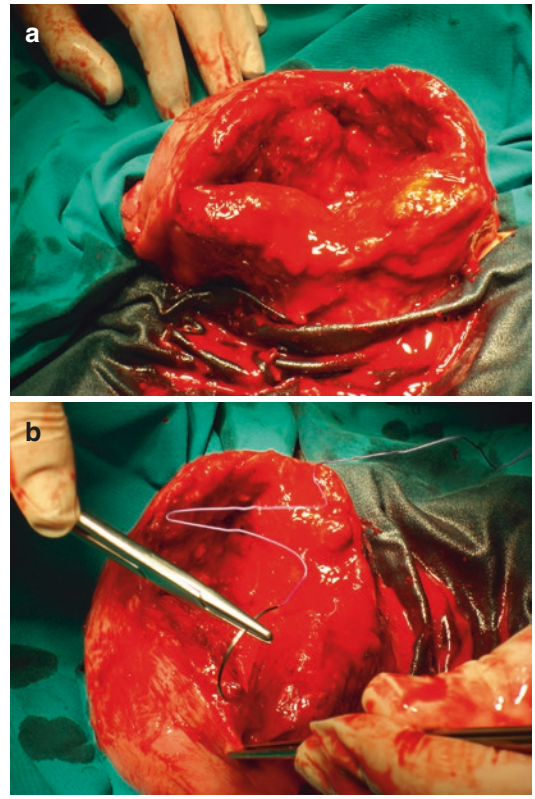

Fig. 31.3 A uterine rupture during pregnancy, in primigravida at 34 weeks, following Bret-Palmer metroplasty. Patient was urgently operated in laparotomy, showing a complete fundal uterine rupture (**a**), treated by a conservative hysterorrhaphy (**b**)

Ehlers-Danlos syndrome is an inherited collagen disorder connected with the risk of uterine rupture [19].

Ruptures may also occur, spontaneously, in a congenital abnormal uterus, after uterine repair of congenital anomalies (Fig. 31.3) and in patients with history of invasive mole [1, 14].

Incidence rate of pregnancy in a rudimentary horn with a bicornuate uterus was estimated as 1 case per 100.000 up to 140.000 pregnancies. Studies indicated to a vast variation in rupture period congenital abnormal uterus, ranging from 5 to 35 weeks and that was attributed to the ability of the horn musculature to hypertrophy and dilate, but it has been identified that around 70–90% occur before 20 weeks and these lead to catastrophic results [20].

Several studies have shown that the shorter the time between a cesarean delivery and a subsequent delivery, the higher the rate of uterine rupture. Commonly, thresholds of 18 and 24 months have been examined. Adjusted odds ratios range from 2.5 to 3.0 for an increased rate of uterine rupture in the women with less time between deliveries. The biologic plausibility of this effect is related to the amount of time required for the uterine scar to heal completely and to nutritional factors [21–23].

Uccella et al. [24] published a review of pre-labor uterine rupture in primiparous women and found that 52.2% of the identified cases had history of infertility. In almost half of them, partial uterine wall defect was the principal recognizable risk factor for pre-labor uterine rupture. The patient they presented had a uterine hysteroscopic

5 mm perforation. At the same time, she had premature ovarian failure, so the authors speculated that wasting of myometrial tissue due to aging and gonadal hormone depletion played a role in uterine dehiscence on the site of previous perforation.

Rarely, rupture can occur following unrecognized injury to the uterus at a previous difficult delivery or dilatation and curettage, iatrogenic uterine perforation, salpingectomy with cornual resection, and deep cornual resection [25, 26].

A Canadian research group reported a single-layer closure of the previous lower segment incision is the most influential factor and is associated with a fourfold increase in the risk of uterine rupture compared with a double-layer closure [27]. This data was defeated by Malvasi et al. [28], in a study on uterine scar evaluated by light microscopy and scanning electron microscopy. The problem of scar resistance depends on biological factors such as whether or not the visceral peritoneum is closed. If the visceral peritoneum is closed, the uterine scar becomes worse in its biological quality. It is therefore advisable to always open the visceral peritoneum, after LUS suture, during cesarean section. Moreover, Malvasi et al. [29] successively confirmed these data in another experimental study, so as Cochrane review [27].

Moreover, Malvasi et al. [30] demonstrated by light microscopy and by immunohistochemistry, for the morphometric quantification of neurotransmitter fibers in the lower uterine segment (LUS) after CS. The substance P (SP) levels are higher in repeat CS, whereas vasoactive intestinal polypeptide (VIP) levels are reduced in the LUS. The increase of SP is probably linked to the attempt to achieve cervical ripening in post-CS LUS, with the possible consequences of dystocia during vaginal birth after CS. However, the decrease of VIP probably affects the relaxation of the internal uterine orifice, compromising the LUS formation and cervical ripening.

A study of Di Tommaso et al. [31] mapped the concentration of neurotransmitters in the non-pregnant uterus; the cervix is the uterine part highly rich in neurotransmitters.

Anything that compromises the distribution of neurotransmitters and neurofibers during labor and/or cesarean delivery may ultimately compromise LUS during gestation or during delivery. It is therefore the case of dystocia or obstructed labor, which causes hypoxia, hysterectomy, and necrosis in the LUS for a relatively long period of time, with subsequent denervation of the uterus area and risk of uterine rupture. Or, it is also the case of the LUS suture type after hysterotomy, in which the visceral peritoneum must not be closed [32].

Researchers, in another investigation on neurotransmitters and neurofibers during pregnancy, concluded that it is not advisable to wait a long time in the case of dystocia or obstructed labor before deciding for cesarean section, because the damage to tissue denervation will be definitive and the LUS will subsequently be at risk of rupture during the subsequent pregnancy [33].

Previous rupture of the scar makes the risk of subsequent rupture even more high. Factors that may influence the incidence of the rupture in cases of scarred uterus are related to individual healing characteristic related to the production of growth factors and collagen deposition. These factors have not been much investigated. Any kind of myometrial injury leads to a growth factor production, thus causing proliferation of the connective tissue forming scar. After each surgical procedure on the uterus, those individual wound healing characteristics may predispose to a uterine rupture. Uterine scars cannot remodel during pregnancy as normal myometrial tissue. Thus, there is a concern about the ability of scarred uterus to withstand pregnancy and labor, and the myometrial tensile strength in the scar is decreased [1].

Spontaneous rupture of the uterus is, in rare cases, also associated with previously performed salpingectomy. Authors [34] reviewed literature on such topic, reporting 33% of cases of uterine rupture following salpingectomy occurred during intrauterine pregnancy, whereas the rest was associated with interstitial ectopic pregnancy. Laparoscopic salpingectomy more often resulted in rupture of the uterus during non-ectopic pregnancy as compared to laparotomy (4 vs. 2 cases, respectively).

Another potential complication of salpingectomy that could lead to uterine rupture is the inter-

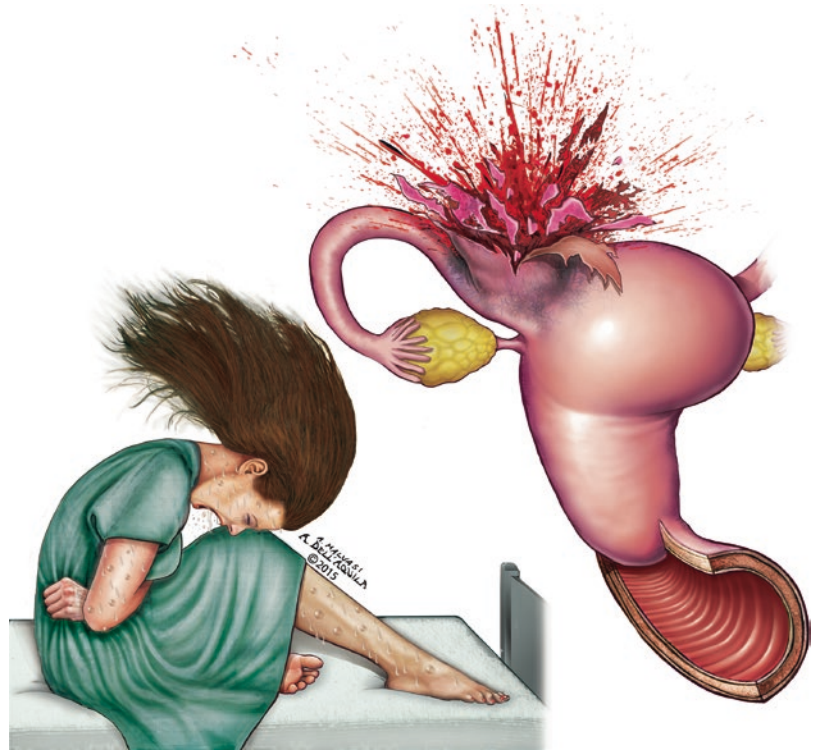

Fig. 31.4 The picture shows an interstitial pregnancy with sudden rupture and painful and hemorrhagic shock of the woman

stitial pregnancy (Fig. 31.4), a rare type of ectopic pregnancy that is responsible for approximately 2.4% of all extrauterine gestations. When interstitial pregnancies were excluded, uterine rupture was a cause of fetal death in 67% of reported gestations. There were no cases of maternal mortality. Conservative treatment was the preferred management option, and total hysterectomy was performed in only two women [34].

Uterine fundal pressure (UFP) is widely used to speed up the time of the second stage of delivery. UFP involves the application of manual pressure on the uppermost part of the uterus, directed toward the birth canal [35].

A survey in the USA found that in 80% of institutions, UFP was applied—there is scarce data about its association with uterine rupture [36]. Thereby, the intrauterine pressure in the second stage of labor transiently increases by up to 86% [37], which might pose a relevant factor in the pathophysiology of uterine rupture. Generally, the use of UFP is only indicated in case of complications such as prolonged second stage of labor, which represents another risk factor for uterine rupture itself, although there is scarce data about its safety. Also the adenomyosis can be a risk factor for uterine rupture due to the weakening of the uterine muscle fibers. In a case report with review of literature, Nikolaou et al. [38] reported a rare case of spontaneous uterine rupture of an unscarred uterus caused by adenomyosis in the early third trimester.

Nagao et al. [39] observed a case of spontaneous uterine rupture in a patient during the 35th week of gestation, after a laparoscopic adenomyomectomy. At a scheduled date in the 35th week of gestation, after combined spinal epidural anesthesia and frequent uterine contractions, a weak pain suddenly ensued. After 13 min of uterine contractions, vaginal bleeding was evident. A CS was performed, and the uterine rupture was found in the scar.

A review published by Morimatsu et al. showed that the rate of uterine rupture after adenomyomectomy during pregnancy is 6.0% [40].

Nagao et al. [39] speculated on some reasons why uterine rupture frequently occurs in pregnant women with prior laparoscopic adenomyo-

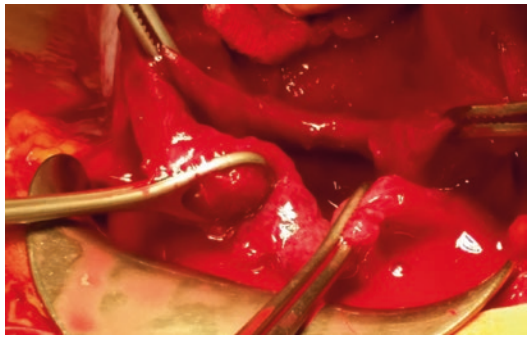

Fig. 31.5 An intraoperatory image of uterine diverticulum, highlighted with ring forceps

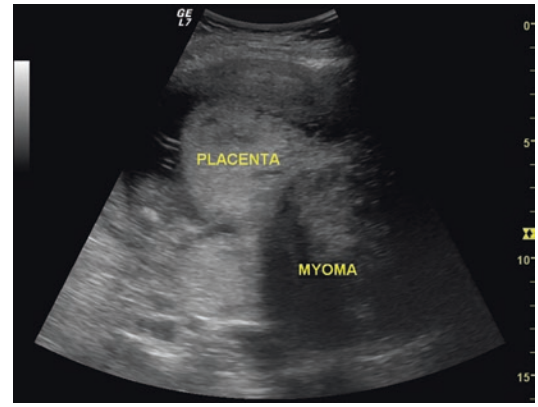

Fig. 31.6 An ultrasonographic image showing a large myoma in pregnancy

mectomies. The boundary between the normal uterine muscle layer and the lesion is unclear. A lesion of adenomyosis tends to remain around the edges of excisions and the area to be sutured, which might lead to weak connections between sutured edges. If a lesion of adenomyosis is enucleated widely to eliminate the lesion, the uterus will be small and irregular in shape, which leads to a diminished capacity to expand. With a laparoscopic adenomyomectomy, it is particularly difficult to delineate the border of the lesion because of a lacking sense of touch and deep sensation.

Agarwal et al. [41] reported a case of intrapartum unscarred uterine fundal rupture in a case of drug abuse. A careful history of drug abuse must be elicited when the common causes of uterine rupture have been excluded or the rupture site is unusual. There are other described cases of uterine rupture associated with cocaine abuse, as well [42].

Also, the cause of uterine rupture could be uterine diverticulum, frequently misunderstood and reported as uterine sacculation [43]. Uterine diverticulum (Fig. 31.5) has a narrow connection with the uterine cavity and a thicker wall than in sacculation. While uterine sacculation is usually observed during pregnancy, diverticulum is usually detected in nonpregnant women. Uterine diverticula as a complication during pregnancy are rare.

Finally, also uterine torsion could be assumed among risk factors of uterine rupture [44]. Uterine torsion is defined as the rotation of the uterus on its long axis by more than 45° [45]. The round ligaments, broad ligaments, and uterosacral ligaments normally stabilize the position of the uterus. Excessive traction on the uterus can cause rotation of the uterus on its long axis [46]. Most reported cases of uterine torsion occur during pregnancy. The most common cause of nongravid uterine torsion is a myomatous uterus but also during pregnancy (Fig. 31.6) [47]. Other causes of nongravid uterine torsion include a bicornuate uterus, pelvic adhesions, adnexal masses, and bowel peristalsis [45]. A review of the literature revealed only three published cases of uterine torsion secondary to an ovarian cyst [44].

Uterine Rupture After Myomectomy

Myomectomy, both in minimally invasive and in traditional open method, is one of the most important gynecological surgeries performed in the woman.

The problem of the appropriateness of myomectomy is to optimize postsurgical reproductive outcomes, including subsequent fertility and ultimately the safe delivery of a healthy neonate.

In the light of advanced age of obstetric population, there is a substantial risk of uterine rupture on the site of previous myomectomy scar (Fig. 31.7). Both myomectomy and cesarean delivery can either directly, or indirectly predisposing formation of abnormally invasive placenta, influence the occurrence of uterine rupture.

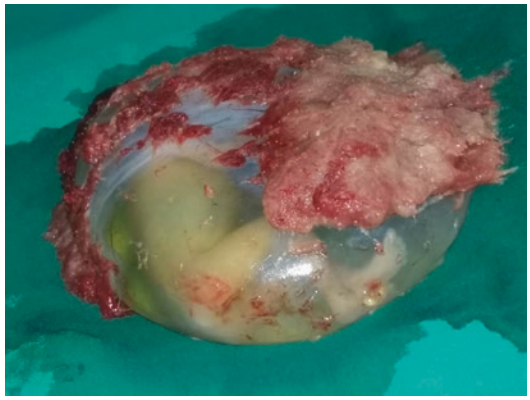

Fig. 31.7 Uterine rupture in a 15-week pregnant woman. The fetus was totally evacuated, with amniotic sac and placenta, in the abdominal cavity. The uterus was unscarred, and the uterine rupture was sutured during laparotomy

In 1964, Garnet [48] identified 3 (4%) uterine ruptures among 83 women who had scars from a previous abdominal myomectomy.

Koo et al. [49] performed a large retrospective review of obstetrical outcomes in women who underwent laparoscopic myomectomy. A total of 523 women with completed pregnancy data after laparoscopic myomectomy were studied. The rate of uterine rupture was 0.6% (3 of 523 deliveries). Although in two cases of uterine rupture the overall maternal-fetal outcomes were favorable, one case occurring at 21 weeks was associated with placenta accreta, hemorrhage, hysterectomy, and fetal demise. The study examined characteristics of the myomas removed, including number size and location. Uterine rupture did not appear to correlate with any of these factors. Literature data published later suggest that the uterine rupture rate following myomectomy is 0.7–1%. Trial of labor after myomectomy is associated with a 0.47% risk of uterine rupture [50].

Today, the use of minimally invasive techniques and laparoscopic and robotic-assisted myomectomies is being performed in greater numbers today than ever before, since minimally invasive surgery has been associated with improvements in perioperative surgical variables [51].

There are, however, many concerns about the minimally invasive surgical benefits of reproduction and birth labor, such as, for example, the risk of uterine rupture.

Sizzi et al. [52] in a multicenter study on laparoscopic myomectomy complications reported 1 rupture among 386 pregnancies (0.26%) out of 2050 operations.

Several studies have demonstrated a 0–1% risk of uterine rupture following laparoscopic myomectomy, even if a true evaluation of the uterine rupture rate after endoscopic myomectomy is difficult as information about this comes primarily from case reports [53, 54].

Many surgeons have proposed various suture techniques to improve the quality of the scar, but no one has ever scientifically demonstrated the benefits of a technique on the other (Fig. 31.8). For example, some surgeons affirm that a multi-

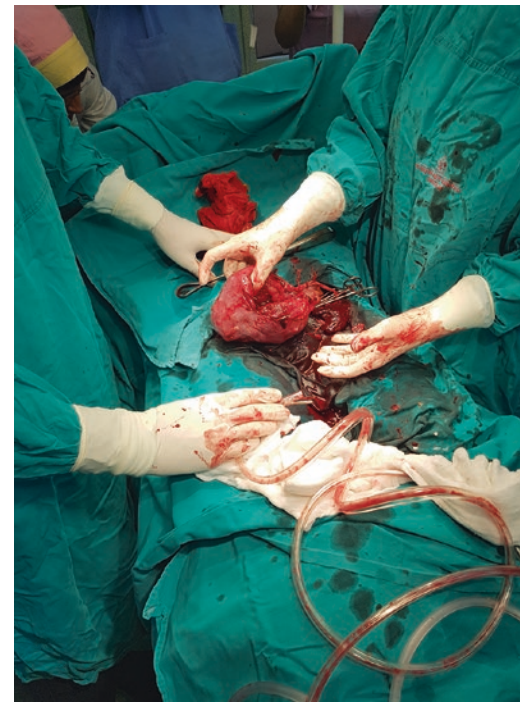

Fig. 31.8 Post-laparoscopic myomectomy uterine rupture in pregnancy. Patient arrived at the hospital in emergency for a uterine rupture at 36.4 weeks in the fundal region. The fetus was mostly in the abdomen, with head, one arm, and placenta in the uterus. Prior to the cesarean section in emergency, the fetal heart rate was 40 bpm. The uterus was sutured, and the mother had an uneventful recovery (Image courtesy of Dr. Radmila Ćirić, Clinic for Gynecology and Obstetrics, Clinical Center of Serbia, Belgrade)

layer repair can improve the strength of the wound and decrease the risk of postoperative hematoma formation, which can also interfere with optimal tissue healing. Anyway, the use of barbed suture (Fig. 31.9) in a continuous suture is a newer adaptation that may increase the tensile strength of the defect. Moreover, the use of electrosurgery should be limited owing to a theoretical risk of devascularization. When possible, alternative energy sources (such as ultrasonic energy) may be preferred. Thus, many surgeons say that it is best to avoid entering the uterine cavity during myomectomy to avoid healing problems.

The influence of myomectomy technique on the incidence of the rupture is still a matter of debate [55]. The rate of uterine rupture after abdominal myomectomy has been estimated as <1% in most, but not all, studies [54].

It is not clear whether the laparoscopic procedure is associated with higher risk of subsequent rupture or whether these cases are being more systematically reported [56].

The myometrial healing following either laparoscopically or at laparotomy performed myomectomy is influenced by the used technique during myomectomy: (1) method and/or instrumentation used for uterine incision, (2) achievement of hemostasis during surgery, (3) myorrhaphy, (4) the potential hematoma formation within the myometrium, and (5) patients' individual characteristics that influence the healing process [57].

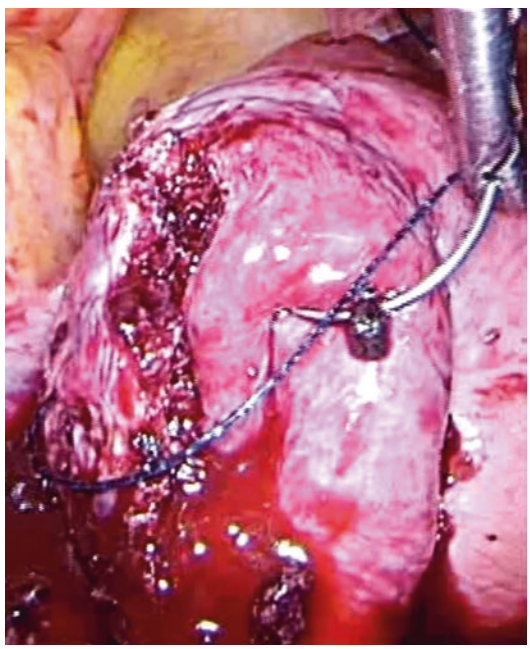

Fig. 31.9 A barbed suture used for myorraphy in continuous suturing

For example, non-expert laparoscopists hardly suture adequately by laparoscopy than by laparotomy. During laparotomy, closure of the myometrial defect is usually accomplished by a multilayered suture. During laparoscopy, failure to suture adequately myometrial defects and lack of hemostasis with subsequent hematoma formation may interfere with wound healing and increase the successive risk of uterine rupture [57].

Moreover, inappropriate use of electrocautery may induce in-depth necrosis of the myometrium with an adverse effect on healing. Excessive use of diathermocoagulation (with inflammation, hypoxia, necrosis, fibrosis, and neuropeptides damaging) can lead to delay in the correct uterine healing and generate a weaker uterine scar.

In Dubuisson et al. [54] study, one rupture occurred on the site of later myomectomy in another institute, due to placenta percreta over the second scar. Although the authors did not calculate this case in their count, second myomectomy was the most probable causative mechanism of forming an abnormally invasive placenta. The other rupture case had a rupture on the site of myomectomy scar which was re-sutured during second-look laparoscopy 7 weeks after the surgery.

Pistofidis and coworkers [56] investigated all seven cases of uterine rupture after laparoscopic myomectomy reported to the Greek Board of Endoscopic Gynecologic Surgery from 1998 to 2011. Only one of those patients had intramural myoma, and the endometrial cavity was not opened in any of the patients. Bipolar diathermy was the sole method of hemostasis in 28.6% of cases and could be characterized as excessive in 87.5% of patients. Most of the ruptures occurred at 34 weeks of gestation or later, with one case at 24 weeks of gestation in twin pregnancy. Those authors concluded that it seems reasonable that

women who have undergone laparoscopic myomectomy would best avoid multiple pregnancies because of potentially increased risk of rupture.

Parker et al. [58] investigated 19 cases of uterine rupture following laparoscopic myomectomy and concluded that it's reasonable to use in laparoscopy to techniques similar to those adopted for open myomectomy, as bipolar diathermy during laparoscopic procedures has potentially detrimental effect on the healing process.

Robotic-assisted laparoscopic surgery is relatively new innovation in the field of gynecologic surgery. An advantage of robotic-assisted laparoscopic myomectomy is the ability to perform an identical multilayer closure to the abdominal approach that controls hemostasis without the need for significant use of electrosurgical instruments [59]. The incidence of uterine rupture in pregnancy after robotic-assisted myomectomy reported by Pitter et al. [60] was 1.1%. The uterine rupture in this study occurred in 33 weeks of gestation in a patient who conceived 18 weeks after the robotic multiple myomectomy without entering the endometrial cavity.

Recurrent uterine rupture rate in patients with prior repair is 4–19% [61]. In the Pistofidis study [56], out of seven cases of uterine rupture after laparoscopic myomectomy, there were two cases of recurrent rupture (28.6%).

The integrity of the hysterotomy scar and the risk of uterine rupture following laparoscopic myomectomy remain topics of debate.

Tinelli et al. [62] evaluated the problem of myometrial healing after myomectomy, analyzing the data of their research on neurotransmission in the nonpregnant uterus and on the uterine myomas. Myometrial healing is an interactive, dynamic process involving neuropeptides, angiogenetic factors, neuromodulators, blood cells, the extracellular matrix, and parenchymal cells. It follows three complex and overlapping phases: inflammation, tissue formation, and tissue remodeling.

Growth factors present in leiomyoma pseudocapsule vessels (Fig. 31.10) promote angiogenesis, a process probably enhanced by leiomyoma, who excites the formation of surrounding vascular structure, ensuring autonomic blood supply for its growth. Biochemical data showed many growth factors and related receptors to be deregulated in leiomyoma tissue. Investigations on leiomyoma pseudocapsule gene expression outlined an angiogenic profile in the pseudocapsule. Scientific evidences suggest to preserve myoma pseudocapsule during myomectomy (Fig. 31.11), since pseudocapsule contains such important peptides and other biologically active molecules [62].

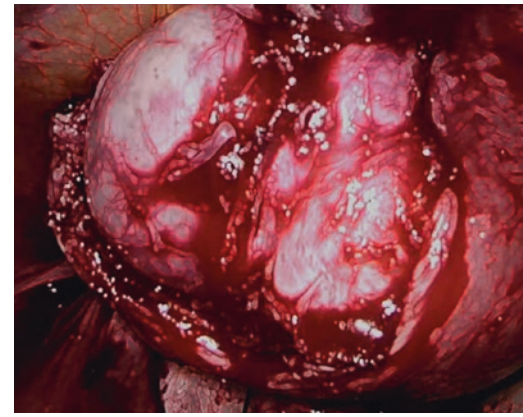

Fig. 31.10 A multi-lobulated myoma surrounded by pseudocapsule vessels

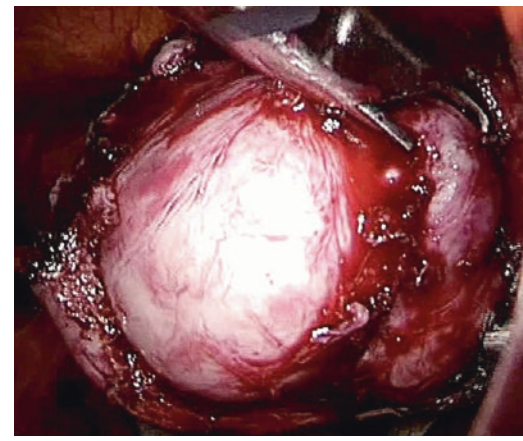

Fig. 31.11 Myoma enucleation during an intracapsular myomectomy pseudocapsule sparing

Even if papers assert the indisputable benefits of myomectomy on fertility in woman affected by leiomyoma-related infertility, so far, literature lacks data regarding surgical technique rationale, explaining all the steps of surgical techniques.

Tinelli et al. [63] explained the rationale for reproductive surgery procedures aiming at leiomyoma enucleation with the preservation of its pseudocapsule, promoter and enhancer of a correct myometrial healing, with positive impact on successive pregnancy and delivery.

Uterine Rupture During Labor

There are no precise diagnostic criteria of uterine rupture during pregnancy and labor.

According to a systematic review of maternal morbidity and mortality by the World Health Organization in 2005, the median incidence of uterine rupture is 5.3 per 10,000 deliveries [4].

The most common sign in women with a uterine rupture without a scar is shock, followed by uterine bleeding, severe abdominal pain, and easily palpable fetal parts. Traditionally, primigravidae and unscarred uteri are considered immune to rupture.

Most reported cases of uterine rupture are associated with previous scarring of the uterus, multiparity, a short length of time (less than 18 months) since the last cesarean section, the number of previous cesarean sections, single-layer closure instead of two-layer closure, placenta previa, and the use of prostaglandins or oxytocin for labor induction or augmentation [23, 64, 65].

Rupture after a prolonged labor is commonly due to obstructed labor, with formation of a retraction or Bandl's ring. First described by Ludwig Bandl in 1875, it represents marked thinning of the lower segment and increased retraction of the upper uterine segment. The tear begins in the lower uterine segment, may extend up to the fundus or down into the vagina, or proceed laterally into the broad ligament. If the tear is posterior, it may go through the posterior vaginal fornix into the pouch of Douglas [66].

A multiparous patient in the obstructed labor will continue to have tetanic contractions until the uterus ruptures, while primiparas will usually go out of labor. The contractions usually stop when the fetus is expelled into the peritoneal cavity (Fig. 31.12).

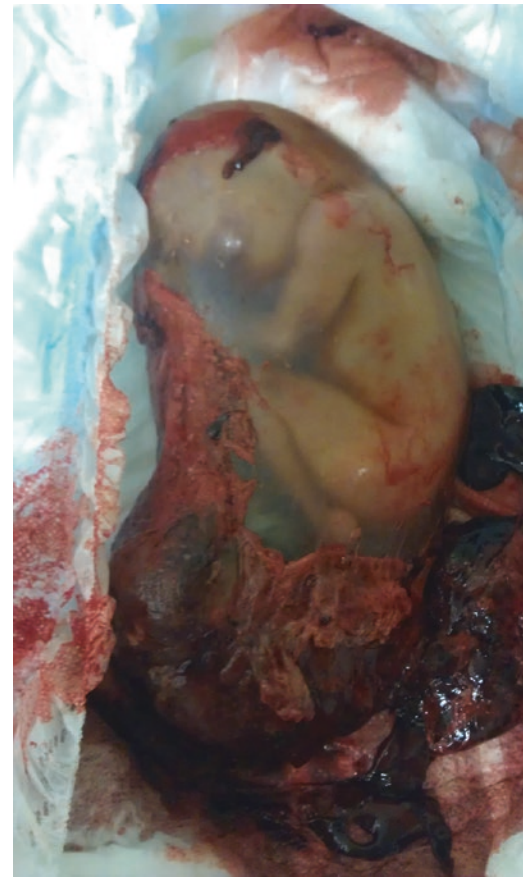

Fig. 31.12 A complete fetal expulsion after uterine rupture in abdominal cavity, with amniotic sac and placenta, at 18 weeks of pregnancy

Fetal heart rate abnormality, most commonly bradycardia, is the most common presentation of uterine rupture. Uterine rupture can also present as abdominal pain, vaginal bleeding, and altered uterine contractions. More rarely, it can present as hypotension, shock, hematuria, and shoulder tip pain and scar tenderness. The most common combination of these symptoms is an abnormal fetal heart rate with abdominal pain [65].

Rupture of the unscarred uterus is generally sudden accompanied by severe abdominal pain with the fetal bradycardia or absence of fetal heart sounds and cessation of uterine contractions in conjunction with vaginal bleeding and followed by vascular collapse.

It causes significant morbidity and mortality rate in both the fetus and the mother.

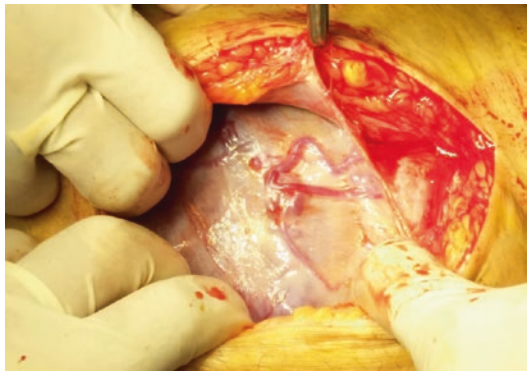

Fig. 31.13 An urgent suprapubic transversal laparotomy for uterine rupture; after the abdomen opening, the placenta attachments appear directly in the pelvis

In less developed countries, it is a significant cause of maternal mortality, contributing for 9.3–14.6% of maternal deaths [3].

Maternal tachycardia is an alarming sign that can, along with another medical signs, alert the physician to the possibility of uterine rupture [67].

From the time of diagnosis to delivery, generally only 10–31 min are available before clinically significant fetal morbidity becomes inevitable (Fig. 31.13). Fetal morbidity occurs as a result of massive hemorrhage, fetal anoxia, or both [68].

Clinical Presentation of Uterine Rupture

Although rare, primary uterine rupture is particularly morbid [69, 70]. An unscarred gravid uterus has the potential for catastrophic hemorrhage, in comparison with rupture or dehiscence of a previous cesarean scar, which can be bloodless [71].

Uterine rupture can occur at any time during gestation and may be difficult to predict [72]. Uterine anomalies are a reported cause of rupture of the unscarred uterus in the first trimester in patients with uterine anomalies [73].

In the differential diagnosis of uterine rupture, placental abruption, placenta previa, uterine inversion, cervical tear, vaginal tear, coagulopathy, uterine atony, and uterine artery rupture may be considered [74, 75].

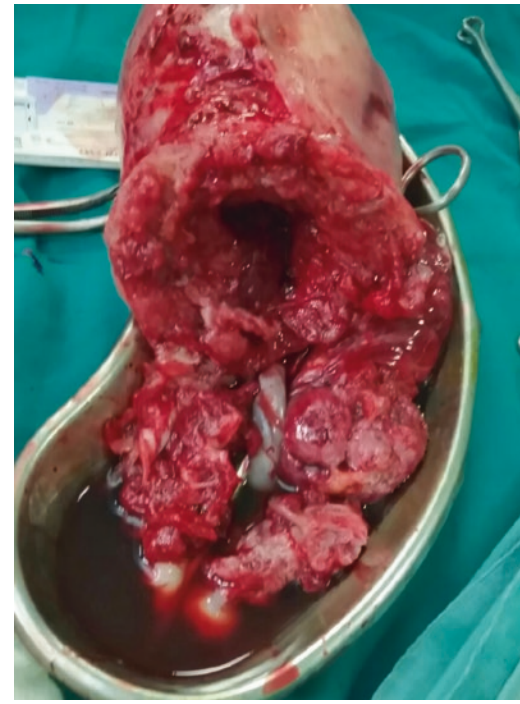

Fig. 31.14 An hysterectomized uterus after a uterine rupture, with a placenta accreta inside the uterus

Endometriosis can cause erosion of the utero-ovarian vessels, resulting in severe hemorrhage [76].

Generally, the most frequent site of uterine rupture is the LUS, the site of the previous CS, but no assumptions can be made concerning the site of rupture or the involvement of other structures. Intra-abdominal bleeding is rare during the first trimester of pregnancy. In the first trimester of pregnancy, most cases of intraabdominal bleeding are related to extrauterine pregnancy [77].

Hemoperitoneum in the second trimester can be attributed to both obstetric and non-obstetric causes. The site of rupture may be posterior, fundal, lateral (sometimes involving one or both uterine arteries), as well as anterior or may extend from the lower segment up to the fundus or down into the cervix and/or the vagina [78].

The causes of these cases can be divided into placental (Fig. 31.14), uterine, and vascular. Placenta percreta is a rare placental abnormality that can cause severe complications, such as hemoperitoneum [78, 79].

Placental abruption is not a cause of hemoperitoneum in the absence of uterine rupture.

However, during pregnancy, the clinical features of hemoperitoneum can trigger a suspicion of placental abruption because these conditions share similar clinical features, and these similarities can cause diagnostic difficulties [80].

Patients with uterine rupture are usually moribund, in severe hypovolemic shock with air hunger. They present with a grossly distended and tender pregnant abdomen with signs of peritonitis. Often very little can be palpated abdominally because of the distention and guarding. However, sometimes fetal limbs are abnormally easy to feel, or the uterus can be separated from the fetus [81].

Typical presenting features include abdominal pain, tachycardia, hypotension, shock, coma, vaginal bleeding, fetal parts palpable through the abdominal wall, and sepsis, depending on the length of time that has elapsed between rupture and arrival at the hospital [82].

Another issue is silent uterine rupture; this has potential risk for complete uterine rupture, which leads to acute life-threatening complications for both the mother and baby. It is difficult to determine whether to manage complete uterine rupture expectantly or surgically, including repair of the uterine wall or termination of the pregnancy, especially in the early second trimester [73].

Instrumental Diagnosis of Uterine Rupture

Possible sites of rupture include the posterior uterine wall, the anterior wall, the lateral uterine side, the fundus, and the lower uterine segment.

Ultrasonography can be a useful tool for the timely detection of uterine rupture in stable patients who have atypical presentations suspicious of uterine rupture. The typical ultrasound manifestations of uterine rupture are the empty uterus and the gestational sac above the uterus.

Ultrasonography can allow for a rapid preliminary survey of uterine wall integrity, which could aid decision-making on the need for immediate surgical intervention.

Other sonographic findings are intrauterine blood and large uterine mass with gas bubbles [83].

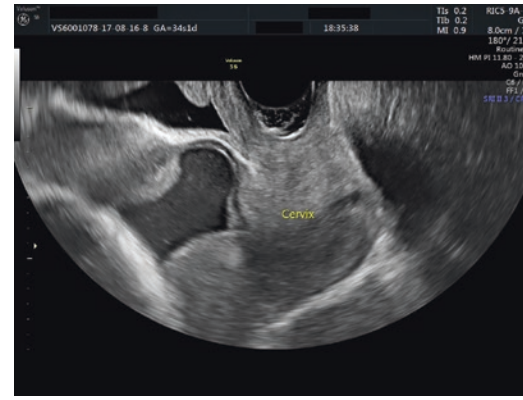

Fig. 31.15 A 34-weeks pregnant patient with a lower uterine thickness of <2.3 mm. The patient had a precesarean section and was hospitalized for high risk of uterine rupture, with urgent cesarean iterative surgery

A secondary assessment of fetal well-being could also be done by cardiotocography.

Ultrasonography has been studied to predict uterine rupture.

Bujold et al. [84] performed an investigation on 125 women with previous CS, undergoing trial of labor. Their analysis determined that optimal cutoff is a LUS thickness of <2.3 mm (Fig. 31.15), with the rate of uterine rupture being 9.1% for this group. The limitation of this study includes the fact that most women with a lower uterine thickness < 2.0 mm did not undergo trial of labor. This might suggest an established practice pattern which might limit future studies using ultrasound to predict uterine rupture.

Kok et al. [85] evaluated the accuracy of antenatal sonographic measurement of LUS thickness in the prediction of risk of uterine rupture during a trial of labor (TOL) in women with a previous CS. Their meta-analysis included 21 studies with a total of 2776 analyzed patients. The estimated sROC curves showed that measurement of LUS thickness seemed promising in the prediction of occurrence of uterine defects (dehiscence and rupture) in the uterine wall. The pooled sensitivity and specificity of myometrial LUS thickness for cutoffs between 0.6 and 2.0 mm were 0.76 (95% CI, 0.60–0.87) and 0.92 (95% CI, 0.82–0.97); cutoffs between 2.1 and 4.0 mm reached a sensitivity and specificity of 0.94 (95% CI, 0.81–0.98) and 0.64 (95% CI,

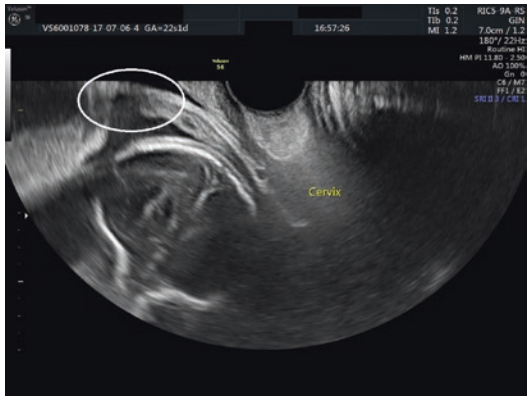

Fig. 31.16 A transvaginal scan evaluating LUS thickness throughout pregnancy in a patient without a previous cesarean section at 22 weeks

0.26–0.90). The pooled sensitivity and specificity of full LUS thickness for cutoffs between 2.0 and 3.0 mm were 0.61 (95% CI, 0.42–0.77) and 0.91 (95% CI, 0.80–0.96); cutoffs between 3.1 and 5.1 mm reached a sensitivity and specificity of 0.96 (95% CI, 0.89–0.98) and 0.63 (95% CI, 0.30–0.87).

Recently, Fukuda et al. [86] evaluated the normal ranges of LUS thickness throughout pregnancy in women without a previous CS (Fig. 31.16) and evaluated the relationship between ultrasound and intraoperative LUS thickness. They performed 20,307 LUS thickness measurements in between 119 and 944 women at each week of gestation, in 944 women during labor, and in 936 women after delivery. They observed a strong relationship between transabdominal and transperineal ultrasound ($p < 0.001$) and an inverse correlation between LUS thickness and gestational age ($p < 0.001$), with a mean thickness of 5.1 ± 1.4 mm at 20 weeks, 3.6 ± 1.3 mm at 30 weeks, and 2.3 ± 0.6 mm at 40 weeks of gestation.

In women undergoing elective CS, we observed a strong relationship between antepartum and intraoperative LUS thickness ($p < 0.001$), with mean thicknesses of 2.2 ± 0.7 mm in 28 women without thinning of LUS, 0.8 ± 0.1 mm in 4 women with grade II uterine scar dehiscence, and 0.4 ± 0.1 mm in 3 women with grade III dehiscence. Authors concluded that a LUS myometrial thickness less than 1.2 mm could have predicted all grade II and grade III uterine scar dehiscence, without false-positive cases.

Barzilay et al. [87] investigated the thickness of the LUS during active labor phase in women with or without a history of a previous CS, by transabdominal sonography in the midsagittal position with a full urinary bladder. They compared a total of 28 women with a previous cesarean delivery, to 29 women without a history of uterine surgery. The median LUS was significantly thinner in women with a uterine scar both during (4 vs. 5 mm, $p = 0.001$) and between contractions (5 vs. 7 mm, $p = 0.011$). Paired comparison of LUS thickness between and during contractions within each group showed that thinning of LUS during contraction was significant for both the previous CS group ($p < 0.001$) and the control group ($p < 0.001$). Authors found that LUS was significantly thinner in women after a previous CS and that the LUS was significantly thinner during contraction, and they showed no correlation between LUS thickness and chances of successful trial of labor after cesarean (TOLAC).

Useful as it is, computerized tomography (CT) is not the first choice for imaging examination of pregnant women with abdominal pain because of the radiation problem.

But in some recent surveys, CT is performed to evaluate pregnant women with abdominal pain, for the benefits are thought to outweigh the risks [88]. Hruska et al. [89] reported the importance of the MRI examination for assessment of pregnant patients in case of uterine rupture.

Authors evaluated tocogram characteristics associated with uterine rupture during trial of labor after CS by a systematic review. Three tocogram characteristics were associated with uterine rupture: (1) hyper-stimulation was more frequently observed compared with controls during the delivery (38% vs. 21% and 58% vs. 53%) and in the last 2 h prior to birth (19% vs. 4%), results of meta-analysis: OR 1.68 (95% CI, 0.97–2.89) and $p = 0.06$; (2) decrease of uterine activity was observed in 14–40%; and (3) an increasing baseline in 10–20%. Five studies documented no changes in uterine activity or Montevideo units. A direct comparison between external tocodynamometer and intrauterine pressure catheters was

not feasible. Authors concluded that uterine rupture can be preceded or accompanied by several types of changes in uterine contractility, including hyperstimulation, reduced number of contractions, and increased or reduced baseline tonus [90].

Management of Uterine Rupture

Early diagnosis and immediate preoperative resuscitation are of great importance in ruptured uterus. Sudden fetal heart abnormalities in laboring patients should be taken as a potential sign of danger. With awareness, prompt diagnosis, rapid replacement of blood loss, and improved techniques in surgical management and neonatal care, maternal and fetal morbidity and mortality can be lowered remarkably. It is possible to reduce fetal and maternal mortality with a prompt intervention, less than 18 min from onset of prolonged deceleration to delivery [23].

The managing clinician should also be aware of the physiologic pregnancy adaptations, where blood and erythrocyte volume increase by 50% and 30%, respectively. A pregnant woman is physiologically prepared to lose blood up to 2 L without any detectable hemodynamic changes. When blood loss approaches 2.5 L, she can deteriorate dramatically [91].

Reports have been published regarding repair of uterine rupture in the second trimester by suturing and/or patching. There have been reported cases of diagnosis of uterine defect in second and third trimester of pregnancy, diagnosed on ultrasound, which were repaired and the pregnancy continued till fetal maturity [92–94].

The management of complete uterine rupture is surgical, and a delay in treatment is often fatal (Fig. 31.17). An emergency laparoscopy or laparotomy is needed for correct diagnosis and to allow the appropriate treatment to take place. Early surgical intervention is usually the key to successful treatment of uterine rupture (Fig. 31.18). Generally, the best chance for

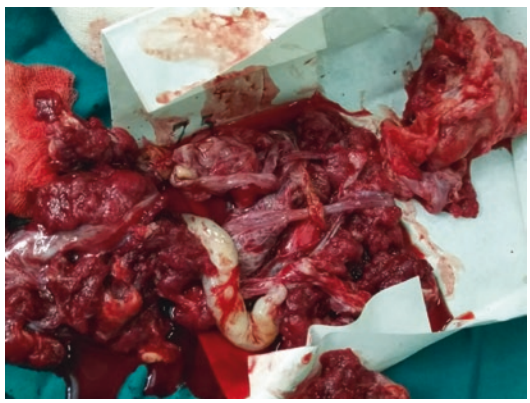

Fig. 31.17 The postoperative image shows a complete uterine rupture with a sort of explosion of pregnant uterus during pregnancy

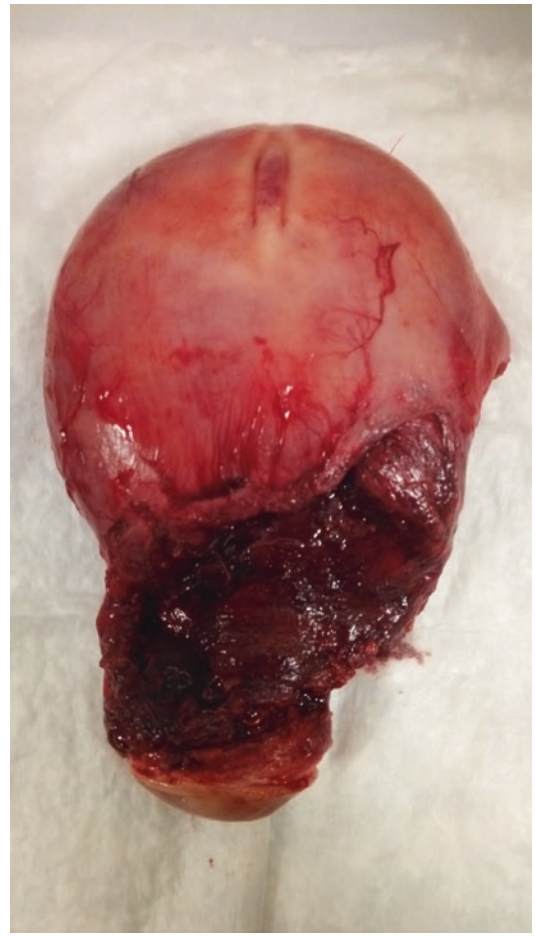

Fig. 31.18 A removed uterus with a complete rupture in a patient with two previous cesarean sections at 24 weeks of pregnancy. The uterus is completely open at the old scars

maternal survival is prompt laparotomy in non-expert laparoscopists.

Although resuscitation of the patient with fluids and blood transfusion is desirable, it is mandatory to explore immediately the pelvis. Once the abdomen is open, the specific clinical circumstance can be assessed. The fetus and the placenta must be removed immediately in case of complete uterine rupture and fetus expulsion in the abdomen. In the vast majority of cases, the fetus will be dead or dying. The rate of perinatal death in cases of uterine rupture is extremely high. Treatment will primarily depend on the extent of the lesion, parity, age and condition of the patient, and expertise of the surgeon [78].

The surgical choices usually come down to one of the four options: total hysterectomy, subtotal (supracervical) hysterectomy, repair of the rupture by suturing, or repair combined with bilateral tubal ligation. The primary goal of surgery is to stop the hemorrhage, resuscitate the patient, and stabilize her as rapidly as possible. The circumstances in which the operation is carried out may be desperate. Often, the operation is undertaken by a surgeon without extensive experience, using inadequate equipment, and who lacks adequate anesthesia and nursing support. Under these circumstances, the best operation may be simple suture repair of the rupture. Not only does this meet the patient's immediate clinical needs, but it preserves the uterus and menstrual function along with it [3].

Pregnancy After Uterine Rupture

The uterine rupture is a very rare and serious circumstance, so there are not many studies that have analyzed this incident. Few literature analyses confirm that postpartum delivery after cuts of the uterus must be faced by CS.

The subsequent pregnancy outcome after conservative management of uterine rupture has only been studied in small case series, among which the prevalence of recurrence ranged from approximately 0 to 33% [95]. Ritchie et al. [96] estimated the rate of involuntary infertility after uterine rupture to be approximately 33%, probably because of the formation of abdominal adhesions and tubal occlusion.

In scientific literature, there are some case reports that describe pregnancies after uterine rupture. Surico et al. [17] published a second trimester uterine rupture repair, on 40-year-old women at 15 weeks and 5 days. Her first pregnancy had resulted in preterm cesarean delivery at 27 weeks of gestation for placental abruption, leading to stillbirth. The initial diagnosis was appendicitis or ovarian torsion, so exploratory laparoscopy was performed. Before the medical procedure, the patient was advised about the potential risks and benefits of the intervention, and she gave her informed consent. Hemoperitoneum (1000 g of blood loss) was found with a myometrial defect on the anterior uterine wall. Uterine rupture with complete opening of the uterine wall at the site of the previous transverse scar was found, with protrusion of the placenta. Conversion to open surgery was necessary. The ruptured uterus was repaired using two layered separate stitch sutures of 1-0 polyglactin 910 (Coated Vicryl, Ethicon, Inc., Somerville, NJ, USA). The patient's postoperative recovery was uneventful, and she was discharged on the fifth postoperative day. She was informed of the potential risks of this conservative management and was discharged home. A healthy baby (weight 2640 g, normal Apgar scores) was delivered by elective traditional cesarean section because of placenta previa at 36 weeks of gestation.

Conclusion

Uterine rupture is a clinical diagnosis, and there must be a high index of suspicion by the healthcare provider. Uterine rupture, whether in a previously scarred uterus or in an unscarred uterus, is potentially life-threatening for both the mother and fetus, and it is associated with significant mortality and morbidity.

Risk factors for such ruptures may include previous uterine scar, short birth spacing, and use of uterotonic (oxytocin/prostaglandin) medications. It can occur during pregnancy, early in labor or following the prolonged labor, most frequently near or at term. Rarely, the uterus can

rupture during early to midpregnancy. A scarred uterus is not a necessary precondition for uterine rupture. The survival of patients after uterine rupture depends on the time interval between rupture and intervention and the availability of blood products for transfusion.

It is very important in clinical trials to have a large number of clinical cases so that one can have safe and reliable clinical indications, avoiding drawing conclusions from studies with few numbers, believed by Tversky and Kahneman [97], who won the Nobel Prize discussing "the error of small numbers."

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