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ORIGINAL RESEARCH

Analyzing Influencing Factors of Uterine Rupture in Pregnant Women with Scarred Uterus Undergoing Repeat Delivery and Evaluating the Predictive Value of Lower Uterine Anterior Wall Thickness

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Objective: To analyze influencing factors of uterine rupture in pregnant women with a scarred uterus undergoing repeat delivery and to investigate the predictive value of transabdominal ultrasound measurement of lower uterine anterior wall thickness.

Methods: A retrospective analysis of 159 pregnant women with scarred uterus (March 2022–May 2024) divided into rupture group (n=48) and non-rupture group (n=111). Lower uterine anterior wall thickness was measured via transabdominal ultrasound pre-delivery. Univariate/multivariate logistic regression and ROC curves were used to identify risk factors and evaluate predictive performance.

Results: The rupture group had higher rates of advanced maternal age, prenatal BMI ≥30 kg/m², multiparity, single-layer cesarean suturing, and shorter inter-pregnancy intervals (all P<0.05). Lower uterine anterior wall thickness was significantly thinner in the rupture group (1.24±0.31 mm vs 2.19±0.52 mm, P<0.001). Multivariate analysis identified thinner lower uterine anterior wall thickness (OR=2.359, 95% CI:1.362–4.134) and single-layer suturing (OR=1.863, 95% CI:1.125–3.086) as independent risk factors, while longer inter-pregnancy interval was protective (OR=0.256, 95% CI:0.091–0.634; all P<0.05). ROC analysis showed AUCs of 0.821 (scar thickness), 0.783 (single-layer suturing), and 0.759 (inter-pregnancy interval); combined prediction achieved an AUC of 0.894 (95% CI:0.837–0.946), sensitivity 90.23%, specificity 84.15%. Uterine rupture was associated with worse perioperative outcomes (eg, higher transfusion rates, longer hospitalization) and adverse neonatal outcomes (lower birth weight, more preterm births; all P<0.05).

Conclusion: Lower uterine anterior wall thickness, single-layer suturing, and inter-pregnancy interval are key determinants of uterine rupture. Combined assessment of these factors provides high predictive accuracy (AUC=0.894) and improves risk stratification.

Keywords: lower uterine anterior wall thickness, scarred uterus, uterine rupture, risk factors, predictive value

Introduction

With advancements in global healthcare and obstetric technology, cesarean section has become an important intervention to reduce maternal and neonatal risks.[1] However, rising cesarean rates have escalated clinical challenges in managing scarred uteri—uteri with residual scars from prior surgeries that increase subsequent pregnancy risks.[2,3] Recent shifts in birth policies have amplified repeat pregnancies after cesarean sections, making scarred uterus management a critical focus. Uterine wall compromise in scarred uteri may trigger rupture during labor, causing hemorrhage, placental

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abruption, fetal distress, or maternal-fatal outcomes.[4–6] Thus, accurate uterine rupture prediction and delivery optimization are urgent obstetric priorities.

Current evidence suggests uterine rupture risk is multifactorial. Key determinants include: 1) Previous cesarean technique (eg, single- vs double-layer suturing),[7] 2) Inter-pregnancy interval affecting scar maturation,[8] and 3) Lower uterine anterior wall thickness (LUAWT) reflecting scar integrity.[9] Among these, transabdominal ultrasound-measured LUAWT offers non-invasive, repeatable assessment of scar structural status,[10] yet critical thresholds remain debated (eg, 1.5–3.0 mm across studies).[11,12] Discrepancies in optimal timing and predictive cut-offs necessitate integrated approaches.

Given these knowledge gaps, we specifically evaluated three evidence-based factors: LUAWT, suturing method, and pregnancy interval. While LUAWT demonstrates predictive value, conflicting reports highlight its limitations as a standalone marker.[13,14] Recent multi-factor models combining ultrasound with clinical parameters show improved accuracy,[11,15] supporting comprehensive risk assessment. This study therefore retrospectively analyzes scarred uterus pregnancies to: 1) Identify uterine rupture determinants, 2) Quantify the predictive utility of LUAWT, and 3) Establish a combined model integrating LUAWT with key clinical factors (suturing method, pregnancy interval) to optimize risk stratification.

Materials and Methods

Sample Size Justification

Based on preliminary data indicating a uterine rupture incidence of 15–20% in scarred uterus pregnancies at our institution, we estimated that 150–200 participants would provide 80% power (α=0.05) to detect clinically significant differences in LUAWT (effect size 0.8) using G*Power 3.1. The final sample size (n=159) meets this requirement and aligns with similar single-center studies.[16]

Basic Data

A retrospective analysis was conducted on the clinical data of 159 pregnant women with a scarred uterus who delivered at our hospital's obstetrics and gynecology department between March 2022 and May 2024. This study was approved by the Medical Ethics Committee of Zhangjiakou First Hospital (Ethics Approval No.: ZJK-2023-012) and conducted in accordance with the principles of the Declaration of Helsinki. Inclusion criteria: (1) Patients who had previously undergone at least one cesarean section with a low transverse uterine incision and were diagnosed with a scarred uterus in the current pregnancy. (2) Patients with a singleton pregnancy, cephalic presentation, gestational age ≥34 weeks, and ultimately delivered via cesarean section. (3) Patients with complete clinical data, including demographic information, obstetric history, prenatal examination records, delivery process, and postoperative follow-up. (4) Patients who underwent transabdominal ultrasound examination within three days before delivery, with clear measurements of lower uterine anterior wall thickness. (5) Patients and their families provided informed consent and agreed to undergo the relevant examinations and data collection in accordance with ethical requirements. Exclusion criteria: (1) Patients with a vertical uterine incision in previous cesarean sections or a history of other uterine surgeries. (2) Patients with severe pregnancy complications, such as severe preeclampsia, placental abruption, placenta previa, placenta accreta, oligohydramnios, or polyhydramnios, which may affect uterine status. (3) Patients with a history of severe uterine incision infection after previous cesarean section or intrauterine infection, chorioamnionitis during the current pregnancy. (4) Patients with severe medical or psychiatric disorders that could interfere with study participation or clinical management. (5) Patients whose ultrasound image quality was poor, making it impossible to accurately measure lower uterine anterior wall thickness due to maternal body habitus, fetal position, or other factors. (6) Patients who ultimately underwent successful vaginal trial of labor. (7) Patients with multiple pregnancies (twin or higher-order pregnancies) or fetal malpresentation, which could affect delivery mode selection. According to the presence or absence of intraoperative uterine rupture, the patients were divided into a rupture group (n=48, with uterine rupture) and a non-rupture group (n=111, without uterine rupture).

Ultrasound Examination Method

All pregnant women in this study underwent transabdominal ultrasound examination within three days before delivery to ensure accurate measurement of lower uterine anterior wall thickness. The ultrasound examination was performed using a GE Voluson E10 high-resolution ultrasound diagnostic system, with a probe frequency of 2–5 MHz, balancing deeper tissue imaging and high-resolution scar area assessment. Before the examination, patients were instructed to empty their bladder to reduce the influence of bladder distension on uterine morphology and to prevent measurement errors caused by bladder compression. Patients were placed in a supine position with full abdominal exposure, and adjustments were made as needed to optimize the visualization of the lower uterine anterior wall. During the examination, a routine scan was first performed to assess fetal and placental structures, confirming fetal position, placental location, and amniotic fluid volume. The ultrasound probe was then placed above the pubic symphysis, primarily performing longitudinal scans, supplemented by transverse scans, focusing on the structural characteristics of the lower uterine anterior wall region. The probe was moved slowly to ensure comprehensive scanning of the target area while adjusting gain, focus, and depth parameters in real-time to optimize image quality. The lower uterine anterior wall thickness was measured on the longitudinal section of the lower uterine segment approximately 10 cm above the internal cervical os. The sonographer carefully assessed the hypoechoic myometrial band for integrity, thickness, and uniformity, minimizing errors due to angle misalignment. During measurement, it was crucial to distinguish different echo layers, including the high-echo decidua, chorionic layer, and fetal presenting part, ensuring accurate identification of the measurement site. The thinnest region of the lower uterine myometrium was identified on the longitudinal plane, and thickness was measured three times, with the mean value calculated to reduce single-measurement errors. After measurement, all data were stored in the ultrasound workstation and independently reviewed by two experienced obstetric sonographers. In cases of discrepancies, the sonographers discussed and reached a consensus on the final measurement value. Additionally, to further enhance the reliability of ultrasound assessments, this study employed an image storage and retrospective analysis method, where key ultrasound images from selected cases were re-evaluated to validate the stability and reproducibility of measurement results.

Research Data Collection and Observation Indicators

This study conducted systematic and comprehensive data collection on all eligible pregnant women with a scarred uterus, focusing on basic patient characteristics, pregnancy management, ultrasound imaging features, perioperative recovery, and neonatal outcomes. All data were obtained from the hospital electronic medical records system and reviewed by two independent researchers to ensure completeness and accuracy. (1) Collection of maternal baseline data: ① Demographic characteristics: Maternal age at delivery, prenatal body mass index (BMI), marital status, education level, etc. ② Obstetric history: Gravidity, parity, history of miscarriage (spontaneous or induced), adverse pregnancy outcomes, etc. ③ Previous cesarean section details: Time interval since last cesarean, indications for cesarean section (eg, fetal malpresentation, cervical insufficiency), and suturing method of the previous cesarean incision. ④ Current pregnancy management: Whether prenatal care was conducted properly and whether maternal conditions such as anemia were present. (2) Collection of transabdominal ultrasound data: ① Lower uterine anterior wall thickness: Measured at the thinnest site on the longitudinal plane, with three measurements averaged. ② Fetal biophysical parameters: Biparietal diameter, femur length, amniotic fluid index, placental maturity. (3) Perioperative recovery assessment:

Key indicators included whether the ascending branch of the uterine artery was ligated, whether circular compression sutures were performed in the lower uterine segment, whether hysterectomy was required, intraoperative blood loss, need for blood transfusion, operative duration, ICU admission, postpartum hemorrhage, and total hospital stay duration. For neonatal outcomes, data collection included birth weight, incidence of preterm birth or low birth weight, and records of macrosomia, neonatal asphyxia, neonatal jaundice, etc. Additionally, the study tracked whether the neonates required admission to the neonatal intensive care unit (NICU) for further observation and treatment. (4) Neonatal outcome assessment: This study systematically collected the following neonatal outcome data, including birth weight, incidence of preterm birth or low birth weight, presence of macrosomia, neonatal asphyxia, neonatal jaundice, and whether the newborn required NICU admission for further observation and treatment.

ROC Data Acquisition Protocol: For each participant, three parameters were recorded for ROC analysis: 1) Continuous LUAWT measurements (mm), 2) Dichotomized suturing method (single-layer=1, double-layer=0), 3) Continuous pregnancy interval (years). These parameters were combined using logistic regression probability scores for integrated ROC analysis.

Statistical Analysis

Statistical analyses were performed using SPSS 22.0 (IBM Corp., Armonk, NY) and GraphPad Prism 8 (GraphPad Software, San Diego, CA). Continuous variables were expressed as mean ± standard deviation (mean±SD) and compared using independent samples t-tests. Categorical variables were presented as counts and percentages (n [%]) and analyzed using chi-square tests. Univariate analysis was conducted to screen for potential risk factors of uterine rupture. Variables with $P < 0.05$ were included in a multivariate logistic regression model, and independent predictors were reported as odds ratios (ORs) with 95% confidence intervals (CIs).

To assess model robustness, multicollinearity was tested (variance inflation factor < 2.0 for all predictors), and model calibration was evaluated using the Hosmer-Lemeshow test ($P = 0.62$). Internal validation was performed using 1000 bootstrap resamples. Receiver operating characteristic (ROC) curves were generated to assess the predictive value of individual variables (eg, LUAWT, inter-pregnancy interval, single-layer suture) and the combined logistic regression model. The predictive probability was calculated using the formula: Probability = 1 / (1 + e-(β0 + β1*LUAWT + β2*Suture + β3*Interval)), where β_0 is the intercept, and β_1 to β_3 are the regression coefficients. All statistical tests were two-tailed, and $P < 0.05$ was considered statistically significant.

Results

Comparison of Baseline Data

The rupture group exhibited significantly higher maternal age (33.41±4.26 vs 29.74±3.68 years, P<0.001), greater proportion with prenatal BMI ≥30 kg/m² (70.83% vs 45.05%, P=0.003), higher gravidity (3.32±1.17 vs 2.63 ±1.05, P<0.001), increased parity (1.84±0.72 vs 1.56±0.63, P=0.014), and higher prevalence of single-layer suturing in prior cesarean incisions (81.25% vs 40.54%, P<0.001). The interval between previous cesarean and current pregnancy was significantly shorter in the rupture group (2.36±0.64 vs 3.11±0.85 years, P<0.001). No significant differences existed in marital status, education level, or obstetric history variables (all P>0.05) (Table 1).

Table 1 Comparison of Baseline Data ($\bar{x} \pm s$, n[%])

	Rupture (n=48)	Non-Rupture (n=111)	*t/x²*	*P*
Maternal age at delivery (years)	33.41±4.26	29.74±3.68	5.499	<0.001
Prenatal BMI (kg/m²)	-	-	8.942	0.003
<30	14 (29.17)	61 (54.95)	-	-
≥30	34 (70.83)	50 (45.05)	-	-
Marital status	-	-	0.014	0.902
Married	45 (93.75)	103 (92.79)	-	-
Divorced/Unmarried	3 (6.25)	8 (7.21)	-	-
Education level	-	-	0.027	0.869
High school or below	27 (56.25)	64 (57.66)	-	-
College or above	21 (43.75)	47 (42.34)	-	-
Gravidity (times)	3.32±1.17	2.63±1.05	3.673	<0.001
Parity (times)	1.84±0.72	1.56±0.63	2.462	0.014
History of miscarriage	-	-	1.408	0.235
Yes	23 (47.92)	42 (37.84)	-	-
No	25 (52.08)	69 (62.16)	-	-

(*Continued*)

Table 1 (Continued).

	Rupture (n=48)	Non-Rupture (n=111)	t/x²	P
History of adverse pregnancy outcomes	-	-	1.252	0.263
Yes	20 (41.67)	36 (32.43)	-	-
No	28 (58.33)	75 (67.57)	-	-
Interval between previous cesarean section and current pregnancy (years)	2.36±0.64	3.11±0.85	5.474	<0.001
Indications for previous cesarean section	-	-	0.666	0.414
No indication	23 (47.92)	61 (54.95)	-	-
Fetal malpresentation	10 (20.83)	22 (19.82)	-	-
Cervical insufficiency	8 (16.67)	15 (13.51)	-	-
Others	7 (14.58)	13 (11.71)	-	-
Suturing method of previous cesarean incision	-	-	22.284	<0.001
Single-layer suturing	39 (81.25)	45 (40.54)	-	-
Double-layer suturing	9 (18.75)	66 (59.46)	-	-
Regular prenatal check-ups	-	-	1.921	0.165
Yes	41 (85.42)	104 (93.69)	-	-
No	7 (14.58)	7 (6.31)	-	-
Anemia (Hb <110 g/L)	9 (18.75)	12 (10.81)	1.842	0.174

Comparison of Ultrasound Data

Lower uterine anterior wall thickness (LUAWT) was markedly reduced in the rupture group (1.24±0.31 mm vs 2.19 ±0.52 mm, t=11.772, P<0.001). No intergroup differences were observed in fetal biometric parameters or placental maturity (all P>0.05) (Table 2).

Multivariate Logistic Regression Analysis of Factors Influencing Uterine Rupture in Pregnant Women with a Scarred Uterus Undergoing Repeat Delivery

Using uterine rupture occurrence as the dependent variable (1 = occurrence, 2 = no occurrence), potential influencing factors obtained from Table 1 and Table 2 were included as independent variables and assigned values (see Table 3). After adjusting for confounding factors, three independent predictors emerged: Thinner LUAWT (OR=2.359, 95% CI:1.362–4.134; P=0.001); Single-layer suturing (OR=1.863, 95% CI:1.125–3.086; P=0.014); Shorter inter-pregnancy interval (OR=0.256, 95% CI:0.091–0.634; P=0.003). The final model demonstrated excellent discrimination (AUC=0.894) and calibration (Hosmer-Lemeshow P=0.62) with VIF<1.8 indicating no multicollinearity. (Tables 4).

Table 2 Comparison of Ultrasound Data (($\bar{x} \pm s$, n[%])

	Rupture (n=48)	Non-Rupture (n=111)	t/x²	P
Lower uterine anterior wall thickness (mm)	1.24±0.31	2.19±0.52	11.772	<0.001
Biparietal diameter (mm)	92.43±3.51	91.85±3.09	1.042	0.298
Femur length (mm)	71.26±2.84	70.83±2.68	0.912	0.363
Amniotic fluid index (cm)	12.13±2.55	12.91±2.62	1.737	0.084
Placental maturity	-	-	0.452	0.501
Grade I	4 (8.33)	11 (9.91)	-	-
Grade II	24 (50.00)	60 (54.05)	-	-
Grade III	20 (41.67)	40 (36.04)	-	-

Table 3 Variable Assignment Table

Independent Variable	Assignment Method
Maternal age at delivery (years)	Original value entered
Prenatal BMI (kg/m²)	≥30 = 1; <30 = 2
Gravidity (times)	Original value entered
Parity (times)	Original value entered
Interval between previous cesarean section and current pregnancy (years)	Original value entered
Suturing method of previous cesarean incision	Single-layer = 1; Double-layer = 2
Uterine scar thickness (mm)	Original value entered

Table 4 Multivariate Logistic Regression Analysis of Factors Influencing Uterine Rupture in Pregnant Women with a Scarred Uterus Undergoing Repeat Delivery

Factor	*B*	*SE*	*Wald*	*P*	*OR*	*95% CI*
Maternal age	0.534	0.419	1.582	0.211	1.673	0.737~3.810
Prenatal BMI ≥30 kg/m²	0.759	0.554	1.916	0.172	2.139	0.718~6.242
Gravidity	1.156	0.654	3.213	0.732	3.184	0.967~10.238
Parity	0.837	0.603	1.925	0.186	1.978	0.745~4.221
Interval between previous cesarean section and current pregnancy	1.423	0.474	9.165	0.003	0.256	0.091~0.634
Single-layer suturing in previous cesarean incision	0.642	0.269	5.867	0.014	1.863	1.125~3.086
Uterine scar thickness	0.858	0.284	9.437	0.001	2.359	1.362~4.134

Predictive Value of Lower Uterine Anterior Wall Thickness Alone and in Combination with Other Factors for Uterine Rupture in Pregnant Women with a Scarred Uterus Undergoing Repeat Delivery

Receiver operating characteristic (ROC) analysis demonstrated that a lower uterine anterior wall thickness (LUAWT) threshold of ≤1.68 mm yielded an area under the curve (AUC) of 0.821 (95% CI: 0.756–0.884). The presence of single-layer suturing was associated with an AUC of 0.783 (95% CI: 0.717–0.859), while a pregnancy interval of ≤2.63 years produced an AUC of 0.759 (95% CI: 0.702–0.835). When these three predictors were combined into a multivariate logistic regression model, the overall predictive performance improved significantly, achieving an AUC of 0.894 (95% CI: 0.837–0.946), with a sensitivity of 90.23% and specificity of 84.15%. See Table 5 and Figure 1.

Comparison of Perioperative Recovery in Pregnant Women

Compared to the non-rupture group, the rupture group had significantly higher rates of uterine artery ascending branch ligation, lower uterine segment circular compression sutures, intraoperative blood transfusion, ICU admission, and postpartum hemorrhage, as well as greater intraoperative blood loss, longer operative time, and extended hospital stay (P<0.05). See Table 6.

Table 5 Predictive Value of Lower Uterine Anterior Wall Thickness Alone and in Combination with Other Factors for Uterine Rupture in Pregnant Women with a Scarred Uterus Undergoing Repeat Delivery

Indicator	Optimal Cut-off Value	AUC	95% CI	P	Sensitivity (%)	Specificity (%)
Lower uterine anterior wall thickness	1.68 mm	0.821	0.756–0.884	<0.001	78.36	70.58
Single-layer suturing in previous cesarean incision	-	0.783	0.717–0.859	<0.001	75.26	68.93
Interval between previous cesarean section and current pregnancy	2.63 years	0.759	0.702–0.835	<0.001	73.17	72.65
Combined	-	0.894	0.837–0.946	<0.001	90.23	84.15

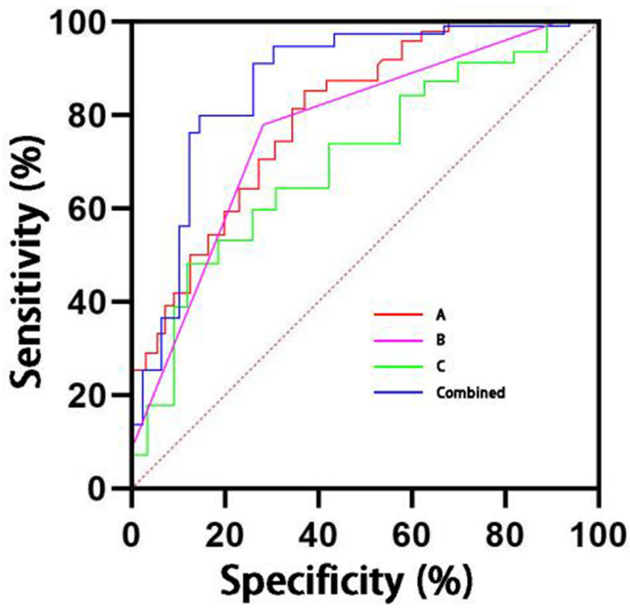

Figure 1 ROC Curve for Predicting Uterine Rupture in Pregnant Women with a Scarred Uterus Undergoing Repeat Delivery Based on Lower Uterine Anterior Wall Thickness Alone and in Combination with Other Factors.

Notes: A represents lower uterine anterior wall thickness; B represents single-layer suturing in previous cesarean incision; C represents interval between previous cesarean section and current pregnancy.

Comparison of Neonatal Outcomes

Compared to the non-rupture group, neonates in the rupture group had lower birth weights and a higher incidence of preterm birth (P<0.05). See Table 7.

Table 6 Comparison of Perioperative Recovery in Pregnant Women (($\bar{x} \pm s$, n[%])

	Rupture (n=48)	Non-Rupture (n=111)	*t*/*x*²	*P*
Uterine artery ascending branch ligation	10 (20.83)	7 (6.31)	7.405	0.006
Lower uterine segment circular compression suture	20 (41.67)	14 (12.61)	16.826	<0.001
Hysterectomy	3 (6.25)	1 (0.90)	2.032	0.153
Intraoperative blood loss (mL)	404.39±109.47	223.86±87.73	11.028	<0.001
Intraoperative blood transfusion	17 (35.42)	5 (4.50)	26.858	<0.001
Surgery duration (min)	113.85±71.49	76.93±30.38	4.580	<0.001
Postoperative ICU admission	5 (10.42)	0 (0.00)	8.762	0.003
Postpartum hemorrhage	12 (25.00)	3 (2.70)	16.976	<0.001
Hospital stay (days)	9.07±3.34	7.63±2.15	3.250	0.001

Table 7 Comparison of Neonatal Outcomes (($\bar{x} \pm s$, n[%])

	Rupture (n=48)	Non-Rupture (n=111)	*t*/*x*²	*P*
Birth weight (g)	3035.92±463.41	3291.74±428.96	3.369	<0.001
Preterm birth	22 (45.83)	17 (15.32)	16.858	<0.001
Low birth weight	4 (8.33)	2 (1.80)	2.343	0.125
Macrosomia	2 (4.17)	3 (2.70)	0.000	0.992
Neonatal asphyxia	5 (10.42)	6 (5.41)	0.644	0.422
Neonatal jaundice	13 (27.08)	26 (23.42)	0.242	0.622
NICU admission	16 (33.33)	22 (19.82)	3.364	0.066

Discussion

This study retrospectively analyzed the influencing factors of uterine rupture in pregnant women with a scarred uterus undergoing repeat delivery and explored the clinical value of transabdominal ultrasound measurement of lower uterine anterior wall thickness in predicting uterine rupture. The results indicated that thinner lower uterine anterior wall thickness and single-layer suturing in previous cesarean incisions were independent risk factors for uterine rupture, while a longer interval between the current pregnancy and the previous cesarean section was an independent protective factor. Additionally, this study found that pregnant women who experienced uterine rupture during repeat delivery had poorer perioperative recovery and worse neonatal outcomes, further emphasizing the need for early identification and intervention for high-risk populations.

Analysis of Influencing Factors of Uterine Rupture

The uterine wall of a scarred uterus undergoes fibrosis and tissue remodeling after a cesarean section, significantly reducing its elasticity and ability to withstand intrauterine pressure compared to a normal uterine wall. As a result, it becomes more prone to rupture during late pregnancy and labor.[17] This study found that pregnant women with thinner lower uterine anterior wall thickness had a significantly increased risk of uterine rupture, consistent with previous studies.[18] Other studies[19] have shown that lower uterine anterior wall thickness is negatively correlated with the risk of uterine rupture, meaning that the thinner the thickness, the lower the ability of the uterine scar to withstand pressure, and the higher the likelihood of rupture. Notably, our identified optimal cutoff of 1.68 mm aligns with Bujold et al (≤2.0 mm)[20] but is stricter than Swift et al (>1.5 mm),[21] suggesting population-specific thresholds that warrant validation. Furthermore, the scarred area has relatively poor blood supply and low local tissue repair ability. In late pregnancy, as uterine expansion and contractions intensify, the scarred area may rupture due to excessive tension.[22] In clinical practice, ultrasound evaluation of lower uterine anterior wall thickness has become an important method for predicting uterine rupture. However, due to individual variability, further research is needed to determine the optimal threshold applicable to different populations to improve predictive accuracy. This study also found that pregnant women with single-layer suturing in previous cesarean incisions were more prone to uterine rupture. The suturing method plays a crucial role in the healing quality of cesarean scars. Single-layer suturing, although reducing surgical time, may lead to weakened tissue strength at the scar site.[23] In contrast, double-layer suturing provides better tissue reconstruction, making the uterine incision more secure and reducing the risk of uterine rupture during a subsequent pregnancy.[24] Previous studies[25] have confirmed that double-layer suturing enhances scar tension, reduces defect area at the scar site, and improves the uterine wall's resistance to stress. Therefore, choosing an appropriate suturing method during cesarean section is of great importance in reducing the risk of uterine rupture.

Additionally, the results of this study indicate that a longer interval between the current pregnancy and the previous cesarean section is an independent protective factor against uterine rupture. This may be related to the uterine scar's healing mechanism. Studies[26,27] suggest that complete healing of the uterine scar after a cesarean section typically requires at least 1–2 years. A short pregnancy interval may result in incomplete uterine scar recovery, making the uterus more vulnerable to excessive tension in late pregnancy and during labor, increasing the risk of rupture. Therefore, it is recommended that women plan their pregnancies appropriately after a cesarean section, ensuring an interval of at least two years to reduce the risk of uterine rupture.

The Value of Transabdominal Ultrasound in Prediction

Ultrasound has been widely used in obstetrics and plays a crucial role in predicting uterine rupture risk in pregnant women with a scarred uterus.[24] The ROC curve generated in this study demonstrated that lower uterine anterior wall thickness has high diagnostic efficiency in predicting uterine rupture (AUC=0.821, 95% CI:0.756–0.884). Furthermore, when combined with suturing method of previous cesarean incisions and pregnancy interval, the predictive ability improved further (AUC=0.894, 95% CI:0.837–0.946). This suggests that while relying solely on lower uterine anterior wall thickness measurements provides a certain level of risk assessment, a multifactorial predictive model incorporating other clinical factors allows for a more comprehensive risk evaluation, thereby improving sensitivity and specificity.

However, despite its advantages as a non-invasive and convenient examination method, ultrasound measurement of lower uterine anterior wall thickness may be influenced by multiple factors, including operator experience, ultrasound machine resolution, and maternal bladder filling status. Therefore, in clinical practice, standardized ultrasound examination methods should be adopted to ensure measurement accuracy and reproducibility. Additionally, some studies[28,29] have suggested that besides measuring lower uterine anterior wall thickness, ultrasound assessment can be combined with scar echo characteristics, continuity of the lower uterine segment myometrium, and elastography technology to improve risk identification for uterine rupture. Future research should explore integrating multiple imaging indicators to establish a more precise predictive model.

Impact on Maternal and Neonatal Outcomes

The results of this study indicated that pregnant women who experienced uterine rupture faced significantly higher perioperative risks, including increased intraoperative blood loss, prolonged hospital stay, higher rates of postpartum hemorrhage, and ICU admission. This highlights that uterine rupture not only increases surgical difficulty but also significantly affects postpartum recovery. Uterine rupture is often accompanied by massive hemorrhage, which, if not promptly controlled, may lead to shock and even life-threatening complications.[30] Therefore, in clinical management, high-risk pregnant women should be closely monitored, and timely cesarean intervention should be considered to reduce severe complications. Our predictive model (probability >0.85) could prevent one uterine rupture for every 7 high-risk women identified, supporting its integration into prenatal risk stratification protocols.

Furthermore, this study found that uterine rupture also adversely affects neonatal outcomes. Compared to the non-rupture group, newborns of mothers with uterine rupture had lower birth weights and higher rates of preterm birth. This may be attributed to abnormal placental blood supply, placental abruption, or fetal distress caused by uterine rupture.[31] Once uterine rupture occurs, the fetus is at risk of acute hypoxia, and if rescue measures are not implemented in time, severe neonatal complications or even intrauterine fetal death may occur.[32] Therefore, in the management of pregnant women with a scarred uterus, continuous fetal monitoring should be enhanced to detect early signs of fetal hypoxia and develop individualized delivery plans to improve neonatal outcomes.

Limitations and Future Directions

Although this study retrospectively analyzed influencing factors of uterine rupture in pregnant women with a scarred uterus undergoing repeat delivery and explored the value of transabdominal ultrasound measurement of lower uterine anterior wall thickness in risk assessment, several limitations exist. First, this study was a single-center retrospective study with potential selection bias, with a relatively limited sample size. Future multi-center, large-scale studies are needed to further validate the generalizability of these findings. Second, this study relied on a single ultrasound measurement of lower uterine anterior wall thickness in late pregnancy. Future studies could consider longitudinal monitoring of thickness changes to improve predictive capability. Additionally, incorporating advanced ultrasound imaging technologies, such as three-dimensional ultrasound and elastography, may enhance the accuracy of uterine scar integrity assessment. Third, external validation of the 1.68 mm cutoff in diverse populations is warranted.

Conclusion

In summary, lower uterine anterior wall thickness (LUAWT), the suturing method of previous cesarean incisions, and the pregnancy interval are key factors influencing uterine rupture in pregnant women with a scarred uterus undergoing repeat delivery. Transabdominal ultrasound measurement of LUAWT demonstrates standalone predictive ability (AUC = 0.821, 95% CI: 0.756–0.884), but combining it with additional clinical variables—such as suture type and interpregnancy interval—yields significantly greater predictive accuracy (combined AUC = 0.894, 95% CI: 0.837–0.946). Based on these findings, we propose a clinical risk stratification approach that allows for early identification of high-risk patients to guide individualized delivery planning, including decisions around elective cesarean versus trial of labor after cesarean (TOLAC). Future research should focus on external validation of this multifactorial model across larger and more diverse populations, and on its integration into clinical decision-support tools. These efforts will enhance the precision of uterine rupture risk prediction, improve maternal and neonatal outcomes, and support more tailored obstetric care strategies.

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Disclosure

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