OBSTETRICS

# A model to predict vaginal delivery in nulliparous women based on maternal characteristics and intrapartum ultrasound

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**OBJECTIVE:** Accurate prediction of whether a nulliparous woman will have a vaginal delivery would be a major advance in obstetrics. The objective of the study was to develop such a model based on maternal characteristics and the results of intrapartum ultrasound.

**STUDY DESIGN:** One hundred twenty-two nulliparous women in the first stage of labor were included in a prospective observational 2-centre study. Labor was classified as prolonged according to the respective countries' national guidelines. Fetal head position was assessed with transabdominal ultrasound and cervical dilatation by digital examination, and transperineal ultrasound was used to determine head-perineum distance and the presence of caput succedaneum. The subjects were divided into a testing set (n = 61) and a validation set (n = 61) and a risk score derived using multivariable logistic regression with vaginal birth as the outcome, which was dichotomized into no/cesarean delivery and yes/vaginal birth. Covariates included head-perineum distance, caput succedaneum, and occiput posterior position, which were dichotomized respectively into the following: ≤40 mm, >40 mm, <10 mm, ≥10 mm, and no, yes. Maternal age, gestational age, and maternal body mass index were included as continuous covariates.

**RESULTS:** Dichotomized score is significantly associated with vaginal delivery ($P = .03$). Women with a score above the median had greater than 10 times the odds of having a vaginal delivery as compared with those with a score below the median. The receiver-operating characteristic curve showed an area under the curve of 0.853 (95% confidence interval, 0.678–1.000).

**CONCLUSION:** A risk score based on maternal characteristics and intrapartum findings can predict vaginal delivery in nulliparous women in the first stage of labor.

**Key words:** cesarean delivery, head-perineum distance, prediction model, transperineal

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Prolonged nulliparous labor is responsible for 30% of all cesarean deliveries.[1] Although risk factors such as induction of labor and occiput posterior position increase the likelihood of cesarean delivery,[2] there is no way of predicting this outcome with precision based on clinical examination alone.

Digital vaginal examination is the key method used worldwide to define the diagnosis of labor and its progress, the findings being plotted manually on a graphical representation of the progress of labor: a partogram. The partogram has been developed to aid the recognition of

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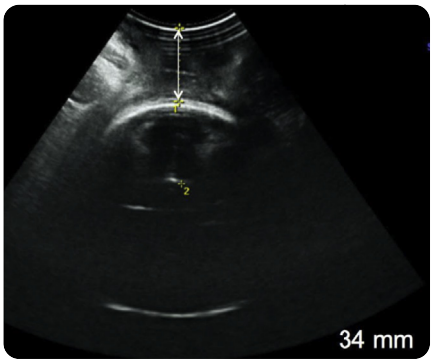
FIGURE 1
**HPD on transperineal ultrasound**




The head-perineum distance (HPD) is the measurement between the fetal skull and the perineum in the transverse section, in this image showing the HPD of 34 mm.

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failure to progress in labor[3-5] and has formed the basis for national guidelines.[6] However, there is much discussion regarding its applicability,[7-9] resulting in the American Association of Obstetricians and Gynecologists issuing guidelines on labor management[10] in 2014.

Digital vaginal examination is also intrusive,[11] subjective,[12] inconsistent,[13] and associated with infection.[14] Our group has recently described an ultrasound-based partogram (sonopartogram) based on nonintrusive intrapartum ultrasound observations,[15] using transabdominal and transperineal ultrasound.

Transabdominal ultrasound can be used to determine the fetal head position in labor with a higher degree of accuracy than by classical clinical palpation.[16] Transperineal ultrasound, first described in the mid-1990s,[17] is a 2-dimensional, noninvasive, objective, simple method of scanning, placing a transducer outside the vagina.[18] It can be used to determine the angle of progression of the fetal head,[15,19-21] head-perineum distance (HPD),[22] and the degree of caput succedaneum.[15,23,24]

Increasingly, models including maternal characteristics and ultrasound findings are used in risk prediction with womens' health, for example in prenatal Down's syndrome screening,[25] and in pre-eclampsia risk prediction.[26] Recently fetal Doppler assessment of the cerebroumbilical ratio prior to the onset of labor has been shown to identify those fetuses at high risk of emergency cesarean delivery because of fetal distress.[27] Knowledge of the likelihood of cesarean delivery, especially in prolonged labor, has the potential to inform obstetric care and expectations of a woman in labor. Taking basic maternal characteristics, clinical and ultrasound observations, we aimed to develop a model for prediction of vaginal birth in the nulliparas in the first stage of labor.

## Materials and Methods

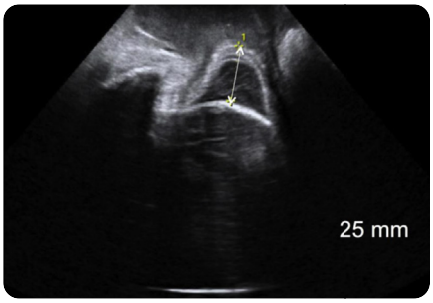
A prospective observational 2-center study investigating the clinical value of ultrasound in labor was performed at Stavanger University Hospital (Stavanger, Norway) and at Addenbrooke's Hospital (Cambridge, United Kingdom) in 2012−2013.

Nulliparous women with a live singleton pregnancy and cephalic presentation in the first stage of labor at term (≥37 weeks) were eligible for the study. Clinical results from the study population have been published previously[24,28] with respect of the individual component measurements. For this study, patients were included in which all measurements were available specifically in this case including caput succedaneum measurements. Ethics Committee approval was obtained in Norway (REK 2011/731) and in the United Kingdom (11/EE/064), and all women gave written consent.

Prolonged first stage of labor was defined according to national guidelines. World Health Organization recommendations were used in Norway when cervical dilatation crossed the action line (4 hours from the alert line).[29] In the United Kingdom, National Institutes of Health and Clinical Excellence guidelines (dilatation of <2 cm in 4 hours) were used.[6]

Gestational age was calculated from a second-trimester scan in Norway and from the first-trimester scan in the United Kingdom. Maternal age was taken as age at the time of labor and booking maternal body mass index (BMI) was entered in the predictive model. Vaginal delivery included spontaneous and assisted operative deliveries using vacuum extraction and/or forceps.

FIGURE 2
**Transperineal ultrasound measurement of caput succedaneum**




In the sagittal view, a *vertical line* is drawn from the fetal skull to the uppermost edge of the cutis.

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During the ultrasound examination, women were in the supine position with flexed hips and knees, membranes had ruptured and the bladder was empty as previously described.[28] The birth attendant (midwife or doctor) performed a digital vaginal examination assessing cervical dilatation and fetal head descent. The descent was categorized using the World Health Organization classification of fetal head station with the ischial spines as reference point 0, −5 at the pelvic inlet, and +5 at the pelvic outlet.[29]

An obstetrician or midwife performed all the ultrasound examinations using Voluson *i* (GE, Zipf, Austria) with a 3.5−7.5 MHz three-dimensional curved multifrequency transabdominal transducer in Norway and Samsung Medison Accuvix XG (Samsung Medison, Medical Imaging Systems Ltd, London, UK) equipment with a 4−6 MHz convex transabdominal transducer in the United Kingdom. Birth attendants were blinded to the ultrasound findings and these findings were also not disclosed to the parents.

Fetal position was assessed with a transabdominal scan and recorded with half-hourly divisions. Positions >03.30

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