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UTERINE RUPTURE DURING PREGNANCY: A COMPREHENSIVE SYSTEMATIC REVIEW

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ABSTRACT

Introduction*: Uterine rupture, a rare but serious obstetric condition involving a tear through the uterine wall, has varying incidences globally, with scarred uteri, morbidly attached placenta, grand multiparity, and oxytocin use being common risk factors. This systematic review aims to comprehensively analyze the literature on uterine rupture during pregnancy, focusing on risk factors, geographical incidence variations, etiological patterns, impact of medical interventions, and maternal outcomes, with a goal to enhance understanding, identify preventive strategies, and improve clinical management.*

Method*: The researchers in this study followed the 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to ensure that their work met the required standards. This was done to ensure the precision and reliability of the conclusions derived from the research.*

Result*: Our search produced 11 results. After looking at the titles and summaries, we found 9 papers that fit our criteria. At first, we excluded several articles because they were written in review style and case reports. But after reading the full papers carefully, we included five papers in our final analysis. These papers included a retrospective observational study, prospective study, and retrospective study.*

Conclusion: *In conclusion, uterine rupture (UR) is a catastrophic event requiring heightened vigilance in pregnant women with high-risk factors to mitigate severe consequences for both obstetricians and patients. Trials of labor after cesarean (TOLAC), a safe delivery option, faces challenges in Shanghai and China, and the risk of uterine rupture emphasizes the need for evaluating dosages and duration of prostaglandins and oxytocin. Our series highlights the grave neonatal prognosis of uterine rupture, stressing the importance of timely management and recognizing fetal heart rate abnormalities. The URIDA investigation, the largest database on UR during pregnancy, reveals insights into the association between previous uterine surgery, leiomyoma, and UR, emphasizing the need for early diagnosis and immediate treatment to minimize complications and ensure favorable outcomes in both the index and subsequent pregnancies.*

Keywords: *Pregnancy, sectio caesaria, uterus rupture, vaginal birth after caesarean*

INTRODUCTION

Uterine rupture, a rare and potentially life-threatening obstetric condition, refers to a tear in the uterine wall that extends through its entire thickness, encompassing the serosa. The incidence of uterine rupture varies, with rates ranging from 1 in 100-500 deliveries in impoverished nations to 1 in 3000-5000 in developed nations.[1,2]

The scarred uterus is the most commonly cited cause of uterine rupture in any trimester, followed by factors such as morbidly attached placenta, grand multiparity, and the imprudent use of oxytocin and prostaglandin.[3] In developed countries, the occurrence of uterine rupture following a cesarean operation has decreased to 1 in 2000, compared to the global average of 1 in 100.[4] Uterine rupture in a non-scarred uterus is exceptionally rare, with estimates ranging from 1 in 8000 to 1 in 15,000. When using misoprostol for second-trimester abortion, the risk of rupture is below 0.35% in scarred uteri and 0.04% in unscarred uteri [8]. Multiparity is another contributing factor, as repeated pregnancies lead to thinning of the uterine muscle. Maternal mortality rates from uterine rupture are 0.2% in developed countries but can rise to 30% in impoverished nations. The risk of uterine rupture resulting in hysterectomy ranges from 14 to 33%.[5]

Clinical diagnosis can be challenging, particularly because uterine rupture in the first or second trimester is exceedingly rare and presents with varied symptoms. However, it is crucial to consider uterine rupture as a possibility in any pregnant woman experiencing severe abdominal discomfort, regardless of gestational age. Other common manifestations include vaginal hemorrhage, maternal tachycardia, hypotension, uterine atony, and abdominal tenderness.[6]

The primary objective of this systematic review is to conduct a comprehensive analysis of existing literature pertaining to cases of uterine rupture during pregnancy. The review aims to elucidate various aspects of this rare obstetric condition to enhance our understanding and contribute valuable insights for clinical practice and research. One key focus of this review is to identify and explore the diverse risk factors associated with uterine rupture. This includes an in-depth examination of factors such as a scarred uterus, morbidly attached placenta, grand multiparity, and the administration of oxytocin and prostaglandin. Understanding these risk factors is crucial for developing targeted preventive strategies and optimizing patient care. Another critical aim is to investigate the incidence disparities of uterine rupture across different geographical regions and settings. By comparing rates between impoverished nations and developed countries, the review seeks to highlight potential disparities in healthcare practices, access, and outcomes related to uterine rupture.

The review also seeks to discover into the etiological patterns of uterine rupture, particularly focusing on the prevalence of rupture in scarred and non-scarred uteri. This analysis aims to provide insights into the specific contexts and conditions that may contribute to the occurrence of uterine rupture during pregnancy. Furthermore, the impact of medical interventions on the incidence of uterine rupture will be explored. This includes assessing the effects of interventions such as cesarean operations and the use of misoprostol, with an emphasis on changes in incidence rates over time and in response to evolving medical practices.

Maternal outcomes associated with uterine rupture will be a critical aspect of the review, with a focus on mortality rates in both developed and impoverished countries. Additionally, the likelihood of uterine rupture leading to hysterectomy will be examined to understand the severity and long-term consequences of this obstetric complication. Given the rarity of these occurrences, exploring the challenges in diagnosis and proposing potential guidelines for early identification will be essential to improve clinical management and outcomes associated with uterine rupture during pregnancy.

METHODS

Protocol

The researchers in this study followed the 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines to ensure that their work met the required standards. This was done to ensure the precision and reliability of the conclusions derived from the research.

Criteria for Eligibility

For inclusion in the study, published articles had to meet particular requirements. They had to be research papers written in English, focusing on uterus rupture during pregnancy. The studies had to meet the following criteria: they needed to have been published after 2014 but within the applicable timeframe for this systematic review. Articles falling into categories like editorials, lacking a DOI, review articles that were already published, or duplicating previously published journal papers were excluded from the assessment.

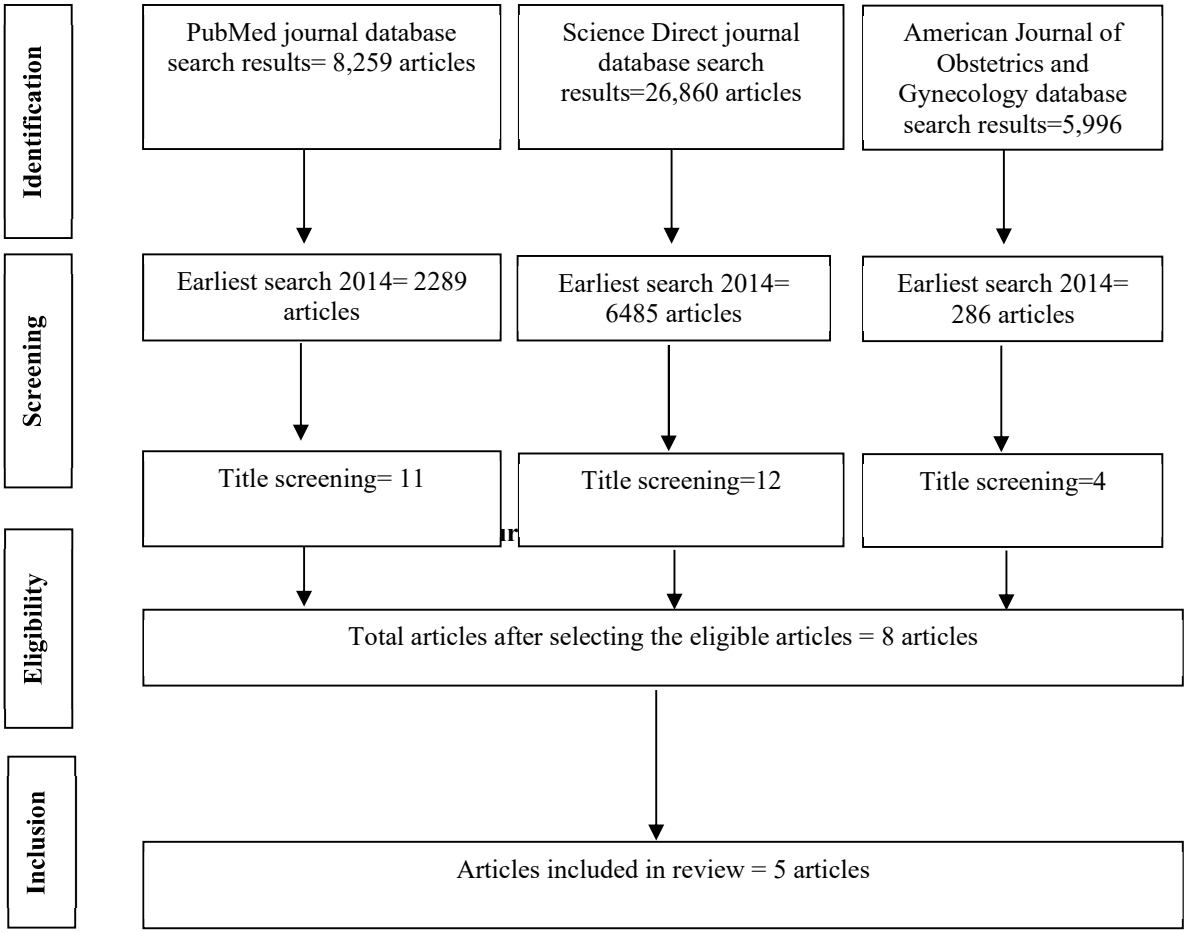
Search Strategy

We conducted a comprehensive literature search using PubMed, ScienceDirect, and American Journal of Obstetrics and Gynecology focusing on studies published from 2014 to 2024. The search terms employed were as follows ("uterine rupture"[MeSH Terms] OR ("uterine"[All Fields] AND "rupture"[All Fields]) OR "uterine rupture"[All Fields]) AND ("pregnancy"[MeSH Terms] OR "pregnancy"[All Fields] OR "pregnancies"[All Fields] OR "pregnancy s"[All Fields]). Moreover, we performed cross-referencing of relevant articles to reveal additional research. The evaluation of study quality, methodology, interventions, and results was undertaken independently by the researchers, resolving any

differences through discussion and agreement. Furthermore, both researchers collected and compared discoveries from all studies, considering the potential for conducting a meta-analysis if deemed feasible.

Inclusion and exclusion criteria

Inclusion criteria for the studies were as follows: (1) original research that assesses uterus rupture during pregnancy; (2) Randomized Controlled Trials (RCTs) or observational studies (cohort or case-control studies); (3) availability of relevant data. Exclusion criteria were as follows: (1) ongoing studies or studies without available data; (2) duplicate publications. In cases of duplicate publications, the most recent article was chosen; (3) Non-English language studies were excluded.



Data Retrieval

The authors conducted a thorough examination of relevant studies, specifically selecting those that met precise inclusion criteria. They focused on original, unpublished papers in English to ensure a refined and high-quality selection. The analysis covered essential information, such as study particulars, authors, publication dates, locations, and research methodologies, aligning with the study's objectives.

RESULT

Our search produced 11 results. After looking at the titles and summaries, we found 9 papers that fit our criteria. At first, we excluded several articles because they were written in review style and case reports. But after reading the full papers carefully, we included five papers in our final analysis. These papers included a retrospective observational study, prospective study, and retrospective study.

Author	Origin	Method	Sample Size	Result
Wan et al., 2022.[7]	China	Retrospective analysis.	A total of 209,112 deliveries were included and 41 cases of uterine rupture were identified.	The incidence of uterine rupture was 1.96/10000 births. Among the 41 cases, 16 (39.0%) had maternal and fetal complications. There were no maternal deaths secondary to uterine rupture, while perinatal fatality related to uterine rupture was 7.3%. Among all cases, 38 (92.7%) were scarred uterus and 3 (7.3%) were unscarred uterus. The most common cause of uterine rupture was previous cesarean section, while cases with a history of laparoscopic myomectomy were more likely to have serious adverse outcomes, such as fetal death. 24 (59.0%) of the ruptures occurred in anterior lower uterine segment. Changes in Fetal heart rate monitoring were the most reliable signs for rupture.
Al-Zirqi, I et al., 2017.[8]	US	Retrospective study.	1,317,967 women without previous cesarean delivery and 57,859 with previous cesarean delivery.	Complete uterine rupture occurred in 51 cases without previous cesarean delivery (0.38 per 10,000) and 122 with previous cesarean delivery (21.1 per 10,000). The strongest risk factor was sequential labor induction with prostaglandins and oxytocin, compared with spontaneous labor, in those without previous cesarean delivery (adjusted odds ratio, 48.0, 95% confidence interval, 20.5-112.3) and those with previous cesarean delivery (adjusted odds ratio, 16.1, 95% confidence interval, 8.6-29.9). Other significant risk factors for those without and with previous cesarean delivery, respectively, included labor augmentation with oxytocin (adjusted odds ratio, 22.5, 95% confidence interval, 10.9-41.2; adjusted odds ratio, 4.4, 95% confidence interval, 2.9-6.6), antepartum fetal death (adjusted odds ratio, 15.0, 95% confidence interval, 6.2-36.6; adjusted odds ratio, 4.0, 95% confidence interval, 1.1-14.2), and previous first-trimester miscarriages (adjusted odds ratio, 9.6, 95% confidence interval, 5.7-17.4; adjusted odds ratio, 5.00, 95% confidence interval, 3.4-7.3). After a previous cesarean delivery, the risk of rupture was increased by an interdelivery interval <16 months (adjusted odds ratio, 2.3; 95% confidence interval, 1.1-5.4) and a previous cesarean delivery with severe postpartum hemorrhage (adjusted odds ratio, 5.6; 95% confidence interval, 2.4-13.2).
Guiliano, M. et al., 2014.[9]	France	Retrospective study of case records.	In a total of 97,028 births during the study period, author identified 52 uterine ruptures (0.05%): 25 complete and 27 partial.	Most (89%) occurred in women with a previous cesarean delivery. In complete ruptures, FHR abnormalities were the most frequent sign (82%), while the complete triad of FHR abnormalities–pain–vaginal bleeding was present in only 9%. The signs and symptoms of partial ruptures were very different; these were asymptomatic in half the cases (48%). Neonatal mortality reached 13.6% among the complete ruptures; 27 and 40% of these newborns Q3 had pH < 6.80 and pH < 7.0, respectively. Among the incomplete ruptures, only 7.7% of the newborns had a pH < 7.0 and there were no deaths.
You, et al., 2018.[10]	Taiwan	Retrospective study.	Thirty patients were included [mean age (±SEM), 34.4 ± 0.7 years;	Four fetal demises, 22 transferals to neonatal intensive care unit, and 17 maternal blood transfusions without maternal mortality were noted. Twenty-two patients presented with acute abdominal pain and/or abnormal fetal heart rate tracing were managed with emergent cesarean delivery. Four ruptures were found in

			mean body mass index, 25.0 ± 0.6 kg/m2] with mean onset of rupture at 34.2 ± 0.9 weeks, in which, 12 occurred at term and 18 at preterm (range 20-34 weeks).	postpartum of vaginal delivery, in which 3 were after trials of labor after cesarean delivery and 1 was unscarred uterus, and two of the four eventually underwent hysterectomy. Unscarred uterus (n ¼ 6) without identifiable risk factor ruptured in significantly later gestation associated with higher fetal birthweights than those of the scarred uterus (n ¼ 24) (both $p < 0.05$), both of which yielded morbidity. The rupture timing between patients of non-lower-segment scar (n ¼ 14) and lower-segment scar (n ¼ 10) were not significantly different.
Tinelli et al., 2021.[11]	Italy	Observational study	Observational cohort retrospective study on 270 patients.	Uterine rupture was significantly associated with previous uterine surgery, occurring, on average, at 36 weeks of pregnancy in women also without previous uterine surgery. UR did not rise exponentially with an increasing number of uterine operations. Fibroids were related to UR. The earliest UR occurred at 159 days after hysteroscopic myomectomy, followed by laparoscopic myomectomy (251 days) and laparotomic myomectomy (253 days). Fertility preservation was feasible in several women. Gestational age and birth weight seemed not to be affected in the subsequent pregnancy.

The incidence of uterine rupture (UR) in the studied population was 7.3%. Among the cases, 21 mothers (51.2%) received a preoperative diagnosis, while 20 mothers (48.8%) were diagnosed intraoperatively. The timing of diagnosis and the proportion of Trial of Labor After Cesarean (TOLAC) were comparable between the two groups ($p = 0.156$). Utilizing multiple logistic regression analyses, the association between signs and symptoms and the presence of complicated UR was examined.[7]

The comprehensive model, encompassing all signs and symptoms as independent variables, revealed that an abnormal fetal heart rate emerged as a significant and independent factor associated with complicated UR when compared to other signs (OR = 12.45; 95% CI: 1.16–133.54; $p < 0.05$). Other clinical signs did not show statistically significant differences. Notably, all three cases of neonatal deaths were associated with abdominal pain, and two of them also exhibited an abnormal fetal heart rate simultaneously. The majority of cases (58.5%) involved the anterior lower uterine segment, followed by 7.3% in the posterior segment, 22.0% in the lateral segment, and 9.8% in the fundal segment. Additionally, one case experienced rupture in more than one location (2.4%).[7]

This registry-based study, inclusive of information from corresponding medical records, involved a two-step search process. Firstly, we examined the Medical Birth Registry of Norway (MBRN), established in 1967. Secondly, the Patient Administration System (PAS), a local registry at each maternity unit, was scrutinized. These registries maintain records of all in-patient diagnoses since 1970. A total of 173 complete ruptures were identified out of 292 uterine ruptures that occurred after the initiation of labor between 1967 and 2008.[8]

Within a population of 1,317,967 women without a prior cesarean delivery (CD), there were 51 instances of complete rupture (0.38 per 10,000) and 5 cases of partial rupture. Among nulliparous women after the onset of labor (631,813 maternities), 13 complete ruptures were recorded (0.2 per 10,000). In the cohort of 57,859 women with a previous CD, there were 122 cases of complete rupture (21.1 per 1000) and 114 cases of partial rupture (19.7 per 10,000). Notably, complete rupture was most prevalent in the fourth decade (2000–2008) among both groups. The total count of 173 complete ruptures from 1967 to 2008 provides a comprehensive overview of uterine rupture occurrences during this period.[8]

This retrospective observational study involved women experiencing complete or partial uterine scar ruptures during pregnancy at one of two study centers. Over the study period, encompassing 97,028 deliveries in two hospitals, 52 uterine ruptures were identified—25 complete ruptures and 27 partial ruptures. Of the complete ruptures, six occurred in unscarred uteri, with an estimated frequency of 0.07 per 1000 unscarred uteri. The remaining 19 complete ruptures occurred in women with previous cesareans, with a frequency of 1.9 per 1000 deliveries with uterine scars. The estimated frequency of partial ruptures was 2.7 per 1000 deliveries with uterine scars. The overall incidence rate of uterine rupture (complete and partial) was 4.6 per 1000 deliveries with uterine scars and 0.5 per 1000 deliveries overall, with or without scars. [9]

The majority of women (98.1%) were multiparous, with 88.5% having at least one uterine scar from previous cesareans. The onset of labor was often induced through cervical ripening (44.2%), and 25% of cases resulted in vaginal deliveries,

while half required emergency cesareans. Fetal heart rate (FHR) abnormalities were the most common sign leading to the discovery of rupture (45.8%), followed by abdominal pain or vaginal bleeding during labor (25%). The mean gestational age at birth was 38.4 weeks, with only 12.5% of births being preterm. Neonatal outcomes were unfavorable, with 20.8% having an Apgar score < 7 at 5 minutes, 22.9% having an arterial pH < 7.0 at birth, and 6.3% experiencing perinatal mortality. No maternal deaths occurred, but severe postpartum hemorrhages (32.7%), bladder injuries (5.8%), and emergency hysterectomies (7.7%) were observed. [9]

Comparison between complete and partial ruptures revealed significant differences in the timing of symptom onset, with complete ruptures more frequently occurring during labor (80.9%) and partial ruptures more often observed during the postpartum period (42.8%). Complete ruptures led to emergency cesareans for fetal or maternal distress significantly more often than partial ruptures (87.5% vs. 46.2%; $p < 0.01$). FHR abnormalities were much more common in complete ruptures (81.8% vs. 15.4%; $p < 0.001$). Additionally, complete ruptures were rarely asymptomatic, while nearly half of partial ruptures were (16.0 vs. 48.1%; $p < 0.05$).

Ruptures of unscarred uteri were associated with grand multiparity, with 66.7% having four or more previous deliveries compared to 8.7% in scarred uteri ($p < 0.01$). Maternal morbidity did not significantly differ based on the type of rupture or the existence of uterine scars. Neonatal prognosis was significantly worse in complete ruptures compared to partial ruptures, with higher rates of low Apgar scores and acidotic arterial pH. Perinatal mortality was 13.6% in the complete rupture group, although this difference did not reach statistical significance ($p = 0.09$). [9]

This retrospective study encompassed patients treated at Linkou Chang-Gung Memorial Hospital, a tertiary referral center. Of the 37 identified uterine ruptures, 7 patients were excluded due to perceived surgical complications or birth trauma. Exclusion reasons included cervical lacerations extending into lower corpuses after vaginal deliveries (2 cases), tearing of incision angles in cesarean sections (4 cases), and iatrogenic uterine perforation after instrumental removal of undiagnosed placenta percreta (1 case). Among the 30 patients who experienced uterine ruptures, 80% had scarred uteri, while the remaining 6 had unscarred uteri.[10]

For those with scarred uteri, prior uterine surgeries included laparoscopic myomectomy (n = 5), laparoscopic adenomyomectomy (n = 4), laparoscopic resection of cornual pregnancy (n = 2), laparotomic myomectomy (n = 2), low transverse cesarean section (n = 10), and classical cesarean delivery (n = 1). Over the study period, there were 51,462 deliveries, yielding an estimated rupture rate of gravid uterus around 5.8 per 10,000 deliveries. [10]

The average maternal age among the thirty cases was 34.4 ± 0.7 years, median parity was 1, and mean BMI was 25.0 ± 0.6 kg/m2. The mean interval between pregnancy and prior surgery was 43.3 ± 9.0 months, with 6 women having intervals <6 months. The mean gestational age of uterine rupture was 34.2 ± 0.9 weeks, with 12 ruptures occurring at term and 18 leading to preterm birth, 16 of which occurred at <30 weeks of gestation. [10]

Acute symptoms followed by emergent cesarean delivery were noted in 22 patients, primarily due to non-reassuring fetal heart rate tracing (NRFHT) or acute abdominal pain suggesting placental abruption. Few patients suspected uterine rupture based on fetal position or ultrasound findings. Additionally, four patients experienced atypical postpartum abdominal pain or shock after vaginal deliveries. No maternal deaths occurred, but 12 had postpartum hemorrhage, with 17 requiring blood transfusions. Two hysterectomies were performed, and one bladder rupture was noted. [10]

Among the uterine ruptures, 20% occurred in unscarred gravid uteri, with varying presentations such as NRFHT, severe abdominal pain, 2nd arrest of cervical dilation, or tocolysis for antepartum hemorrhage. Most maternities resulted in emergent cesarean delivery, except for one case where uterine rupture was not identified until postpartum of vaginal delivery, leading to hemoperitoneum and eventual hysterectomy. [10]

Given that 80% of patients had scarred uteri, further subgroup analysis was conducted, dividing patients into lower segment scar or non-lower segment scar groups to explore potential characteristics and risk factors. Median maternal parities differed significantly between the groups, with primipara predominating in the non-lower segment scar group and multipara in the lower segment scar and unscarred uterine groups ($p = 0.002$). Although the median intervals from prior surgery to conception were shorter in the non-lower segment scar group, the difference was not statistically significant. Uterine rupture occurred later in gestation in patients with unscarred uteri than those with scarred uteri ($p = 0.034$), resulting in significantly higher fetal body weights in the unscarred uterine group ($p = 0.043$). Other factors, including maternal age, BMI, estimated maternal blood loss, and neonatal Apgar scores, showed no significant differences among the three groups. A review of subsequent pregnancies after uterine rupture revealed three women with subsequent pregnancies, all resulting in cesarean deliveries with favorable maternal and fetal outcomes, without evidence of recurrent uterine rupture. [10]

The URIDA study encompassed women diagnosed with uterine rupture (UR) during pregnancy, following them from the initiation of pregnancy until UR occurred, with a focus on cases where UR documentation was available. The study excluded cases of uterine dehiscence. It involved UR instances from the last 15 years, ensuring a minimum 5-year follow-up in each center diagnosing and treating UR. Obstetrics & Gynecology Departments with senior physicians, each

overseeing more than 1500 deliveries annually, contributed data to the URIDA study. The study comprised 270 patients from 14 different centers, with an average age of 33.90 ± 5.27 years. [11]

There were notable differences among centers, particularly in women's body mass index (BMI), with those in Argentina having a significantly lower mean BMI (22.69 ± 3.86; P = 0.010). Parity varied, with patients from Mayane Hayeshua Medical Center, Israel, having the highest parity (4.96 ± 2.67) and those from the University of Perugia, Italy, having the lowest (0.083 ± 0.28; P < 0.001). [11]

Regarding surgical history before UR, of the 224 women with documented previous surgical history, 71.3% had undergone one prior uterine operation, 10.8% had two, and 1.1% had three. The most common uterine surgery was cesarean section (CS), observed in 65.69% of patients, followed by myomectomy (open or laparoscopic). Gestational age at UR showed a statistically significant risk in women with a history of previous uterine surgery compared to those without (P = 0.033). The mean gestational age at UR was 37.32 ± 5.09 weeks. [11]

Fibroids were present in 17.6% of patients before UR, primarily subserosal fibroids. Lower uterine segment (LUS) was the most frequent site of UR in patients with fibroids. All patients underwent laparotomy, and interventions included uterus removal in 57 cases. Symptoms associated with UR included lower abdominal and shoulder pain, vaginal bleeding, abnormal fetal heart rate tracings, and incidental diagnosis during cesarean section. [11]

Postoperative outcomes indicated a mean hospitalization of 6.54 ± 4.85 days, with some patients remaining hospitalized for over 20 days. Complications were reported in 40.74% of patients, with maternal and perinatal mortality rates of 0.7% and 2.2%, respectively. Neonatal outcomes after UR showed an average birth weight of 3106 ± 653.75 g. Subsequent pregnancies after UR occurred in 174 women, with 142 delivering via CS, 13 vaginally, two via vacuum delivery, and one undergoing hysterectomy after CS. The main indication for CS was a previous UR (67%).[11]

DISCUSSION

Uterine rupture (UR) during pregnancy, though rare, poses life-threatening risks to both the mother and fetus. The global incidence of UR is 0.07%, generally lower in developed than developing countries.[12] In our study, conducted in economically developed Shanghai, the UR rate was 0.0196%, aligning with rates in developed regions. No maternal deaths due to UR were observed. Over time, UR etiology has exhibited considerable variation. In developed countries, increased rates of Trial of Labor After Cesarean (TOLAC) and uterotonic use are predominant factors.[13] Conversely, in developing nations, UR results from diverse obstetric and non-obstetric factors such as multi-gravidity, teen-age pregnancy, old primi, poor socio-economic status, previous cesarean section scar, unsupervised labor, and imprudent uterotonic use.

Study by Wan et al in 2022 underscores that the key UR risk factor is the presence of a scar, with previous cesarean section being the primary cause of uterine scarring. To curtail UR rates, strict control of cesarean section indications is imperative. Global cesarean delivery rates have risen steadily, primarily due to elective repeat cesarean sections. Approximately one-third to half of elective cesareans stem from a history of cesarean delivery. While routine elective repeat cesarean section is neither universally advocated nor without risk, Vaginal Birth After Cesarean (VBAC) emerges as a safer alternative.[14] VBAC is linked to fewer complications, shorter hospitalization, reduced blood loss, and diminished puerperal infections and thrombotic events [29]. While VBAC is endorsed by various countries, China's VBAC rate in 2016 was only 9.6%, lagging behind the United States at 12.4%.[15] Despite being a widely accepted practice, TOLAC remains controversial, associated with fewer complications for successful VBACs but more complications for failed attempts. China, currently in a stage akin to the second phase of the U.S. experience, should promote TOLAC with a focus on safety to alleviate UR-related risks. Our study demonstrates that, under strict control and indications, TOLAC is safe and reliable.[16]

Two additional causes of uterine scarring identified in our study are previous myomectomy and previous cornual pregnancy. Laparoscopic myomectomy, while considered minimally invasive, raises debate regarding its impact on subsequent UR risk. This study indicates that UR cases following laparoscopic myomectomy tended to have more severe outcomes, highlighting the need for vigilant monitoring, especially in patients with this surgical history. There is no clear evidence regarding the optimal contraception period after myomectomy to prevent UR, suggesting the necessity for cautious management.[7]

In contrast to UR in women attempting TOLAC, UR in women with unscarred uteruses occurs unexpectedly. Researchers observed a UR incidence of 3/209112 deliveries in women without previous uterine scars, with multiple pregnancies and obstructed labor identified as major risk factors. Timely detection of UR is crucial for improved outcomes, and our study emphasizes that fetal heart rate changes are the most reliable clinical symptom, along with abnormal pain and vaginal bleeding.[7] The lower uterine segment, predominantly the scar site from previous cesarean sections, was the most common rupture site in our study (58.5%), aligning with similar findings in the literature. This underscores the importance of careful monitoring during pregnancy and childbirth for women with scarred uteruses to ensure the well-being of both mother and newborn.

This study by Al-Qirzi et al aimed to determine the incidences of complete uterine rupture during labor among women with and without a prior cesarean delivery (CD) in Norway spanning 1967 to 2008. The highest incidence of complete

rupture was observed in the final decade of the study (2000 to 2008). A significant finding was that sequential induction involving prostaglandins and oxytocin exhibited the highest odds ratio for complete uterine ruptures in both groups, regardless of a prior CD. Other notable risk factors common to both groups included labor augmentation with oxytocin, antepartum fetal death, and a history of previous miscarriage. [8]

The strengths of this study lie in its examination of a rare complication within over half of Norway's pregnant population over four decades. The recruited units represented diverse sizes and geographic regions, ensuring a representative sample. Despite the inclusion of all 48 units in additional analyses, the odds ratios for uterine rupture remained consistent, reinforcing the study's robustness. Potential misclassifications of risk factors in the Medical Birth Registry of Norway (MBRN) were considered nondifferential and likely underestimated effects. The study's focus on complete ruptures, validation against medical records, and a lengthy observation period contributed to reliable identification of true cases.

However, limitations include potential type II errors in subgroups with smaller sample sizes, such as breech extraction and sequential induction in intact uteri, given the rarity of uterine rupture as an outcome. Changes in obstetric practices over time were considered by adjusting for decades in the analysis. The study reported lower incidence rates than those previously documented, possibly due to the inclusion of only complete ruptures and the extended study duration. The elevated rupture rate in the first decade might be linked to more aggressive vaginal deliveries during that period, specifically a higher percentage of classical uterine incisions and more manipulative deliveries.

The study highlighted that sequential induction posed a substantial risk for complete rupture in both women with and without a prior CD. Mechanical induction was associated with the lowest rupture risk compared to prostaglandins or oxytocin, warranting further investigation into the dose and duration of these agents. Labor augmentation with oxytocin carried a heightened risk of complete rupture, emphasizing the need for future studies exploring the relationship between oxytocin dose and rupture risk.

The study revealed that a prior miscarriage significantly increased the risk of uterine rupture, suggesting a potential link to uterine wall weakening. The study acknowledged limitations in determining whether miscarriages weakened the uterine wall or if the effect was related to the method of termination, which was not consistently recorded in the MBRN. The study observed a decrease in rupture rate after miscarriages in later decades, possibly reflecting changes in termination methods. Regarding antepartum fetal death, the study found a rupture rate of 0.6%, higher than a previous study, indicating the need for extra vigilance during labors involving unviable fetuses. Risk factors such as severe postpartum hemorrhage at a prior CD and a short interdelivery interval should be considered when counseling on the mode of delivery due to their association with a weakened scar. Notably, a prior prolonged labor and a previous emergency CD were not identified as risk factors, potentially attributed to vigilant management of these cases.

Study by You et al in 2017 identified 24 patients with a history of prior cesarean deliveries or gynecologic uterine surgeries, along with 6 cases of unscarred gravid uterine ruptures over a 13-year period. Notably, the gestational age at rupture in unscarred uteri was significantly later than in scarred gravid uteri, corresponding to higher fetal weights. However, maternal blood loss did not show a significant difference between ruptures in scarred and unscarred cases. The study also highlighted that gestational age and fetal body weights exhibited no significant differences between ruptures in lower- and non-lower uterine scars.[10]

Most patients presented acute symptoms such as non-reassuring fetal heart tracings (NRFHT) or severe abdominal pain, resembling a possible hypertonic uterus. However, some patients exhibited subtle and atypical symptoms, and a few cases remained undetected until postpartum after vaginal delivery. This delayed awareness and management of uterine rupture, especially in unscarred gravid uteri, could lead to maternal and fetal complications. The experiences documented in this study could serve an educational purpose in obstetric practice.[10]

The overall incidence of uterine rupture in the study was 5.8 per 10,000 deliveries, with 2 neonatal demises among 31 fetus deliveries at $\leq$ 24 weeks (rate: 64.5/1000). This rate aligns with findings from a World Health Organization (WHO) systematic review. Independent risk factors for uterine rupture identified in previous multivariable analyses included prior cesarean delivery, malpresentation, multiparity, and dystocia during the first and second stages of labor. Other reported risk factors encompassed induction of labor, macrosomia, and advanced maternal age, with women over 30 years old experiencing 2 to 3 times the risk compared to younger women.[10]

The mean maternal age in this study was 34.4 $\pm$ 3.9 years, and 86.6% of the maternity cases were aged over 30. Advanced maternal age should be emphasized due to its association with increased rupture risk. Additionally, multiparity emerged as another noteworthy risk factor, particularly in the group with non-lower segment scars. The median parity in this group was 1, signifying the need for obstetricians to exercise caution regarding uterine rupture in primiparous women with non-lower segment scars.[10]

The onsets and locations of ruptures varied among patients, but the majority occurred after 30 weeks of gestational age and were situated at previous scars. The occurrence after 30 weeks could be linked to the acceleration of uterine enlargement in the third trimester or subclinical uterine contractions. Interestingly, larger ruptures were noted at the fundus

based on medical records, although an objective measurement of rupture size was lacking in the retrospective chart review.[10]

For patients with rupture at previous scars, the mean interval between prior uterine surgery and conception was 43.3 ± 9.1 weeks. Notably, 25.0% of these women had an interval < 6 months, emphasizing the potential risk associated with short interpregnancy intervals. The study suggested that patients who underwent lower-segment transverse cesarean delivery did not necessarily have a lower risk of ruptures compared to those who had myomectomy or cornual resection before conception, regardless of the years of interpregnancy.[10]

Among the 14 non-lower segment scars, all had uterine ruptures before the onset of labor, with only one experiencing preterm uterine contraction with tocolysis for one day. This underscores the significance of vigilance, especially considering that 71.4% of ruptures in this group occurred in 30-34 weeks, presenting with severe abdominal pain or NRFHT even in the absence of evidence of uterine contraction. This finding aligns with studies reporting uterine ruptures during pregnancy after laparoscopic myomectomy, occurring mostly before the onset of labor.[10]

The series included 4 ruptures after Trial of Labor After Cesarean (TOLAC), with one diagnosed before delivery due to NRFHT and three diagnosed postpartum after vaginal deliveries. While literature reports a rupture rate of about 7.8/1000 in TOLAC, the exact rupture rate in this series was unclear due to a lack of data on failed TOLAC.[10]

In the six unscarred uterine ruptures, no definite risk factor was identified, and labor courses were uneventful compared to normal deliveries. Risk factors for unscarred uterine rupture typically include congenital uterine anomalies, a history of difficult dilatation and curettage (D&C), or operative hysteroscopy. However, among the six women, three had a history of D&C, and the remaining three had no surgical history. None of them experienced recurrent perforation. The study emphasizes the need for further research to identify independent factors that may contribute to unscarred uterine rupture.[10]

The data analysis from URIDA indicated an association between uterine rupture (UR) and previous uterine surgery. However, contrary to this finding, the present study aligns with existing literature by demonstrating that UR can also occur in patients without a history of prior uterine surgery. Notably, the incidence of UR did not exhibit an increase with a rising number of previous uterine operations or when multiple types of operations were performed. While UR primarily occurred after a previous cesarean section (CS), myomectomy also played a significant role. It's noteworthy that the incidence of UR did not rise with an increasing number of previous uterine surgeries, potentially due to the scheduling of elective CS before contractions, which might explain the lack of an observed increase in UR. Current trends emphasize efforts to minimize the risk of UR in patients with a history of CS. Specialized techniques, including ultrasound assessments to determine scar thickness, have been developed to predict the likelihood of UR or dehiscence. Despite efforts, the timing and effectiveness of such predictions remain a subject of debate, with conflicting results from thickness assessments during the first and third trimesters. Therefore, clinical attention is also directed towards the circumstances surrounding the previous CS.[11]

The URIDA investigation revealed that UR occurred at a mean gestational age of 36.81 ± 6.16 weeks, even in patients without previous surgery. Consequently, precautions should be taken to predict and prevent UR in all patients. Analyzing the gestational age at UR indicated a 75% probability of UR occurring after 280 days (40 weeks) of gestation, with a substantial increase in probability after 40 weeks. [11]

Fibroids emerged as a risk factor for UR in the URIDA database, particularly in cases of unoperated fibroids. The study highlighted that subserosal fibroids, particularly in the lower uterine segment (LUS), were associated with a higher likelihood of rupture. The anatomical characteristics of the LUS, including thinner muscle fibers and greater elasticity, make it susceptible to rupture during labor, especially when fibroids are present. The location of fibroids, particularly subserosal ones, may influence the site and frequency of UR. [11]

Analyzing UR at the site of a previous uterine scar emphasized the challenges in uterine healing. The scar tissue, often fibrotic and avascular, lacks the robustness of healthy muscular tissue, increasing the vulnerability to dehiscence and rupture. Second operations associated with UR occurred at a gestational age above 195 days, suggesting that precautionary monitoring starting at 32 weeks of gestation, particularly after previous uterine surgery, may be prudent. The study provided insights into UR associated with various intrauterine surgical procedures, including dilatation and curettage, hysteroscopic metroplasty, and laparoscopic salpingectomy. These procedures were linked to UR occurring at specific gestational ages, underscoring the need for careful consideration of their potential impact on uterine integrity during pregnancy. Regarding subsequent pregnancies after UR, the data suggested that such pregnancies could be feasible and safe. The absence of reported subsequent UR events in the URIDA data contradicted some literature findings, reinforcing the need for ongoing research in this area. The study also emphasized the importance of actively planning the predicted route of delivery in subsequent pregnancies.[11]

The clinical presentation of uterine rupture can vary depending on the uterine site and the type of labor analgesia, necessitating a heightened index of suspicion. For instance, a rupture involving the posterior uterus or parametrium in a patient with epidural anesthesia may lead to significant vital sign changes but minimal patient discomfort or vaginal

bleeding. Conversely, a rupture involving the cervix and upper vaginal wall may present with substantial vaginal bleeding, while bladder involvement might manifest as a sudden onset of hematuria. Postpartum presentation is more common with the unscarred uterus, indicating a rupture shortly before birth.[22]

Antepartum: Pain emerges as the primary indicator of antepartum uterine rupture. In one series, all eight cases of antepartum complete ruptures among over two million patients with an unscarred uterus exhibited acute abdominal pain.[22]

Intrapartum: Fetal heart rate changes, often characterized by bradycardia preceded by variable or late decelerations, stand out as the most prevalent clinical sign of uterine rupture. However, no fetal heart rate pattern definitively indicates rupture, and relying solely on fetal heart rate changes is insufficient for detection or exclusion. Loss of station may occur if part or all of the fetus passes through the rupture site into the peritoneal cavity. Abdominal pain, with or without hemodynamic changes, is a hallmark of uterine rupture, marked by continuous abdominal pain and signs of intra-abdominal hemorrhage. Neuraxial analgesia may mask rupture-related pain, and the sudden onset of pain following previously effective anesthesia could signal uterine rupture. Uterine tenderness, cessation of contractions, and/or a change in uterine shape may accompany rupture due to the extrusion of part or all of the fetus and/or amniotic sac. [22]

Interestingly, the intuitive correlation between the loss of uterine wall integrity and a decrease in intrauterine pressure is not consistently observed. Case series with an intrauterine pressure catheter during rupture generally report no significant pressure changes compared to laboring patients without rupture. Notably, an increase in baseline intrauterine pressure was observed in four of 39 patients in one series. Vaginal bleeding may be modest despite substantial intra-abdominal hemorrhage, with heavy bleeding more likely when the cervix and upper vaginal wall are involved. Intraperitoneal bleeding may lead to hypovolemic shock even without excessive vaginal bleeding. Hematuria may occur if the rupture extends into the bladder. [22]

Postpartum: Maternal symptoms of uterine rupture generally persist postpartum. However, a notable additional finding may be excessive vaginal bleeding that persists despite the use of uterotonic drugs. [22]

Uterine rupture demands immediate action to mitigate maternal and fetal risks, as any delay in delivery, resuscitation, or surgery can exacerbate the situation. Fetal bradycardia is typically associated with uterine rupture, necessitating the initial response of an urgent cesarean delivery, with or without an exploratory laparotomy. General endotracheal anesthesia is usually necessary to expedite delivery, especially when a labor epidural is already in place. Labor epidurals take 5 to 15 minutes to establish a surgical block, which is deemed unacceptable in the context of uterine rupture. General anesthesia offers additional benefits by enabling effective management of maternal acid-base status through minute ventilation adjustments, stabilizing the airway, and providing neuromuscular blockade to facilitate laparotomy. Notably, neuraxial anesthesia is contraindicated in cases of hemodynamic instability and severe bleeding diathesis.[23]

Addressing uterine rupture involves concurrent delivery and management of maternal hemorrhage. Initiatives such as placing a second large-bore intravenous line and ordering blood for prompt delivery to the operating room are crucial. In instances where obtaining large-bore intravenous access proves challenging, central venous access using a large bore sheath introducer should be considered. Initial resuscitation often entails infusing Lactated Ringer's electrolyte solution, and rapid blood transfusion is recommended in the event of brisk and substantial blood loss. If bleeding persists, the placement of an arterial line becomes essential for accurate and frequent blood pressure monitoring, ensuring a quicker response to hypotension, and facilitating serial laboratory tests. [23]

When intraperitoneal bleeding is suspected, opting for a midline abdominal incision over a Pfannenstiel incision is advisable. A midline incision provides superior surgical exposure for identifying the source of bleeding and may reduce the time interval between surgical incision and delivery. In cases of smaller ruptures where the uterus is amenable to repair, repair may be considered. However, in situations involving hemodynamic instability or significant uterine injury, a hysterectomy becomes the indicated course of action. Approximately one in three women experiencing uterine rupture ultimately undergo a hysterectomy. [23]

CONCLUSION

In summary, uterine rupture (UR) stands as a catastrophic event with severe consequences for both obstetricians and patients, demanding heightened vigilance and monitoring of pregnant women with high-risk factors to mitigate maternal and infant mortality. Although trials of labor after cesarean (TOLAC) offer a safe delivery option, its widespread promotion faces challenges in Shanghai and China. The risk of uterine rupture increases with sequential labor induction, emphasizing the need for future studies to evaluate dosages and duration of prostaglandins and oxytocin. Our series underscores the grave neonatal prognosis associated with uterine rupture, emphasizing the importance of timely management and recognizing fetal heart rate abnormalities as common signs. Furthermore, the URIDA investigation, the largest database on UR during pregnancy, provides valuable insights into the association between previous uterine surgery, leiomyoma, and UR. While the most common operations preceding UR involve cesarean section, abdominal, and laparoscopic myomectomy, it is notable that UR can occur even without prior uterine surgery. Early diagnosis and immediate treatment are crucial for minimizing complications and ensuring favorable outcomes in both the index pregnancy and subsequent pregnancies.

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