Transvaginal Sonographic Assessment of Previous Cesarean Section Scar in Late Pregnancy in correlation with Intra operative Scar condition

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Abstract

Background: Cesarean section (CS) rates have risen significantly over the past decades, exceeding 29% in some regions. The rate of CS in Egypt is very high, with recent studies and reports indicating a rate of over 50% and even reaching 72.2%. This makes Egypt one of the countries with the highest CS rates globally, particularly when compared to WHO recommendations and other countries in the region. Accurate assessment of the uterine scar is essential for selecting candidates for VBAC.

Objectives: This study investigates the role of transvaginal sonography (TVS) in evaluating lower uterine segment (LUS) thickness in late pregnancy and its correlation with intraoperative scar findings.

Patients and methods: TVS was performed due to its superior resolution and proximity to the cesarean scar. LUS thickness was measured from the bladder wall (muscularis and mucosa) to the chorioamniotic membrane, including the myometrium.

Results: All cases with thick LUS were classified intraoperatively as Class I. Among thin LUS cases, 41.9% were Class II, and 6.5% were Class IV. A significant association was found between the number of previous CS and scar classification. At a cut-off of 4.5 mm, TVS showed 100% specificity and positive predictive value, with 66.7% sensitivity and 61.3% negative predictive value.

Conclusion: TVS-measured LUS thickness correlates with intraoperative scar quality. At a 4.5 mm threshold, TVS is a specific tool for identifying well-formed scars and can aid in selecting candidates for a trial of labor after cesarean.

Keywords: Cesarean section scar; Scar dehiscence; Trial of labor after cesarean (TOLAC); Uterine rupture; Vaginal birth after cesarean (VBAC).

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Introduction

In recent years, global cesarean section (CS) rates have significantly increased. The rate has risen from around 7% in 1990 to 21.1% in 2018, with projections indicating a continued upward trend, reaching an estimated 28.5% by 2030 **(WHO, 2021).** In Egypt, CS rates are among the highest worldwide, with the 2021 Demographic and Health Survey reporting a prevalence of approximately 59% of all births **(Egypt DHS, 2021).** Research suggests that labor following a previous CS may carry serious risks, including uterine rupture and fetal mortality **(WHO, 2021).**

Trial of labor after cesarean (TOLAC) has been identified as a safe and effective strategy to reduce repeat CS rates. The success of vaginal birth after cesarean (VBAC) is significantly higher in cases where the initial cesarean was due to non-recurring indications such as breech presentation or fetal distress, as opposed to recurrent causes like cephalopelvic disproportion (CPD). The history of previous vaginal delivery, especially following a CS, is also a strong predictor of successful VBAC outcomes **(Trojano et al., 2019)**.

Transvaginal ultrasonography (TVS) has emerged as a valuable diagnostic tool for evaluating the risk of intrapartum uterine rupture in women with a prior CS. TVS assessment of the lower uterine segment (LUS) enhances obstetric decision-making regarding the feasibility of a trial of labor in these patients **(Rozenberg et al., 2018)**.

Sonographically, uterine scars may present in one of three patterns: a dense, echogenic area; a fluid-filled space anterior to the scar, located between the bladder and uterus; or a sonolucent area at the scar site, between the external surface of the LUS and the uterine lumen **(Mansour et al., 2015)**.

The LUS typically appears as a two-layered structure on ultrasound, consisting of the echogenic visceral-parietal reflection (comprising the muscularis and mucosa of the bladder) and the hypoechoic myometrium. In late pregnancy, the decidualized endometrium and chorioamniotic membrane usually blend with the myometrial layer, especially in vertex presentations where the fetal part rests directly on the LUS, obscuring amniotic fluid between the layers **(McLeish et al., 2023)**.

Some studies, however, advocate for a three-layered approach when measuring LUS thickness from the bladder's muscularis and mucosa (outer layer) to the inner chorioamniotic membrane based on this sonographic distinction **(Sen et al., 2004)**.

The current study aimed to evaluate the effectiveness of transvaginal ultrasonography in measuring lower uterine segment (LUS) thickness in women with a previous cesarean section in late pregnancy, and to correlate sonographic findings with intraoperative assessment of the uterine scar.

Patients and methods

This cross-sectional study was conducted on 120 pregnant women with a history of one or more previous cesarean sections. All participants were healthy, carrying singleton pregnancies at a gestational age beyond 36 weeks, with the fetus in cephalic presentation.

A standardized grading system by **Gaughran et al. (2024)** was used intraoperatively to classify the condition of the cesarean scar: Grade 1: Fully formed lower uterine segment, Grade 2: Thin lower segment with no visible contents, Grade 3: Translucent area with visible fetal parts or membranes, and Grade 4: Clear defect or dehiscence in the uterine wall.

Inclusion criteria comprised pregnant women who met the above conditions and had a prior cesarean section. Exclusion criteria included women with a history of

uterine rupture repair, prior puerperal sepsis, postpartum hemorrhage requiring blood transfusion, placenta previa or placenta accreta, and those with corporal or cervical fibroids.

Ethical approval: This study was conducted following the ethical standards of the institutional research committee and in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Faculty of Medicine, Benha University Research Ethics Committee under approval number (RC: 8-4-2024). Written informed consent was obtained from all participants prior to enrollment.

All women enrolled underwent a thorough evaluation starting with a detailed medical and obstetric history, followed by a full clinical examination. Abdominal ultrasound was performed to assess fetal gestational age, lie, and presentation, as well as placental location, particularly in relation to the previous cesarean scar. Additionally, the uterine scar was evaluated during this assessment.

Transvaginal ultrasonography was performed for each patient to measure the thickness of the LUS. The LUS was visualized in sagittal sections in both the midline and lateral planes. Measurements were taken from the outer bladder wall, including the muscularis and mucosa, to the inner chorioamniotic membrane, encompassing the intervening myometrial layer. Examinations were conducted with the bladder partially filled to optimize visualization. Some patients were in active labor at the time of measurement.

Scar evaluation was carried out either intraoperatively during cesarean delivery or, in cases of vaginal birth, through examination under general anesthesia. For women who underwent successful VBAC, scar integrity was assessed via digital vaginal examination in the lithotomy position. Typically, a fine ridge or furrow could be palpated along the scar line, and any deficiency in its continuity was easily detectable.

The measurement of CS scar thickness is often done by a single observer, but studies show that inter-observer agreement (agreement between different observers) is also important for reliable measurements. While a single observer can provide consistent measurements, especially when using standardized techniques, involving multiple observers helps to assess the reproducibility of the measurements and identify potential biases.

Sample size justification

Sample size was calculated using PASS program, setting the type-1 error (α) at 5%. Results from previous study **(Bassiony et al., 2024)** showed that the transvaginal sonographic measurements of caesarean section scar thickness for detection of dehiscence (Grade II, III and IV) had a sensitivity of 75% and specificity equal to 88.9%. Based on these values, a total sample size of 98 cases achieves 95% power to detect a change in sensitivity from 50% to 75% and to detect a change in specificity from 50% to 88.9% using a two-sided binomial test. However, the study included 120 cases to compensate for dropouts.

Statistical analysis

Data were analyzed using SPSS version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics summarized quantitative data as means ± standard deviation and categorical data as frequencies and percentages. The Chi-square test and Fisher exact tests assessed associations between categorical variables. Receiver Operating Characteristic (ROC) curve analysis was used to evaluate the predictive value of lower uterine segment thickness. A p-value < 0.05 was considered statistically significant.

Results

The mean thickness of LUS was 4.8 ± 1.6 with cut-off value at 4.5 mm according to ROC curve in which 51.7% of included women had thin LUS (< 4.5 mm) and 48.3% had thick LUS (≥ 4.5) (**Table .1**).

Table 1. Sonographic assessment of LUS thickness at cut-off value of 4.5 mm

Mean lower uterine segment thickness (mm)	**n = 120**
Mean ± SD	4.8 ± 1.6
Range	2-9.2
Thin LUS < 4.5	62 (51.7%)
Thick LUS ≥ 4.5	58 (48.3%)

Cases with thin LUS had significantly higher parity and higher number of previous CS than case of thick LUS, while no cases reported of Normal Vaginal Delivery (NVD) before and after CS in cases with thin LUS (**Table .2**).

Table 2. Comparison of demographic characteristics between cases with thin LUS and with thick LUS

Variables	**Thin (< 4.5) (n = 62)**	**Thick (≥ 4.5) (n = 58)**	**t***	**p**
Age				
Mean ± SD	29.7 ± 4.6	28.5 ± 4	1.5	0.12 (NS)
Range	22-39	20-37		
Gestational age at examination				
Mean ± SD	38.4 ± 1.4	38.5 ± 1.1	0.41	0.67 (NS)
Range	36-40	37-40		
Parity				
One parity	18 (29%)	34 (58.6%)	X2 = 10.68**	0.001 (HS)
> One parity	44 (71%)	24 (41.4%)		
NVD				
Before CS	0 (0%)	8 (13.8%)	FE†	0.002 (HS)
After CS	0 (0%)	2 (3.8%)	FE†	0.232 (NS)
Number of previous CS				
One CS	18 (29%)	42 (72.4%)	X2=22.5**	< 0.001 (HS)
> One CS	44 (71%)	16 (27.6%)		

*Student t test - **Chi square test - †Fisher exact test

There is significant association between thickness of LUS and mode of delivery in which 100% of thin LUS and 82.8% of thick LUS delivered by RECS (p < 0.05). While there is no significant difference between LUS thickness and fetal outcome (**Table.3**).

Table 3. Comparison between cases with thin LUS and cases with thick LUS as regard mode of delivery and fetal outcome

Variables	Total	Thin LUS (< 4.5) (n = 62)	Thick LUS (≥ 4.5) (n = 58)	Test statistic	p
Mode of delivery					
VBAC	10 (8.3%)	0 (0%)	10 (17.2%)	FE†	< 0.001 (HS)
RECS	110 (91.7%)	62 (100%)	48 (82.8%)		
Fetal outcome					
GA at delivery	38.4 ± 1.4 (36-41)	38.5 ± 1.37 (36-40)	38.7 ± 1.1 (37-41)	t = 1.35**	0.17 (NS)
Birth weight at delivery (gm)	3.08 ± 0.6 (2.4-4.5)	3 ± 0.6 (2.4-4.5)	3.1 ± 0.6 (2.2-4)	t = 1.2**	0.2 (NS)
Apgar score at 5 minutes					
≥ 7	110 (91.7%)	54 (45%)	56 (45.7%)	FE†	0.097 (NS)
< 7	10 (8.3%)	8 (6.7%)	2 (1.6%)		
Neonatal ICU admission	3 (2.5%)	2 (1.7%)	1 (0.8%)	FE†	1 (NS)

†Fisher exact test - **Student t test

All cases (48 cases) of thick LUS were classified as class I while 41.9% of thin LUS was classified as class II and 6.5% of thin LUS was classified as class IV (**Table.4**).

Table 4. Relation between LUS thickness by TVS and intraoperative finding

Variables	Total (n = 110)	Thin (< 4.5) (n = 62)	Thick (≥ 4.5) (n = 48)	p†
Grade I	72 (65.5%)	24 (38.7%)	48 (100%)	< 0.001 (HS)
Grade II	26 (23.6%)	26 (41.9%)	0 (0%)	
Grade III	8 (7.3%)	8 (12.9%)	0 (0%)	
Grade IV	4 (3.6%)	4 (6.5%)	0 (0%)	

†Fisher exact test

There is significant association between number of previous CS and intraoperative classification in which 52.8% of class I was previous one CS, while 100% of class III, class IV and 53.8% of class II were more than CS (**Table.5**).

Table 5. Intraoperative finding of LUS in relation to number of previous CS

Variables	I (n = 72)	II (n = 26)	III (n = 8)	IV (n = 4)	P*
Previous one CS (n = 50)	38 (52.8%)	12 (46.2%)	0 (0%)	0 (0%)	0.005 (HS)
> One CS (n = 60)	34 (47.2%)	14 (53.8%)	8 (100%)	4 (100%)	

*Fisher exact test

No significant difference could be detected between thin and thick LUS as regard maternal outcome (**Table.6**). TVS is 100% in specificity and positive predictive value while lowest in sensitivity and negative predictive value (66.7% and 61.3%) respectively in relation to intraoperative classification at cut-off value of 4.5 mm (**Fig.1, Table.7**).

Table 6. Comparison between cases with thin LUS and with thick LUS as regard maternal outcome

Complication	Thin (< 4.5) (n = 62)	Thick (≥ 4.5) (n = 58)	X2	p
Bleeding				
Mild	45 (72.6%)	50 (86.2%)	1.78*	0.18
Moderate	13 (21%)	8 (13.8%)	0.27*	0.6
Severe	4 (6.4%)	0 (0%)	FE†	0.12
Rupture uterus	4 (6.4%)	0 (0%)	FE†	0.12
Cesarean hysterectomy	1 (1.6%)	0 (0%)	FE†	1

†Fisher exact test

Table 7. Validity of TVS of LUS thickness in relation to intraoperative classification at cut-off value of 4.5 mm

Variables	I	II	III	IV	AUC (CI)*	Sensitivity	Specificity	PPV†	NPV‡
Thick (≥ 4.5)	58	0	0	0	0.83 (0.75-0.93)	66.7%	100%	100%	61.3%
Thin (< 4.5)	24	26	8	4					

*Area under curve (confidence interval), †Positive predictive value, and ‡ Negative predictive value

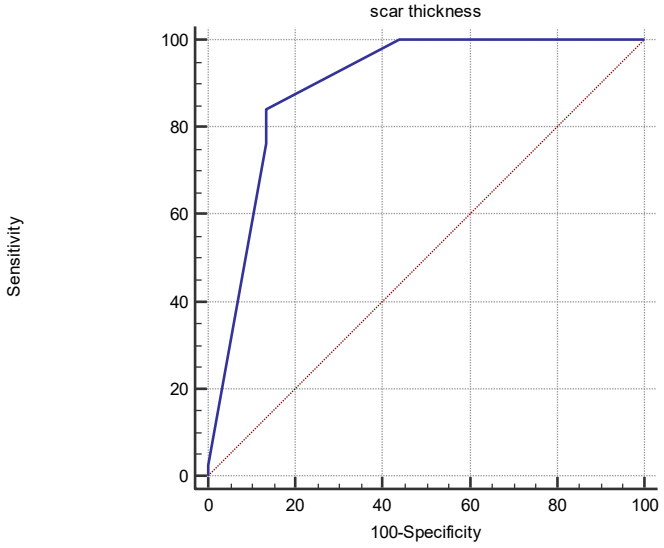

Fig.1. ROC curve at cut-off value of 4.5 mm.

Discussion

The global prevalence of CS continues to rise, surpassing 25% in many regions. This increase carries significant maternal and fetal risks, particularly with repeat CS, and underscores the importance of individualized clinical decision-making **(Cahill et al., 2006)**. One of the most critical considerations in managing patients with a prior CS is the risk of uterine rupture, which can lead to catastrophic outcomes for both mother and fetus. Therefore, appropriate patient selection for a trial of labor is essential **(Wang et al., 2020)**.

In this cross-sectional study involving 120 pregnant women with a history of one or more CS, we evaluated the LUS thickness using transvaginal sonography (TVS) between 36–40 weeks of gestation **(Del Campo et al., 2023)**. The mean LUS thickness measured by TVS was 4.8 ± 1.6 mm, which aligns with prior findings indicating that women with previous CS have significantly thinner LUS in late pregnancy compared to those without prior CS (mean 4.7 ± 1.1 mm vs. 6.6 ± 2 mm) **(McLeish et al., 2023)**.

Variability in scar thickness across studies may stem from differences in surgical techniques (e.g., uterine and peritoneal closure), healing processes, sonographic approach (transabdominal vs. transvaginal), ultrasound machine resolution, interobserver variability, and most importantly, the lack of a standardized method for scar measurement **(McLeish et al., 2023)**. Some authors advocate for a three-layered assessment, measuring from the bladder's muscularis and mucosa to the chorioamniotic membrane **(Swift et al., 2019)**. Notably, scar assessment should be avoided during uterine contractions due to transient thickening, known as pseudodilatation, which may result in inaccurate measurements **(van Gils et al., 2024)**.

Our findings showed no statistically significant correlation between maternal age and LUS thickness, which is consistent with previous studies reporting no association between maternal age and scar thinning or gaping **(Tilahun et al., 2023)**. In our study, 110 out of 120 patients (91.7%) delivered via CS, while only 10 (8.3%) achieved successful VBAC. A statistically significant

difference in LUS thickness was observed between VBAC and repeat CS groups, with all VBAC cases having a scar thickness ≥ 4.5 mm, while the majority of elective repeat CS cases had a thickness < 4.5 mm.

Our VBAC rate (8.3%) is lower than reported rates in the United States, where it was 10.6% in 2003 and higher in prior years by the **National Vital Statistics Reports, (2014)**. Other studies report VBAC success rates as high as 46%, often due to better patient selection and improved intrapartum monitoring. Multicenter trials have documented VBAC success rates ranging from 60% to 90% in appropriately selected candidates **(Arabin et al., 2014)**. In our study setting, VBAC success may have been limited by the lack of labor augmentation and a cautious clinical approach favoring emergency CS over continued monitoring in cases of labor deviation. This practice has likely contributed to the lower VBAC rate. Other authors report success rates up to 74.5% under more liberal trial-of-labor conditions **(Tilahun et al., 2023)**.

Statistical analysis using the chi-square test confirmed a significant association between scar thickness and mode of delivery. Moreover, we found that LUS thickness < 4.5 mm was associated with a higher likelihood of repeat CS, reinforcing its predictive value for uterine scar integrity. However, while many studies support the utility of ultrasound-measured scar thickness, no universally accepted cut-off has been established. Reported thresholds vary widely, from 1.5 mm to 4.5 mm, depending on sonographic technique and measurement criteria **(McLeish et al., 2023)**.

Additionally, our study showed a significant correlation between the number of previous CS and poorer intraoperative scar grades. This supports previous findings by **Zaigham (2024)** that a higher number of CS is associated with reduced LUS thickness and increased scar defects. However, some studies argue that the frequency of scar rupture does not necessarily correlate with the number of previous CS **(Relić et al., 2019)**. This discrepancy may reflect differences in scar quality and healing, as unhealthy scars may fail to regenerate isthmic tissue, resulting in progressive thinning in subsequent pregnancies and increasing the risk of dehiscence **(Dall'asta et al., 2023)**.

This study highlights a strong relationship between third-trimester LUS thickness and the risk of uterine scar defects. The findings support the use of transvaginal ultrasound as a reliable tool in assessing the structural and potentially functional integrity of the cesarean scar, thereby aiding clinical decisions regarding the safety of VBAC.

Recommendations: Transvaginal ultrasound should be considered a useful tool in late pregnancy for assessing lower uterine segment thickness in women with previous cesarean sections. It can aid in selecting candidates for a TOLAC. Larger, multicenter studies are needed to standardize measurement techniques and establish a universal cut-off value.

Limitations: This study was limited by its single-center design and relatively small sample size. Interobserver variability in ultrasound measurements may have influenced results. The low number of VBAC cases limited subgroup analysis, and the absence of long-term maternal and neonatal outcome data is also noted.

Conclusion

There is a significant association between a thick cesarean section scar, as assessed by transvaginal ultrasound, and favorable intraoperative findings of a well-developed lower uterine segment. Transvaginal sonography demonstrated strong predictive value for detecting uterine scar dehiscence, with a sensitivity of 66.7%, specificity of 100%, positive predictive

value of 100%, and negative predictive value of 61.3% at a cut-off thickness of 4.5 mm. Although our study found that ultrasound is a moderately valid tool for assessing the scar when compared to intraoperative assessment, it does not significantly reflect the safety of a trial of labor after cesarean. These findings support the role of transvaginal ultrasound in aiding clinical decision-making, but they should be interpreted alongside other clinical and obstetric factors when evaluating candidates for TOLAC.

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