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Can Intrapartum Ultrasound At 6-Cm Cervical Dilatation Predict Time To Delivery In Nulliparous Women? A Prospective Cohort Study

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Abstract

Objective

To investigate whether intrapartum ultrasonography performed at 6-cm cervical dilatation can provide early prediction of time to delivery in nulliparous women and to identify the most clinically useful ultrasound parameter for this purpose.

Methods

This prospective cohort study included 57 nulliparous women with singleton, cephalic pregnancies in the active phase of labor. After confirmation of 6-cm cervical dilatation and ruptured membranes, intrapartum ultrasound was performed using transperineal and transabdominal approaches. Transperineal ultrasound was used to measure the angle of progression (AoP), head–perineum distance (HPD), and midline angle (MLA), while transabdominal ultrasound assessed fetal head orientation and occiput position. The primary outcome was the interval between ultrasound assessment and delivery. Maternal, fetal, and labor-related characteristics were prospectively recorded. Statistical analyses included Mann–Whitney U, Kruskal–Wallis, Spearman correlation, multivariable linear regression, and receiver operating characteristic (ROC) curve analyses to evaluate the predictive performance of AoP and HPD for delivery within 1, 2, and 4 hours. Statistical significance was defined as $P<.05$.

Results

Among all intrapartum ultrasound parameters, AoP demonstrated the strongest overall predictive performance for time to delivery. AoP showed a significant negative correlation with time to delivery, whereas HPD demonstrated a significant positive correlation. ROC analysis demonstrated that AoP had moderate predictive performance for delivery within 2 hours (AUC = 0.692), with an optimal cutoff of ≥ 124.5° (sensitivity 62.5%, PPV 65.2%), and good predictive performance for delivery within 4 hours (AUC = 0.761), with a cutoff of ≥ 119.5° (sensitivity 65.2%, PPV 93.8%). HPD showed moderate predictive performance for delivery within 1 hour (AUC = 0.697); no woman with an HPD > 39.5 mm delivered within the first hour. Head station was the strongest independent predictor (β = 0.258; p = 0.017), with significantly higher delivery rate within 2 hours when station was ≥ + 1 (p < 0.001). Occiput anterior and upward head direction were associated with shorter labor, whereas prolonged labor correlated with lower Apgar scores. MLA showed no significant predictive value.

Conclusion

In nulliparous women, intrapartum ultrasound performed at the onset of the active phase of labor provides objective parameters for predicting time to delivery. Although fetal head station was the

strongest independent predictor, AoP was the most clinically applicable ultrasound parameter because it provided objective prediction of delivery within 2–4 hours early in the active phase of labor, whereas HPD was particularly useful for excluding delivery within the first hour. Our findings suggest that intrapartum AoP assessment at the onset of active labor enables clinically meaningful prediction of delivery time several hours before the second stage of labor, extending the role of intrapartum ultrasound beyond assessment of labor progress to early prognostic decision-making.

1. INTRODUCTION

Labor is a physiological process characterized by regular and effective uterine contractions leading to progressive cervical effacement and dilation, ultimately resulting in the spontaneous vaginal delivery of the fetus, placenta, and membranes. Although generally considered a normal physiological event in healthy women, labor is regulated by a complex neuroendocrine mechanism involving interactions between maternal, fetal, and placental factors [1, 2]. In clinical practice, labor management is largely based on traditional clinical assessment. However, digital vaginal examination is subjective and associated with considerable interobserver variability, potentially limiting its accuracy. In contrast, intrapartum ultrasonography has emerged as a more objective and reproducible tool for assessing labor progress [3, 5]. Recent studies have focused on transperineal ultrasound parameters, particularly the angle of progression (AoP), head–perineum distance (HPD), and midline angle (MLA), as predictors of labor outcomes. Among these, AoP has been shown to provide an objective assessment and to correlate significantly with labor duration [6]. Most available studies evaluated intrapartum ultrasound during the second stage of labor or immediately before operative vaginal delivery. Evidence regarding ultrasound assessment at the onset of the active phase of labor remains limited. Therefore, this study aims to evaluate the clinical utility of intrapartum ultrasonography at the beginning of the active phase of labor in nulliparous women and to investigate its role in predicting time to delivery, as well as delivery mode.

2. MATERIALS AND METHODS

This prospective cohort study was conducted to evaluate the ability of intrapartum ultrasound parameters obtained at the onset of the active phase of labor to predict the time to delivery in nulliparous women. The study was approved by the Clinical Research Ethics Committee of Akdeniz University Faculty of Medicine (Approval No. 98; March 5, 2024) and conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines. Written informed consent was obtained from all participants.

Between March 2024 and August 2025, consecutive nulliparous women admitted to the Labor and Delivery Unit of Akdeniz University Hospital for planned vaginal delivery were prospectively recruited. Eligible participants were aged ≥ 18 years, had a singleton pregnancy with cephalic presentation, no previous cesarean delivery, and were in the active phase of labor. To ensure standardized assessment, intrapartum ultrasound was performed only after confirmation of 6-cm cervical dilatation and ruptured membranes by digital vaginal examination. Women with cervical dilatation > 6 cm, non-cephalic

presentation, previous cesarean delivery, age < 18 years, or absence of active labor were excluded. A total of 57 women were enrolled. During labor, three women underwent cesarean delivery because of fetal distress and two because of arrest of labor. Labor induction or augmentation with oxytocin was performed when clinically indicated according to institutional protocols.

Following confirmation of eligibility, intrapartum ultrasound was performed using transperineal and transabdominal approaches. Transperineal ultrasound was used to measure the Angle of Progression (AoP), Head–Perineum Distance (HPD), and Midline Angle (MLA). AoP was defined as the angle between the longitudinal axis of the pubic symphysis and a line tangential to the leading bony edge of the fetal skull [7, 8]. HPD was defined as the shortest distance between the presenting fetal skull and the perineum, whereas MLA was measured as the angle between the fetal sagittal suture and the maternal sagittal pelvic axis. Fetal head asynclitism was assessed by visualization of the falx cerebri. MLA measurements were not performed in women with occiput posterior position (n = 10). Transabdominal ultrasound was subsequently performed to determine fetal head orientation and occiput position using standard intracranial landmarks [9, 10, 11]. The interval between ultrasound examination and delivery was calculated and defined as the primary outcome. Maternal demographic characteristics, gestational age, body mass index, neonatal birth weight, fetal head station, fetal head orientation, occiput position, labor induction or augmentation, epidural analgesia, episiotomy, mode of delivery, and 1- and 5-minute Apgar scores were prospectively recorded.

Continuous variables were summarized as mean ± standard deviation or median (interquartile range), as appropriate, and categorical variables as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Comparisons between groups were performed using the Mann–Whitney U test or Kruskal–Wallis test. Correlations between continuous variables were assessed using Spearman's rank correlation coefficient. Variables associated with time to delivery in univariable analyses were entered into a multivariable linear regression model after logarithmic transformation of the dependent variable. Receiver operating characteristic (ROC) curve analysis was used to evaluate the predictive performance of AoP and HPD for delivery within 1, 2, and 4 hours after ultrasound assessment. The area under the curve (AUC), optimal cutoff values, sensitivity, specificity, positive and negative predictive values, and likelihood ratios were calculated. Statistical analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA), and a two-sided $P<.05$ was considered statistically significant.

3. RESULTS

The descriptive characteristics and intrapartum ultrasonographic parameters of the 57 nulliparous pregnant women included in the study are summarized in Table 1. The mean gestational age was 38.7 ± 1.65 weeks, with the majority of the cases (91.2%) classified as term pregnancies. The mean maternal body mass index was 27.96 ± 4.86 kg/m², and approximately one-third of the participants were in the overweight or mildly obese category.

Table 1. Ultrasonographic parameters and maternal–fetal characteristics in nulliparous women at the onset of the active phase of labor

Characteristic Features	Median (range) or n (%)			
Maternal		**Neonatal**		
Age (years)	24 (18-43)	Birth weight (g)	3220	(1930–3990)
Gestational week	38 (34–41)	1st minute Apgar score	8 (5–9)	
Body mass index (kg/m²)	27 (19–46)	5th minute Apgar score	9 (7–10)	
Intrapartum Ultrasonography		**Fetal Head Station**		
AoP (°)	121 (83–152) °	-1	6 (10.5%)	
HPD (mm)	36 (24–56)	0	18 (31.6%)	
MLA (°)	47 (0–90) °	1	27 (47.4%)	
Head Direction		2	6 (10.5%)	
Downward	10 (17.5%)			
Horizontal	12 (21.1%)			
Upward	35 (61.4%)			
Occiput Position				
Anterior	21 (36.8%)			
Posterior	10 (17.5%)			
Transverse	26 (45.6%)			

Abbreviations: BMI: Body mass index; AoP: Angle of progression; HPD: Head–perineum distance; MLA: Midline angle

Fetal head direction and fetal head station were significantly associated with labor duration. Women with an upward fetal head orientation had significantly shorter labor than those with a downward orientation (P=0.010). Likewise, a more advanced fetal head station was associated with a shorter duration of labor, with the shortest labor observed in women with fetal head station +2 (P=0.001). The mean duration of labor was shorter in cases with occiput anterior position compared to occiput posterior and occiput transverse positions.

Spearman correlation analysis of intrapartum ultrasonographic parameters and labor duration in nulliparous women demonstrated a statistically significant inverse correlation between labor duration and both the 1-minute Apgar score (r = −0.324, p = 0.014) and the 5-minute Apgar score (r = −0.305, p = 0.021). These findings suggest that prolonged labor is associated with lower neonatal Apgar scores at both the 1st and 5th minutes after birth. Among the intrapartum ultrasonographic parameters, a

statistically significant negative correlation was observed between the angle of progression (AoP) and duration of labor ($r = -0.394$, $p = 0.002$). This result suggests that higher AoP values are associated with shorter labor duration. In contrast, a significant positive correlation was found between head–perineum distance (HPD) and duration of labor ($r = 0.303$, $p = 0.022$), indicating that increased HPD—reflecting a greater distance of the fetal head from the pelvic floor—is associated with prolonged labor. No significant correlation was observed between the midline angle (MLA) and duration of labor ($r = 0.055$, $p = 0.711$).

The association between intrapartum ultrasound parameters at the onset of active labor and delivery within 1, 2, and 4 hours is presented in Table 2. Fetal head station was the most significant predictor of early delivery. Delivery within 1 hour was significantly associated with head station, with a higher likelihood observed in cases with station ≥+1. This association was stronger for delivery within 2 hours ($p<0.001$), where head station remained the most powerful predictor. Fetal head direction showed a trend toward significance for predicting delivery within 2 hours ($p=0.062$) and 4 hours ($p=0.093$), although these did not reach statistical significance. Although occiput anterior position was associated with a higher likelihood of delivery within the first hour, this finding was not statistically significant. Overall, higher fetal head station (≥+1) was consistently associated with shorter time to delivery, indicating its strong predictive value.

Table 2. Predictive Value of Intrapartum Ultrasound at Active Labor Onset for Delivery Within 1, 2, and 4 Hours in Nulliparous Women

Variable	Delivery ≤1 h (n=11), n (%)	*p*	Delivery ≤2 h (n=24), n (%)	*p*	Delivery ≤4 h (n=46), n (%)	*p*
Head direction		0.058		0.062		0.093
Downward	1 (9.1)		2 (8.3)		6 (13.0)	
Upward	10 (90.9)		3 (12.5)		31 (67.4)	
Horizontal	0 (0)		19 (79.2)		9 (19.6)	
Occiput position		0.113		0.856		0.999
Anterior	6 (54.5)		10 (41.7)		17 (37.0)	
Posterior	3 (27.3)		4 (16.7)		8 (17.4)	
Transverse	2 (18.2)		10 (41.7)		21 (45.7)	
Fetal head station		**0.020**		**<0.001**		**0.034**
-1	1 (9.1)		1 (4.2)		5 (10.9)	
0	0 (0)		2 (8.3)		11 (23.9)	
+1, +2	10 (90.9)		21 (87.5)		30 (65.2)	

As shown in table 3, the diagnostic performance of AoP for predicting delivery within 1, 2, and 4 hours was evaluated using ROC analysis. For delivery within 1 hour, the AUC was 0.594 (95% CI: 0.356–0.832; p=0.439), indicating limited discriminative ability. At a cut-off value of ≥133°, AoP demonstrated low sensitivity (45.5%) but high specificity (91.3%), suggesting limited utility as a standalone predictor for early delivery. For delivery within 2 hours, the AUC was 0.692 (95% CI: 0.548–0.836; p=0.009), indicating a statistically significant and moderate discriminative ability. At a cut-off value of ≥124.5°, AoP showed moderate sensitivity (62.5%) and specificity (75.8%), with a balanced overall diagnostic performance. For delivery within 4 hours, the AUC increased to 0.761 (95% CI: 0.616–0.905; p < 0.001), indicating good discriminative ability. At a cut-off value of ≥119.5°, AoP demonstrated moderate sensitivity (65.2%) and high specificity (81.8%), with a positive likelihood ratio of 3.59.

Table 3. ROC Analysis of the Diagnostic Performance of AoP Measured by Intrapartum Ultrasound at Active Labor Onset for Predicting Delivery Within 1, 2, and 4 Hours in Nulliparous Women

Time to Delivery	Cut-off (Youden)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	AUC	*p*
≤1 h (n=11)	≥133°	45.5	91.3	55.6	87.5	0.594	0.439
≤2 h (n=24)	≥124.5°	62.5	75.8	65.2	73.5	**0.692**	**0.009**
≤4 h (n=46)	≥119.5°	65.2	81.8	93.8	36.0	**0.761**	**<0.001**

Abbreviations: AUC, area under the curve; PPV, positive predictive value; and NPV, negative predictive value

Overall, the predictive performance of AoP improved with increasing time intervals, showing limited value for very early delivery but moderate-to-good accuracy for predicting delivery within 2 to 4 hours. The corresponding ROC curves are shown in Fig. 1.

The diagnostic performance of head–perineum distance (HPD) for predicting delivery within 1, 2, and 4 hours was evaluated using ROC analysis. For delivery within 1 hour, the AUC was 0.697 (95% CI: 0.549–0.844; p=0.009), indicating a statistically significant discriminative ability. At a cut-off value of ≤39.5 mm, HPD demonstrated very high sensitivity (100.0%) but low specificity (39.1%), with a high negative predictive value (100.0%), suggesting strong ability to exclude delivery within 1 hour when HPD is above the threshold. For delivery within 2 hours, the AUC was 0.652 (95% CI: 0.507–0.798; p=0.040), indicating moderate discriminative ability. At the same cut-off (≤39.5 mm), HPD showed high sensitivity (87.5%) but moderate specificity (45.5%), with a relatively high negative predictive value, supporting its usefulness in ruling out early delivery. For delivery within 4 hours, the AUC decreased to 0.444 (95% CI: 0.256–0.632; p=0.557), indicating no significant discriminative ability. At a cut-off value of ≥43.5 mm, HPD demonstrated low sensitivity and limited overall diagnostic performance.

Overall, HPD appears to be a useful parameter for excluding delivery within the early time intervals (1–2 hours), but its predictive value declines for longer durations.

4. DISCUSSION

The principal finding of this study is that AoP measured at the onset of the active phase of labor provides clinically useful prediction of time to delivery several hours before the second stage of labor. AoP is one of the most widely investigated ultrasound parameters for assessing labor progression because it objectively reflects fetal head descent. In our study, increasing AoP values were significantly associated with shorter delivery intervals, and ROC analysis demonstrated moderate predictive performance for delivery within 2 and 4 hours but limited discrimination for delivery within the first hour. The lower predictive performance for delivery within the first hour was expected because fetal head descent is still incomplete at the beginning of the active phase. Conversely, the higher AUC for delivery within four hours suggests that AoP is more suitable for predicting short-term labor progression than imminent birth. Previous studies have shown that an AoP ≥120° during the second stage of labor is

strongly associated with successful vaginal delivery [6]. Unlike these studies, our measurements were obtained at the beginning of the active phase (6-cm cervical dilatation); measuring AoP at 6-cm cervical dilatation may offer a clinically advantageous time point because management decisions regarding labor progress, augmentation, maternal counseling, and transfer of care are still modifiable, whereas measurements obtained during the second stage primarily reflect imminent delivery rather than allowing early prediction.

HPD was positively correlated with labor duration, indicating that greater distance between the fetal head and perineum reflects less advanced fetal descent. Although HPD was not an independent predictor after adjustment, it remained clinically informative. In particular, no woman with an HPD >39.5 mm delivered within the first hour, indicating excellent ability to exclude imminent delivery. Early prediction may also reduce unnecessary anxiety by providing women with more realistic expectations regarding labor duration. These findings are consistent with previous reports linking increased HPD with prolonged labor and a higher likelihood of operative or cesarean delivery [12, 13, 14, 15].

Among all evaluated variables, fetal head station emerged as the strongest independent predictor of time to delivery. Women with more advanced fetal head descent had significantly shorter labor durations. The loss of significance of AoP and HPD in the multivariable model likely reflects partial collinearity, as these sonographic parameters quantify the same biological process represented clinically by fetal head station. Nevertheless, the regression model explained only part of the variability in labor duration, indicating that additional factors, including uterine contractility, maternal pelvic characteristics, fetal head molding, and intrapartum management, also influence labor progression.

Occiput anterior position was associated with shorter labor compared with occiput posterior and transverse positions, although these differences were not statistically significant. Similarly, MLA and fetal head orientation were not independently associated with labor duration, possibly because fetal rotation is a dynamic process that may not be adequately captured by a single measurement obtained early in the active phase.

The negative correlation between labor duration and 1- and 5-minute Apgar scores further supports previous evidence that prolonged labor may adversely affect early neonatal adaptation [16]. Although the observed associations were modest, they highlight the potential clinical importance of early identification of women at risk for prolonged labor.

The absence of prior childbirth experience in nulliparous women makes the prediction of labor progression challenging for clinicians. A distinctive strength of the present study is that intrapartum ultrasound assessment was performed at the onset of the active phase of labor (6-cm cervical dilatation), demonstrating that clinically meaningful prediction of delivery timing can already be achieved at this early stage, unlike previous studies that primarily evaluated ultrasound parameters during the second stage of labor, when fetal head descent is already advanced and delivery is imminent [17, 18, 19, 20]. By obtaining ultrasound measurements earlier in the course of labor, our study demonstrates that clinically relevant information regarding the expected time to delivery can be obtained before the second

stage begins. This earlier prediction may provide clinicians with additional time for individualized labor management, optimization of maternal counseling, and timely planning of intrapartum interventions when necessary. Therefore, our findings suggest that intrapartum ultrasound should not be regarded solely as a tool for assessing labor progress during the second stage but also as a valuable prognostic modality during the early active phase of labor.

To our knowledge, this is among the first studies evaluating multiple intrapartum ultrasound parameters at the onset of the active phase of labor rather than during the second stage. The strengths of this study include its prospective design, the homogeneous nulliparous population, standardized ultrasound assessment at 6-cm cervical dilatation, and comprehensive evaluation of multiple sonographic parameters. However, several limitations should be acknowledged. This was a single-center study with a relatively small sample size, ultrasound measurements were operator-dependent, and serial ultrasound assessments were not performed. In addition, dynamic parameters such as changes in AoP during labor were not evaluated [21] . Future studies with larger sample sizes and the incorporation of additional ultrasound parameters, such as delta AoP, may further enhance the accuracy and reliability of predicting labor duration and progression in nulliparous women.

5. CONCLUSION

In nulliparous women, intrapartum ultrasound performed at the onset of the active phase of labor provides objective parameters for predicting time to delivery. Although fetal head station was the strongest independent predictor, AoP was the most clinically applicable ultrasound parameter because it provided objective prediction of delivery within 2–4 hours early in the active phase of labor, whereas HPD was particularly useful for excluding delivery within the first hour. Our findings suggest that intrapartum AoP assessment at the onset of active labor enables clinically meaningful prediction of delivery time several hours before the second stage of labor, extending the role of intrapartum ultrasound beyond assessment of labor progress to early prognostic decision-making.

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Author Contribution

M.A.C. conceived and designed the study, performed intrapartum ultrasound examinations, collected and analyzed the data, interpreted the results, and drafted the original manuscript. I.I.M. supervised the research, provided scientific guidance, and critically reviewed and revised the manuscript for important intellectual content. R.S.C., G.A.B., O.F.O., and C.D. contributed to patient recruitment, clinical data collection, and critical review and revision of the manuscript. All authors read and approved the final version of the manuscript and agreed to be accountable for their contributions to the work.

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Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Figures

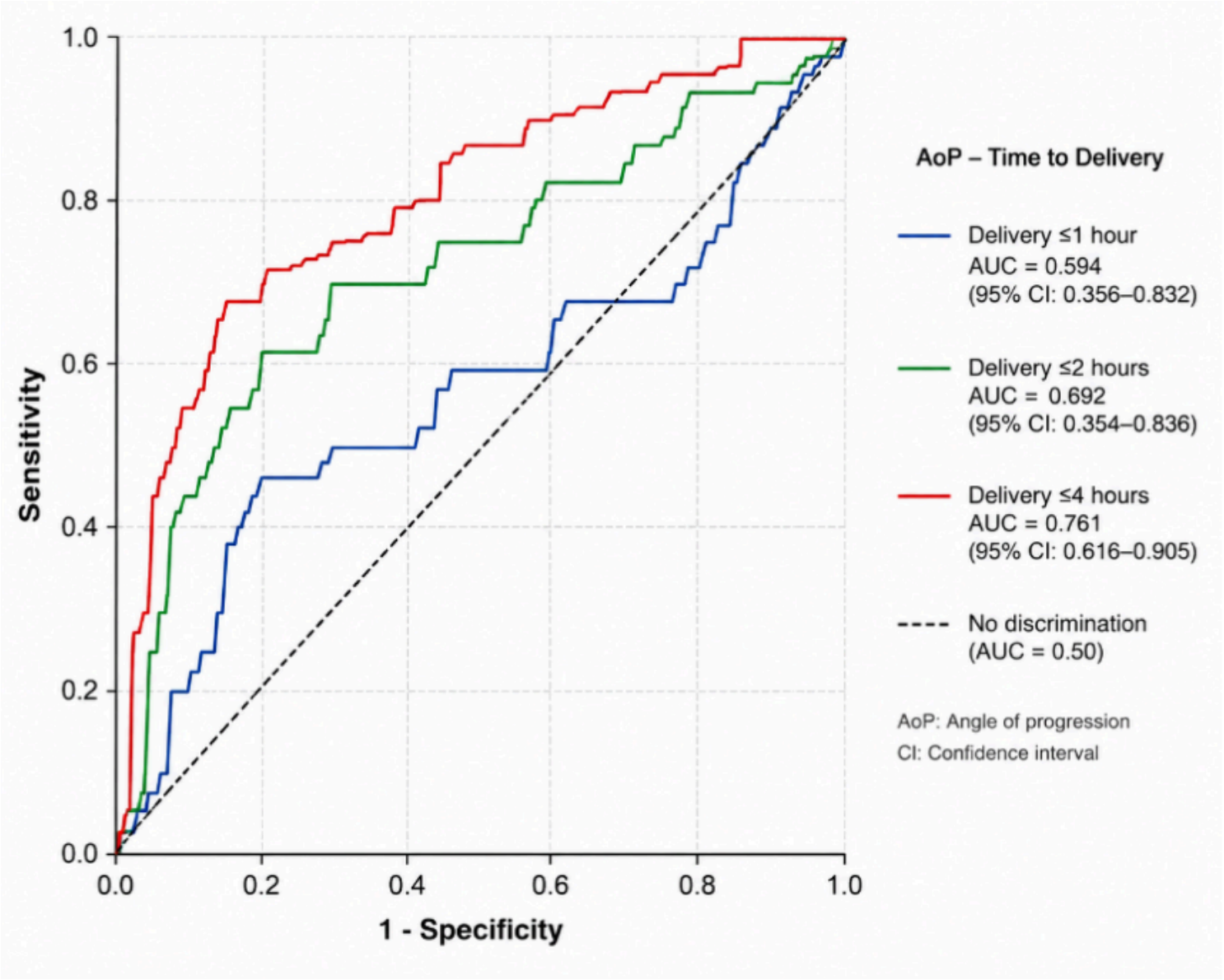

Figure 1

Receiver operating characteristic (ROC) curves of the angle of progression (AoP) measured at the onset of the active phase of labor for predicting delivery within 1, 2, and 4 hours in nulliparous women.

Supplementary Files

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