Simple models to predict vaginal delivery and spontaneous fetal occiput rotation based on intrapartum ultrasound and maternal characteristics

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Abstract

Objective: To develop the prediction models for identifying fetal occiput rotation and vaginal delivery based on intrapartum sonographic findings. Design: Prospective observational study. Setting: Hangzhou, China. Population: Nulliparous women with a singleton cephalic presentation at term. Methods: Serial intrapartum ultrasonography were performed in the latent phase (T1) and every three hours after that (T2, T3 and T4). The managing clinicians performed paired digital vaginal examinations to assess labor progress. Main Outcome Measures: Delivery mode and successful internal fetal head rotation to the occiput anterior (OA) position. Results: 614 women were included, of whom 524 underwent vaginal delivery, and 90 required cesarean section. The percentage of women with fetuses in non-occiput anterior position at the latent phase was 53.9% (331 cases), as 257 women underwent spontaneous rotation to OA position before delivery, 74 were with persistent occiput posterior or transverse position. We developed a model on the basis of the maternal height and middle angel to predict the spontaneous fetal occiput rotation, with the area under the receiver operating characteristic curve (AUC) was 0.667 (95%CI 0.583-0.751). Moreover, a prediction model based on the maternal height and angle of progression to evaluate whether women underwent vaginal delivery was also developed, of which the AUC was 0.738(95% CI: 0.763-0.793). Both models showed satisfactory calibration. Conclusion: Simple models based on maternal characteristics and intrapartum ultrasound findings might provide useful information for predicting vaginal delivery and internal fetal occiput rotation.

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Running title: Delivery prediction models, intrapartum ultrasound

ABSTRACT

Objective: To develop the prediction models for identifying fetal occiput rotation and vaginal delivery based on intrapartum sonographic findings.

Design: Prospective observational study.

Setting: Hangzhou, China.

Population: Nulliparous women with a singleton cephalic presentation at term.

Methods: Serial intrapartum ultrasonography were performed in the latent phase (T1) and every three hours after that (T2, T3 and T4). The managing clinicians performed paired digital vaginal examinations to assess labor progress.

Main Outcome Measures: Delivery mode and successful internal fetal head rotation to the occiput anterior (OA) position.

Results: 614 women were included, of whom 524 underwent vaginal delivery, and 90 required cesarean section. The percentage of women with fetuses in non-occiput anterior position at the latent phase was 53.9% (331 cases), as 257 women underwent spontaneous rotation to OA position before delivery, 74 were with persistent occiput posterior or transverse position. We developed a model on the basis of the maternal height and middle angel to predict the spontaneous fetal occiput rotation, with the area under the receiver operating characteristic curve (AUC) was 0.667 (95%CI 0.583-0.751). Moreover, a prediction model based on the maternal height and angle of progression to evaluate whether women underwent vaginal delivery was also developed, of which the AUC was 0.738(95% CI: 0.763-0.793). Both models showed satisfactory calibration.

Conclusion: Simple models based on maternal characteristics and intrapartum ultrasound findings might provide useful information for predicting vaginal delivery and internal fetal occiput rotation.

Key words: Prediction model, intrapartum ultrasound, angle of progression, midline angle, vaginal delivery, fetal occiput rotation

Tweetable abstract

Simple models based on maternal height and ultrasound findings can predict the delivery mode and internal fetal head rotation.

INTRODUCTION

Operative deliveries are associated with increased maternal (obstetric hemorrhage, perineal injuries, wound infection) [1, 2]and neonatal morbidity (neonatal seizures, and intracranial hemorrhage)[2-6]. It is important to monitor labor progress to prevent these maternal and neonatal complications [7]. The conventional assessment currently relies on a serial digital examination, which has been demonstrated to be subjective, imprecise, and poorly reproducible [8, 9]. Furthermore, digital vaginal examinations can also cause discomfort [10] and may introduce infection [9]. Intrapartum ultrasonographic examinations have been introduced to complement assessments of labor progress [11].

Occiput posterior (OP) and occiput transverse (OT) positions account for 15 to 49% at the onset of labor [12-15], and in most cases, the fetal head will rotate spontaneously to the occiput anterior (OA) positions. Accumulating evidence implicates the persistent OP or OT position is associated with obstetric complications, including prolonged labor, operative delivery, postpartum hemorrhage and third or fourth-degree perineal lacerations[16-18]. The spontaneous internal rotation of the fetal occiput from the transverse or posterior position to the anterior position is associated with multiparity, a maternal age of fewer than 35 years, maternal stature, BMI, and newborn birth weight (<4000 g) [14, 19, 20]. However, there is still no model, which can help predict successful fetal head rotation during the delivery.

In the last decade, various sonographic parameters have been proposed, including the angle of progression (AoP)[21], head-perineum distance (HPD)[22] and midline angle (MLA) [23]. Several studies have reported that intrapartum ultrasonography is a reliable and noninvasive approach for determining fetal head position, station and descent [24-27]. The AoP has been used to assess fetal head station and be predictive of spontaneous vaginal delivery or successful instrumental vaginal delivery[28-31], and the MLA was associated with the fetal head station and rotation[11].

In the majority of studies, a single assessment of sonographic parameters was performed in either the first or second labor phase[30, 32-35]. Moreover, few studies have developed predictive models associated with successful internal rotation and vaginal delivery. Therefore, the primary aim of the present study was to assess serial intrapartum ultrasound measurements at different time points during delivery for the prediction of the delivery mode in nulliparous women. A secondary aim was to develop a model to predict successful internal fetal occiput rotation.

METHODS

This prospective, longitudinal observational, single-center study was conducted in the Women's Hospital at Zhejiang University School of Medicine in Hangzhou, China, between May 2020 and November 2020. Nulliparous women with a singleton pregnancy in a cephalic presentation at term (37 or more full weeks of gestation) attempting vaginal birth were eligible for the study. Women were excluded if they were under 18 years of age, had intrauterine death or had emergencies (e.g., premature placental abruption, uterine rupture, cardiac disease of New York Heart Association (NYHA) grade 3 or 4, eclampsia). We also excluded the cases if they required cesarean deliveries purely because of fetal distress. The study was approved by the local ethics and research committees (IRB-20200148-R). Written consent was obtained from the women who agreed to participate.

Ultrasound assessments

The ultrasound assessments were carried out by four operators (X.X.Z., H. K. B., P.Y.L. and H.Q.Y.), who have had at least three year's obstetric ultrasound experience and were not involved in the clinical management of the recruited women. When the participants were in the semirecumbent position with an empty bladder, a two-dimensional transperineal ultrasonography scan was performed to assess the AoP, MLA and HPD using a GE Logiq V2 ultrasound system (GE Healthcare, USA) with a 2-5 MHz curvilinear transducer, as previously described[21-23]. The fetal occiput position was assessed transabdominally or transperineally [36], and the position was defined using the 12-hour clock system (see SUS1)[37]. The AoP is the angle between the long axis of the pubic bone and the leading part of the fetal skull in the midsagittal plane [21] (Figure 1a). The HPD is the shortest distance between the outer bony limit of the fetal skull and the perineum in the transverse plane [22](Figure 1b). The MLA is defined as the angle between the anteroposterior axis of the maternal pelvis and the midline of the fetal head [23](Figure 1c).

Digital examinations were performed by experienced obstetricians or midwives to assess cervical dilation, fetal head position and fetal head station before the ultrasonographic scans. The fetal head station was defined as the distance from the lowest part of the fetal head to the ischial spine (i.e., from -3 to +3, with 0 at the ischial spine). The interval between the paired examinations was no more than ten minutes, and the researchers were blinded to the findings of both examinations. The first intrapartum ultrasonographic examination was performed during the first stage of labor when the cervix was fully effaced and dilated by at least 3-4 cm but no more than 6 cm (latent phase) (T1), and intrapartum ultrasonographic scans were performed every three hours after that (T2, T3 and T4) until delivery.

The clinical team followed the standard local protocol of the research unit to manage labor progress. With a fully effaced cervix and cervical dilation of at least 3 cm, the women in labor were admitted to the predelivery room for continuous fetal heart monitoring. Labor augmentation with oxytocin was considered if there was suboptimal uterine power and unsatisfactory progress, as demonstrated by a partogram, and there was no evidence of obstructed labor. Failure to progress was defined as longer than 12 hours in the latent phase or cervix failed to dilate at a rate of 1cm per hour for at least 2 hours.

Maternal clinical data, such as age, gestational age at delivery, height, body mass index (BMI), induced or spontaneous labor, premature rupture of the membrane, the use of epidural anesthesia, labor augmentation with oxytocin, the final mode of delivery and the indication for operative delivery, were recorded. Data on the neonatal outcomes were also collected: sex, birth weight, Apgar scores after 1 and 5 minutes and the admission of the newborn to the neonatal unit. Gestational age was determined by the date of the first day of the last menstrual period and confirmed by the first-trimester ultrasound measurement of crown-rump length[38]. BMI was calculated according to the standard formula, and overweight was defined as BMI [?] 25 kg/m^2. Successful internal rotation was defined as the fetal head rotating to the occiput anterior (OA) position from a non-occiput anterior (non-OA) position (transverse or posterior) during the labor. Vaginal delivery in our unit included spontaneous and operative delivery using forceps.

Calculation of sample size

We assumed that the non-OA (OP and OT) prevalence during the first stage of labor was 60%. We hypothesized that the rate of spontaneous internal rotation to the OA position would be 80% in the group, and the proportions of cesarean delivery in the non-OA position and OA position were 30% and 10%, respectively. The total estimated sample size was 507 by accepting an alpha risk of 0.05 (two-sided) and a power of 80%. Finally, we increased the number by 20% (634 women) to compensate for the dropout rate and any secondary exclusion.

Statistical analysis

Descriptive statistics were calculated, and the data are presented as the means (standard deviations [SDs]) or medians (ranges) for numeric variables. Comparisons of normally and nonnormally distributed continuous variables between study groups were performed using the Kruskal-Wallis test. Categorical variables are reported as numbers (percentages) and were compared by Fisher's exact test. Multivariable logistic regression analyses were performed to control potential cofounders and predict the successful fetal head rotation and vaginal delivery. The variables chosen in these logistic models were significant or marginally significant ($P<0.1$) in univariate analysis and were described in the previous studies [20, 39]. Discrimination (the ability of the model to differentiate between the presence and absence of the event) was assessed by the area under the receiver operating characteristic curve (AUC). While calibration was assessed with calibration plots to measure how well the predicted outcome of the model agrees with the observed outcome. Statistical results with two-sided P values were reported, and a value of $P < 0.05$ was considered statistically significant. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 26 (IBM, Armonk, NY, USA) and R statistical software, version 4.0.3.

RESULTS

Maternal characteristics

A total of 634 nulliparous women were recruited, fifteen of whom were excluded because of incomplete data, and five withdrew due to discomfort during the ultrasound examination. Of the remaining 614 women, 524 (85.3%) women underwent vaginal delivery and 90 (14.7%) were required cesarean delivery. The percentage of women with fetuses in non-OA position at the first time of ultrasound examination was 53.9% (331 cases) in our study, as 159 (25.9%) cases were in the OP position and 172 (28.0%) were OT position. The main characteristics of the participants are shown in Table 1.

Comparison of clinical findings and ultrasound parameters by the mode of delivery

The maternal and neonatal demographic characteristics compared between the vaginal delivery and cesarean delivery groups are shown in Table S1. There were no significant differences between these two groups, except for maternal height (161.2 +- 4.6 vs. 158.8+-5.1 cm, $P < 0.001$) and neonatal birth weight (3390.5 +- 366.7 vs. 3550.7 +- 380.4 g, $P < 0.001$) (Table S1). Focusing on the sonographic parameters, the women who underwent vaginal delivery had a significantly larger AoP compared with the women who required cesarean section over time (Table 2). For HPD measurements, the cesarean delivery group showed significantly longer distance than did the vaginal delivery group (Table 2). Accounting for MLA, the vaginal delivery group showed comparable measurements to the cesarean delivery group initially (T1: 55.27+-27.36 vs. 60.09+-27.93deg; P = 0.201), whereas from three hours afterward, a significantly narrower angle was observed among the women who achieved vaginal delivery (T2: 47.42 +- 27.36 vs. 68.18+-25.49deg, P<0.001; T3: 38.96 +-24.37 vs. 63.18 +- 30.79deg; P=0.004) (Table 2).

A simple model to predict the internal rotation

A total of 257(77.6%) women with a fetus in non-OA position during the latent phase underwent spontaneous rotation to OA position before delivery; however, 74 (22.4%) were persistent OP or OT position. According to the occurrence of internal fetal head rotation, the individual characteristics were similar besides maternal height (161.0+-4.4 vs. 159.7+-5.2 cm; P = 0.022) (Table S2). The multivariable logistic regression analysis demonstrated that the MLA (adjusted odds ratio [aOR]: 1.021, 95% confidence interval [CI]:1.008-1.034) and maternal height (aOR: 1.107, 95% CI:1.026-1.195) were the significant predictors of spontaneous fetal occiput rotation after adjusting for maternal age, gestational age, overweight, premature rupture of the membrane, labor induction, oxytocin augmentation and the use of epidural analgesia (Table S3). The final model that predicted internal fetal head rotation based on MLA at the first ultrasound scan and the maternal height was shown in Table 3, which obtained the AUC was 0.667 (95% CI, 0.583-0.751; P<0.001) (Figure 2). The calibration curve shows good agreement between predicted and observed probabilities for the occurrence of spontaneous fetal head rotation (Figure 3(a)).

A simple model to predict vaginal deliveries

We performed a forward multivariate logistic regression analysis model that included the factors associated with the delivery mode in the univariate analysis (P<0.1). In this model, the AoP and maternal height were the independent factors associated with the mode of delivery after adjustment for confounders, including maternal age, gestational age, overweight (BMI[?]25 Kg/m^2), premature rupture of the membrane, labor induction and oxytocin augmentation (Table S4). The combination of maternal height and the AoP could evaluate whether women were to undergo vaginal delivery, yielding an AUC of 0.738 (95% CI, 0.763-0.793; P<0.001) at T1, 0.820 (95% CI, 0.752-0.888; P<0.001) at T2 and 0.940 (95% CI, 0.885-0.995; P<0.001) at T3 (Figure 4), respectively. Figure 3(b) showed the optimal calibration of the prediction model. This model was also suitable for women with fetuses in the occiput posterior or transverse position at the latent phase, yielding AUC 0.725 (95% CI, 0.649-0.801; P<0.001) at T1 and 0.790 (95% CI, 0.705-0.874; P<0.001) at T2, respectively (Figure S2).

DISCUSSION

Main Findings

In the present study, we performed intrapartum ultrasonographic assessments of fetal head station and position, which differed significantly at various times during the labor. We developed a binary logistic regression model based on maternal height and angle of progression to predict 73.8% of vaginal deliveries at the latent labor phase. Moreover, a simple prediction model combining middle angel and maternal height for estimating the spontaneous fetal head rotation was also obtained. Because these two models both require only two parameters (one clinical variable and one intrapartum ultrasound parameter) that can be easily acquired, we suppose both models can be applied in any delivery unit.

Strengths and Limitations

The strengths of our study include the following: (1) this study is a prospective longitudinal study that measured ultrasound parameters of the fetal head station and position throughout the first and second labor stages in women with singleton pregnancies at term. (2) In this double-blinded study, the researchers and the managing clinicians were both blinded to the respective findings to avoid potential bias. (3) New objective and simple models based on the ultrasound parameters and clinical variables were shown to predict the internal fetal head rotation and delivery mode. However, we do acknowledge some limitations. Firstly, our study population included only Chinese women, and our results might not be representative of other ethnic populations. Secondly, neonatal birth weight is also a significant risk factor according to the mode of delivery in our observational study; however, we did not introduce this item as a predictive factor because of lacking a precise method to estimate the fetal weight before delivery. Furthermore, we should carry out the external validation of the prediction model.

Interpretation (in light of other evidence)

Non-occiput anterior (transverse or posterior) positions are associated with a high risk of cesarean section, operative vaginal delivery and other peripartum complications, including third- or fourth-degree perineal lacerations, postpartum hemorrhage and chorioamnionitis[13, 18, 40, 41]. Compared with neonates born in the OA position, neonates born in a non-occiput anterior position have a lower Apgar score, a higher risk of neonatal intensive care unit admissions and higher rates of birth trauma [18, 19]. The incidence of persistent OP position is between 5% and 12% [12, 18, 42], and that of persistent OT position varies from 3% to 8%[13, 40, 43]. A study by Petitjean et al. [44] identified oxytocin augmentation, excessive gestational weight gain, direct OP position and macrosomia as independent factors associated with non-OA to OA rotation during the first stage of labor. In our study, maternal height is the single individual factor associated with internal fetal occiput rotation. On the other hand, the degree of fetal head rotation, as measured by the MLA, was parallel between vaginal and cesarean delivery groups at first. However, the MLA of the women who experienced vaginal delivery was narrower subsequently, indicating the occurrence of spontaneous rotation.

Moreover, we develop a simple model based on the intrapartum sonographic parameter and maternal characteristic to predict spontaneous fetal head rotation in the first stage of labor. We think this finding might provide the clinicians an opportunity to take earlier action to reduce the obstetric complications associated with persistent OP and OT positions.

Accumulating studies showed that maternal and neonatal characteristics, including parity, maternal age, height, BMI, neonatal birth weight and fetal head position, are independent factors that affect the mode of delivery [28, 45, 46]. Burke et al. [47]reported a risk prediction model for cesarean delivery using five parameters (maternal age, height, BMI, fetal head circumference and fetal abdominal circumference), with excellent discrimination (Kolmogorov- Smirnov, D statistic, 0.29; 95% CI, 0.28- 0.30). Furthermore, Eggebo et al. [39]introduced intrapartum ultrasound to developed another risk score based on maternal characteristics (gestational age, maternal weight, BMI and cervical dilatation), occiput position and intrapartum findings (head perineal distance and caput succedaneum) to predict vaginal birth, which yielded an AUC of 0.853 (95%CI, 0.678-1.000). Our study illustrated a much simple prediction model based on only two parameters (maternal stature and AoP) for evaluating the delivery mode in the nulliparas in the first stage of labor. We started the intrapartum ultrasound assessment during the latent phase (cervical dilatation less than 6 cm), which allowed clinicians to identify early the women who required cesarean delivery. We caution that the knowledge derived from our model should not alter obstetric decision making. However, our study might provide useful information about the chance of spontaneous rotation and vaginal birth, allowing appropriate interventions at the proper time.

CONCLUSION

In conclusion, our study provides simple models based on maternal characteristics and intrapartum ultrasound findings that can predict the chance of vaginal birth and successful internal fetal head rotation in nulliparous women. We suppose these models can be implemented in any delivery unit.

Disclosure of Interests

The authors report no conflict of interest. Completed disclosure of interest forms are available to view online as supporting information.

Contribution to Authorship

Concept and design: CC, XXZ, XHG, BHZ and QL.

Data acquisition: HKB, YMZ, HQY, PYL and YLW.

Statistical analysis: CC, XXZ, XFY and XY

Drafting of manuscript: CC, BHZ and QL.

Review of manuscript: all authors.

Details of Ethics Approval

Ethical approval for the study was obtained from the Ethics Committee of Women's Hospital, Zhejiang University School of Medicine on 25 May 2020 (Number IRB-20200148-R).

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Legends

Figure 1. Sonographic parameters of fetal head descent and rotation: (a) The angle of progression (AoP) in the transperineal longitudinal plane; (b) The head-perineum distance (HPD) measured on a sagittal scan and (c) the midline angle in the transperineal axial plane.

Figure 2. Receiver operating characteristic curve for the prediction model of the midline angle combined with the maternal height. The area under the curve (AUC) for the prediction of successful fetal head rotation was 0.667 (95% CI, 0.583-0.751; P<0.001).

Figure 3. Calibration curves for prediction models. (a) Model of fetal occiput rotation; (b) Model of vaginal delivery.

Figure 4. Receiver operating characteristic curve of the combination of maternal height and angle of progression (AoP) for predicting vaginal delivery at different scan intervals. The first scan time (T1) was at the latent labor phase (red line). Subsequent scans were performed at 3 hours intervals (T2, blue line; T3, green line). The areas under the curves (AUCs) for the prediction model were 0.738 (95% CI, 0.763-0.793; P<0.001) at T1, 0.820 (95% CI, 0.752-0.888; P<0.001) at T2 and 0.940 (95% CI, 0.885-0.995; P<0.001) at T3, respectively.

Table 1 Maternal and newborn characteristics of participants

Table 2 The angle of progression (AoP), head–perineum distance (HPD) and midline angle (MLA) at different time points, according to the mode of delivery

Table 3 Final logistic regression models to predict spontaneous fetal occiput rotation and vaginal delivery

Supporting information

The following supplementary materials are available for this article:

Figure S1. Classification of fetal occiput position based on 12-hour clock face.

Figure S2. Receiver operating characteristic curve of the model for predicting vaginal delivery in nulliparous women with fetuses in the occiput posterior or transverse position at latent phase.

Table S1. Maternal and neonatal characteristics of the study population, according to the mode of delivery.

Table S2. Maternal and neonatal characteristics of the study population, according to internal rotation.

Table S3. Maternal and neonatal characteristics of the study population, according to internal rotation.

Table S4. Logistic regression analysis for the prediction of delivery mode, according to serial ultrasound evaluations

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Table 1 Maternal and newborn characteristics of participants

Variables	Variables	Findings
Maternal age, y, mean±SD	Maternal age, y, mean±SD	29.0±3.2
[?]35, n (%)	[?]35, n (%)	33(5.4%)
Maternal height, cm, mean±SD	Maternal height, cm, mean±SD	160.8±4.8
Maternal weight, kg, mean±SD	Maternal weight, kg, mean±SD	67.5±8.6
Body mass index, kg/m^2, mean ±SD	Body mass index, kg/m^2, mean ±SD	26.1±2.9
Overweight, n (%)	Overweight, n (%)	382(62.2%)
Gestational age at delivery, weeks, mean±SD	Gestational age at delivery, weeks, mean±SD	39.6±1.0
Gestational pathology, n (%)	Gestational diabetes mellitus, n (%)	93(15.1%)
	Gestational hypertensive disorder, n (%)	34(5.5%)
	Intrahepatic cholestasis of pregnancy, n (%)	13(2.1%)
Fetal head position at inclusion	Occiput anterior, n (%)	283(46.1%)
	Occiput transverse, n (%)	172(28.0%)
	Occiput posterior, n (%)	159(25.9%)
Premature rupture of membranes, n (%)	Premature rupture of membranes, n (%)	155(25.2%)
Epidural, n (%)	Epidural, n (%)	557(90.7%)
Induction of labor, n (%)	Induction of labor, n (%)	234(38.1%)
Augmentation, n (%)	Augmentation, n (%)	411(66.9%)
Delivery mode	Vaginal delivery, n (%)	524(85.3%)
	Cesarean delivery, n (%)	90(14.7%)
Birth weight, g, mean ± SD	Birth weight, g, mean ± SD	3414.0±372.8
Newborn gender, male, n (%)	Newborn gender, male, n (%)	326(53.1%)
Apgar 1 min, median (range)	Apgar 1 min, median (range)	10(3-10)
Apgar 5 min, median (range)	Apgar 5 min, median (range)	10(5-10)
Meconium amniotic fluid, n (%)	Meconium amniotic fluid, n (%)	98(16.0%)
NICU, n (%)	NICU, n (%)	58(9.4%)

Overweight: Body mass index [?]25 kg/m^2; NICU, Admission to neonatal intensive care unit.

Table 2 The angle of progression (AoP), head–perineum distance (HPD) and midline angle (MLA) at different time points, according to the mode of delivery

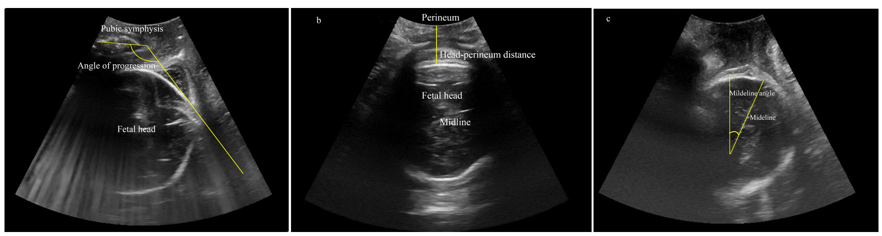
HPD (cm)	P value	**<0.001**	**<0.001**	**0.003**	**-**
	Cesarean delivery	5.16±0.89 (n=90)	5.02±1.01 (n=40)	4.81±0.55 (n=10)	-
	Vaginal delivery	4.57±0.97 (n=524)	4.09±1.17 (n=268)	3.69±1.15 (n=98)	3.39±0.93 (n=16)
MLA (°)	P value	0.201	**<0.001**	**0.004**	**-**
	Cesarean delivery	60.09±27.93 (n=86)	68.18±25.49 (n=40)	63.18±30.79 (n=10)	-
	Vaginal delivery	55.27±27.36 (n=518)	47.42±27.36 (n=268)	38.96±24.37 (n=98)	35.47±21.60 (n=16)
AoP(deg)	P value	**<0.001**	**<0.001**	**<0.001**	**-**
	Cesarean delivery	105.32±12.76(n=90)	110.46±12.5 (n=40)	111.35±11.1 (n=10)	
	Vaginal delivery	116.06±16.96 (n=524)	128.43±22.93 (n=268)	138.78±22.43 (n=98)	143.97±45.00 (n=16)

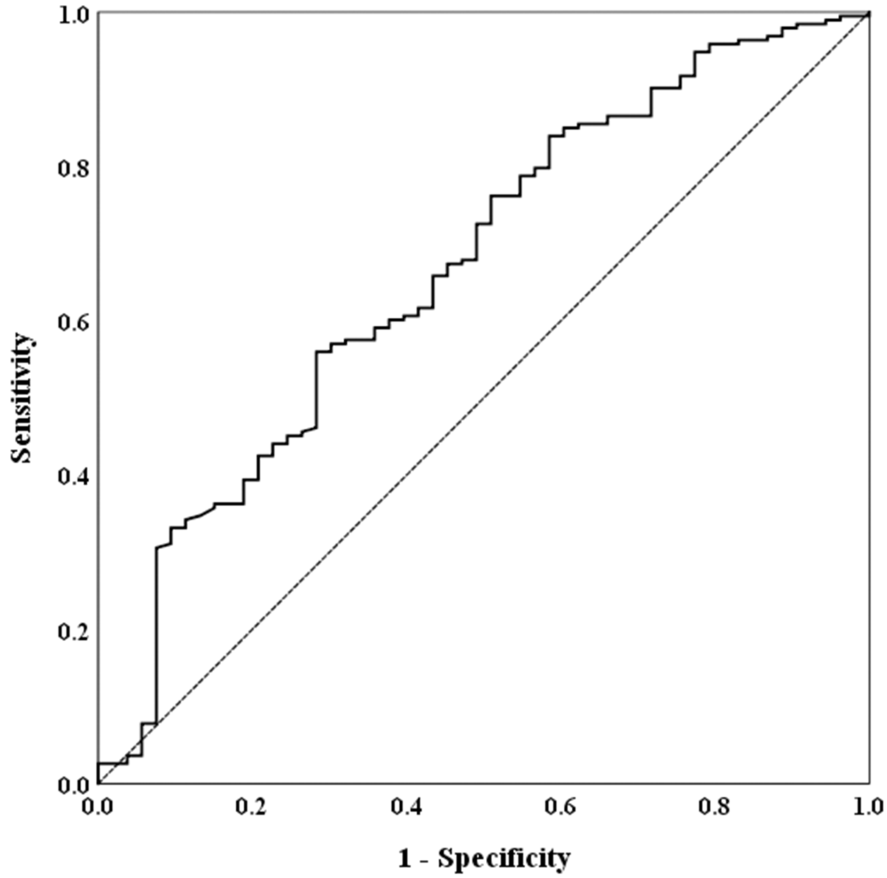
HPD (cm)	P value	**<0.001**	**<0.001**	**0.003**	**-**
	Time point	T1	T2	T3	T4

Table 3 Final logistic regression models to predict spontaneous fetal occiput rotation and vaginal delivery

Variables in the equation	aOR	95% CI	*P* value
spontaneous rotation model	spontaneous rotation model	spontaneous rotation model	spontaneous rotation model
Midline angle	1.019	1.007-1.031	**0.002**
Maternal height	1.083	1.010-1.162	**0.026**
Constant	-12.634		
Delivery model	Delivery model	Delivery model	Delivery model
Angle of progression	1.052	1.034-1.071	**<0.001**
Maternal height	1.134	1.075-1.195	**<0.001**
Constant	-23.944		

aOR, adjusted odds ratio; CI, confidence interval.

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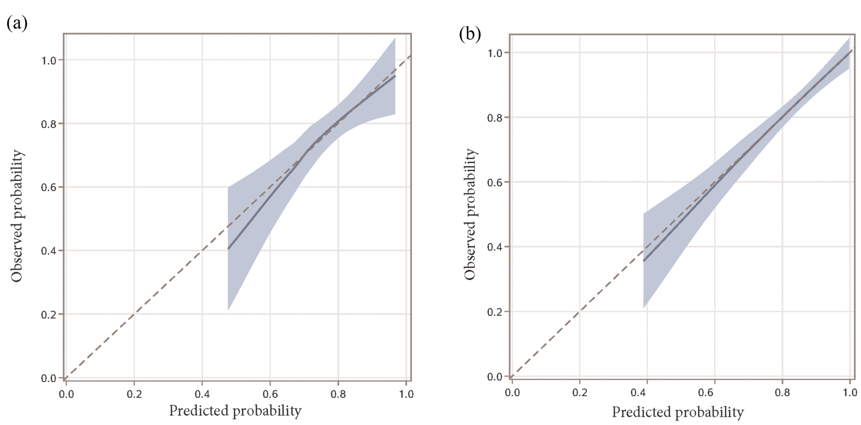
0.2
0.4
0.6
0.8
1.0


(a)
(b)
Observed probability
Predicted probability
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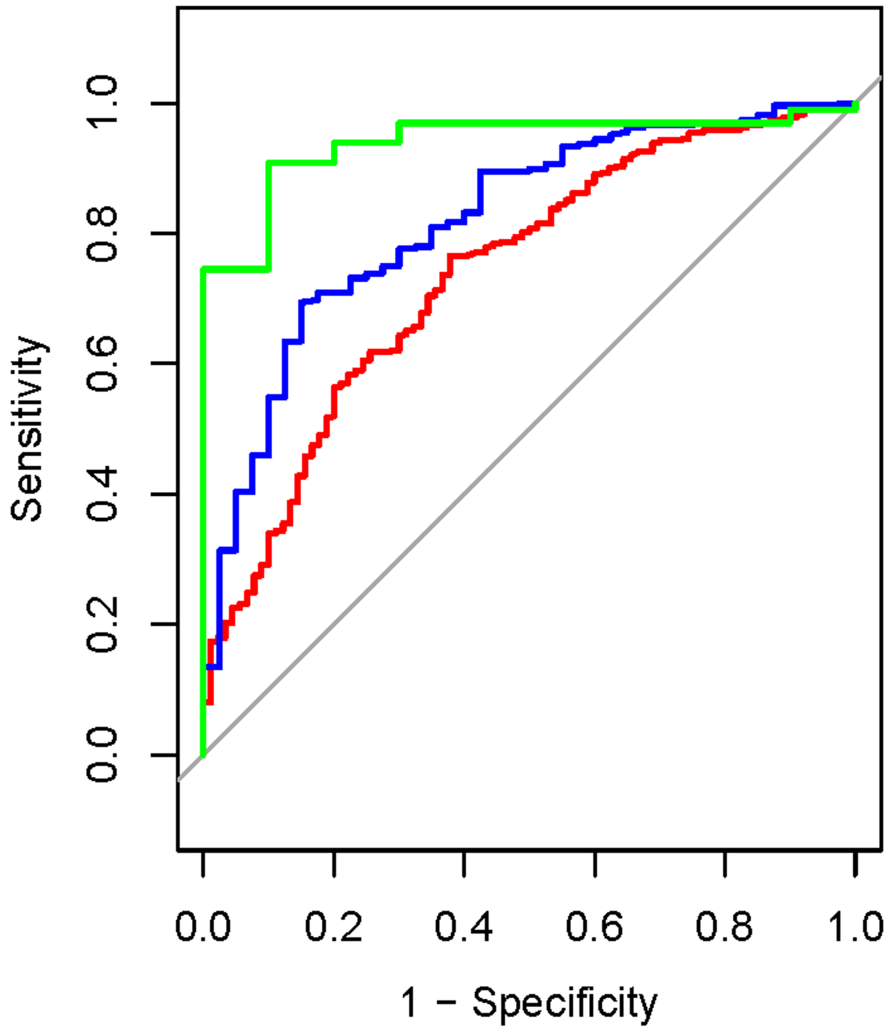
0.2
0.4
0.6
0.8
1.0



Sensitivity
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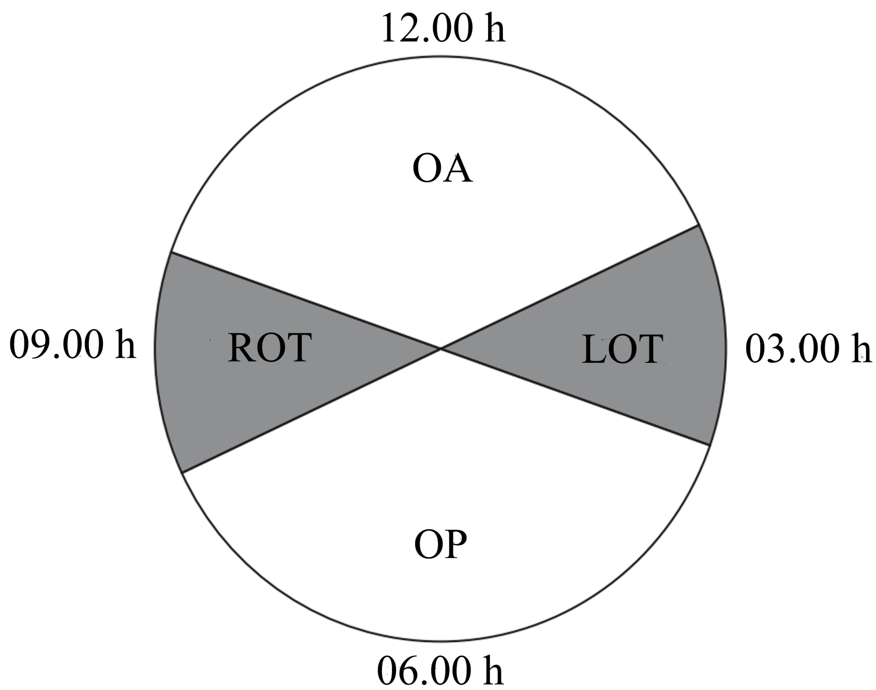
1 − Specificity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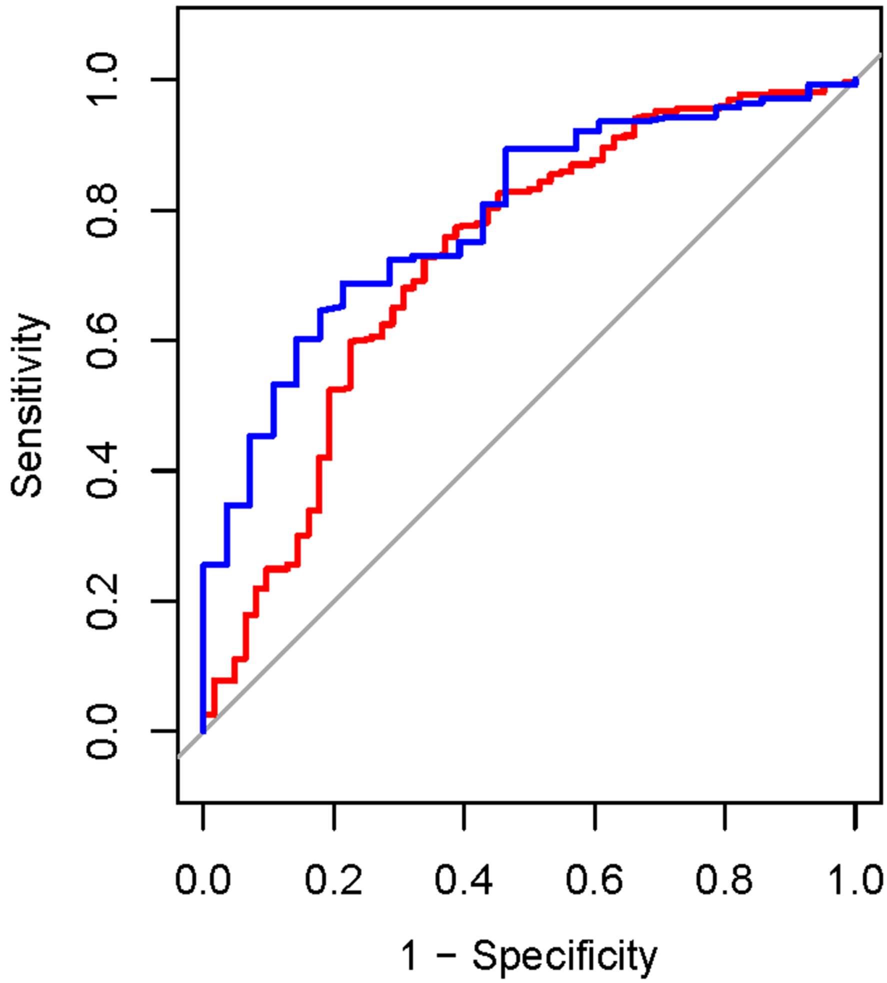
Sensitivity
0.0
0.2
0.4
0.6
0.8
1.0
1 − Specificity