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Implementation of sonopartogram: multicenter feasibility study

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KEYWORDS: angle of progression; AOP; caput succedaneum; cervical dilatation; feasibility; fetal head station; head–perineum distance; HPD; parasagittal angle of progression; SCD; sonographic cervical dilation; transperineal ultrasound

CONTRIBUTION

What are the novel findings of this work?
We have shown that transabdominal and transperineal ultrasound measurements can be performed successfully to monitor progress in labor, and may reduce the level of pain experienced during examination.

What are the clinical implications of this work?
Ultrasound parameters for monitoring progress in labor are known to be reliable and reproducible, and full integration of ultrasound into intrapartum care would represent a paradigm shift towards objective assessment of the progress of labor and improved care for women.

ABSTRACT

Objectives *Well-established clinical practice for assessing progress in labor involves routine abdominal palpation and vaginal examination (VE). However, VE is subjective, poorly reproducible and painful for most women. In this study, our aim was to evaluate the feasibility of systematically integrating transabdominal and transperineal ultrasound assessment of fetal position, parasagittal angle of progression (psAOP), head–perineum distance (HPD) and sonographic cervical dilatation (SCD) to monitor the progress of labor in women undergoing induction of labor (IOL). We also aimed to determine if ultrasound can reduce women's pain during such examinations.*

Methods *Women were recruited as they presented for IOL in three maternity units. Ultrasound assessments were performed in 100 women between 37 + 0 and 41 + 6 weeks' gestation. A baseline combined transabdominal and transperineal scan was performed, including assessment of fetal biometry, umbilical artery and fetal middle cerebral artery Doppler, amniotic fluid index, fetal spine and occiput positions, psAOP, HPD, SCD and cervical length. Intrapartum scans were performed instead of VE, unless there was a clinical indication to perform a VE, according to protocol. Participants were asked to indicate their level of pain by verbally giving a pain score between 0 and 10 (with 0 representing no pain) during assessment. Repeated measures data were analyzed using mixed-effect models to identify significant factors that affected the relationship between psAOP, HPD, SCD and mode of delivery.*

Results *A total of 100 women were included in the study. Of these, 20% delivered by Cesarean section, 65% vaginally and 15% by instrumental delivery. There were no adverse fetal or maternal outcomes. A total of 223 intrapartum ultrasound scans were performed in 87 participants (13 women delivered before intrapartum ultrasound was performed), with a median of two scans per participant (interquartile range (IQR), 1–3). Of these, 76 women underwent a total of 151 VEs with a median of one VE per participant (IQR, 0–2), with no significant difference between vaginal- or Cesarean-delivery groups. After excluding those with epidural anesthesia during examination, the median pain score for intrapartum scans was 0 (IQR, 0–1) and for VE it was 3 (IQR, 0–6). Cesarean delivery was significantly associated with a slower rate of change in psAOP, HPD and SCD.*

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Conclusions *Comprehensive transabdominal and transperineal ultrasound assessment can be used to assess progress in labor and can reduce the level of pain experienced during examination. Ultrasound assessment may be able to replace some transabdominal and vaginal examinations during labor.* © *2024 The Authors. Ultrasound in Obstetrics & Gynecology published by John Wiley & Sons Ltd on behalf of International Society of Ultrasound in Obstetrics and Gynecology.*

INTRODUCTION

Abdominal palpation and vaginal examination (VE) are standard practice for assessing progress in labor. However, VEs have significant inter- and intraobserver variability[1,2], are painful for women[3] and can cause infection[4,5]. An objective, reliable, non-invasive method of accurately assessing progress in labor would be a major step forward in obstetrics.

A number of techniques have been described using ultrasound to assess the progress of labor[1,6–12]. Ultrasound can be used to determine fetal position, descent, head rotation, flexion and cervical dilatation[8–14]. Transperineal ultrasound parameters include the angle of progression (AOP), head–perineum distance (HPD) and sonographic cervical dilatation (SCD). The AOP is the angle from the leading part of the fetal skull to the maternal symphysis pubis in the sagittal plane[7]. It correlates with fetal head descent (station) and flexion[15–18]. The SonoL&D software (GE Healthcare, Zipf, Austria) measures the parasagittal AOP (psAOP) because the pubic rami visualized in a parasagittal view are more echogenic than in the midsagittal plane, and there is good correlation between AOP and psAOP[19]. HPD is the distance from the fetal skull to the perineum[6] and is correlated with head station[20–22]. SCD is the diameter of the cervix in a transverse plane[23]. Fetal position can be evaluated by both transperineal and transabdominal ultrasound by observing the position of the spine and cranial structures, such as orbits, interhemispheric midline or cerebellum[10].

The use of ultrasound to monitor the progress of labor is not standard practice. An ultrasound 'sonopartogram' was first conceptualized and shown to be feasible in 2014[8]. Intrapartum transperineal scanning measurements have been shown previously to be reliable, reproducible and have good agreement between fetal head descent and cervical dilatation determined by VE[8,16,17,24–27]. Our group has shown previously, in a study involving 308 women undergoing induction of labor (IOL), that the measurement of psAOP, HPD and SCD has high inter-observer intraclass correlation coefficients of > 0.8[28]. Subsequently, we reported 1139 paired vaginal and transperineal ultrasound measurements in 326 women and showed high reproducibility in psAOP, HPD and SCD[24]. It has also been shown that the level of agreement in measurements obtained by consultant obstetricians and attending midwives is high[29].

In this study, our aim was to evaluate the feasibility of systematically integrating transabdominal and transperineal ultrasound assessment of fetal position, psAOP, HPD and SCD to monitor the progress of labor in women undergoing IOL. We also aimed to determine if ultrasound can reduce women's pain during such examinations.

METHODS

This was a prospective longitudinal cohort study in women with a singleton pregnancy undergoing IOL at or after 37 weeks' gestation, carried out in one maternity unit in Hong Kong SAR, China (Department of Obstetrics and Gynecology, Prince of Wales Hospital, The Chinese University of Hong Kong, Shatin), and two units in Madrid, Spain (Department of Obstetrics, Hospital Universitario La Paz, and Obstetrics and Gynecology Department, Hospital Universitario de Torrejón, Torrejón de Ardoz), between 1 December 2021 and 31 July 2023. Inclusion criteria for the study were pregnant women with a live fetus in cephalic presentation and intact membranes undergoing IOL between $37 + 0$ and $41 + 6$ weeks' gestation. Exclusion criteria included women who were unconscious or severely ill, those with learning difficulties or serious mental illness, breech presentation or age < 18 years. Written informed consent was obtained from the women agreeing to participate in the study, which was approved by the institutional review board of each recruiting center (Joint Chinese University of Hong Kong – New Territories East Cluster Clinical Research Ethics Committee, Reference Number CRE-2021.247; Ethics Committee of Hospital Universitario La Paz, Reference number PI-5448 ACTA: 20/2022; Hospital Universitario de Torrejón local ethics committee, Reference Number CPMP/ICH/135/95, 2021.036).

After obtaining written informed consent, maternal history and demographics were recorded from the patient's medical records and an initial ultrasound assessment was performed immediately prior to IOL. VE was performed to assess the cervix using a modified Bishop score, and the method of IOL was determined. Labor was induced using either artificial rupture of membranes (ARM), prostaglandin E2, oxytocin, Cook Balloon® (Cook Cervical Ripening balloon; Cook Medical LLC, IN, USA) or misoprostol.

The participants were managed according to standard care, apart from replacing VE by ultrasound assessment. Ultrasound was performed every 12 h until the participant was spontaneously contracting regularly or when oxytocin infusion was commenced. Thereafter, ultrasound assessment was performed every 4 h during the latent phase and every 2 h after the active phase of labor, until the SCD could no longer be assessed, which most commonly occurs when cervical dilatation is ≥ 8 cm[27,30]. Cesarean section or instrumental delivery was performed as clinically indicated.

During labor, VE was performed when: (1) there was a non-reassuring cardiotocogram pattern; (2) there was a need to confirm ultrasound findings of slow progress

of labor and Cesarean section was potentially indicated; (3) there was antepartum hemorrhage; and (4) procedures such as fetal scalp electrode application or ARM were required. Participants were asked to indicate their level of pain by verbally giving a pain score between 0 and 10 (with 0 representing no pain) during assessment.

The mode of delivery, timing of delivery, umbilical cord arterial pH and neonatal outcome were recorded immediately following delivery.

Ultrasound assessment

Trained midwives or obstetricians performed the ultrasound scans. Examinations were performed with the woman in a supine position and with an empty bladder. A GE HealthCare Voluson™ SWIFT or Voluson S8 ultrasound machine (GE Healthcare) with a wide-band, convex transducer (RAB6-RS or 4C-RS) was used. Fetal lie and head and spine position were determined through transabdominal ultrasound using the method described by Akmal *et al.*[9], with results recorded at half-hourly intervals. During the baseline transabdominal ultrasound examination, fetal biometry was measured and umbilical artery pulsatility index, middle cerebral artery pulsatility index and amniotic fluid index were recorded. Subsequent scans did not include fetal growth and Doppler assessment.

The participant was then asked to flex and abduct her hips. The transducer was placed between the labia majora at the level of the posterior fourchette to obtain a sagittal view including the symphysis pubis and the fetal head. Small lateral movements of the transducer were made to align the ultrasound beam in a parasagittal orientation to include the whole length of the parasagittal pubic bone and the fetal skull[28]. The psAOP was measured between the longitudinal axis of the pubic bone and the lowest convexity of the fetal skull. The SCD was then measured by identifying the anterior edge of the cervix in the sagittal plane and turning the transducer 90° to acquire a full view of the cervix, as described by Hassan *et al.*[23] in 2021. The SCD was measured in the anteroposterior plane with the cursors placed on the inner part of the cervical tissue anteriorly and the inner part of the cervical tissue posteriorly ('inner-to-inner')[31]. In the same transverse view, the HPD was then measured as the shortest distance from the outer bony limit of the fetal skull to the skin surface of the perineum. The transducer was moved and angled until the shortest distance to the fetal head was visualized. The soft tissue was compressed with firm pressure without causing discomfort[7]. Examples of the measurement of psAOP, HPD and SCD can be seen in Figure 1. Fetal head and spine position were assessed by both transabdominal and transperineal ultrasound, with results recorded at half-hourly intervals as previously described.

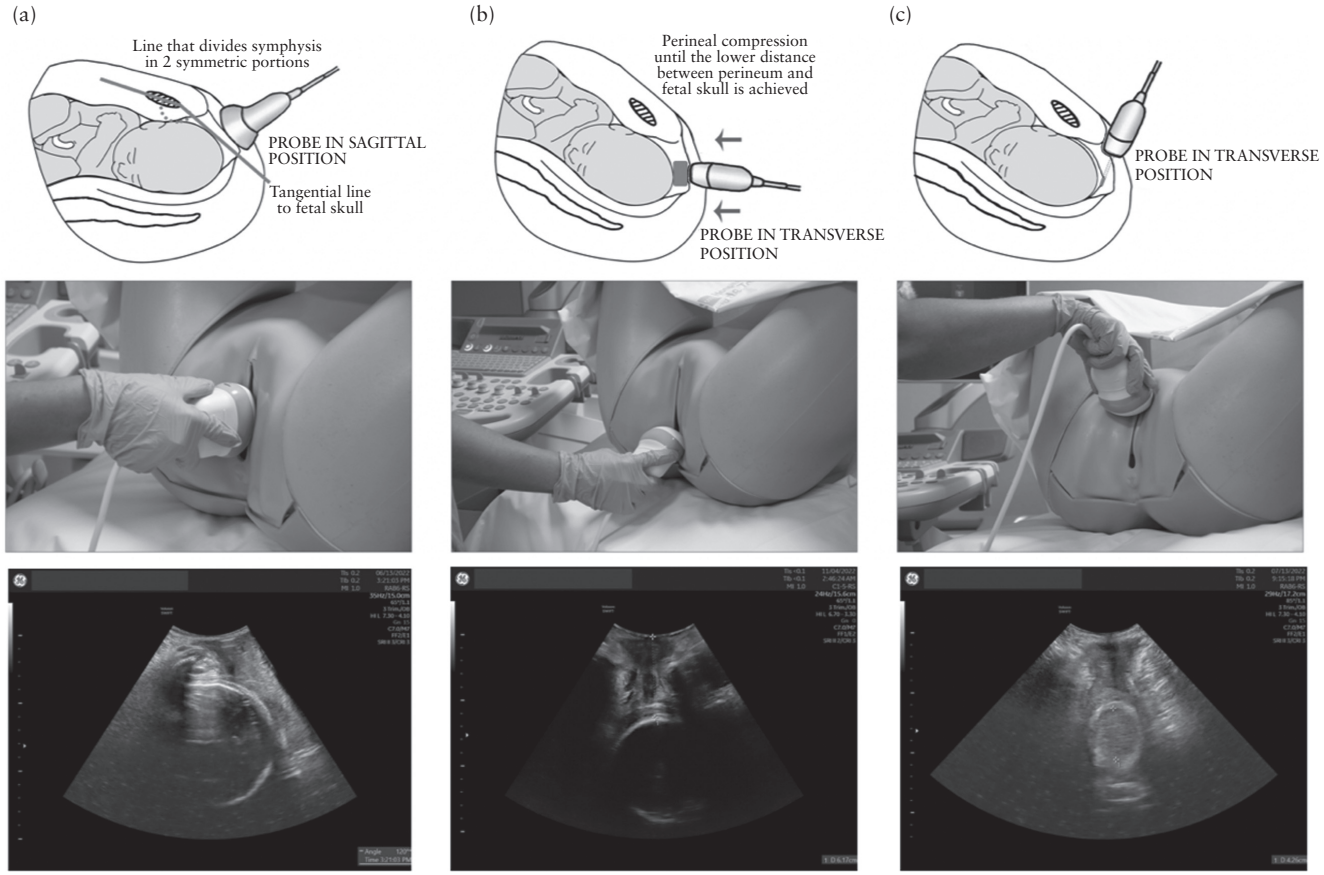

Figure 1 Diagrams (top) and simulation models (middle) showing probe positioning and resulting ultrasound images (bottom) for measurement of: (a) parasagittal angle of progression, (b) head–perineum distance and (c) sonographic cervical dilatation. Reproduced with permission from GE Healthcare Austria GmbH & Co OG.

The participants' data and ultrasound measurements were anonymized, stored locally in a secure electronic file and transferred to Hong Kong for analysis. Data on pregnancy and labor outcomes were retrieved from computerized medical records and stored in a secure database.

Induction of labor

IOL was performed according to a standardized protocol. The modified Bishop score was determined, and labor was induced if the cervix was favorable (Bishop score = 6) with ARM followed by oxytocin infusion. Oxytocin infusion was also administered if spontaneous rupture of membranes had occurred.

If the cervix was unfavorable, a 10-mg dinoprostone slow-release vaginal pessary (Propess®; Ferring Pharmaceuticals, Saint-Prex, Switzerland) was inserted vaginally and removed 24 h later. If spontaneous rupture of membranes had occurred, either 25-mg misoprostol was administered orally followed by oxytocin infusion 4 h later, or direct oxytocin infusion was commenced.

In women who had had a previous Cesarean delivery, a Cook cervical ripening balloon was inserted and removed 12 h later. The women were then reassessed and, if the cervix remained unfavorable, a further 10 mg of Propess was given. If the cervix was favorable, ARM was then performed.

Following ARM, if a woman remained in the latent phase after 12 h of oxytocin infusion, or if there were two or more episodes in which the cervix failed to dilate at a rate of at least 1 cm/h after the cervix was >3 cm dilated, labor was considered to not be progressing and a Cesarean delivery was performed.

Statistical analysis

We included 100 women from three different settings to ensure that there would be a sufficient number of examinations to encounter all possible implementation problems, and to show a significant difference in pain level in those women without epidural anesthesia[32].

Quantitative data are presented as median (interquartile range (IQR)) while categorical data are expressed as *n* (%). Categorical variables were compared using the χ-square test or Fisher's exact test. For comparison of continuous data, the Mann–Whitney *U*-test or Student's *t*-test was used for non-parametric and parametric data, respectively.

For the repeated-measures analysis of psAOP, HPD and SCD, a linear mixed-effects analysis, including fixed effects and random effects, was performed. The fixed-effect component included maternal height, parity, epidural status, number of intrapartum scans and mode of delivery. The random-effect component included the intercept (patient identity number) and slope (number of intrapartum scans). The Bayesian information criterion (BIC) was used to select the best model among fixed intercept–fixed slope model, fixed intercept–random slope model, random intercept–fixed slope model and random intercept–random slope model. The final models were selected based on the lowest BIC[33]. The values of the estimated marginal mean of each sonographic parameter assessed across the duration of labor are presented. Data were analyzed using SPSS version 23.1 (IBM Inc., Armonk, NY, USA); $P < 0.05$ was considered to indicate statistical significance.

RESULTS

A total of 106 women were recruited, of whom six were excluded owing to incomplete assessments, leaving 100 women included in the study. Maternal characteristics, labor details and pregnancy outcomes are shown in Table 1. Cesarean sections performed during IOL were considered to be emergency Cesarean deliveries. Women delivering vaginally were significantly taller than women undergoing Cesarean section ($P = 0.04$), but there were no other significant differences between the groups.

The median modified Bishop score was 6 (range, 3–6). Induction methods included ARM (53%), Propess (33%), Cook cervical ripening balloon (9%), misoprostol (3%) and oxytocin (2%) (Table 1). Of the 100 women, 20% delivered by Cesarean section, 65% by vaginal delivery and 15% by instrumental delivery. There were no adverse fetal or maternal outcomes.

Intrapartum assessment of pain score

A total of 223 intrapartum ultrasound scans were performed in 87 participants, and of these, 76 had a total of 151 intrapartum VEs performed. Thirteen women delivered soon after commencing IOL, before an intrapartum scan could be performed. The median number of intrapartum scans (excluding the baseline scan) performed per participant was two (IQR, 1–3) and that of VEs was one (IQR, 0–2), with no significant difference between vaginal- or Cesarean-delivery groups.

The median pain score was 0 (IQR, 0–2) for the baseline assessment scan, and 6 (IQR, 4–7) for the baseline VE ($P < 0.001$). After excluding those who had epidural anesthesia during examination, a total 118 scans and 120 VEs were included in the analysis. For intrapartum VE, the pain score was 3 (IQR, 0–6) and for ultrasound it was 0 (IQR, 0–1) ($P < 0.001$).

Baseline and intrapartum ultrasound measurements

The posterior fontanelle position and fetal biometry measurements (biparietal diameter, head circumference, abdominal circumference, femur length) were recorded successfully in all women, while the spine position, psAOP, HPD and SCD were recorded successfully in ≥ 95% of women (Table 2).

Out of the 223 intrapartum scans, posterior fontanelle position was recorded in 215 (96.4%) scans, spine position in 217 (97.3%), psAOP in 209 (93.7%), HPD in 214 (96.0%) and SCD in 184 (82.5%) cases. Out of

Table 1 Demographic and baseline characteristics and pregnancy outcomes in 100 women undergoing induction of labor at ≥ 37 weeks, overall and according to delivery mode

Parameter	*Total* (n = *100*)	*Vaginal delivery* (n = *80*)	*Cesarean delivery* (n = *20*)	P
Maternal age (years)	33 (30–35)	33 (30–35)	34 (28–38)	0.604
Racial origin				0.711
Afro-Caribbean	3 (3.0)	3 (3.8)	0 (0)	
Asian	58 (58.0)	45 (56.3)	13 (65.0)	
Caucasian	31 (31.0)	26 (32.5)	5 (25.0)	
South American	8 (8.0)	6 (7.5)	2 (10.0)	
Height (cm)	160 (156–165)	162 (156–166)	158 (156–160)	0.036
Weight (kg)	59 (53–70)	59 (53–70)	62 (53–73)	0.756
Body mass index (kg/m^2)	23 (21–27)	23 (20 –27)	24 (22–30)	0.238
Parity				0.180
Nulliparous	58 (58.0)	42 (52.5)	16 (80.0)	
Parous	42 (42.0)	38 (47.5)	4 (20.0)	
GA at induction (weeks)	39.3 (38.1–41.6)	39.3 (38.1–40.4)	39.2 (37.7–41.2)	0.779
Induction method				0.465
ARM	53 (53.0)	42 (52.5)	11 (55.0)	
Cook balloon	9 (9.0)	9 (11.3)	0 (0)	
Misoprostol	3 (3.0)	3 (3.8)	0 (0)	
Oxytocin	2 (2.0)	2 (2.5)	0 (0)	
Propess	33 (33.0)	24 (30.0)	9 (45.0)	
Birth weight (g)	3110 (2698–3440)	3122 (2745–3482)	3050 (2636–3390)	0.418
1-min Apgar score	9 (9–9)	9 (9–9)	9 (6–9)	0.032
5-min Apgar score	10 (10–10)	10 (10–10)	10 (10–10)	0.994
Umbilical cord arterial pH	7.25 (7.2–7.3)	7.2 (7.2–7.3)	7.3 (7.2–7.3)	0.579
Total number of VEs	1 (0–2)	1 (0–2)	1 (1–2)	0.633
Total number of intrapartum scans	2 (1–3)	2 (1–3)	2 (1–4)	0.762

Data are given as median (interquartile range) or *n* (%). ARM, artificial rupture of membranes; GA, gestational age; VE, vaginal examination.

Table 2 Baseline ultrasound measurements in 100 women undergoing induction of labor at ≥ 37 weeks, overall and according to delivery mode

Measurement	*Failed to capture*	*Total* (n = *100*)	*Vaginal delivery* (n = *80*)	*Cesarean delivery* (n = *20*)	P
Posterior fontanelle position	0				0.847
Occiput anterior		28 (28.0)	22 (27.5)	6 (30.0)	
Occiput posterior		26 (26.0)	21 (26.3)	5 (25.0)	
Left occiput transverse		24 (24.0)	20 (25.0)	4 (20.0)	
Right occiput transverse		22 (22.0)	17 (21.3)	5 (25.0)	
Spine position	3				0.684
Anterior		25/97 (25.8)	20 (25.0)	5/17 (29.4)	
Posterior		17/97 (17.5)	13 (16.3)	4/17 (23.5)	
Transverse left		34/97 (35.1)	29 (36.3)	5/17 (29.4)	
Transverse right		21/97 (21.6)	18 (22.5)	3/17 (17.6)	
BPD (cm)	0	9.2 (8.9–9.6)	9.2 (8.6–9.7)	9.2 (8.9–9.7)	0.569
HC (cm)	0	32.6 (31.7–33.5)	32.5 (31.6–33.5)	32.9 (32.3–33.5)	0.552
AC (cm)	0	34.2 (32.4–35.5)	34.2 (31.9–35.3)	34.3 (33.0–35.6)	0.632
FL (cm)	0	7.1 (6.8–7.4)	7.2 (6.9–7.4)	7.0 (6.6–7.3)	0.174
AFI (cm)	35	12 (10–15)	12 (10–15)	12 (12–15)	0.872
psAOP (°)	1	100 (90–112)	102 (90–112)	90 (89–106)	0.365
HPD (mm)	5	47 (40–55)	47 (40–55)	50 (45–55)	0.262
SCD (mm)	1	7.6 (4.6–10.9)	8.0 (5.0–12.0)	4.9 (4.2–8.3)	0.084
Cervical length (cm)	3	2.1 (1.6–2.6)	2.1 (1.6–2.6)	2.1 (1.4–2.6)	0.810
Modified Bishop score	0	6 (3–6)	5 (3–6)	6 (3–6)	0.648

Data given as *n*, *n* (%), *n*/*N* (%) or median (interquartile range). AC, abdominal circumference; AFI, amniotic fluid index; BPD, biparietal diameter; FL, femur length; HC, head circumference; HPD, head–perineum distance; psAOP, parasagittal angle of progression; SCD, sonographic cervical dilatation.

the 39 (17.5%) cases in which SCD was not recorded, 22 (56.4%) had cervical dilatation of ≥ 8 cm.

Reasons for intrapartum vaginal examination

The most frequent reason for VE was to perform ARM ($n = 33$ (21.9%)), followed by suspicion of full dilatation or the woman experiencing the urge to push ($n = 30$ (19.9%)), a cardiotocography concern ($n = 29$ (19.2%)), or suspected no progress in labor ($n = 25$ (16.6%)) (Table 3).

Repeated time measures of ultrasound parameters of labor progress

The best-fit model (Table S1 and Appendix S1) showed that the estimated marginal mean of psAOP across the duration of labor adjusted for number of intrapartum scans and the interaction between number of intrapartum scans and delivery outcomes was significantly lower in the Cesarean-section group compared with the vaginal-delivery group (110.6° *vs* 126.8°; $P = 0.029$) (Table 4, Figure 2a). Conversely, the Cesarean-section group had a higher estimated marginal mean of HPD across the duration of labor adjusted for number of intrapartum scans compared with the vaginal-delivery group (46.4 mm *vs* 38.2 mm; $P = 0.008$) (Table 4, Figure 2b). The estimated marginal mean of SCD across duration of labor adjusted for the number of intrapartum scans and delivery outcomes was significantly higher for those in the vaginal-delivery group *vs* those in the Cesarean-section group (28.3 mm *vs* 19.1 mm; $P = 0.025$) (Table 4, Figure 2c).

Table 3 Reason for intrapartum vaginal examination ($n = 151$ total examinations in 87 women)

Reason	n *(%)*
Artificial rupture of membranes	33 (21.9)
Suspicion of full dilatation/urge to push	30 (19.9)
Cardiotocography concern	29 (19.2)
No progress of labor	25 (16.6)
Could not see sonographic cervical dilatation	9 (6.0)
Suspected antepartum hemorrhage	5 (3.3)
Patient request	3 (2.0)
Not documented	17 (11.3)

Table 4 Estimated marginal means of ultrasonographic parameters of labor progress adjusted for number of scans, according to mode of delivery

	Estimated marginal mean (95% CI)		
Variable	*Vaginal delivery*	*Cesarean section*	P
psAOP (°)	126.84 (120.49–133.19)	110.57 (97.33–123.81)	0.029
HPD (mm)	38.15 (34.94–41.35)	46.39 (40.67–52.12)	0.008
SCD (mm)	28.25 (23.94–32.57)	19.14 (11.58–26.70)	0.025

HPD, head–perineum distance; psAOP, parasagittal angle of progression; SCD, sonographic cervical dilatation.

DISCUSSION

Combined abdominal examination and VE has long been established as normal practice, therefore, integrating the use of ultrasound on the labor ward into routine clinical practice may mean overcoming various obstacles and barriers. The first step is to identify which ultrasonographic measurements are the most useful, accurate and reproducible. The development of an ultrasound-based intrapartum examination, known as a 'sonopartogram', was conceptualized in 2014 and was shown to be feasible[8]. To the best of our knowledge, this is the first attempt to fully integrate ultrasound to monitor the progress of labor, and replace some VEs with ultrasound assessment. Our study has demonstrated that using combined transabdominal and transperineal ultrasound measurements instead of abdominal palpation and VEs to monitor labor is feasible, and can reduce women's pain during such examinations.

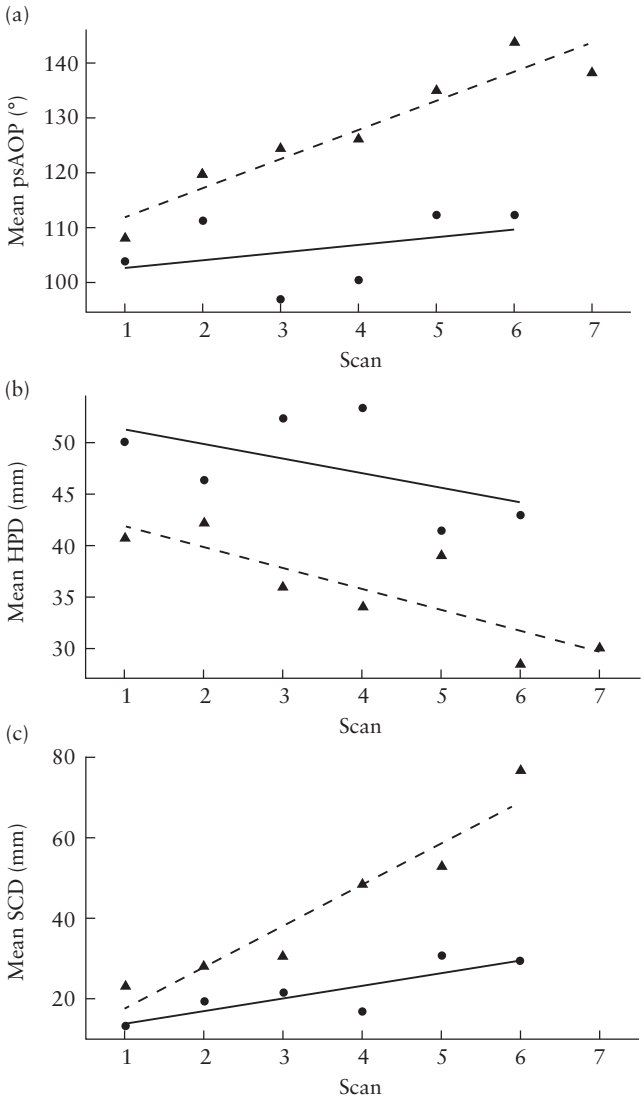

Figure 2 Change in mean parasagittal angle of progression (psAOP) (a), head–perineum distance (HPD) (b) and sonographic cervical dilatation (SCD) (c) according to number of intrapartum scans across duration of labor in women who delivered vaginally (-▲-) and those who delivered by Cesarean section (—●—).

There is a lack of consensus in the literature with regard to which intrapartum ultrasound parameter is the most useful for monitoring progress in labor. Our data shows that spine position, psAOP and HPD were successfully captured during the majority of scans. The lower number of SCD measurements could be explained by the fact that SCD can be difficult to visualize once cervical dilatation is ≥ 8 cm, as reported in previous studies[8,34]. As the cervix effaces, the head is pressed against the thinning dilated cervix, and therefore it becomes increasingly difficult to visualize a cervix that is in close approximation to the fetal scalp. Further, the fetal skull bone may also obscure a thin cervix, and the presence of caput succedaneum can further hinder the measurement of SCD[34]. In our study, 56% of unrecorded SCDs resulted when the participants had cervical dilation of ≥ 8 cm. This is in agreement with the results of previous studies[7,28].

The concept underpinning the use of a partogram is to improve maternal and fetal outcomes and allow timely intervention to ensure safe progress in labor and delivery. The sonopartogram is an extension of this concept, with the additional benefit of objective serial measurements rather than subjective assessment with poor inter- and intraobserver reliability. Usman *et al.*[35] published a recent review of the sonopartogram and its relevance in modern obstetric care. With the trend towards individualized risk prediction model-based care, for example in pre-eclampsia or trisomy screening, there is interest in developing a labor-outcome prediction model that could improve delivery management and allow informed decision-making for women.

Pre-existing maternal factors, clinical assessments and ultrasound measurements can allow reliable prediction of the mode of delivery[12,35–37]. Intrapartum ultrasound can also be used to predict the duration of labor. A longer labor is associated with the need for operative delivery and poorer fetal outcomes. The development of a reproducible sonopartogram that has predictive capability and has been validated in different populations would represent a paradigm shift in modern obstetrics, providing better quality of information to facilitate counseling and shared decision-making between healthcare providers and patients.

More research is required for the further development and implementation of a sonopartogram, with the aim of providing improved labor management, patient experience and delivery outcomes.

Strengths and limitations

Strengths of the current study include its longitudinal design with repeated ultrasonographic measurements from the commencement of IOL until full cervical dilatation or when delivery occurred, and the inclusion of multiple transabdominal and transperineal ultrasound measurements (fetal spine and head positions, psAOP, HPD, SCD) obtained in a single clinical encounter. Although multiple sonographers across different sites performed the ultrasound assessments, it has previously been shown that intersonographer variability is low[29,38].

Limitations of this study include its small sample size and findings that might not be generalizable, as we included mainly Chinese and Spanish women who underwent IOL at term. We included only women undergoing IOL in this study as we wanted to capture ultrasound measurements from the onset of labor. Further work will be needed to evaluate the relationship between serial intrapartum ultrasound measurements in women undergoing spontaneous labor.

Conclusions

Comprehensive transabdominal and transperineal ultrasound assessment can be successfully used to assess progress in labor and can reduce the level of pain experienced during examination. It may be possible to replace some transabdominal and vaginal examinations during labor with ultrasound assessment.

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SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:

Appendix S1 Best-fit model for repeated time measures of ultrasound parameters of labor progress

Table S1 Estimated marginal means of parasagittal angle of progression (psAOP), head–perineum distance (HPD) and sonographic cervical dilatation (SCD) across duration of labor, adjusted for number of intrapartum scans and interaction between number of intrapartum scans and delivery outcomes