Can ultrasound on admission in active labor predict labor duration and a spontaneous delivery?

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Condensation

Ultrasound at the beginning of the active phase can predict length of labor and mode of delivery in nulliparous women.

Short Title

Ultrasound as an admission test in active labor

AJOG at a Glance (130 words)

A. ***Why was the study conducted***?

- Predicting the length of labor and a spontaneous delivery on admission could be valuable.
- The performance of ultrasound as an admission test using head-perineum distance (HPD), angle of progression (AoP), fetal head position and cervical dilatation was investigated.

B. ***What are the key findings***?

- Duration of labor expressed as the HR for spontaneous delivery was 1.90 for HPD (95% CI; 0.83 to 2.60), for AoP the HR was 2.07 (95% CI; 1.15 to 3.72) and for cervical dilatation 3.11 (95% CI; 1.68 to 5.77).
- HPD and AoP was associated with spontaneous delivery with an AUC of 0.68 and 0.67, respectively
- Fetal head position was not associated with labor duration or mode of delivery.

C. ***What does this study add to what is already known***?

- Ultrasound can be used as an admission test in active labor

- Fetal head station was associated with labor duration and spontaneous delivery
- Cervical dilatation was associated with labor duration
- Fetal head position was neither significantly associated with labor duration nor mode of delivery

Structured Abstract

Background

Identifying predictive factors for a normal outcome at admission in the labor ward would be of value for planning labor care, timing interventions and in preventing labor dystocia. Clinical assessments of fetal head station and position at the start of labor have some predictive value but the value of ultrasound methods for this purpose has not been investigated. Studies using transperineal ultrasound before labor onset show possibilities of using these methods to predict outcome.

Objective

To investigate if ultrasound measurements during the first examination in the active phase of labor were associated with the duration of labor phases and the need for operative delivery.

Study Design

This was a secondary analysis of a prospective cohort study at Landspitali University Hospital, Reykjavik, Iceland. Nulliparous women at ≥37 weeks with a single fetus in cephalic presentation and spontaneous labor onset were eligible. The recruitment period was from January 2016 to April 2018.

Women were examined by a midwife on admission and included if in established active phase defined as regular contractions with a fully effaced cervix, open four cm or more. An ultrasound examination was performed by a separate examiner within 15 minutes, both examiners were blinded to the other's results. Transabdominal and transperineal ultrasound were used to assess fetal head position, cervical dilatation and fetal head station expressed as head-perineum distance and angle of progression.

Duration of labor was estimated as the hazard ratio for spontaneous delivery using Kaplan-Meier curves and Cox regression analysis. The hazard ratios were adjusted for maternal age and BMI. The associations between study parameters and mode of delivery were evaluated using receiver-operating characteristic curves.

Results

Median time to spontaneous delivery when head-perineum distance was ≤45 mm was 490 minutes compared to 682 min when >45mm (log rank test, p=0.009, but the adjusted HR for shorter HPD was 1.47; 95% CI; 0.83 to 2.60). For angle of progression ≥93° the median duration was 506 minutes compared to 732 min when <93° (log rank test, p=0.008, adjusted HR for AoP as continuous variable was 2.07; 95% CI: 1.15 to 3.72). The median time to delivery for non-occiput posterior positions was 506 minutes compared with 677 minutes for occiput posterior positions (log rank test, p=0.07, adjusted HR 1.52; 95% CI: 0.96-2.38) Median time to delivery was 429 minutes for dilatation of ≥6 cm and 704 minutes for dilatation of 4-5 cm (log rank test, p=0.002, adjusted HR 3.11; 95% CI: 1.68 to 5.77).

Spontaneous deliveries were 75, 16 were instrumental vaginal (one forceps and 15 ventouse) and eight were cesarean deliveries. Head-perineum distance was associated with spontaneous delivery with AUC=0.68 (95% CI; 0.55 to 0.80) and angle of progression with AUC=0.67 (95% CI; 0.55 to 0.80). Ultrasound measurement of cervical dilatation or position at inclusion were not significantly associated with a spontaneous delivery.

Conclusions

Ultrasound examinations showed that fetal head station and cervical dilatation was associated with the duration of labor but measurements of fetal head station were the variables best associated with operative deliveries.

Abbreviations: OP, occiput posterior; HR, hazard ratio; CI, confidence intervals; AUC, area under the curve; HPD, head perineum distance; AoP, angle of progression.

Keywords

Angle of progression, fetal head station, head perineum distance, labor, transperineal ultrasound, delivery time

Introduction

The length of labor is highly individual. Prolonged labor is known to increase the risk of adverse outcomes for the mother and fetus and is associated with a negative birth experience.[1, 2] Slow progress in labor occurs in 13-37% of nulliparous women and dystocia is a frequent indication for cesarean section during labor.[3-5] It would be advantageous to be able to predict which women will deliver vaginally when they enter labor. Various factors have been used to try to predict the need for cesarean section before labor, especially before labor induction[6-9] or in women who have had a previous cesarean section. Very few studies have been done among women expecting to go into spontaneous labor or when they are admitted to a labor ward.[10-12] Among the factors investigated are maternal characteristics such as age, height, BMI and gestational age, but also clinical factors such as cervical dilatation and station and position of the fetal head.

Although cervical dilatation is relatively easily assessed with digital vaginal palpation, assessments of both head station and position have been shown to be subjective and often inaccurate.[13-16]

Transabdominal and transperineal ultrasound is increasingly used as an adjunct to clinical assessment during labor, since fetal head position and descent into the pelvic cavity are more accurately determined with ultrasound than digitally.[16-18] The International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) has published guidelines for the use of ultrasound in labor.[19] We have shown that these methods can be used to follow labor progress in terms of fetal head station and position.[20, 21] Identifying predictive factors for a normal outcome early in the labor process would be desirable and of value for planning labor care, allowing for better targeted interventions and resources when labor dystocia is more likely to arise. Previous studies using transperineal ultrasound before spontaneous or induced labor have shown that it is possible to use these methods to predict outcome.[22-24] A prediction model in normal and prolonged nulliparous labors has even been constructed.[25] We aimed to investigate how ultrasound assessments during the first examination in the active phase of labor were associated with duration of labor phases and delivery mode.

Materials and methods

This was a secondary analysis of a prospective cohort study at Landspitali University Hospital in Reykjavík, Iceland, between January 2016 and April 2018. We examined 99 women with ultrasound longitudinally through the active phase of labor. The fetal head descent and fetal rotation patterns in this group have been published.[20, 21] In this study we

concentrate on the predictive value of the first ultrasound examination.

Women over the age of 18 with a single fetus in cephalic presentation and a spontaneous start of labor at gestational age ≥37 weeks were eligible and recruited in a non-consecutive manner. The study population corresponded to the definition of group 1 in the Robson 10-group classification system (nulliparous women in spontaneous labor).[26] Oral and written information about the study was provided by a midwife on admission to the labor ward and written consent obtained before inclusion.

Active labor was defined by a clinical examination as a fully effaced cervix, open at least four centimeters in the presence of regular contractions in agreement with the actual WHO recommendations.[27, 28] Women were included after the initial examination if they were in established active phase or when the active phase was diagnosed in the women who had been admitted in the latent phase.

A midwife examined cervical dilatation clinically at admission. An ultrasound examination was then done by one of two obstetricians trained in both transabdominal and transperineal scanning within 15 minutes. Results of the ultrasound examination were not revealed to the labor ward staff and the ultrasound examiners were not involved in clinical decisions regarding the laboring women.

The main outcome measure was duration of the active phase of labor estimated as the likelihood for spontaneous delivery and expressed by a hazard ratio (HR). Secondary outcomes were duration of the second stage, duration of active pushing phase and mode of delivery. Independent test variables were the ultrasound findings of head-perineum distance (HPD), angle of progression (AoP), fetal head position and cervical dilatation.

189 The guidelines at the hospital have no upper limit for the duration of the active phase of
190 labor, but the second stage should not be longer than four hours and active pushing no
191 longer than two hours.

192 The ultrasound device used was Voluson *i* (GE Medical systems, Zipf, Austria)
193 with a 3.5-7.5- MHz 3D curved multi-frequency transabdominal transducer. The
194 ultrasound examination comprised both a transabdominal and transperineal scan. To
195 determine the fetal head position, the transabdominal approach was used first. For this
196 purpose, views of the fetal spine, orbits, midline structures of the fetal head and the
197 choroid plexus were obtained. When this was not possible, due to deep engagement of the
198 fetal head, the transperineal approach was used to determine position, obtaining views of
199 the midline structures, the thalami and the choroid plexuses. The fetal head position was
200 defined as the position of the occiput marked on a clock face graph with half-hour
201 intervals. The occiput posterior position was categorized as ≥04:00 and ≤08:00 o'clock as
202 described by Akmal et al.[29, 30]
203 Further, during the transperineal scan, AoP, HPD and cervical dilatation were
204 assessed. AoP was measured in the sagittal plane as the angle between the longitudinal
205 axis of the pubic symphysis and a line from the most inferior edge of the symphysis
206 tangentially to the lowest contour of the fetal head.[31] The HPD was measured in the
207 frontal plane (transverse plane related to perineum) as the shortest distance from the
208 transducer to the fetal skull as previously described.[24, 32] After measuring HPD, the
209 transducer was tilted posteriorly until the cervix could be seen.[33-35] Both the anterior-
210 posterior and transverse diameters of the cervical dilatation were measured and the mean
211 value used for calculations. All measurements were done in-between contractions.

All data were collected and managed using REDCap electronic data capture tools hosted at Landspitali University Hospital.[36] The study was approved by the Landspitali Ethics Committee, reference no. 26/2015.

Statistical analysis

The associations between spontaneous vaginal delivery vs. all operative deliveries related to ultrasound assessed HPD, AoP and cervical dilatation as continuous variables were evaluated using receiver-operating characteristic (ROC) curves. The best cut-off levels for predicting spontaneous delivery were used to determine HPD and AoP categories. Hvilken test?

To evaluate differences in the time interval from inclusion to spontaneous vaginal delivery according to fetal head station, position and cervical dilatation, we used Kaplan-Meier methods and Cox regression analyses. The Kaplan-Meier method was used to generate plots for fetal head station categories, for OP vs. non-OP positions and for cervical dilatation <4-5 cm vs. ≥6 cm. The plots were compared with a log rank test. Cox regression analyses were used to calculate hazard ratios (HR) as an estimate of the likelihood ("risk") of spontaneous delivery using the same categories for HPD, AoP, cervical dilatation and occiput positions for comparison. Cesarean sections and operative vaginal deliveries were censored.

We used the statistical software package R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Results

Study population

One hundred women were included, but one woman withdrew her consent. The study population characteristics and labor outcomes are given in Table 1. Clinically assessed cervical dilatation at inclusion was four cm in 26 women, five in 30, six in 19, seven in 16 and eight in six women and in two women the dilatation was nine and ten cm. At inclusion, 49 women had confirmed rupture of membranes.

Spontaneous delivery

In all, 75/99 women achieved a spontaneous delivery, and 24 were delivered operatively; eight with a cesarean and 16 with an instrumental vaginal delivery. All but one of the operative deliveries were owing to prolonged first or second stage of labor (further details can be found in a longitudinal study describing the patterns of fetal head descent).[21] Of the 52 women that had a fetus in the OP position at inclusion, 35 (67%) delivered spontaneously compared with 40/47 (85%) women who had a fetus in a non-OP position (p=0.06). The ROC curve analyses for the associations between HPD and AoP at inclusion in prediction of a spontaneous delivery are shown in Figure 1. HPD was associated with spontaneous delivery with AUC=0.68 AUC (95% CI: 0.55 to 0.80) and AoP with 67% AUC=0.67 (95% CI: 0.55 to 0.80). The best cut-off level for predicting spontaneous delivery was HPD of ≤45mm and AoP of ≥93°. These levels were also used for stratification into groups for comparison of labor duration. Ultrasound measurement of cervical dilatation was not associated with a spontaneous delivery, with an AUC of

0.50 (95% CI, 0.38-0.63). The test characteristics of ultrasound measurements in predicting spontaneous delivery are presented in Table 2.

Duration of labor

At inclusion fetal station expressed as ultrasound measured HPD was ≤45 mm in 60 women and >45 mm in 39. The estimated median time in active labor when HPD was ≤45 mm was 490 minutes vs. 682 min if the HPD >45 mm (log rank test, p=0.009). The probability of being delivered is illustrated with Kaplan-Meier curves (1-survival) in Figure 2. The HR for a spontaneous vaginal delivery showed a shorter duration of labor associated with smaller HPD (HR=1.90 (95%CI, 1.16 to 3.11), but the association was not significant after adjusting for maternal age and BMI (HR =1.47, 95% CI, 0.83-2.60).

Fetal station expressed as AoP was ≥93° in 69 women and <93° in 30 women. The estimated median time in active labor was 506 min in the former vs. 732 min in the latter group (log rank test, p=0.008) and the probability of being delivered is shown in Figure 3. The HR for a spontaneous delivery associated with wider AoP values was 2.06 (95% CI, 1.19 to 3.56) and remained significant after adjusting for maternal age and BMI; HR 2.07 (95% CI, 1.15 to 3.72).

Of the fetuses 52/99 were in the OP position at inclusion. The estimated median time in active labor was not significantly associated with fetal position at inclusion, i.e. 506 min in non-OP positions vs. 677 min in OP positions (log rank test, p=0.07). The HR for a spontaneous delivery associated with non-OP positions illustrated as a Kaplan-Meier plot (1-survival) in Figure 4 was 1.51 (95% CI, 0.96 to 2.38) and it did not change after adjusting for maternal age and BMI; HR 1.54 (95% CI, 0.97 to 2.46).

Ultrasound assessment of cervical dilatation showed that 64 women had dilatation

of 4-5 cm, 23 women were dilated ≥6 cm and in 12 women dilatation could not be measured. Dilatation could be assessed in 40/49 with ruptured membranes versus 45/48 with intact membranes, p=0.26. The estimated median duration of active labor was 429 min for dilatation of ≥6 cm and 704 for dilatation of 4-5 cm (log rank test, p=0.002). The HR for spontaneous delivery associated with greater dilatation illustrated as a Kaplan-Meier plot (1-survival) in Figure 5 was 1.23 (95% CI, 0.95-1.59) and this became significant after adjusting for maternal age and BMI; HR 1.32 (95% CI, 1.02-1.73).

Duration of the second stage

The estimated median duration of the second stage was 92 minutes if HPD was ≤45 mm at inclusion vs. 109 minutes if HPD was >45 mm (p=0.06). The HR for a spontaneous delivery related to smaller HPD values was 1.61 (95%CI, 0.97 to 2.64), but the association was not significant after adjusting for maternal age and BMI (HR =1.50, 95% CI, 0.85-2.65). The estimated median duration of the second stage was 93 minutes if the AoP was ≥93 degrees at inclusion vs. 124 minutes if AoP was <93 degrees (p=0.04). For larger AoP values the HR for spontaneous delivery was 1.76 (95% CI, 1.02 to 3.04) and was 1.59 (95% CI, 0.88 to 2.88 after adjusting for maternal age and BMI.

Occiput position and cervical dilatation at inclusion were not associated with the estimated duration of the second stage.

The estimated median duration of the active second stage was 62 min if AoP was ≥93 degrees at inclusion vs. 75 min if AoP was <93 degrees (p=0.03). For larger AoP values the HR for spontaneous delivery was 1.86 (95% CI, 1.05 to 3.32) and after adjusting for age and BMI it was 1.97 (95% CI 1.06 to 3.68). None of the other

parameters examined were associated with the estimated duration of active pushing (Table 3).

Comment

Principal Findings

Fetal head station measured with ultrasound as HPD and AoP in the early active phase of labor was associated with both the time remaining in labor and with the duration of the second stage. HPD and AoP were associated with a spontaneous delivery with AUC=0.68 and 0.67, respectively. Ultrasound assessed cervical dilatation in the early active phase of labor was significantly associated with labor duration, but not with delivery mode. Fetal head position at the first examination in the active phase was neither associated with duration of labor nor delivery mode.

Results in context

The prediction of mode of delivery in nulliparous women using clinical factors on admission in labor has been investigated.[10, 11, 37-39] Turcot et al. found that cervical dilatation on admission could predict operative delivery but less than one third of women had a cervical dilatation ≥4 cm at inclusion.[39] Janssen et al. found that less advanced cervical dilatation and higher fetal station predicted cesarean delivery and a model developed based on these and a few other factors predicted cesarean delivery with AUC=0.71.[11] However, in their study only one quarter of the women were included at >4 cm. Wilkes et al. found that a change in cervical dilatation and station 2 h after admission was better in predicting cesarean delivery than the initial dilatation and station.[38] de Souza et al. studied nulliparous and multiparous women in both spontaneous and induced

labor at less than 7 cm dilatation and a prediction model based on clinical factors on admission predicted cesarean delivery with AUC=0.78, but that prediction was better when using information obtained during labor.

The value of transperineal ultrasound in predicting labor outcomes has previously been investigated before the onset of labor and in laboring women.[22-25, 40-42] In these studies the cohorts have comprised mixed groups of parous and nulliparous women and labors with spontaneous and induced labors. Marsoosi et al. studied 70 nulliparous and parous women and suggested that AoP might predict vaginal delivery when measured on admission in active labor.[40] Chor et al. studied hourly changes of several clinical and ultrasound parameters in nulliparous women in both induced and spontaneous labor and found that changes in progression distance could be of use for predicting cesarean delivery due to non-progressive labor.[42] Chan et al. studied nulli- and multiparous women in active, induced and spontaneous labor and suggested that a combination of AoP and HPD could be used to predict time to a normal spontaneous delivery.[41] Torkildsen et al studied women in prolonged labor and found HPD and AoP to predict vaginal delivery with AUC of 0.81 and 0.76 respectively.[5] Eggebø et al. studied nulliparous women in prolonged labor and found that a model combining maternal factors known to be associated with delivery mode with ultrasound factors could be useful in predicting vaginal delivery.[25] Fetal head position was found to be of value in predicting cesarean delivery in nulliparous women with a prolonged first stage in another study by Eggebø et al. but did not predict operative vaginal delivery nor remaining time in labor.[43] Comparisons with these studies suggest that the value ultrasound in assessing fetal head station and reliably confirming position may be greater in predicting operative delivery

when labor is prolonged than at the outset of a spontaneous labor.

Ultrasound AoP and HPD are different but interrelated methods for assessing fetal head station. We included both in our study and found good correlation between the methods as shown before.[44] Both methods may be associated with the duration of labor and delivery mode because there was only modest variation of the respective predictive values and their confidence limits. Both approaches have in previous studies been found to be of value to indicate the likelihood of successful descent of the fetal head through the birth canal and thus vaginal delivery.[5, 31, 32, 45-48]

Ultrasound measurements of cervical dilatation are more challenging than assessment of position and measurements of HPD and AoP, especially after rupture of the membranes. Objective measurements are possible after training, and good repeatability has been shown.[33] Ultrasound cannot replace clinical assessment of cervical dilatation at late stages, but has the potential to be used as an admission test.[35]

Clinical Implications

Our results show the expected variation of duration of the active phase of labor and that cervical dilatation at admission is associated with the duration of labor. In addition, we show that assessing the fetal head station with ultrasound has a role as it is not only associated with duration of the active phase and the second stage but also with spontaneous vaginal delivery. We can confirm suggestions from previous studies that the position of the fetal head at the diagnosis of the active phase does not seem to have an effect on the duration of labor or the mode of delivery.[17, 22]

Based on our results, measuring HPD and AoP on admission in the active phase of labor could identify those women who are at low risk of intervention and assessed as being more likely to have shorter durations of labor. These women could then be reassured and offered a low risk environment but other women who are assessed as having a higher risk, based on measurements showing high fetal head station, could be observed more closely for signs of slow progress in terms of fetal descent and cervical dilatation. They could also be better informed of more realistic expectations of labor duration and offered more effective pain relief as soon as active labor is diagnosed. Other supportive measures could also be ensured, such as one-to-one midwifery care. Our results do not suggest that we have, as yet, a reliable method to find those women who ultimately will need an operative delivery as progress is so individual. Given the late occurrence of fetal head descent and rotation observed in our longitudinal study of the same group of women[20] it is possible that change over time is a better predictor of outcome than a spot assessment at admission, as suggested by other researchers.[38, 39, 49, 50]

Research Implications

We investigated the association between ultrasound and spontaneous vaginal deliveries instead of cesarean delivery as we only had eight such deliveries. Results based on such small numbers could be subject to greater errors so this should be studied in larger groups. It is possible that fetal head station is more strongly associated with cesarean delivery than all operative deliveries. If confirmed the results could be used to construct a labor admission test helping to stratify risk along with other demographic and pregnancy risk factors.

Strengths and Limitations

A strength of our study was the homogenous group of spontaneously laboring nulliparous women recruited and assessed when the active phase was diagnosed. We were also able to report on ultrasound measurements of cervical dilatation as well as fetal position and station using methods that can be regarded as established. The ultrasound examiners were fetal medicine experts, which is a strength in documenting the potential value of ultrasound, but also a potential limitation for external validation. At the present time, only few obstetricians and midwives are trained in these methods, but that is likely to change. In 2018 WHO changed the definition of the active phase of labor, and recommended that cervical dilatation should be at least five cm at the start of the active phase.[51] We used the WHO criteria recommended at the time when the study was planned and executed; regular contractions, cervix effaced and dilatation of ≥4 cm.[27] Women were also recommended to stay at home until contractions were regular.

That women had varying degrees of cervical dilatation at inclusion could be considered a limitation. We had no way of knowing the actual length of the active phase among most of the women because they were already in established labor on admission. On the other hand, this reflects the reality of labor and we were keen to observe whether outcomes could be predicted at the time of the ultrasound examination. Other limitations were the observational design and the size of the cohort. The low cesarean section rate in this population was in line with usual audits from our hospital, but differs from many other departments; which may limit the external validation.

Conclusions

We found that ultrasound assessments of fetal head station on entry to the labor ward in the active phase were associated with labor duration and the duration of the second stage and to be modestly associated with spontaneous delivery. Cervical dilatation assessed with ultrasound at the same time was associated with the duration of labor but not with spontaneous delivery. Ultrasound assessments of fetal head position were neither associated with labor duration nor the mode of delivery. Ultrasound can be used to categorize women into low- and high-risk groups, but it cannot, reliably, define a subset of women needing operative delivery.

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Legends for tables and figures.

Legend for Table 1:
Characteristics of the study population of 99 nulliparous women with a singleton fetus at term, examined with ultrasound early in the active phase of labor.

Characteristics	Median (range) or n (%)
Age	27.0 (18-40)
Body mass index (kg/m^2)	23.3 (16.7-36.3)
Oxytocin augmentation	41 (41.4)
Epidural analgesia	61 (61.6)
Spontaneous delivery	75 (75.8)
Ventouse delivery	15 (15.2)
Forceps delivery	1 (1.0)
Cesarean section	8 (8.1)
Blood loss (ml)	400 (100-2000)
Episiotomy	13 (13.3)
Degrees of perineal tear	
None	19 (19.2)
1°	22 (22.2)
2°	53 (53.5)
3°	5 (5.1)
Birthweight (g)	3540 (2480-5000)
Apgar score at 1 min	9 (2-10)
Apgar score at 5 min	10 (5-10)
Gestational age (days)	280 (259-293)

Legend for Table 2:
Test characteristics of ultrasound measurements of head-perineum distance and angle of progression in predicting spontaneous vaginal delivery

	Sensitivity	FPR	PPV	NPV	LR
Head perineum distance (mm)					
≤40	0.33 (0.23, 0.45)	0.12 (0.03, 0.32)	0.89 (0.72, 0.98)	0.30 (0.19, 0.42)	2.67
≤46	0.67 (0.45, 0.84)	0.33 (0.16, 0.55)	0.87 (0.75, 0.94)	0.41 (0.26, 0.58)	2.08
≤50	0.80 (0.69, 0.88)	0.75 (0.53, 0.90)	0.77 (0.66, 0.86)	0.29 (0.11, 0.52)	1.07
≤60	0.97 (0.91, 1.00)	0.95 (0.79, 1.00)	0.76 (0.66, 0.84)	0.33 (0.01, 0.91)	1.02
Angle of progression (°)					
≥110	0.24 (0.15, 0.35)	0.04 (0.00, 0.21)	0.95 (0.74, 1.00)	0.29 (0.19, 0.40)	5.76
≥100	0.57 (0.45, 0.69)	0.33 (0.16, 0.55)	0.84 (0.71, 0.93)	0.33 (0.20, 0.48)	1.72
≥93	0.79 (0.68, 0.87)	0.54 (0.33, 0.74)	0.82 (0.71, 0.90)	0.41 (0.22, 0.61)	1.45
≥90	0.87 (0.77, 0.93)	0.71 (0.49, 0.87)	0.79 (0.69, 0.87)	0.41 (0.18, 0.67)	1.22
≥80	1.00 (0.95, 1.00)	0.88 (0.68, 0.97)	0.78 (0.69, 0.86)	1.00 (0.29, 1.00)	1.14

639 Legend for Table 3:
640 Cox regression analysis for risk ("likelihood") of a spontaneous delivery in nulliparous women
641 examined at the diagnosis of the active phase of labor

Parameter	Unadjusted HR	95% CI	Adjusted HR	95% CI
Active phase				
Non-occiput posterior	1.51	0.96-2.38	1.54	0.97-2.46
HPD	**1.90**	**1.16-3.11**	1.47	0.83-2.60
AoP	**2.06**	**1.19-3.56**	**2.07**	**1.15-3.72**
Cervical dilatation examined with ultrasound	**2.45**	**1.38-4.36**	**3.11**	**1.68-5.77**
Second stage				
Non-occiput posterior	1.40	0.89-2.21	1.43	0.89-2.29
HPD	1.61	0.97-2.64	1.50	0.85-2.65
AoP	**1.76**	**1.02-3.04**	1.59	0.88-2.88
Cervical dilatation examined with ultrasound	1.57	0.91-2.70	1.76	0.98-3.16
Active second stage				
Non-occiput posterior	1.45	0.92-2.28	1.54	0.97-2.46
HPD	1.55	0.94-2.55	1.52	0.87-2.65
AoP	**1.86**	**1.05-3.32**	**1.97**	**1.06-3.68**
Cervical dilatation examined with ultrasound	1.43	0.83-2.47	1.50	0.84-2.68

HR with CI not crossing 1.0 were assumed significant
CI, confidence interval; HR, hazard ratio; HPD, head-perineum distance; AoP, angle of progression

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Legend for Figure 1:
Receiver-operating characteristic (ROC) curves for angle of progression and head-perineum distance measurements in the prediction of spontaneous vaginal delivery in nulliparous women on admission in active spontaneous labor at term.

Legend for Figure 2:
Kaplan-Meier curves of time from the first examination in the active phase to delivery in 99 nulliparous women in spontaneous labor. The curves are stratified as to head-perineum distance ≤45mm and >45mm. Cases with operative delivery were censored (diamonds on survival lines).

Legend for Figure 3:
Kaplan-Meier curves of time from the first examination in the active phase to delivery in 99 nulliparous women in spontaneous labor. The curves are stratified as to angle of progression ≥93° and <93. Cases with operative delivery were censored (diamonds on survival lines).

Legend for Figure 4
Kaplan-Meier curves of time from the first examination in the active phase to delivery in 99 nulliparous women in spontaneous labor. The curves are stratified as to non-occiput posterior and occiput posterior positions. Cases with operative delivery were censored (diamonds on survival lines).

Legend for Figure 5
Kaplan-Meier curves of time from the first examination in the active phase to delivery in 99 nulliparous women in spontaneous labor. The curves are stratified as to ultrasound assessed cervical dilatation of 4-5 cm and ≥6 cm. Cases with operative delivery were censored (diamonds on survival lines).