

# Lower Uterine Segment Thickness Assessed by Transvaginal Ultrasound Before Labor Induction with Misoprostol: Reproducibility Analysis and Relationship with Delivery Outcome

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## Abstract

**Objectives:** To evaluate the reproducibility of transvaginal ultrasound measurement of lower uterine segment thickness before labor induction and to assess its association with successful vaginal delivery, mode of delivery, and duration of induction.

**Methods:** This cross-sectional analytic study was conducted at Kasr Al-Ainy Obstetrics and Gynecology Hospital, Cairo University, between October 2024 and May 2025. A total of 232 term pregnant women ( $\geq 37$  weeks) scheduled for induction of labor with misoprostol were included. All participants underwent pre-induction transvaginal ultrasound assessment of lower uterine segment thickness. Demographic, obstetric, induction, and delivery data were collected.

**Results:** The mean lower uterine segment thickness was  $3.1 \pm 0.69$  mm. Women who achieved vaginal delivery had significantly thinner lower uterine segment thickness compared with those who underwent cesarean section ( $2.82 \pm 0.37$  mm vs  $3.7 \pm 0.82$  mm,  $p < 0.001$ ). A lower uterine segment thickness cutoff value of  $>3.5$  mm predicted cesarean delivery with 68.5% sensitivity, 100% specificity, and an area under the curve of 0.82 ( $p < 0.001$ ). Lower uterine segment thickness showed significant positive correlations with maternal age, body mass index, and duration of induction.

**Conclusions:** Transvaginal ultrasound measurement of lower uterine segment thickness before induction of labor is feasible and reproducible. A lower uterine segment thickness is significantly associated with favorable induction outcomes and may serve as a valuable adjunct to traditional clinical predictors in pre-induction assessment.

**Keywords:** Induction of labor; lower uterine segment thickness; transvaginal ultrasound; cesarean section; vaginal delivery; Bishop score; labor induction outcome.

## Introduction

Induction of labor (IOL) refers to the artificial initiation of uterine contractions before the spontaneous onset of labor in order to achieve vaginal delivery.<sup>1</sup> IOL is a commonly used obstetric intervention performed when the anticipated benefits of delivery outweigh the risks of continuing the pregnancy. Rates of induction of labor have increased in many settings, although substantial variation persists across countries and practice environments.<sup>2,3</sup> This increasing use underscores the need for reliable and objective predictors of induction outcomes.

Common indications for IOL include post-term pregnancy ( $\geq 41$  weeks), hypertensive disorders, fetal growth restriction, oligohydramnios, diabetes mellitus, intrahepatic cholestasis of pregnancy, and other

maternal or fetal complications. Elective induction at or beyond 39 weeks has also become more frequent, although its benefits remain debated.<sup>4,5</sup> Regardless of indication, IOL does not consistently result in vaginal delivery. Failed induction increases the risk of prolonged labor, infection, maternal exhaustion, fetal compromise, and unplanned cesarean section (CS), highlighting the importance of identifying women most likely to respond successfully.<sup>6</sup>

Cervical assessment is central to predicting IOL success. The Bishop Score remains the most widely used tool.<sup>7</sup> However, its subjective nature and limited interobserver reliability restrict its clinical value. As a result, objective and reproducible ultrasound-based parameters have gained attention, particularly cervical length and lower uterine segment (LUS) thickness.<sup>8</sup>

The LUS forms from the lower uterine isthmus in late pregnancy and undergoes progressive thinning and remodeling in preparation for labor.<sup>9</sup> A thinner LUS reflects greater uterine compliance, whereas a thicker segment may indicate reduced readiness for labor. A study reported that thinner LUS measurements (commonly <5 mm) are associated with higher rates of vaginal delivery, while thicker measurements correlate with prolonged labor, failed induction, and increased CS rates.<sup>10</sup> Although LUS thickness has been extensively studied in women with previous CSs due to rupture risk, emerging evidence suggests it may also predict induction outcomes in women with unscarred uteri.<sup>11</sup>

Transvaginal ultrasound (TVUS) provides high-resolution, reproducible measurements of LUS thickness and is more accurate than transabdominal ultrasound, particularly in obese women or when the fetal head is engaged.<sup>10</sup> Standardized TVUS techniques allow objective measurement with good intra- and interobserver reliability, offering clear advantages over subjective digital examination.<sup>12</sup>

Despite increasing evidence supporting LUS thickness as a predictor of IOL success, data from the Middle East and North Africa region remain scarce. Population-specific factors, including maternal body mass index (BMI), parity, and obstetric practice patterns, may influence both LUS characteristics and measurement reproducibility, limiting the generalizability of existing findings. This gap justifies the present cross-sectional analytic study, which aims to assess the reproducibility of TVUS measurement of LUS thickness before misoprostol-induced labor and to examine its association with delivery outcomes in a defined patient population.

## Methods

This was a cross-sectional analytic study conducted at Kasr Al-Ainy Obstetrics and Gynecology Hospital, Cairo University, Cairo, Egypt, over an eight-month period from October 2024 to May 2025. The hospital is a tertiary referral center that provides comprehensive obstetric care and serves a large and diverse population. The study was designed to evaluate the association between LUS thickness measured by TVUS and labor induction outcomes at a single pre-induction time point.

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Cairo University (MD-397-2023). All eligible participants were informed about the study objectives, procedures, potential risks, and benefits, and written informed consent was obtained from each participant prior to enrollment.

The study population comprised pregnant women admitted to the obstetrics and gynecology emergency department who were scheduled for IOL. All participants were assessed at term pregnancy and prior to the initiation of induction protocols.

Women were eligible for inclusion if they met all of the following criteria: singleton pregnancy, gestational age  $\geq 37$  completed weeks confirmed by first-trimester ultrasound or reliable last menstrual period, cephalic fetal presentation, Bishop Score  $\leq 6$ , and planned labor induction for medical or obstetric indications such as premature rupture of membranes or post-date pregnancy. Participants were required to have no contraindications to vaginal delivery, including malpresentation, malposition, or suspected cephalopelvic disproportion.

Women were excluded if they had a history of previous CS or uterine surgery, multiple gestations, non-cephalic fetal presentation, known major fetal anomalies, preterm labor, contraindications to labor

induction (including placenta previa or vasa previa), or known allergy or contraindication to misoprostol administration.

A minimum sample size of 232 participants was calculated to provide 97% statistical power at a significance level of 0.05. The calculation was based on detecting a difference in mean LUS thickness between women with failed induction resulting in CS (mean  $5.13 \pm 2.4$ ) and those with successful vaginal birth leading to vaginal delivery (mean  $6.9 \pm 4.3$ ), as reported by Del Campo et al. (2023).<sup>8</sup> The sample size was estimated using a two-sample means test according to the following equation:

$$N = [(4\sigma^2)(Z(1-\alpha/2) + Z(1-\beta))^2] \div E^2$$

Where N is the required sample size,  $\sigma$  is the pooled standard deviation of the outcome measure,  $Z(1-\alpha/2)$  is the standard normal deviate corresponding to the desired two-sided significance level,  $Z(1-\beta)$  is the standard normal deviate corresponding to the desired statistical power, and E is the expected difference in mean lower uterine segment thickness between the two study groups.

No separate inflation factor for attrition was applied because participant recruitment continued until the minimum required analyzable sample size was reached.

Data collection was performed prospectively before labor induction using a structured data collection sheet. Baseline demographic data included maternal age, BMI, parity, and gravidity. Obstetric variables included gestational age at induction, indication for labor induction, antenatal complications, and relevant medical or obstetric history.

A digital transvaginal examination was performed by an experienced obstetrician to assess cervical status and calculate the Bishop Score. The score was derived from cervical dilation, effacement, consistency, position, and fetal station, in accordance with standard clinical practice.<sup>7</sup> Only women with a Bishop Score  $\leq 6$  were included to ensure a uniform population with unfavorable cervixes.

TVUS was performed within 24 hours prior to initiation of labor induction using a Medison SonoAce X6 ultrasound machine equipped with a high-frequency endocavitary probe. Two trained and experienced sonographers who were familiar with standardized obstetric ultrasound protocols. To reduce interobserver variability, both sonographers used the same predefined scanning and measurement protocol, and all images were independently reviewed for quality assurance.

Participants were examined in the dorsal lithotomy position with partial bladder filling to enhance visualization of the bladder wall and adjacent myometrium. The transvaginal probe was gently inserted without exerting excessive pressure to avoid distortion of cervical or uterine anatomy. A mid-sagittal plane of the cervix and LUS was obtained, clearly identifying the internal os, external os, cervical canal, endocervical mucosa, bladder wall, and adjacent myometrium.

LUS thickness was defined as the full thickness of the myometrial layer between the bladder-myometrium interface and the interface between the uterine wall and the amniotic fluid or fetal presenting part. Calipers were positioned with the first cursor placed at the boundary between the bladder wall and the myometrium and the second cursor at the boundary between the uterine wall and the amniotic fluid or fetal scalp. The thinnest visible portion of the LUS was selected for measurement.

Each LUS thickness measurement was obtained three separate times during uterine quiescence, and the mean value was calculated and used for statistical analysis. To ensure measurement reproducibility, all acquired images were independently reviewed by an investigator who was an experienced sonographer.

Ultrasound images were considered acceptable for analysis only if they met predefined quality criteria: (1) the cervix occupied approximately 75% of the ultrasound image, allowing optimal visualization of the LUS; and (2) the bladder wall was clearly delineated with urine present. Images that failed to meet these criteria or were affected by motion artifacts, uterine contractions, or inadequate visualization were excluded from the final analysis.

Labor induction was performed using vaginal misoprostol at a dose of 25  $\mu\text{g}$  administered every six hours for a maximum duration of 24 hours, in accordance with established clinical protocols.<sup>13,14</sup> All participants were monitored according to standard hospital guidelines, including regular assessment of uterine activity, fetal heart rate monitoring, and maternal vital signs. Subsequent labor management and

decisions regarding augmentation or operative delivery were made by the attending obstetric team based on clinical indications.

The primary outcome was successful vaginal delivery following induction of labor, defined as achievement of vaginal delivery following induction. The secondary outcome was the duration of induction, defined as the time interval from the first dose of misoprostol to the onset of active labor or delivery. Additional recorded outcomes included mode of delivery (vaginal or cesarean), time to successful vaginal delivery, neonatal outcomes, and maternal or neonatal complications.

The diagnostic intervention in this study was TVUS measurement of LUS thickness. The therapeutic intervention was vaginal misoprostol used for labor induction. An illustrative transvaginal ultrasound image demonstrating the measurement technique and caliper placement [Figure 1].



**Figure 1:** Representative transvaginal ultrasound image from the study cohort demonstrating LUST measurement before induction of labor. The thinnest visible portion measured 2.8 mm in this example.

Potential risks included uterine hyperstimulation and associated fetal heart rate abnormalities following misoprostol administration. Rare but serious adverse outcomes, such as uterine rupture, asphyxia, and fetal death, have been reported in the literature when large populations are studied.<sup>15</sup> All participants were closely monitored to identify and manage any adverse events promptly.

All study-related data were stored securely at the study site. Paper records were kept in locked cabinets with restricted access, and electronic data were password protected. Participant identifiers were removed during data analysis, and information was not disclosed outside the research team.

Statistical analysis was performed using STATA version 15.1 (Copyright 1985–2017 Stata Corp LLC). Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean  $\pm$  standard deviation for normally distributed data or median with interquartile range for non-normally distributed data. The Shapiro–Wilk test was used to assess normality. Comparisons between women with successful and failed induction were performed using the chi-square test for categorical variables and the independent samples t-test or Mann–Whitney U test for continuous variables, as appropriate. Multivariable logistic regression analysis was conducted to identify independent predictors of failed labor induction. A p-value  $<0.05$  was considered statistically significant.

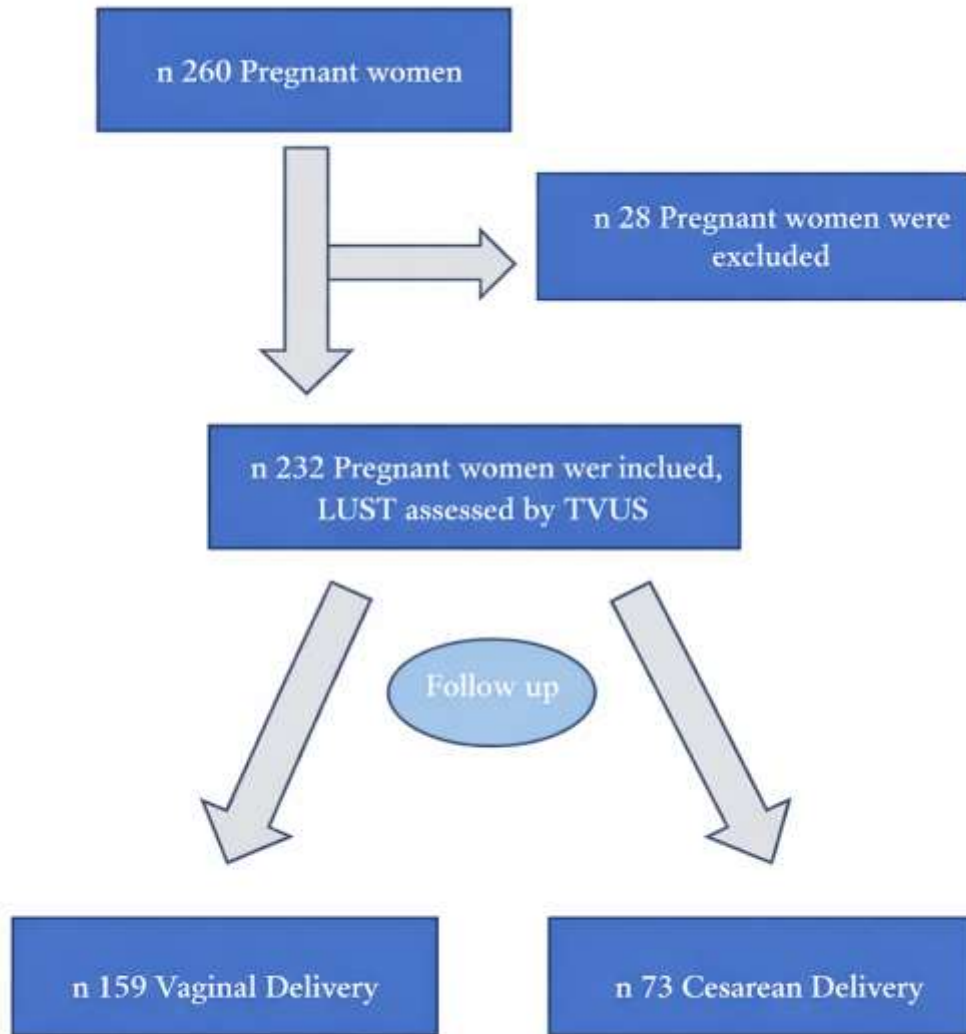
## Results

The study included 232 pregnant women with a mean age of  $25.3 \pm 5.2$  years (range: 18–42) and a mean BMI of  $32.2 \pm 4.2$  kg/m<sup>2</sup> (range: 21.5–38.1) [Figure 2]. Nearly half of the participants were nulliparous (44.8%), while 28.9% were para 2. The mean gestational age at induction was  $39.8 \pm 1.2$  weeks (range: 37–42). Diabetes mellitus was present in 5.2% of participants and hypertension in 6%, while 14.2% had other medical comorbidities. Previous surgical history was uncommon, with appendectomy being the most frequent (3.4%) [Table 1].

**Table 1:** Baseline demographic, obstetric, and clinical characteristics of the studied patients (N = 232).

| Variable                 | Category                     | Value          |
|--------------------------|------------------------------|----------------|
| Age (years)              | Mean $\pm$ SD                | 25.3 $\pm$ 5.2 |
|                          | Range                        | 18 – 42        |
| BMI (kg/m <sup>2</sup> ) | Mean $\pm$ SD                | 32.2 $\pm$ 4.2 |
|                          | Range                        | 21.5 – 38.1    |
| Parity                   | Nullipara                    | 104 (44.8%)    |
|                          | Para 1                       | 36 (15.5%)     |
|                          | Para 2                       | 67 (28.9%)     |
|                          | Para 3                       | 12 (5.2%)      |
|                          | Para 4                       | 11 (4.7%)      |
|                          | Para 5                       | 1 (0.4%)       |
|                          | Para 6                       | 1 (0.4%)       |
|                          | Para 8                       | 1 (0.4%)       |
| Gestational age (weeks)  | Mean $\pm$ SD                | 39.8 $\pm$ 1.2 |
|                          | Range                        | 37 – 42        |
| Medical history          | Diabetes mellitus            | 12 (5.2%)      |
|                          | Hypertension                 | 14 (6.0%)      |
|                          | Others                       | 33 (14.2%)     |
| Surgical history         | Appendectomy                 | 8 (3.4%)       |
|                          | Surgical evacuation          | 1 (0.4%)       |
|                          | Salpingectomy                | 3 (1.3%)       |
|                          | Pelvic surgery               | 1 (0.4%)       |
|                          | Laparoscopic cholecystectomy | 1 (0.4%)       |
|                          | Hemorrhoidectomy             | 1 (0.4%)       |

*Data are presented as mean  $\pm$  standard deviation (SD), range, or number (percentage), as appropriate. Abbreviations: BMI, body mass index.*



**Figure 2:** Study flowchart illustrating participant enrollment, exclusions, and final inclusion in the study.

Pelvic examination showed a mean cervical dilatation of  $1.14 \pm 1.01$  cm (range: 0–4) and a mean effacement of  $42 \pm 7.8\%$  (range: 20–60). The mean Bishop score was  $5.06 \pm 0.73$  (range: 4–6), with 46.1% of women scoring 5 and 30.2% scoring 6. TVUS assessment demonstrated a mean LUST of  $3.1 \pm 0.69$  mm, ranging from 1.7 to 6.7 mm [Table 2].

**Table 2.** Cervical examination findings and LUS thickness (N = 232).

| Variable                 | Measure       | Value           |
|--------------------------|---------------|-----------------|
| Cervical dilatation (cm) | Mean $\pm$ SD | $1.14 \pm 1.01$ |
|                          | Range         | 0 – 4           |
| Cervical effacement (%)  | Mean $\pm$ SD | $42 \pm 7.8$    |
|                          | Range         | 20 – 60         |
| Bishop score             | Mean $\pm$ SD | $5.06 \pm 0.73$ |
|                          | Range         | 4 – 6           |
|                          | Score 4       | 55 (23.7%)      |
|                          | Score 5       | 107 (46.1%)     |
|                          | Score 6       | 70 (30.2%)      |

|                  |           |            |
|------------------|-----------|------------|
| <b>LUST (mm)</b> | Mean ± SD | 3.1 ± 0.69 |
|                  | Range     | 1.7 – 6.7  |

*Bishop score was assessed by digital pelvic examination before labor induction. LUST, lower uterine segment thickness; SD, standard deviation.*

Post-date pregnancy was the most common indication for induction (62.5%), followed by rupture of membranes (21.1%). Other indications included diabetes mellitus (3.9%), gestational hypertension (2.2%), non-severe preeclampsia (3.0%), severe preeclampsia (2.2%), non-reassuring cardiotocography (2.2%), intrauterine fetal death (1.3%), gestational thrombocytopenia (0.9%), elevated liver enzymes (0.4%), and fetal congenital anomalies (0.4%). The mean duration to successful vaginal delivery was 13.7 ± 4.5 hours (range: 3–21). Vaginal delivery occurred in 68.5% of women, while 31.5% underwent CS. Failed induction accounted for 78.1% of cesarean deliveries. No maternal complications were reported, and neonatal complications occurred in 0.9% of cases [Table 3].

**Table 3:** IOL characteristics and delivery outcomes (N = 232).

| <b>Variables</b>                  | <b>Category</b>              | <b>Value</b> |
|-----------------------------------|------------------------------|--------------|
| <b>Indication for IOL</b>         | Post-date                    | 145 (62.5%)  |
|                                   | ROM                          | 49 (21.1%)   |
|                                   | Diabetes mellitus            | 9 (3.9%)     |
|                                   | Gestational hypertension     | 5 (2.2%)     |
|                                   | Non-severe preeclampsia      | 7 (3.0%)     |
|                                   | Severe preeclampsia          | 5 (2.2%)     |
|                                   | Non-reassuring CTG           | 5 (2.2%)     |
|                                   | IUFD                         | 3 (1.3%)     |
|                                   | Gestational thrombocytopenia | 2 (0.9%)     |
|                                   | Elevated liver enzymes       | 1 (0.4%)     |
|                                   | Fetal congenital anomalies   | 1 (0.4%)     |
| <b>IOL duration (hours)</b>       | Mean ± SD                    | 13.7 ± 4.5   |
|                                   | Range                        | 3 – 21       |
| <b>Mode of delivery</b>           | NVD                          | 159 (68.5%)  |
|                                   | CS                           | 73 (31.5%)   |
| <b>Indication for CS (n = 73)</b> | Failed induction             | 57 (78.1%)   |
|                                   | Severe preeclampsia          | 6 (8.2%)     |
|                                   | Fetal distress               | 5 (6.8%)     |
|                                   | Failure to progress          | 5 (6.8%)     |
| <b>Maternal complications</b>     | Yes                          | 0 (0%)       |
| <b>Neonatal complications</b>     | Yes                          | 2 (0.9%)     |

*Duration of induction was calculated from the first dose of misoprostol until successful vaginal delivery. Abbreviations: CS, cesarean section; CTG, cardiotocography; IOL, induction of labor; IUFD, intrauterine fetal death; NVD, normal vaginal delivery; ROM, rupture of membranes; SD, standard deviation.*

Correlation analysis demonstrated a statistically significant positive correlation between LUST and maternal age ( $r = 0.138$ ,  $p = 0.035$ ) as well as BMI ( $r = 0.134$ ,  $p = 0.041$ ). No significant correlation was found between LUST and gestational age ( $r = -0.06$ ,  $p = 0.306$ ). Additionally, LUST showed a statistically significant positive correlation with duration of induction ( $r = 0.2$ ,  $p = 0.006$ ), indicating that increased LUST was associated with longer time to successful vaginal delivery [Table 4].

**Table 4:** Correlation between LUST and maternal characteristics and induction duration.

| <b>Variable</b>                      | <b>r</b> | <b>p-value</b> |
|--------------------------------------|----------|----------------|
| <b>LUST vs Age</b>                   | 0.138    | 0.035*         |
| <b>LUST vs Gestational age</b>       | -0.06    | 0.306          |
| <b>LUST vs BMI</b>                   | 0.134    | 0.041*         |
| <b>LUST vs Duration of induction</b> | 0.2      | 0.006*         |

*Correlations were assessed using Pearson correlation analysis. p-value < 0.05 indicates statistical significance. Abbreviations: BMI, body mass index; LUST, lower uterine segment thickness.*

Women who achieved vaginal delivery had a significantly lower mean LUST ( $2.82 \pm 0.37$  mm; range: 1.7–3.5) compared with those who underwent CS ( $3.7 \pm 0.82$  mm; range: 2.1–6.7), with a highly significant difference ( $T = -11.4$ ,  $p < 0.001$ ). ROC curve analysis demonstrated that a LUST cutoff value of  $>3.5$  mm predicted cesarean delivery with a sensitivity of 68.5%, specificity of 100%, positive predictive value of 100%, and negative predictive value of 87.4% (AUC = 0.82,  $p < 0.001$ ) [Table 5].

**Table 5:** Association and diagnostic performance of LUST for mode of delivery.

**A. Comparison of LUST according to mode of delivery**

| Mode of delivery | Mean $\pm$ SD (mm) | Range (mm) | Test        | p-value   |
|------------------|--------------------|------------|-------------|-----------|
| NVD (n = 159)    | $2.82 \pm 0.37$    | 1.7 – 3.5  | $T = -11.4$ | $< 0.001$ |
| CS (n = 73)      | $3.7 \pm 0.82$     | 2.1 – 6.7  |             |           |

**B. ROC analysis of LUST for prediction of cesarean section**

| Cutoff     | AUC  | Sensitivity | Specificity | PPV  | NPV   | p-value   |
|------------|------|-------------|-------------|------|-------|-----------|
| $> 3.5$ mm | 0.82 | 68.5%       | 100%        | 100% | 87.4% | $< 0.001$ |

*Independent samples t-test was used for group comparison. ROC curve analysis assessed diagnostic performance. Abbreviations: AUC, area under the curve; CS, cesarean section; LUST, lower uterine segment thickness; NPV, negative predictive value; NVD, normal vaginal delivery; PPV, positive predictive value; SD, standard deviation.*

## Discussion

IOL is among the most frequently performed obstetric interventions and has been implicated as a contributor to the rising CS rate. Currently, approximately 20–30% of pregnancies undergo IOL, and a similar proportion result in unplanned cesarean delivery following induction. Accurate prediction of IOL outcomes therefore remains a clinical priority. Traditionally, cervical status assessed by the Bishop score has been the primary predictor; however, its predictive performance is limited despite its simplicity and widespread use.<sup>16</sup>

Failed induction, often defined as cesarean delivery following a prolonged latent phase exceeding 15 hours after oxytocin initiation, is associated with increased maternal and neonatal morbidity, including infection, postpartum hemorrhage, and neonatal intensive care unit admission.<sup>17</sup> These risks emphasize the need for objective and reproducible predictors that can better stratify patients prior to induction.

Several ultrasound-based parameters have been proposed to improve prediction of IOL success, including cervical length, cervical angles, fetal head position, and emerging techniques such as elastography. However, many of these tools are not universally available, particularly in low-resource settings, and their clinical utility remains under investigation. Consequently, the Bishop score continues to be widely used despite its limitations.<sup>18</sup>

During pregnancy, the uterine isthmus progressively remodels to form the LUS, a process characterized by thinning that is inversely correlated with gestational age. Sonographic assessment of LUS thickness has been extensively studied in women with previous CSs, where it is associated with uterine scar integrity and rupture risk. More recently, LUS thickness has been explored as a potential predictor of preterm delivery and IOL outcomes, although evidence remains limited.<sup>19</sup> We hypothesized that women undergoing IOL who achieve vaginal delivery would have a thinner LUS than those requiring CS, reflecting more favorable uterine remodeling.

TVUS was selected for LUS measurement because it provides superior visualization of the cervix and LUS compared with the transabdominal approach, particularly near term when fetal head ossification may obscure imaging. Previous studies have demonstrated a strong inverse relationship between LUS thickness and gestational age, with mean thickness decreasing from  $5.1 \pm 1.4$  mm at 20 weeks to  $2.3 \pm 0.6$  mm at 40 weeks.<sup>20</sup>

Our findings support the hypothesis that LUS thickness is associated mode of delivery after induction of labor. Women who achieved vaginal delivery had significantly thinner LUS measurements than those who underwent CS. These results are consistent with Del Campo et al. (2023), who demonstrated

significant associations between LUS thickness and overall cesarean delivery, cesarean delivery for failed induction, and cesarean delivery for labor arrest.<sup>8</sup>

Physiologically, thinning of the LUS likely reflects uterine remodeling that facilitates fetal descent and effective labor. Although cervical tissue and myometrium differ in structure and receptor distribution, both contribute to labor progression. In women without prior CS, a thinner pre-labor LUS may represent one of several subtle indicators of a more favorable uterine environment; however, its predictive value should be interpreted in conjunction with other clinical factors.

In contrast to our findings, Hamza et al. (2021) reported no significant association between LUS thickness and successful vaginal birth.<sup>21</sup> This discrepancy may be explained by differences in study populations and methodology. Compared with Hamza et al., our cohort included older women, less favorable Bishop scores, higher gestational ages at induction, and a greater proportion of post-term inductions. Additionally, the primary outcome differed (delivery within 24 hours versus mode of delivery), and the absence of a standardized LUS measurement protocol in their study limits comparability.

In the present study, LUS thickness >3.5 mm predicted failed induction and cesarean delivery with 68.5% sensitivity, 100% specificity, 100% positive predictive value, and 87.4% negative predictive value (AUC = 0.82,  $p < 0.001$ ). These findings align with prior studies that proposed similar cutoff values. Rosenberg et al. (1996) identified 3.5 mm as an optimal threshold, while Montanarj et al. (1999) confirmed its high diagnostic accuracy.<sup>22,23</sup> Although Thomas et al. (2015) reported a lower cutoff (2.4 mm), differences in sensitivity and specificity highlight the influence of population characteristics and measurement techniques.<sup>24</sup>

Correlation analysis in this study demonstrated weak but statistically significant positive associations between LUS thickness and maternal age and BMI. These findings are consistent with Del Campo et al. (2023) and Ibrahim and El-Omda (2023).<sup>8,25</sup> Age-related changes in myometrial composition, including increased collagen deposition and reduced elasticity, may contribute to thicker LUS measurements. The association with higher BMI may reflect systemic metabolic or inflammatory influences on tissue remodeling, although technical factors related to ultrasound imaging cannot be entirely excluded despite the use of the transvaginal approach.<sup>26</sup> Additionally, we observed a significant positive correlation between LUS thickness and duration of induction, indicating that thicker LUS measurements were associated with longer induction-to-delivery intervals. This relationship may reflect the coexistence of thicker LUS with other unfavorable induction factors, such as lower Bishop scores, which independently prolong labor.

A further limitation of the present study is that the response of grand multiparous women to misoprostol induction was not specifically evaluated or reported. In addition, grand multiparous women were minimally represented in the study cohort, which precluded any meaningful subgroup analysis. Future studies should specifically investigate induction outcomes in this subgroup.

## **Conclusion**

This cross-sectional analytic study demonstrates that TVUS measurement of LUS thickness before IOL is feasible and reproducible in routine clinical practice. A lower LUS thickness was significantly associated with successful vaginal delivery after induction of labor and showed improved predictive performance when integrated with clinical and sonographic variables, compared with reliance on the Bishop score alone. These findings support the potential role of LUS thickness as an objective adjunct in pre-induction assessment. Further well-designed studies are warranted to refine predictive models and to validate the clinical utility of LUS thickness across diverse populations and settings.

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