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# Uterine rupture: up to date

*Andrea Tinelli*

Department of Obstetrics and Gynecology, Division of Experimental Endoscopic Surgery, Imaging, Technology and Minimally Invasive Therapy, Vito Fazzi Hospital, Lecce, Italy
The International Translational Medicine and Biomodelling Research Group Department of Applied Mathematics, Moscow Institute of Physics and Technology (State University) Moscow Region, Russia

andreatinelli@gmail.com - andrea.tinelli@unisalento.it

**Abstract**
The uterine rupture is a dramatic obstetrical event, fortunately unusual. Unfortunately, onset is often sudden, very often during pregnancy, in the third trimester, and during labor. The uterine rupture depends on a number of biological and mechanical factors, in which the muscular scarring process is the main responsible factor. The biology of uterine muscle scarring depends on a set of biomolecular processes involving growth factors, neurotransmitters, neoangiogenesis, deposition and reabsorption of collagen fibers, ect. Any interference in this precess creates the conditions for the uterine rupture, which occurs under contract, during the maximum muscular tension. Separation of the fibers almost always involves a traumatic vascular interruption with copious haemorrhage. Here is why uterine rupture is a very rare event, but very dangerous for the life of the woman and the fetus inside it.

**Keywords:** Uterine rupture, pregnancy, myomectomy, fibroids, neonagiogenesis, growth factors

## *Introduction*

Uterine rupture is an uncommon but life-threatening obstetric complication. It leads to high maternal and perinatal morbidity and mortality, and it is complete or incomplete. It may be incomplete, when uterine serosa remains intact, or complete, in cases of 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. The uterine rupture may be spontaneous, traumatic or the result of the scar dehiscence (Guseh et al. 2016, 255-67).
It can either occur in women with (Gardeil, Daly et Turner 1994, 107-10) a native, unscarred uterus or  a uterus with a surgical scar from previous surgery.
It can occur during pregnancy, early in labor or following the prolonged labor, most frequently near or at term. Rarely, uterus can rupture during early to mid-pregnancy (Guseh et al. 2016, 255-67).
Any surgical insult to the uterus can lead to uterine dehiscence and rupture. Nevertheless, different surgical procedures and techniques may cause a different healing process, thus causing differences in the uterine rupture rate. Anyway, the initial symptoms and signs of uterine rupture are typically nonspecific, which makes the diagnosis difficult and sometimes delays definitive therapy. From the time of diagnosis to delivery, generally only 10-37 minutes are available before clinically significant fetal morbidity becomes inevitable. Fetal morbidity occurs as a result of catastrophic hemorrhage, fetal anoxia, or both (Nahrum et Pham).

*Incidence*

From 1976-2012, 25 peer-reviewed publications described the incidence of uterine rupture, and these reported 2,084 cases among 2,951,297 pregnant women, yielding an overall uterine rupture rate of 1 in 1,146 pregnancies (0.07%) (Nahrum et Pham).
The overall incidence of uterine rupture published from less developed countries is 9.3% of deliveries; in fact in developing countries this rate is much higher than in the developed countries for obstructed labor (Rajaram, Agrawal et Swain 2017, 7-10).
In the Second Report on Confidential Enquiries into Maternal Deaths in South Africa 1999–2001, ruptured uterus caused 6.2% of deaths due to direct causes and 3.7% of all deaths (1.9% due to rupture of an unscarred uterus and 1.8% due to rupture of a scarred uterus) (Gülmezoglu et al. 2004, 16).
No estimates exist to assess the magnitude of this potentially life-threatening condition.
Ofir et al found that the risk for uterine rupture among women who had not undergone previous Cesarean section (CS) is 0.02%, and overall risk of uterine rupture is 0.035% of all singleton deliveries (Ofir et al. 2004, 425-29).
The reported incidence of the uterine rupture of an unscarred uterus in developed world is near 1:10000-20000 deliveries (Parant 2012, 803-16). In developing countries, the published incidence of uterine rupture varies from 1,45 to 25%, with 25% in Ethiopian woman with obstructed labor (Berhe et Wall 2014, 695-707).
A 10-year Irish study by Gardeil et al showed that the overall rate of unscarred uterine rupture during pregnancy was 1 per 30,764 deliveries (0.0033%). No cases of uterine rupture occurred among 21,998 primigravidas, and only 2 (0.0051%) occurred among 39,529 multigravidas with no uterine scar (Guseh et al. 2016, 255-67).
A meta-analysis of 8 large, modern (1975-2009) studies from industrialized countries revealed 174 uterine ruptures among 1,467,534 deliveries. This finding suggests that the modern rate of unscarred uterine rupture during pregnancy is 0.012% (1 in 8,434). This rate of spontaneous uterine rupture has not changed appreciably over the last 50 years, and most of these events occur at term and during labor. An 8-fold increased incidence of uterine rupture of 0.11% (1 in 920) has been noted in developing countries, with this increased incidence of uterine rupture having been attributed to a higher-than-average incidence of neglected and obstructed labor due to inadequate access to medical care (Nahrum et Pham).
Schrinsky and Benson reported 22 cases of uterine rupture in gravidas with unscarred uteri. Nineteen occurred during labor (86%), and 3 occurred before labor (14%). This percentage was markedly different from that of gravidas with a previous uterine scar, for whom the timing of uterine rupture between labor and the antepartum period was nearly evenly distributed (Schrinsky et Benson 1978, 217-32).
Author conducted a review to evaluate the overall incidence of rupture of a uterus with a previous CS scar for World Health Organization (WHO). For unselected pregnant women, the prevalence of uterine rupture reported was considerably lower for community-based (median 0.053, range 0.016–0.30%) than for facility-based studies (0.31, 0.012–2.9%). The prevalence tended to be lower for countries defined by the United Nations as developed than the less or least developed countries. For women with previous caesarean section, the prevalence of uterine rupture reported was in the region of 1%. Only one report gave a prevalence for women without previous caesarean section, from a developed country, and this was extremely low (0.006%) (Gülmezoglu et al. 2004, 16).
Currently, the problem of uterine rupture is related, for developing countries, to the increasing rate of cesarean delivery. The increasing number of woman presenting with scared uterus either from Cesarean Section (CS) or uterine surgery leads to an increase in the number of women exposed to the uterine rupture risk.
*A Norwegian study published in the Journal has found that for women with previous CS, the risk of uterine rupture was 8 times higher after trial of labour (TOL) than at repeated elective CS. Induction of labor (using prostaglandins) was associated with the highest risk of uterine rupture* (Al-Zirqi et al. 2010, 809-20).
The American college of Obstetricians and Gynecologists (ACOG) estimated the risk of uterine rupture in women with a previous CS and

concluded that the lower segment caesarean scar has a minimum risk (0.2-1.5%) of rupture during vaginal delivery (AA. VV. 1999, 201-8).

Canadian study, trial of labor following previous CS was associated with increased risk of uterine rupture (by 0.56%), but fewer maternal deaths than elective CS (1.6 vs 5.6 per 100,000) (Wen et al. 2004, 1263-69).

A trial of labor following a previous CS increases the risk of uterine rupture compared to the elective repeat cesarean section. The risk is also influenced by the number of previous cesarean deliveries and on whether the labor is induced, augmented or spontaneous. The inter-delivery interval may also influence this risk.

In a study by Lydon-Rochelle et al of 10 789 patients with a single previous CS, who later labored spontaneously in singleton pregnancy, the uterine rupture rate was 0.52% (Lydon-Rochelle et Cahill 2010, 249-57).

In cases of trial of labor in women with previous low vertical scar uterine rupture rate is 1.1% and the trial of labor following previous CS with unknown type of cesarean scar is associated with the rate of 0.56% of uterine rupture (Nahrum et Pham).

*Risk factors for uterine rupture*

The major characteristics for determining the risk of uterine rupture in pregnant are listed below.

Uterine status is either unscarred or scarred. Scarred status may include previous cesarean delivery, including the following: single low transverse (further subcategorized by 1-layer or 2-layer hysterectomy closure); single low vertical; classic vertical; multiple previous cesarean deliveries (Nahrum et Pham).

*Scarred status may also include previous laparoscopic or laparotomic myomectomy (Hagneré et al. 2011, 162-65).*

*In case of uterine rupture, uterine morphology may be regular or may involve a congenital uterine anomaly (Shahid et al. 2010, 121-25). Pregnancy considerations include the following traditional risk factors: grand multiparity, maternal age, placentation (accreta, percreta, increta, previa, abruption), cornual (or angular) pregnancy, uterine overdistension (multiple gestation, polyhydramnios), dystocia, fetal macrosmia, contracted pelvis, gestation longer than 40 weeks, trophoblastic invasion of the myometrium (Ofir et al. 2003, 1042-46).*

*The risk factors for labor are as follows: patient not in labor, patient with spontaneous labor, induced labor - with oxytocin, with prostaglandins, augmentation of labor with oxytocin, duration of labor and obstructed labor (Goyal 2009, 1117-23).*

*Obstetric management risk factors for uterine rupture include the following: operative delivery (forceps or vacuum); intrauterine manipulation (external cephalic version, internal podalic version, breech extraction, shoulder dystocia, manual extraction of placenta); fundal pressure (i.e. Kristeller maneuver) (LANG et LANDON 2010, 237-51).*

*Uterine trauma linked to uterine ruptures are the following: direct uterine trauma (eg, motor vehicle accident, fall), violence (eg, gunshot wound, blunt blow to abdomen), rupture of the unscarred uterus (Uccella et al. 2011).*

The normal, unscarred uterus is least susceptible to rupture. Grand multiparity, neglected labor, malpresentation, breech extraction, and uterine instrumentation are all predisposing factors for uterine rupture (Guseh et al. 2016, 255-67).

*The problem of uterine scar*

Women with prior myomectomy or prior traditional CS often have an early cesarean delivery because of concern for uterine rupture. The problem is related to the quality of the uterine scar. Unfortunately, until now, nobody has been able to perform the "in vivo studies" on the uterine muscle, the myometrium, as it is not easy to make a monitoring of a scar tissue which the myometrium, appropriately, all studies performed are indirectly, by growth factors and proteins, by imaging, or by other non-invasive methods. All studies conducted so far have the limitation of poor biological reliability. The problem is not of simple solution in that the uterine scar is the weak of the myometrium, which, subjected to the contraction stress, can suddenly breaking down. Unfortunately, we must be content of reports and investigations on overall and selected rates of uterine ruptures. In fact, the rate of uterine rupture recently published in developed countries following classical cesarean delivery is 0.88 %, which is much lower than the quoted rate of up to 9% in women with prior classical cesarean who labor (Gülmezoglu et al. 2004, 16).

This is probably due to elective late preterm delivery in such cases. The frequency of uterine rupture following prior classical cesarean delivery in labor is 1.8% (Gyamfi-Bannerman et al. 2012, 1332-37).

The uterine rupture rate in women with previous classic, inverted T or J incision who either refused repeat cesarean delivery or presented in labor in Landon et al study was 1.9% (Landon et Lynch 2011, 257-61).

*Uterine rupture after myomectomy*

The same trend is followed for delivery for women with prior myomectomy because it is thought that the scar from myomectomy is functionally equivalent to the scar from classical cesarean delivery (Qahtani 2013, 214-19).

One of the first author who investigated uterine ruptures after myomectomy was, in 1964, Garnet who identified 3 (4%) uterine ruptures among 83 women who had scars from a previous abdominal myomectomy (Garnet 1964, 898-905).

The prevalence of uterine rupture following myomectomy - all types of surgery – is 0.79 % and it is comparable with that after cesarean section. Based on the available evidence, there is no significant difference between the incidences of a rupture during pregnancy following a laparoscopic (1.2 %) versus an open myomectomy (0.4 %) (Claeys et al. 2014, 197-206).

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. It is also clear that the location and size of the fibroids might affect the likelihood of uterine rupture following previous myomectomy, and the difference may be partially explained by confounding factors. Between 1970 and 2013, there has been an overall increase in the CS rates leading to a higher primary C-section rate in the last two decades (the "era of laparoscopy") compared to the era of open surgery. Indeed, in the last two decades, the laparoscopic approach has become the preferred technique, with laparoscopic suturing requiring more than average technical expertise. Furthermore, it is striking to observe that a uterine rupture in a woman following a myomectomy almost exclusively occurs during pregnancy and very exceptionally during active labor, as opposed to following a prior cesarean section. This can be explained to differences in the site of the incision with the majority of myomectomies being done in the corporeal part of the womb as opposed to the lower uterine segment in the case of cesarean delivery. Thus, Claeys et al concluded that the risk of a uterine rupture following a myomectomy regardless of the technique used seems very rare (less than 1 % of the ongoing pregnancies) (Claeys et al. 2014, 197-206).

Literature data suggest that the overall uterine rupture rate following myomectomy is 0.2% (Claeys et al. 2014, 197-206).

A true evaluation of the uterine rupture rate after endoscopic myomectomy is difficult, as information about this comes, primarily, from case reports (Pistofidis et al. 2012).

Anyway, uterine rupture following myomectomy is one of the major complications of myomectomy. In the light of advanced age of obstetric population, there is a potential risk of uterine rupture on the site of previous myomectomy scar. Both myomectomy and CS can be, either directly or indirectly, predisposing factors of abnormally invasive placenta, influencing the risk of uterine rupture. The influence of myomectomy technique on the incidence of the rupture is still a matter of debate, even if Tinelli et all published studies showing the reduced incidence of uterine rupture by intracapsular myomectomy myometrial sparing (Tinelli et al. 2016, 129-39).

The myometrial healing following myomectomy is affected by the method and/or instrumentation used during surgery. Uterine incision, achievement of hemostasis and closing the myometrial defect, the extent of tissue damage (influenced by myoma characteristics such as type, size and number), the potential formation of hematoma within the myometrium, gas pneumoperitoneum in laparoscopic procedures, and patients individual characteristics influence the healing process (Mynbaev et al. 2016, 1013-15; Tinelli et al. 2012, 119-29).

It is more difficult to make an adequate suture by laparoscopy than by laparotomy. At laparotomy, closure of the myometrial defect is usually accomplished by a multilayered suture. During laparoscopy, failure to suture adequately myometrial defects, lack of hemostasis with subsequent hematoma formation may interfere with wound healing and increase the risk of rupture (Mettler et al. 2012, 1-8).

Inappropriate use of electrocautery may induce in-depth necrosis of the myometrium with an adverse effect on healing. Excessive use of diathermocoagulation (with inflammation, necrosis, fibrosis, neuropeptides damaging) can lead to delay in the correct uterine healing and generate a weaker uterine scar (Tinelli et Malvasi 2015, 73-93).

In a review, 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 (Parker et al. 2010, 551-54).

Pistofidis and coworkers investigated all 7 cases of uterine rupture after laparoscopic myomectomy reported to the Greek Board of Endoscopisc 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 1 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 (Pistofidis et al. 2012).

Parker et al. investigated 19 cases of uterine rupture following laparoscopic myomecyomy and concluded that its reasonable to use in laparoscopy to techniques similar to those adoptes for open myomectomy as bipolar diathermy during laparoscopic procedures has potentially detrimental effect on the healing process (Parker et al. 2010, 551-54).

Sizzi et al. in a multicentric study of laparoscopic myomectomy complications reported 1 rupture among 386 pregnancies (0.26%) out of 2050 operations (Sizzi et al. 2007, 453-62).

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 (Rossi et Prefumo 2015, 273-80; Tinelli et al. 2011, 12-24).

The incidence of uterine rupture in pregnancy after robotic-assisted myomectomy reported by Pitter et al is 1.1%, which is incomparable with the previously reported incidence after conventional laparoscopic myomectomy (Claeys et al. 2014, 197-206). The uterine rupture occurred, in this study, in a patient at 33 weeks of gestation; such patient conceived 18 weeks after the robotic multiple myomectomy without entering the endometrial cavity.

The real recurrent uterine rupture rate, in patients with prior repair is unknown. In the Pistofidis study, out of 7 cases of uterine rupture after laparoscopic myomectomy there were two cases of recurrent rupture (28.6%) (Pistofidis et al. 2012).

The incidence of peripartum hysterectomy following uterine rupture recently reported by Charach and Sheiner is the 20.7% (Charach et Sheiner 2013, 1196-1200). The independent risk factors for peripartum hysterectomy following uterine rupture are: relaparotomy, extended tear involving uterine cervix, severe bleeding requiring packed cells transfusion and grand multiparity (Charach et Sheiner 2013, 1196-1200).

Although CS and repeated CS were found to be separate risk factors for uterine rupture and emergency peripartum hysterectomy in previous publications, cited authors documented a significantly reduced number of hysterectomies following uterine rupture in the women who underwent CS or had a previous CS, thus expressing the importance of fertility preserving surgery in modern obstetrics and use of hyster-

ectomy as last option procedure (Qahtani 2013, 214-19).
It is more commonly necessary in cases of traumatic or spontaneous rupture, and its incidence in such cases in some reports has been 85% (Charach et Sheiner 2013, 1196-1200).

*Spontaneous uterine rupture*

Traditionally, primigravidae and women with unscarred uterus are considered immune to rupture. Spontaneuos uterine rupture usually occurs in labor. Rupture of an unscarred uterus is a rare event, as the majority of uterine rupture during pregnancy involves scarred uterus. Rupture of an unscarred uterus is a rare event involving 1 : 5,700–20,000 deliveries (Ofir et al. 2004, 425-29).
This frequency is often higher in developing countries, where it can reach 75% of cases in some areas (Guèye et al. 2012, 598356).
In a study of uterine ruptures in The Netherlands, the incidence of rupture in unscarred and scarred uteri was 0.7 and 5.1 per 10,000 deliveries, respectively; ruptures of unscarred uteri accounted for 13 percent of all ruptures (Al-Zirqi et al. 2016, 780-87).
Although uncommon in nuliparous woman, spontaneous uterine rupture is described in juveniles black African women due to contracted pelvis [5,7].
A major factor in spontaneous uterine rupture is obstructed labor, especially in the developing world (Berhe et Wall 2014, 695-707).
Schrinsky and Benson reported 22 cases of uterine rupture in gravidas with unscarred uteri. Nineteen occurred during labor (86%), and 3 occurred before labor (14%). This percentage was markedly different from that of gravidas with a previous uterine scar, for whom the timing of uterine rupture between labor and the antepartum period was nearly evenly distributed (Schrinsky et Benson 1978, 217-32).
Rupture of an unscarred uterus may be caused by trauma or congenital or acquired weakness of the myometrium, such as collagen disease (McCarthy et Germain 2013, 71-80). Sources of trauma include motor vehicle accidents and obstetric maneuvers (eg, internal or external version).

Clinical signs of uterine rupture during pregnancy are nonspecific and can be confusing. Indeed, it is not always easy to distinguish it with other abdominal emergencies (appendicitis, gallstones, pancreatitis, etc.) (Suner et al. 1996, 181-85).
Early surgical intervention is usually the key to successful treatment of uterine rupture. The therapeutic management is a total or subtotal hysterectomy. The suture can be performed and helps to preserve the reproductive function of patients who have never given birth with a recurrence risk of uterine rupture assessed between 4 and 19% at a subsequent pregnancy. For this reason, it has been recommended that women with a previous uterine rupture undergo an elective Caesarean delivery as soon as fetal lung maturity can be demonstrated (Guèye et al. 2012, 598356).

*Uterine rupture after cesarean section*

The effect of previous cesarean delivery on the risk of uterine rupture has been studied extensively. In a meta-analysis, Mozurkewich and Hutton used pooled data from 11 studies and showed that the uterine rupture rate for women undergoing a trial of labor after cesarean section (TOLAC) was 0.39% compared with 0.16% for patients undergoing elective repeat cesarean delivery (odds ratio [OR], 2.10; 95% CI, 1.45-3.05). After restricting the meta-analysis to 5 prospective cohort trials, similar results were found (OR, 2.06; 95% CI, 1.40-3.04) (Mozurkewich et Hutton 2000, 1187-97).
Hibbard et al examined the risk of uterine rupture in 1,324 women who underwent a TOLAC. They reported a significant difference in the risk of uterine rupture between women who achieved successful vaginal birth compared with women in whom attempted vaginal delivery failed (0.22% vs 1.9%; OR, 8.9; 95% CI, 1.9-42) (Hibbard et al. 2001, 1365-73).
The effect of previous CS on the rate of subsequent pregnancy-related uterine rupture have been evaluated by investigations on vaginal birth after cesarean section (VBAC).
The overall rate of VBAC in the United States increased from 3.4% in 1980 to a peak of 28% in 1996. Commensurate with this 8-fold in-

crease in the VBAC rate, reports of maternal and perinatal morbidity also increased, in particular with reference to uterine rupture. By 2007, the VBAC rate in the United States had fallen nationally to 8.5%. Not surprisingly, the cesarean delivery rate also reached an all-time high of 32% in 2007. In its most recent guidelines pertaining to VBAC in August 2010, the American Congress of Obstetricians and Gynecologists (ACOG) adopted the recommendation not to restrict women's access to VBAC (AA. VV. 2010, 450-63).

About traditional CS by vertical incision, in a meta-analysis, Rosen et al reported an 11.5% absolute risk of uterine rupture (3 of 26 cases) in women with classic vertical cesarean scars who underwent an unplanned TOLAC (Rosen, Dickinson et Westhoff 1991, 465-70).

For women who underwent repeat cesarean section, Chauhan et al reported that the uterine rupture rate for 157 women with prior classical uterine cesarean scars was 0.64% (95% CI, 0.1-3.5%). All patients in that study underwent repeat cesarean delivery, but a high rate of preterm labor resulted in 49% of the patients being in labor at the time of their cesarean delivery (Chauhan et al. 2002, 946-50). Chauhan et al observed also a 9% rate of asymptomatic uterine scar dehiscence (95% CI, 5-15%).

Landon et al (Landon et al. 2004, 2581-89) reported a 1.9% absolute uterine rupture rate (2 of 105 cases) in women with a previous classic, inverted *T,* or *J* incision who either presented in advanced labor or refused repeat cesarean delivery. This meta-analysis of pooled data from 5 studies demonstrated a 1.1% absolute risk (12 of 1,112 cases) of symptomatic uterine rupture in women undergoing a TOLAC with a low vertical cesarean scar (Landon et al. 2004, 2581-89). Compared to women with low transverse cesarean scars, these data suggest no significantly increased risk of uterine rupture or adverse maternal and perinatal outcomes.

For 322 pregnancies that occurred after a low vertical cesarean delivery, the overall rate of uterine rupture was 0.62%. This rate could be further divided as 1.15% for 174 women who underwent a TOLAC compared with no ruptures among 148 women who underwent elective repeat cesarean delivery (Naef et al. 1995, 1666-74).

The Maternal-Fetal Medicine Units (MFMU) Network cesarean delivery registry reports a 0.5% risk (15 of 3,206) of uterine rupture for patients who underwent a TOLAC with an unknown uterine scar (Landon et al. 2004, 2581-89).

For cases in which there are 1 or 2 unknown prior uterine incisions, there is a single small, randomized, controlled trial by Grubb et al that compared labor augmentation with oxytocin (n=95) with no intervention (n=93) in women with prior cesarean deliveries involving either 1 or 2 unknown uterine incisions. Four uterine dehiscences and 1 uterine rupture occurred, all in the group that underwent labor augmentation. In the 1 case of uterine rupture, the unknown uterine scar was in a patient with 2 prior cesarean deliveries, one of which involved a vertical incision. Had the uterine scar status for this patient been known in advance, it would have represented a contraindication to TOLAC (Naef et al. 1995, 1666-74).

In a study of 20,095 women by Lydon-Rochelle et al (Lydon-Rochelle et Cahill 2010, 249-57), the spontaneous uterine rupture rate among 6,980 women with a single cesarean delivery scar who underwent scheduled repeat cesarean delivery without a TOL was 0.16%. This investigation showed that the uterine rupture rate among 10,789 women with a single previous cesarean delivery who labored spontaneously during a subsequent singleton pregnancy was 0.52% (Lydon-Rochelle et Cahill 2010, 249-57). This rate of uterine rupture implies an increased relative risk (RR) of 3.3 (95% CI, 1.8-6.0) for women who labor spontaneously compared with women who undergo elective repeat cesarean delivery.

This finding indicates that uteri with cesarean scars have an intrinsic propensity for rupture that exceeds that of the unscarred organ during pregnancy, which is 0.012% (OR increase of approximately 12-fold). Therefore, all other uterine rupture rates in women with a previous cesarean delivery should be referenced to this expected baseline rate.

In a study by Ravasia et al of 1,544 patients with a previous cesarean delivery who later labored spontaneously, the uterine rupture rate was 0.45% (Ravasia, Wood et Pollard 2000, 1176-79).

Zelop et al found that, among 2,214 women with 1 previous cesarean delivery who labored spontaneously, the uterine rupture rate was 0.72%. The authors of this article performed a meta-analysis of 29,263 pregnancies from 9 studies from 1987-2004 and showed that the overall risk of uterine rupture was 0.44% for women who labor spontaneously after a previous cesarean delivery (Ravasia, Wood et Pollard 2000, 1176‑79).

*Uterine rupture in previous CS, with oxytocin and induction of labor*

The use of oxytocin during labor in patients with previous CS is a very little used practice for related fear of uterine rupture. Thus, very few studies have stratified their data by labor augmentation versus labor induction and the data that do exist are conflicting. There is wide variance in the frequency of clinical use of oxytocin as well as in the dose and dosing schedules of oxytocin that are used. It is therefore not possible to draw complete conclusions about the related risk of uterine rupture in such patients.

On the contrary, current ACOG guidelines discourage the use of prostaglandins to induce labor in most women with a previous cesarean delivery. This recommendation is based on considerable evidence for an increased risk of uterine rupture associated with prostaglandins.

Blanchette et al (Blanchette et al. 2001, 1478‑87) reported the rate of uterine rupture for 288 women who underwent oxytocin augmentation of labor after a previous cesarean delivery; it was 1.4%, compared with 0.34% for 292 women who underwent a trial of spontaneous labor. This finding suggests a 4-fold increased risk of uterine rupture in women who undergo labor augmentation with oxytocin compared with spontaneous labor after a previous cesarean delivery.

In the MFMU Network study, the rate of uterine rupture with oxytocin augmentation was 0.9% (52 of 6,009 cases) versus 0.4% (24 of 6,685 cases) without oxytocin use. In contrast, a meta-analysis of studies published prior to 1989 found that the use of oxytocin was unassociated with uterine rupture (National Institutes of Health 2010, 351‑65).

Zelop et al also found that labor augmentation with oxytocin did not significantly increase the risk for uterine rupture (Ravasia, Wood et Pollard 2000, 1176‑79).

However, conclusions of such studies are both limited and suspect because, in general, no proper adjustment has been made for the potential (and very likely) confounding-by-indication that occurs in the observational studies that attempt to compare the rate of uterine rupture for women receiving treatment with oxytocin versus those who do not.

*On the contrary, emerging data indicate that induction of labor after a prior cesarean delivery appears to be associated with an increased risk of uterine rupture.*

Zelop et al found that the rate of uterine rupture in 560 women who underwent labor induction after a single previous cesarean delivery was 2.3% compared with 0.72% for 2,214 women who had labored spontaneously ($P$=.001) (Ravasia, Wood et Pollard 2000, 1176‑79).

In a study by Ravasia et al of 575 patients who underwent labor induction, the uterine rupture rate was 1.4% compared with 0.45% for women who labored spontaneously ($P$=.004) (Ravasia, Wood et Pollard 2000, 1176‑79).

*Blanchette et al (Blanchette et al. 2001, 1478‑87) found that the uterine rupture rate after previous cesarean delivery when labor was induced was 4% compared with 0.34% for women who labored spontaneously. This last finding suggests a 12-fold increased risk of uterine rupture for women who undergo labor induction after previous cesarean delivery.*

Bujold et al found no statistically significant difference among the uterine rupture rates of 1.1% for spontaneous labor, 1.2% for induction by amniotomy with or without oxytocin, and 1.6% for induction by transcervical Foley catheter ($P$=0.81) (Bujold, Blackwell et Gauthier 2004, 18‑23).

Hoffman et al reported a 3.67-fold increased risk of uterine rupture (95% CI, 1.46-9.23) with Foley catheter use for preinduction cervical ripening. Importantly, however, many of these patients received concomitant oxytocin together with application of the transcervical Foley catheter (Hoffman et al. 2004, 217‑22).

Pettker et al (Pettker et al. 2008, 1320-26) found that the addition of oxytocin to the use of a transcervical Foley catheter for labor induction does not shorten the time to delivery and has no effect on either the likelihood of delivery within 24 hours or the vaginal delivery rate.

In a systematic review that evaluated maternal and neonatal outcomes following induction of labor (4,038 women) and spontaneous labor (13,374 women) in women who previously underwent cesarean section, Rossi & Prefumo reported a lower incidence of vaginal delivery with induced labor but higher rates of uterine rupture/dehiscence, repeat cesarean section, and postpartum hemorrhage (Rossi et Prefumo 2015, 273-80).

Facchinetti et al (Facchinetti et al. 2015, 55-58) indicated that women with a previous cesarean delivery being induced for premature rupture of membranes and who have a favorable Bishop have a higher likelihood of success.

*Signs, symptoms and diagnosis of uterine rupture*

Classical signs and symptoms of the uterine rupture have been reported in 19th century and the signs and symptoms of uterine rupture largely depend on the timing, site, and extent of the uterine defect (Guseh et al. 2016, 255-67). Prolonged, late, or recurrent variable decelerations or fetal bradycardias are often the first and only signs of uterine rupture (Gardeil, Daly et Turner 1994, 107-10).

The most common clinical presentation is sudden appearance of fetal distress during labor and maternal shock. The classic signs and symptoms of uterine rupture are (1) fetal distress (as evidenced most often by abnormalities in fetal heart rate), (2) diminished baseline uterine pressure, (3) loss of uterine contractility, (4) abdominal pain, (5) recession of the presenting fetal part, (6) hemorrhage, and (7) shock. This typical clinical presentation is rarely present, and in some cases, uterine rupture is incidental finding on laparotomy (Guseh et al. 2016, 255-67).

*Uterine rupture at the site of a previous uterine scar is typically less violent and less dramatic than a spontaneous or traumatic rupture because of their relatively reduced vascularity (Golan, Sandbank et Rubin 1980, 549-54; Guseh et al. 2016, 255-67; Gardeil, Daly et Turner 1994, 107-10).*

Sudden or atypical maternal abdominal pain occurs more rarely than fetal heart rate decelerations or bradycardia. In 9 studies from 1980-2002, abdominal pain occurred in 13-60% of cases of uterine rupture. In a review of 10,967 patients undergoing a TOLAC, only 22% of complete uterine ruptures presented with abdominal pain and 76% presented with signs of fetal distress diagnosed by continuous electronic fetal monitoring (Revicky et al. 2012, 665-73).

In a study of Bujold and Gauthier (Bujold et al. 2002, 1199-1202), abdominal pain was the first sign of rupture in only 5% of patients and occurred in women who developed uterine rupture without epidural analgesia but not in women who received an epidural block.

So, abdominal pain is an unreliable and uncommon sign of uterine rupture. Initial concerns that epidural anesthesia might mask the pain caused by uterine rupture have not been verified and there have been no reports of epidural anesthesia delaying the diagnosis of uterine rupture. The ACOG guideline from 2010 suggests there is no absolute contraindication to epidural anesthesia for a TOLAC because epidurals rarely mask the signs and symptoms of uterine rupture.

The diagnosis of uterine rupture is complex and often relied on the experience and intuition of clinicians. Several reports have suggested that transabdominal, transvaginal, or sonohysterographic ultrasonography may be useful for detecting uterine-scar defects after cesarean delivery. Rozenberg et al prospectively examined 642 women and found that the risk of uterine rupture after previous cesarean delivery was directly related to the thickness of the lower uterine segment, as measured during transabdominal ultrasonography at 36-38 weeks of gestation. The risk of uterine rupture increased significantly when the uterine wall was thinner than 3.5 mm. Using a 3.5 mm cutoff, the authors had a sensitivity of 88%, specificity of 73.2%, positive predictive value of 11.8%, and a negative predictive value of 99.3% in predicting subsequent uterine rupture (Rozenberg et al. 1999, 39-45).

In a study of 722 women, Gotoh et al (Gotoh et al. 2000, 596-600) reported that a uterine wall thinner than 2 mm, as determined with ultrasonography performed within 1 week of delivery, significantly increased the risk of uterine rupture. Positive and negative predictive values were 73.9% and 100%, respectively.

*Conclusion*

Uterine rupture is a rare but often catastrophic obstetric complication with an overall incidence of approximately 1 in 1,536 pregnancies (0.07%). In developed countries, the uterine rupture rate during pregnancy for a woman with an unscarred and normal uterus is 1 in 8,434 pregnancies (0.012%). Uterine ruptures occur, generally, in scarred uteri, most of which are the result of previous myomectomy or/and CSs. A single cesarean scar increases the overall rupture rate to 0.5%, with the rate for women with two or more cesarean scars increasing to 2%. Other subgroups of women who are at increased risk for uterine rupture are those who have a previous single-layer hysterotomy closure, a short interpregnancy interval after a previous CS, a congenital uterine anomaly, a macrosomic fetus, prostaglandin exposure, and a failed previous trial of a vaginal delivery.
Surgeon has less than 10-37 minutes after uterine rupture to minimize the risk of permanent perinatal injury to the fetus, even if often the damage is not preventable (Nahrum et Pham).
The general clinical early indicator of uterine rupture is the onset of a prolonged, persistent, and profound fetal bradycardia. Other signs and symptoms, such as abdominal pain, abnormal progress in labor, and vaginal bleeding, are less consistent and less valuable than bradycardia in establishing the appropriate diagnosis.
Generally, the obstetricians should be able to start cesarean delivery within 20-30 minutes of a diagnosis of fetal distress is of minimal utility with respect to uterine rupture. In the case of fetal or placental extrusion through the uterine wall, irreversible fetal damage can be expected before that time.

*References*


- AA. VV. (2010). Practice Bulletin No. 115: Vaginal Birth After Previous Cesarean Delivery. *Obstetrics & Gynecology* 116, no 2, Part 1, 450-63. doi:10.1097/AOG.0b013e3181eeb251.
- AA. VV. (1999). ACOG practice bulletin. Vaginal birth after previous cesarean delivery. Number 2, October 1998. Clinical management guidelines for obstetrician-gynecologists. American College of Obstetricians and Gynecologists. *International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics* 64, no 2, 201-8. http://www.ncbi.nlm.nih.gov/pubmed/10189037.
- Al-Zirqi, I, B Stray-Pedersen, L Forsén, A-K Daltveit et S Vangen. (2016). Uterine rupture: trends over 40 years. *BJOG : an international journal of obstetrics and gynaecology* 123, no 5, 780-87. doi:10.1111/1471-0528.13394.
- Al-Zirqi, I, B Stray-Pedersen, L Forsén et S Vangen. (2010). Uterine rupture after previous caesarean section. *BJOG: An International Journal of Obstetrics & Gynaecology* 117, no 7, 809-20. doi:10.1111/j.1471-0528.2010.02533.x.
- Berhe, Yibrah et L. Lewis Wall. (2014). Uterine Rupture in Resource-Poor Countries. *Obstetrical & Gynecological Survey* 69, no 11, 695-707. doi:10.1097/OGX.0000000000000123.
- Blanchette, Howard, Martha Blanchette, John McCabe et Susan Vincent. (2001). Is vaginal birth after cesarean safe? Experience at a community hospital. *American Journal of Obstetrics and Gynecology* 184, no 7, 1478-87. doi:10.1067/mob.2001.114852.
- Bujold, Emmanuel, Sean C. Blackwell et Robert J. Gauthier. (2004). Cervical Ripening With Transcervical Foley Catheter and the Risk of Uterine Rupture. *Obstetrics & Gynecology* 103, no 1, 18-23. doi:10.1097/01.AOG.0000109148.23082.C1.
- Bujold, Emmanuel, Shobha H Mehta, Camille Bujold et Robert J Gauthier. (2002). Interdelivery interval and uterine rupture. *American journal of obstetrics and gynecology* 187, no 5, 1199-1202. doi:10.1067/MOB.2002.127138.
- Charach, Ron et Eyal Sheiner. (2013). Risk factors for peripartum hysterectomy following uterine rupture. *The Journal of Maternal-Fetal & Neonatal Medicine* 26, no 12, 1196-1200. doi:10.3109/14767058.2013.771165.

- Chauhan, Suneet P, Everett F Magann, Christopher D Wiggs, P.Scott Barrilleaux et James N Martin. (2002). Pregnancy after classic cesarean delivery. *Obstetrics & Gynecology* 100, no 5, 946‑50. doi:10.1016/S0029-7844(02)02239-1.
- Claeys, J., I. Hellendoorn, T. Hamerlynck, J. Bosteels et S. Weyers. (2014). The risk of uterine rupture after myomectomy: a systematic review of the literature and meta-analysis. *Gynecological Surgery* 11, no 3, 197‑206. doi:10.1007/s10397-014-0842-8.
- Facchinetti, Fabio, Cinzia Del Giovane, Elisabetta Petrella et Eleonora Annessi. (2015). Induction of labor in women that had a previous cesarean delivery. *The Journal of Maternal-Fetal & Neonatal Medicine* 28, no 1, 55‑58. doi:10.3109/14767058.2014.900750.
- Gardeil, François, Sean Daly et Michael J. Turner. (1994). Uterine rupture in pregnancy reviewed. *European Journal of Obstetrics & Gynecology and Reproductive Biology* 56, no 2, 107‑10. doi:10.1016/0028-2243(94)90265-8.
- Garnet, James D. (1964). Uterine rupture during pregnancy: an analysis of 133 patients. *Obstetrics and gynecology* 23, 898‑905. http://www.ncbi.nlm.nih.gov/pubmed/14170210.
- Golan, A, O Sandbank et A Rubin. (1980). Rupture of the pregnant uterus. *Obstetrics and gynecology* 56, no 5, 549‑54. http://www.ncbi.nlm.nih.gov/pubmed/7432723.
- Gotoh, Hideo, Hideaki Masuzaki, Atsushi Yoshida, Shuichiro Yoshimura, Tsunetake Miyamura et Tadayuki Ishimaru. (2000). Predicting incomplete uterine rupture with vaginal sonography during the late second trimester in women with prior cesarean. *Obstetrics & Gynecology* 95, no 4, 596‑600. doi:10.1016/S0029-7844(99)00620-1.
- Goyal, Vinita. (2009). Uterine Rupture in Second-Trimester Misoprostol-Induced Abortion After Cesarean Delivery. *Obstetrics & Gynecology* 113, no 5, 1117‑23. doi:10.1097/AOG.0b013e31819dbfe2.
- Guèye, Mamour, Magatte Mbaye, Mame Diarra Ndiaye-Guèye, Serigne Modou Kane-Guèye, Abdoul Aziz Diouf, Mouhamadou Mansour Niang, Hannegret Diaw et al. (2012). Spontaneous Uterine Rupture of an Unscarred Uterus before Labour. *Case reports in obstetrics and gynecology* 2012, 598356. doi:10.1155/2012/598356.
- Gülmezoglu, A Metin, Lale Say, Ana P Betrán, Jose Villar et Gilda Piaggio. (2004). WHO systematic review of maternal mortality and morbidity: methodological issues and challenges. *BMC Medical Research Methodology* 4, no 1, 16. doi:10.1186/1471-2288-4-16.
- Guseh, Stephanie H., Daniela A. Carusi, Andrea Tinelli et Antonio R. Gargiulo. (2016). Spontaneous Uterine Rupture Prior to Twenty Weeks of Gestation. Dans *Management and Therapy of Early Pregnancy Complications*, 255‑67. Cham: Springer International Publishing. doi:10.1007/978-3-319-31377-1_11.
- Gyamfi-Bannerman, Cynthia, Sharon Gilbert, Mark B Landon, Catherine Y Spong, Dwight J Rouse, Michael W Varner, Steve N Caritis et al. (2012). Risk of uterine rupture and placenta accreta with prior uterine surgery outside of the lower segment. *Obstetrics and gynecology* 120, no 6, 1332‑37. doi:http://10.1097/AOG.0b013e318273695b.
- Hagneré, P, I Denoual, A Souissi et S Deswarte. (2011). [Spontaneous uterine rupture after myomectomy. Case report and review of the literature]. *Journal de gynecologie, obstetrique et biologie de la reproduction* 40, no 2, 162‑65. doi:10.1016/j.jgyn.2010.08.006.
- Hibbard, Judith U., Muhammed A. Ismail, Yantao Wang, Catherine Te, Theodore Karrison et Mahmoud A. Ismail. (2001). Failed vaginal birth after a cesarean section: How risky is it?: I. Maternal morbidity. *American Journal of Obstetrics and Gynecology* 184, no 7, 1365‑73. doi:10.1067/mob.2001.115044.
- Hoffman, Matthew K, Anthony Sciscione, Maha Srinivasana, D. Paul Shackelford et Lamar Ekbladh. (2004). Uterine Rupture in Patients with a Prior Cesarean Delivery: The Impact of Cervical Ripening. *American Journal of Perinatology* 21, no 4, 217‑22. doi:10.1055/s-2004-828608.
- Landon, Mark B., John C. Hauth, Kenneth J. Leveno, Catherine Y. Spong, Sharon Leindecker, Michael W. Varner, Atef H. Moawad et al. (2004). Maternal and Perinatal Outcomes Associated with a Trial of Labor after Prior Cesarean Delivery. *New England Journal of Medicine* 351, no 25, 2581‑89. doi:10.1056/NEJMoa040405.
- Landon, Mark B. et Courtney D. Lynch. (2011). Optimal Timing and Mode of Delivery After Cesarean with Previous Classical Incision or Myomectomy: A Review of the Data. *Seminars in Perinatology* 35, no 5, 257‑61.

doi:10.1053/j.semperi.2011.05.008.

- Lang, Christofer T. et Mark B. Landon. (2010). Uterine Rupture as a Source of Obstetrical Hemorrhage. *Clinical Obstetrics and Gynecology* 53, no 1, 237‑51. doi:10.1097/GRF.0b013e3181cc4538.
- Lydon-Rochelle, Mona T. et Alison G. Cahill. (2010). Birth After Previous Cesarean Delivery: Short-Term Maternal Outcomes. *Seminars in Perinatology* 34, no 4, 249‑57. doi:10.1053/j.semperi.2010.03.004.
- McCarthy, Fergus et Sarah Germain. (2013). Connective tissue disorders and dermatological disorders in pregnancy. *Obstetrics, Gynaecology & Reproductive Medicine* 23, no 3, 71‑80. doi:10.1016/j.ogrm.2013.02.003.
- Mettler, Liselotte, Thoralf Schollmeyer, Andrea Tinelli, Antonio Malvasi et Ibrahim Alkatout. (2012). Complications of Uterine Fibroids and Their Management, Surgical Management of Fibroids, Laparoscopy and Hysteroscopy versus Hysterectomy, Haemorrhage, Adhesions, and Complications. *Obstetrics and Gynecology International* 2012, 1‑8. doi:10.1155/2012/791248.
- Mozurkewich, Ellen L. et Eileen K. Hutton. (2000). Elective repeat cesarean delivery versus trial of labor: A meta-analysis of the literature from 1989 to 1999. *American Journal of Obstetrics and Gynecology* 183, no 5, 1187‑97. doi:10.1067/mob.2000.108890.
- Mynbaev, Ospan A., Sergei S. Simakov, Antonio Malvasi et Andrea Tinelli. (2016). Is CO2 Pneumoperitoneum Desufflation Triggering Factor of Postsurgical Oxidative Stress? *Journal of Minimally Invasive Gynecology* 23, no 6, 1013‑15. doi:10.1016/j.jmig.2016.02.023.
- Naef, Robert W., Mark A. Ray, Suneet P. Chauhan, Holli Roach, Pamela G. Blake et James N. Martin. (1995). Trial of labor after cesarean delivery with a lower-segment, vertical uterine incision: Is it safe? *American Journal of Obstetrics and Gynecology* 172, no 6, 1666‑74. doi:10.1016/0002-9378(95)91398-X.
- Nahrum, Gerard G. et Krystle Q. Pham. Uterine Rupture in Pregnancy: Overview, Rupture of the Unscarred Uterus, Previous Uterine Myomectomy and Uterine Rupture, s. d.
- National Institutes of Health. (2010). National Institutes of Health Consensus Development Conference Statement vaginal birth after cesarean: new insights March 8-10, 2010. *Seminars in perinatology* 34, no 5, 351‑65. doi:10.1053/j.semperi.2010.06.002.
- Ofir, Keren, Eyal Sheiner, Amalia Levy, Miriam Katz et Moshe Mazor. (2004). Uterine rupture: differences between a scarred and an unscarred uterus. *American Journal of Obstetrics and Gynecology* 191, no 2, 425‑29. doi:10.1016/j.ajog.2004.01.026.
- Ofir, Keren, Eyal Sheiner, Amalia Levy, Miriam Katz et Moshe Mazor. (2003). Uterine rupture: risk factors and pregnancy outcome. *American Journal of Obstetrics and Gynecology* 189, no 4, 1042‑46. doi:10.1067/S0002-9378(03)01052-4.
- Parant, O. (2012). [Uterine rupture: prediction, diagnosis et management]. *Journal de gynecologie, obstetrique et biologie de la reproduction* 41, no 8, 803‑16. doi:10.1016/j.jgyn.2012.09.036.
- Parker, William H., Jon Einarsson, Olav Istre et Jean-Bernard Dubuisson. (2010). Risk Factors for Uterine Rupture after Laparoscopic Myomectomy. *Journal of Minimally Invasive Gynecology* 17, no 5, 551‑54. doi:10.1016/j.jmig.2010.04.015.
- Pettker, Christian M., Sean B. Pocock, Dorothy P. Smok, Shing M. Lee et Patricia C. Devine. (2008). Transcervical Foley Catheter With and Without Oxytocin for Cervical Ripening. *Obstetrics & Gynecology* 111, no 6, 1320‑26. doi:10.1097/AOG.0b013e31817615a0.
- Pistofidis, George, Evangelos Makrakis, Panagiotis Balinakos, Evangelos Dimitriou, Nick Bardis et Vincent Anaf. (2012). Report of 7 Uterine Rupture Cases After Laparoscopic Myomectomy: Update of the Literature. *Journal of Minimally Invasive Gynecology*. Vol. 19, 2012. doi:10.1016/j.jmig.2012.07.003.
- Qahtani, Nourah Al. (2013). Fertility after complete uterine rupture. *Current Opinion in Obstetrics and Gynecology* 25, no 3, 214‑19. doi:10.1097/GCO.0b013e32835fab11.
- Rajaram, P, A Agrawal et S Swain. Determinants of maternal mortality: a hospital based study from south India. *Indian journal of maternal and child health : official publication of Indian Maternal and Child Health Association* 6, no 1, 7‑10. http://www.ncbi.nlm.nih.gov/pubmed/12319806.
- Ravasia, Debra J., Stephen L. Wood et Jeffrey K. Pollard. (2000). Uterine rupture during induced trial of labor among women with previous cesarean delivery. *American Journal of Obstetrics and Gynecology* 183, no 5, 1176‑79.

doi:10.1067/mob.2000.109037.

- Revicky, Vladimir, Aruna Muralidhar, Sambit Mukhopadhyay et Tahir Mahmood. (2012). A Case Series of Uterine Rupture: Lessons to be Learned for Future Clinical Practice. *The Journal of Obstetrics and Gynecology of India* 62, no 6, 665‑73. doi:10.1007/s13224-012-0328-4.
- Rosen, M G, J C Dickinson et C L Westhoff. (1991). Vaginal birth after cesarean: a meta-analysis of morbidity and mortality. *Obstetrics and gynecology* 77, no 3, 465‑70. http://www.ncbi.nlm.nih.gov/pubmed/1825136.
- Rossi, A. C. et Federico Prefumo. (2015). Pregnancy outcomes of induced labor in women with previous cesarean section: a systematic review and meta-analysis. *Archives of Gynecology and Obstetrics* 291, no 2, 273‑80. doi:10.1007/s00404-014-3444-9.
- Rozenberg, Patrick, François Goffinet, Henri Jean Philippe et Israel Nisand. (1999). Thickness of the lower uterine segment: its influence in the management of patients with previous cesarean sections. *European Journal of Obstetrics & Gynecology and Reproductive Biology* 87, no 1, 39‑45. doi:10.1016/S0301-2115(99)00069-X.
- Schrinsky, D C et R C Benson. (1978). Rupture of the pregnant uterus: a review. *Obstetrical & gynecological survey* 33, no 4, 217‑32. http://www.ncbi.nlm.nih.gov/pubmed/347349.
- Shahid, Anupama, Oladimeji Olowu, Gomathy Kandasamy, Charlie O'Donnell et Funlayo Odejinmi. (2010). Laparoscopic management of a 16-week ruptured rudimentary horn pregnancy: a case and literature review. *Archives of Gynecology and Obstetrics* 282, no 2, 121‑25. doi:10.1007/s00404-009-1212-z.
- Sizzi, Ornella, Alfonso Rossetti, Mario Malzoni, Luca Minelli, Francesco La Grotta, Liberato Soranna, Simona Panunzi et al. (2007). Italian multicenter study on complications of laparoscopic myomectomy. *Journal of Minimally Invasive Gynecology* 14, no 4, 453‑62. doi:10.1016/j.jmig.2007.01.013.
- Suner, Selim, Liudvikas Jagminas, Jeffrey F. Peipert et James Linakis. (1996). Fatal spontaneous rupture of a gravid uterus: Case report and literature review of uterine rupture. *The Journal of Emergency Medicine* 14, no 2, 181‑85. doi:10.1016/0736-4679(95)02091-8.
- Tinelli, Andrea et Antonio Malvasi. (2015). Uterine Fibroid Pseudocapsule. Dans *Uterine Myoma, Myomectomy and Minimally Invasive Treatments*, 73‑93. Cham: Springer International Publishing. doi:10.1007/978-3-319-10305-1_6.
- Tinelli, Andrea, Antonio Malvasi, Sarah Gustapane, Maurizio Buscarini, Indy S. Gill, Michael Stark, Farr R. Nezhat et Liselotte Mettler. (2011). Robotic Assisted Surgery in Gynecology: Current Insights and Future Perspectives. *Recent Patents on Biotechnology* 5, no 1, 12‑24. doi:10.2174/187220811795655913.
- Tinelli, Andrea, Antonio Malvasi, Brad S Hurst, Daniel A Tsin, Fausto Davila, Guillermo Dominguez, Domenico Dell'edera et al. (2012). Surgical management of neurovascular bundle in uterine fibroid pseudocapsule. *JSLS : Journal of the Society of Laparoendoscopic Surgeons* 16, no 1, 119‑29. doi:10.4293/108680812X13291597716302.
- Tinelli, Andrea, Ospan Mynbaev, Radmila Sparic, Daniele Vergara, Silvia Tommaso, Michel Salzet, Michele Maffia et Antonio Malvasi. (2016). Angiogenesis and Vascularization of Uterine Leiomyoma: Clinical Value of Pseudocapsule Containing Peptides and Neurotransmitters. *Current Protein & Peptide Science* 18, no 2, 129‑39. doi:10.2174/1389203717666160322150338.
- Uccella, Stefano, Antonella Cromi, Giorgio Bogani, Eleonora Zaffaroni et Fabio Ghezzi. (2011). Spontaneous prelabor uterine rupture in a primigravida: a case report and review of the literature. *American Journal of Obstetrics and Gynecology*. Vol. 205, 2011. doi:10.1016/j.ajog.2011.08.013.
- Wen, Shi Wu, I.D. Rusen, Mark Walker, Robert Liston, Michael S. Kramer, Tom Baskett, Maureen Heaman, Shiliang Liu, for the Maternal Health Study Group et Canadian Perinatal Surveillance System. (2004). Comparison of maternal mortality and morbidity between trial of labor and elective cesarean section among women with previous cesarean delivery. *American Journal of Obstetrics and Gynecology* 191, no 4, 1263‑69. doi:10.1016/j.ajog.2004.03.022.