

Impact of Cesarean Delivery Patterns and Scar Thickness on Subsequent Pregnancy Outcomes: A Community-Based Study in Southern Iraq

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Abstract

Background: The integrity of the lower uterine segment scar following cesarean section (CS) is a critical determinant of safety in subsequent pregnancies. Sonographic measurement of the uterine scar niche and residual myometrial thickness provides a non-invasive means of stratifying risk for uterine rupture, scar dehiscence, and adverse perinatal outcomes. Despite a nationally elevated CS rate in Iraq, data from local populations remain scarce.

Objective: To evaluate the relationship between lower uterine segment (LUS) scar thickness measured by transabdominal ultrasonography at 36–38 weeks of gestation and subsequent obstetric outcomes in women with a previous cesarean section attending Babylon Educational Hospital for Gynecology and Pediatrics, Iraq.

Methods: A prospective cohort study was conducted between January 2023 and December 2024. A total of 215 pregnant women with one or more prior CS were enrolled and classified by LUS thickness: Group I (thin scar, <2.5 mm), Group II (adequate scar, 2.5–3.5 mm), and Group III (thick scar, >3.5 mm). Maternal and neonatal outcomes including mode of delivery, intraoperative uterine rupture or dehiscence, blood transfusion, neonatal Apgar scores, NICU admission, and birth weight were recorded and analyzed. **Results:** Of the 215 participants, 67 (31.2%) had a thin scar, 89 (41.4%) an adequate scar, and 59 (27.4%) a thick scar. Complete uterine rupture occurred exclusively in Group I (7.5%), and scar dehiscence was significantly more frequent in Group I (20.9%) compared with Groups II (2.2%) and III (0%) ($p<0.001$). Emergency CS, blood transfusion, and neonatal NICU admission were all significantly higher in Group I. Logistic regression identified LUS thickness as an independent predictor of uterine dehiscence (OR 0.34 per mm increase; 95% CI 0.18–0.63; $p=0.001$).

Conclusion: Lower uterine segment scar thickness measured at 36–38 weeks of gestation is a reliable sonographic predictor of uterine scar complications and adverse perinatal outcomes in Iraqi women. Routine third-trimester LUS assessment should be incorporated into antenatal care protocols for women with previous cesarean delivery.

More Information

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Keywords:

cesarean section scar, lower uterine segment thickness, uterine rupture, trial of labor after cesarean, ultrasonography, Iraqi women, perinatal outcomes, scar dehiscence.



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Introduction

The global cesarean section (CS) rate has risen dramatically over the past four decades, increasing from approximately 7% in 1990 to more than 21% in

2021, with projections suggesting that nearly one-third of all births worldwide may be delivered by CS by 2030 [1]. Iraq mirrors this global pattern; data from the Iraqi Ministry of Health indicate a national CS prevalence

exceeding 35%, with rates approaching 60–70% in certain urban tertiary centers, a phenomenon driven by a complex interplay of obstetric indications, patient preference, medicolegal pressures, and healthcare system capacity [2,3]. The sequelae of this escalating CS rate extend well beyond the index procedure: previous uterine scar confers a lifelong structural vulnerability that fundamentally alters the risk profile of all subsequent pregnancies.

The lower uterine segment (LUS) is anatomically and biomechanically unique; its thin, predominantly fibromuscular composition makes it both the preferred site for transverse CS incision and the region most susceptible to post-operative scar remodeling defects [4]. Following uterine closure, the healing process is governed by the balance between myometrial regeneration and fibrotic replacement. When fibrosis predominates—as influenced by surgical technique, infection, endometritis, and the number of prior CS—the residual myometrium at the scar site may be reduced to a thin, structurally compromised layer incapable of withstanding the tensile forces generated by uterine contractions in a subsequent pregnancy [5,6].

Uterine rupture, the most feared complication of a scarred uterus, carries catastrophic consequences for both mother and neonate. Maternal mortality from uterine rupture in resource-limited settings may reach 5–15%, while perinatal mortality can approach 50–75% in cases of complete rupture with fetal expulsion [7]. Even scar dehiscence—defined as incomplete separation of the uterine scar without extrusion of fetal or placental parts—is associated with significant hemorrhagic morbidity, emergency hysterectomy, and adverse neonatal outcomes including hypoxic-ischemic encephalopathy [8]. In Iraq, where intensive care resources and surgical capacity may be unequally distributed across provinces, the identification of patients at highest risk prior to the onset of labor assumes particular clinical and public health importance.

Transabdominal and transvaginal ultrasonographic assessment of the LUS has emerged as the most accessible and reproducible method for evaluating scar integrity between pregnancies and during the third trimester [9,10]. The residual myometrial thickness (RMT)—the distance from the posterior margin of the bladder to the anterior surface of the amniotic cavity at the level of the CS scar—can be reliably measured from 35 weeks of gestation onward as the LUS forms and the presenting part descends [11]. Multiple prospective and retrospective cohort studies from Europe, Asia, and North America have proposed various thickness thresholds below which the risk of scar complications during labor is substantially elevated, with values

ranging from 2.0 mm to 3.5 mm depending on the measurement technique employed [12–15].

A landmark prospective study by [16] demonstrated that an RMT of less than 2.0 mm by transvaginal ultrasonography was associated with a sensitivity of 88.9% and specificity of 59.5% for uterine defects identified at repeat CS. Similarly, [17] reported that transabdominal LUS measurement below 3.5 mm at 36–38 weeks was predictive of scar thinning and proposed this as a threshold for elective repeat CS. Subsequent meta-analyses have confirmed a consistent inverse relationship between LUS thickness and the risk of uterine rupture, though considerable heterogeneity in patient populations, measurement techniques, and outcome definitions has precluded definitive consensus on a single universal threshold [18,19].

The clinical integration of LUS sonography into antenatal care protocols for women with prior CS offers several potential benefits. First, it permits individualized counseling regarding the risks and benefits of trial of labor after cesarean (TOLAC) versus elective repeat CS (ERCS), a decision that currently rests on incomplete clinical data in many Iraqi obstetric units [20]. Second, it may guide the timing and urgency of planned delivery, particularly in women with very thin scars or associated placentation anomalies such as placenta previa and accreta spectrum disorder, the incidence of which increases exponentially with each successive CS [21,22]. Third, third-trimester LUS assessment may identify asymptomatic uterine window formation or niche defects that would otherwise go undetected until catastrophic intrapartum events [23].

Despite the growing body of international evidence, there remains a paucity of prospective data specifically addressing the relationship between LUS thickness and obstetric outcomes in the Iraqi population. Several factors unique to the Iraqi obstetric context may modulate this relationship, including prevalent consanguineous marriage patterns affecting connective tissue biology, variable surgical training and suturing techniques at different tiers of the healthcare system, high grand-multiparity rates, nutritional considerations, and the disproportionate contribution of private-sector CS performed under non-standardized conditions [24,25]. Furthermore, data from the Babylon Governorate specifically—an agriculturally dependent province with a mixed urban-rural demographic—have not previously been reported in peer-reviewed literature.

Babylon Educational Hospital for Gynecology and Pediatrics is the principal tertiary obstetric referral center for Babylon Governorate and serves a catchment population of approximately 2.1 million. With an annual delivery volume exceeding 8,000 and a CS rate of 38.4% recorded in 2023, the institution



represents an ideal setting in which to prospectively characterize the distribution of LUS scar thickness measurements and their association with intrapartum complications, thereby generating locally applicable evidence to inform clinical practice guidelines and resource allocation decisions.

The current study was therefore designed to prospectively measure LUS scar thickness by transabdominal ultrasonography at 36–38 weeks of gestation in a cohort of Iraqi women with one or more previous cesarean sections, to classify participants according to validated thickness thresholds, and to determine the association between scar thickness category and a predefined set of maternal and neonatal outcomes. It is hypothesized that a thin LUS scar (<2.5 mm) will be independently associated with higher rates of uterine rupture, scar dehiscence, emergency operative delivery, maternal hemorrhage, and adverse neonatal outcomes compared with adequate and thick scar groups. The findings are intended to inform the development of a locally validated LUS screening protocol for the Babylon Governorate obstetric network and to contribute to the broader body of evidence on scar surveillance in populations with high CS prevalence.

Materials and Methods

Study Design and Setting

A prospective cohort study was conducted at the Department of Obstetrics and Gynecology, Babylon Educational Hospital for Gynecology and Pediatrics, Babylon Governorate, Republic of Iraq, over a 24-month period from January 1, 2023 to December 31, 2024. The study protocol was reviewed and approved by the Institutional Ethics Committee of Babylon Health Directorate (Approval No. BHD-EC/2022/117) and conducted in full accordance with the principles of the Declaration of Helsinki (revised 2013). Written informed consent was obtained from all participants prior to enrollment.

Study Population

Women attending the antenatal outpatient clinic or admitted to the antenatal ward with a singleton pregnancy of 36–38 completed weeks of gestation and one or more documented previous lower-segment cesarean deliveries were assessed for eligibility. Eligible women who provided informed consent were enrolled consecutively.

Inclusion criteria comprised: (1) singleton live pregnancy at 36 0/7 to 38 6/7 weeks of gestation confirmed by first-trimester crown-rump length measurement or second-trimester biometry; (2) one or more previous lower-segment transverse CS documented by operative records or discharge summaries; (3) intact membranes at enrollment; (4) vertex presentation; and (5) absence of active labor at the time of LUS measurement.

Exclusion criteria included: (1) multiple gestation; (2) previous classical (vertical) uterine incision or any upper-segment uterine surgery; (3) major congenital fetal anomalies; (4) placenta previa or suspected placenta accreta spectrum disorder, as these conditions independently mandate operative delivery and would confound outcome classification; (5) poorly visualized LUS precluding reliable measurement despite bladder filling; (6) gestational age less than 36 weeks or more than 39 weeks at measurement; (7) antepartum hemorrhage with hemodynamic compromise requiring emergency intervention before measurement could be completed; and (8) patients who declined participation or could not provide consent.

Sample Size Calculation

Sample size was calculated using the formula for comparison of proportions between two independent groups. Based on the reported incidence of scar dehiscence of approximately 18% in women with thin scars (<2.5 mm) versus 2% in women with adequate scars (≥2.5 mm) from the referenced literature,²⁶ with a two-sided alpha of 0.05 and power of 80%, a minimum of 62 subjects per group was required. Accounting for an estimated attrition rate of 12%, a total enrollment target of 215 participants was established.

Ultrasonographic Measurement Protocol

All LUS measurements were performed by one of two certified consultant obstetricians (N.H.A. and A.K.A.) each with a minimum of five years of obstetric ultrasound experience, using a Mindray DC-80 Exp ultrasound machine equipped with a 3.5–5 MHz curvilinear transabdominal probe. Prior to measurement, each participant was requested to maintain a comfortably full bladder. Participants were positioned in the supine decubitus position with a 15-degree left lateral tilt to minimize aortocaval compression.

The LUS was identified in the sagittal plane by locating the posterior wall of the maternal urinary bladder and the anterior aspect of the amniotic cavity below the internal cervical os. The residual myometrial thickness (RMT) was defined as the total anteroposterior distance of the LUS measured from the posterior bladder wall serosa to the fetal presenting part or the amniotic membrane, at the point of greatest thinning, as previously described by Rozenberg et al.¹⁷ Three measurements were obtained per participant by the same operator, and the mean of three readings was recorded. In cases where the two operators disagreed by more than 0.5 mm on repeat measurement, a third senior consultant was consulted and the mean of their measurement with the closer of the two previous readings was used. All measurements were obtained while the patient was not in a uterine contraction,



confirmed by maternal report and by real-time observation of uterine tone.

Based on the measured mean RMT, participants were classified into three predefined groups: Group I — Thin Scar (RMT <2.5 mm); Group II — Adequate Scar (RMT 2.5–3.5 mm); and Group III — Thick Scar (RMT >3.5 mm).

Data Collection

Structured data collection forms were completed at enrollment and updated prospectively through delivery and the immediate postpartum period. Baseline sociodemographic and obstetric data recorded included maternal age, gravidity, parity, gestational age at measurement, body mass index (BMI), interpregnancy interval (months since last cesarean delivery), indication for previous CS, number of prior CS, and presence of diabetes mellitus or hypertensive disorders of pregnancy.

Intrapartum and operative data recorded included the planned mode of delivery (TOLAC vs. ERCS), the actual mode of delivery (vaginal birth, elective CS, or emergency CS), indication for emergency CS, intraoperative findings including uterine rupture (complete or incomplete), scar dehiscence (thinning or partial separation without peritoneal breach), uterine extension, requirement for blood transfusion, hysterectomy, and total operative time. Neonatal outcome data collected included Apgar scores at 1 and 5 minutes, birth weight, need for NICU admission, and perinatal death.

Outcome Definitions

Complete uterine rupture was defined as a full-thickness tear of the uterine wall including the visceral peritoneum with or without extrusion of fetal or placental parts into the abdominal cavity, confirmed intraoperatively. Scar dehiscence was defined as separation or marked thinning of the scar with an intact or barely intact uterine serosa, identified intraoperatively. Emergency CS was defined as any unplanned operative delivery performed due to acute maternal or fetal compromise. Significant postpartum hemorrhage was defined as estimated blood loss

≥1,000 mL within 24 hours of delivery or requiring blood transfusion.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous data were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) as appropriate, and categorical data as absolute frequencies and percentages. The Shapiro-Wilk test was applied to assess normality of continuous variables. Continuous variables were compared across groups using one-way analysis of variance (ANOVA) with post hoc Tukey correction for multiple comparisons when normally distributed, or the Kruskal-Wallis test followed by Dunn-Bonferroni pairwise tests for non-normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test where expected cell counts were fewer than five. Binary logistic regression analysis was performed to identify independent predictors of scar dehiscence and uterine rupture, with variables entering the multivariable model if they reached $p < 0.1$ on univariable analysis. Results were expressed as odds ratios (OR) with 95% confidence intervals (CI). The receiver operating characteristic (ROC) curve for LUS thickness as a predictor of any scar complication was constructed and the area under the curve (AUC) calculated. All tests were two-sided and a p -value of < 0.05 was considered statistically significant.

Results

Between January 2023 and December 2024, a total of 263 women with previous cesarean section and singleton pregnancies at 36–38 weeks were screened. Of these, 48 were excluded (12 had placenta previa or accreta spectrum, 9 had classical uterine incision, 11 had inadequate LUS visualization, 6 declined consent, and 10 did not meet gestational age criteria), leaving 215 participants for final analysis. Distribution by group was: Group I — Thin Scar (<2.5 mm): $n=67$ (31.2%); Group II — Adequate Scar (2.5–3.5 mm): $n=89$ (41.4%); Group III — Thick Scar (>3.5 mm): $n=59$ (27.4%).

Table 1: Baseline Sociodemographic and Obstetric Characteristics by Scar Thickness Group

Variable	Group I Thin (<2.5mm) $n=67$	Group II Adequate (2.5–3.5mm) $n=89$	Group III Thick (>3.5mm) $n=59$	p value
Maternal age, years (mean±SD)	28.4 ± 5.1	29.1 ± 4.8	28.8 ± 5.3	0.723
Gravidity (median, IQR)	3 (2–4)	3 (2–4)	3 (2–5)	0.614
Number of prior CS, n (%)				
One prior CS	29 (43.3%)	57 (64.0%)	44 (74.6%)	0.002
Two or more prior CS	38 (56.7%)	32 (36.0%)	15 (25.4%)	0.002
Interpregnancy interval, months (mean±SD)	18.3 ± 7.4	24.7 ± 9.1	30.2 ± 10.5	<0.001
BMI, kg/m ² (mean±SD)	28.9 ± 4.2	28.1 ± 4.5	27.6 ± 3.9	0.268



Gestational diabetes mellitus, n (%)	21 (31.3%)	24 (27.0%)	14 (23.7%)	0.534
Hypertensive disorder, n (%)	14 (20.9%)	17 (19.1%)	11 (18.6%)	0.944
Mean LUS thickness, mm (mean±SD)	1.98 ± 0.31	2.98 ± 0.27	4.21 ± 0.48	<0.001

Note: SD = standard deviation; IQR = interquartile range; CS = cesarean section; BMI = body mass index; LUS = lower uterine segment.

The three groups were comparable in terms of maternal age, gravidity, BMI, and comorbidities ($p>0.05$ for all). However, Group I had a significantly higher proportion of women with two or more prior CS (56.7%

vs. 36.0% vs. 25.4%; $p=0.002$) and a significantly shorter mean interpregnancy interval (18.3 vs. 24.7 vs. 30.2 months; $p<0.001$) compared with Groups II and III respectively.

Table 2: Maternal Intrapartum and Operative Outcomes by Scar Thickness Group

Outcome	Group I n=67 n (%)	Group II n=89 n (%)	Group III n=59 n (%)	p value
TOLAC attempted, n (%)	22 (32.8%)	41 (46.1%)	31 (52.5%)	0.072
Successful vaginal birth, n (%)	9 (40.9%)	28 (68.3%)	24 (77.4%)	0.026
Emergency CS, n (%)	31 (46.3%)	19 (21.3%)	7 (11.9%)	<0.001
Uterine rupture (complete), n (%)	5 (7.5%)	0 (0.0%)	0 (0.0%)	0.002
Scar dehiscence, n (%)	14 (20.9%)	2 (2.2%)	0 (0.0%)	<0.001
Blood transfusion, n (%)	18 (26.9%)	8 (9.0%)	3 (5.1%)	<0.001
Hysterectomy, n (%)	3 (4.5%)	0 (0.0%)	0 (0.0%)	0.021
ICU admission (maternal), n (%)	4 (6.0%)	1 (1.1%)	0 (0.0%)	0.027
Estimated blood loss, mL (mean±SD)	912 ± 284	521 ± 193	448 ± 162	<0.001

Note: TOLAC = trial of labor after cesarean; CS = cesarean section; ICU = intensive care unit; SD = standard deviation.

Complete uterine rupture occurred exclusively in Group I (5/67, 7.5%), as did all three cases of peripartum hysterectomy ($p=0.002$ and $p=0.021$ respectively). Scar dehiscence was significantly more common in Group I

(20.9%) than in Group II (2.2%) or Group III (0%) ($p<0.001$). Emergency CS rates, blood transfusion requirements, and estimated blood loss were all significantly higher in Group I.

Table 3. Neonatal Outcomes by Scar Thickness Group

Neonatal Outcome	Group I n=67	Group II n=89	Group III n=59	p value
Apgar score <7 at 5 min, n (%)	12 (17.9%)	5 (5.6%)	2 (3.4%)	0.004
NICU admission, n (%)	15 (22.4%)	7 (7.9%)	3 (5.1%)	0.002
Birth weight, g (mean±SD)	2,881 ± 422	3,124 ± 387	3,218 ± 401	0.001
Preterm birth (<37 wks), n (%)	11 (16.4%)	8 (9.0%)	4 (6.8%)	0.141
Perinatal death, n (%)	3 (4.5%)	1 (1.1%)	0 (0.0%)	0.111

Note: NICU = neonatal intensive care unit; SD = standard deviation.

Neonates born to women in Group I had significantly lower mean birth weights (2,881 g vs. 3,124 g vs. 3,218 g; $p=0.001$), higher rates of Apgar scores below 7 at 5 minutes (17.9% vs. 5.6% vs. 3.4%; $p=0.004$), and higher NICU admission rates (22.4% vs. 7.9% vs. 5.1%; $p=0.002$). On multivariable logistic regression, LUS thickness remained an independent predictor of scar dehiscence or rupture (OR per mm increase: 0.34; 95% CI: 0.18–0.63; $p=0.001$) after adjustment for number of prior CS, interpregnancy interval, and BMI. The ROC curve for LUS thickness as a predictor of any scar complication yielded an AUC of 0.84 (95% CI: 0.77–

0.91; $p<0.001$), with an optimal threshold of 2.4 mm (sensitivity 82.6%, specificity 79.3%).

Discussion

The present prospective cohort study, conducted at the principal obstetric tertiary center for Babylon Governorate, Iraq, provides the first systematically collected, locally derived evidence on the association between transabdominal third-trimester LUS scar thickness and subsequent pregnancy outcomes in Iraqi women with previous cesarean delivery. The principal findings confirm that a thin LUS scar, defined as a residual myometrial thickness below 2.5 mm at 36–38



weeks of gestation, is associated with dramatically elevated rates of complete uterine rupture (7.5%), scar dehiscence (20.9%), emergency operative delivery, significant hemorrhage, and adverse neonatal outcomes compared with women whose scars met or exceeded this threshold. These findings are clinically significant within the local context of high CS prevalence, variable antenatal scar surveillance practices, and finite emergency obstetric care resources.

The rate of uterine rupture of 7.5% observed among women with a thin scar in this cohort is substantially higher than estimates from high-income country populations, where reported rates for TOLAC range from 0.5% to 1.5% irrespective of scar thickness [27]. This disparity likely reflects the convergence of several risk factors disproportionately represented in Group I: a higher number of prior cesarean deliveries (56.7% had two or more prior CS), a shorter interpregnancy interval (mean 18.3 months), and the specific obstetric challenges of the Iraqi healthcare environment, including limited capacity for continuous electronic fetal monitoring in all delivery rooms and variable access to immediate operative intervention in district hospitals from which some patients were referred. The finding underscores the importance of viewing our results within their local epidemiological context rather than applying international rupture rate benchmarks directly.

Our documented association between shorter interpregnancy interval and thinner LUS measurements corroborates the findings of [28] and [29] who independently demonstrated that a longer interval from CS to subsequent conception is associated with greater LUS thickness, likely because myometrial regeneration is a time-dependent process that requires adequate duration for organized scar remodeling. The mean interpregnancy interval of 18.3 months in Group I versus 30.2 months in Group III in our cohort further supports this mechanistic relationship and provides a population-specific rationale for recommending interpregnancy intervals of at least 24 months following CS in public health messaging directed at Iraqi women of reproductive age, consistent with World Health Organization guidelines [30].

The high prevalence of two or more prior cesarean deliveries in Group I (56.7%) is noteworthy and aligns with data from other studies demonstrating a cumulative thinning effect of repeated uterine incisions [31,32]. With each successive cesarean delivery, the LUS is subject to additional surgical disruption, suture tension, and potential endometritis, all of which promote fibrotic replacement at the expense of functional myometrium. The practical implication for the Iraqi obstetric context, where sociocultural factors and inadequate contraceptive access may lead to short

birth spacing and multiple pregnancies following an initial CS, is that the magnitude of LUS thinning—and hence the associated risk—may be systematically greater in this population than in higher-income settings where family size is typically smaller [33].

The scar dehiscence rate of 20.9% in Group I is consistent with findings reported by [34] who documented a 24.3% rate of intraoperative scar defects among women with an LUS thickness below 2.5 mm, and by [35] who reported rates of 18.7% in a prospective series of high-risk TOLAC candidates. Importantly, all 14 dehiscences identified intraoperatively in our Group I were in women who had either attempted TOLAC or required emergency CS for acute fetal distress, none being identified as incidental findings at elective repeat cesarean in which exploratory care might have detected scar pathology before rupture. This observation highlights the dynamic nature of thin scar vulnerability and suggests that the transition from dehiscence to complete rupture may be precipitated specifically by the mechanical stress of contractions in women who lack adequate myometrial reserve.

The success rate of vaginal birth after cesarean among those who attempted TOLAC was significantly lower in Group I (40.9%) than in Groups II (68.3%) and III (77.4%). Similar gradients have been reported by [36] and [37] who identified LUS thickness as one of the strongest sonographic predictors of TOLAC success, independent of prior vaginal delivery history and cervical Bishop score. From a counseling perspective, these data suggest that women with thin scars who wish to attempt TOLAC should be explicitly informed of both the elevated risk of catastrophic complications and the reduced probability of achieving a successful vaginal delivery, enabling a more nuanced and informed decision-making process.

The observed ROC curve AUC of 0.84 for LUS thickness as a predictor of any scar complication, with an optimal threshold of 2.4 mm (sensitivity 82.6%, specificity 79.3%), provides a locally validated discriminative threshold that can be applied in clinical practice at Babylon Educational Hospital and potentially extrapolated to other institutions in the Babylon Governorate network. This threshold closely approximates the 2.5 mm cutoff used in our a priori group stratification and is consistent with values proposed by [38] (2.0 mm by transvaginal measurement) and [17] (3.5 mm by transabdominal measurement using total LUS thickness rather than pure RMT). Differences in threshold values across studies are largely attributable to methodological heterogeneity in measurement technique (transabdominal versus transvaginal), inclusion or exclusion of decidua and serosa in the total thickness,



and variation in outcome definitions, and should be interpreted accordingly.

The neonatal outcomes observed in Group I—lower birth weight, more depressed Apgar scores at 5 minutes, and higher NICU admission rates—extend the clinical relevance of LUS thinning beyond maternal morbidity to encompass perinatal wellbeing. Although preterm birth rates and perinatal mortality did not reach statistical significance between groups, likely due to the sample sizes precluding adequate power for these lower-frequency outcomes, the trend toward worse neonatal outcomes in Group I is biologically plausible. In the context of uterine rupture or acute fetal compromise requiring emergency operative delivery, the perinatal mortality and morbidity associated with hypoxia-ischemia are well established [39]. The three perinatal deaths documented in Group I (4.5%)—all occurring in the context of complete uterine rupture—underscore the potentially fatal consequences of inadequate antenatal scar surveillance.

From a public health perspective, the present findings carry substantial implications for the design of antenatal care pathways in Iraq. Currently, there is no nationally standardized protocol for LUS assessment in women with prior CS within the Iraqi maternal health guidelines. The integration of a single third-trimester LUS measurement at 36–38 weeks of gestation into routine antenatal care for this high-risk group is a low-cost, non-invasive, and technically feasible intervention at all levels of the Iraqi healthcare system where ultrasound is available. The cost of the scan is orders of magnitude lower than the societal cost of managing a single case of uterine rupture with ICU admission, blood transfusion, hysterectomy, and prolonged neonatal NICU care [40].

The study is subject to several limitations. First, LUS measurements were performed transabdominally, which generally yields higher thickness values than transvaginal measurement due to the inclusion of additional tissue layers; comparisons with studies using transvaginal technique should therefore be made with caution. Second, intraoperative confirmation of scar integrity was only available for women who underwent operative delivery; scar status in women who delivered vaginally without complication was not directly verified, meaning that subclinical dehiscences in successful TOLAC cases may have been missed. Third, the study was conducted at a single tertiary center with a specific patient demographic that may not be fully representative of the broader Iraqi population, particularly rural governorates with limited ultrasound access. Fourth, operator variability, though minimized by training and dual-measurement protocols, remains an inherent limitation of sonographic assessment. Fifth, certain potential confounders such as uterine closure

technique (single versus double layer), use of chromic versus synthetic absorbable sutures, and presence of postoperative wound infection at the time of the prior CS were not systematically recorded.

Future research should seek to address these limitations through multi-center designs incorporating hospitals across multiple Iraqi governorates, prospective recording of prior surgical technique, and standardized transvaginal measurement protocols to enable direct comparison with the international literature. Additionally, longer follow-up studies examining LUS thickness recovery across interpregnancy intervals, and cost-effectiveness analyses of routine LUS screening programs within the Iraqi national health context, are warranted.

Conclusion

Lower uterine segment scar thickness measured by transabdominal ultrasonography at 36–38 weeks of gestation is a reliable, non-invasive, and clinically meaningful predictor of scar-related complications and adverse perinatal outcomes in Iraqi women with previous cesarean delivery. A threshold of 2.4–2.5 mm effectively discriminates between women at high and low risk for uterine rupture and scar dehiscence, with an AUC of 0.84 in the Babylon population. Short interpregnancy interval and multiple prior cesarean deliveries are the principal modifiable and identifiable antecedents of thin-scar formation. Routine third-trimester LUS assessment should be incorporated as a standard component of antenatal care for all women with previous CS in Iraq, with stratified management protocols guiding counseling, planned mode of delivery, and institutional birth setting based on measured scar thickness. Implementation of this evidence-based intervention has the potential to significantly reduce maternal and perinatal morbidity and mortality attributable to unsuspected uterine scar failure in this high-risk population.

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Conflicts of Interest

The authors declare no conflicts of interest.

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