The sonopartogram

Sana Usman, MD, MRCOG, PhD; Arwa Hanidu, MD; Mariya Kovalenko, MD; Wassim A. Hassan, MD, PhD; Christoph Lees, MD, FRCOG

The assessment of labor progress from digital vaginal examination has remained largely unchanged for at least a century, despite the current major advances in maternal and perinatal care. Although inconsistently reproducible, the findings from digital vaginal examination are customarily plotted manually on a partogram, which is composed of a graphical representation of labor, together with maternal and fetal observations. The partogram has been developed to aid recognition of failure to labor progress and guide management-specific obstetrical intervention.

In the last decade, the use of ultrasound in the delivery room has increased with the advent of more powerful, portable ultrasound machines that have become more readily available for use. Although ultrasound in intrapartum practice is predominantly used for acute management, an ultrasound-based partogram, a sonopartogram, might represent an objective tool for the graphical representation of labor. Demonstrating greater accuracy for fetal head position and more objectivity in the assessment of fetal head station, it could be considered complementary to traditional clinical assessment. The development of the sonopartogram concept would require further undertaking of serial measurements. Advocates of ultrasound will concede that its use has yet to demonstrate a difference in obstetrical and neonatal morbidity in the context of the management of labor and delivery.

Taking a step beyond the descriptive graphical representation of labor progress is the question of whether a specific combination of clinical and demographic parameters might be used to inform knowledge of labor outcomes. Intrapartum cesarean deliveries and deliveries assisted by forceps and vacuum are all associated with a heightened risk of maternal and perinatal adverse outcomes. Although these outcomes cannot be precisely predicted, many known risk factors exist. Malposition and high station of the fetal head, short maternal stature, and other factors, such as caput succedaneum, are all implicated in operative delivery; however, the contribution of individual parameters based on clinical and ultrasound assessments has not been quantified.

Individualized risk prediction models, including maternal characteristics and ultrasound findings, are increasingly used in women's health—for example, in preeclampsia or trisomy screening. Similarly, intrapartum cesarean delivery models have been developed with good prognostic ability in specifically selected populations. For intrapartum ultrasound to be of prognostic value, robust, externally validated prediction models for labor outcome would inform delivery management and allow shared decision-making with parents.

Key words: angle of progression, cervical dilatation, head descent, head-perineum distance, intrapartum ultrasound, partogram

Introduction

The current partogram (also known as the partograph) is a chart used to provide a visual overview of labor progress—maternal and fetal conditions—with time from the start of labor represented on the horizontal axis. In many maternity settings worldwide, labor progress has been described according to the partogram developed from the Friedman labor curves (Figure 1).[1–3] In these studies, from the 1950s, a graphical representation of labor from a general population was constructed, defining its normal length and duration. Labor progress was assessed using rectal examinations of the cervix and recorded against time, depicted as a sigmoid curve. In 1954, the first study demonstrated the value of plotting cervical dilatation against time as a method of graphically analyzing labor.[1] Labor was subdivided into 4 phases, the first phase or latent phase, the second phase or accelerative phase, the third phase in which there is a steady period of linear cervical dilatation, and the fourth phase or deceleration of cervical dilatation, known as the transition period. The average length of the latent phase was 8.6 hours. Once the active phase of labor was established, on average, the cervix dilated at a rate of 3 cm per hour until 9 cm following which a slight delay in reaching 10 cm from 9 cm was observed. The average length of time of the active phase of labor was reported to be 4.9 hours. The average length of the active second stage (maternal expulsive efforts: "pushing") was 0.95 hours. Deviations from the expected labor progress were described as

From the Department of Metabolism, Digestion and Reproduction, Imperial College London, London, United Kingdom (Drs Usman, Hanidu, and Lees); Centre for Fetal Care, Queen Charlotte's and Chelsea Hospital, Imperial College Healthcare NHS Trust, London, United Kingdom (Drs Usman, Hanidu, Kovalenko, and Lees); Fetal Medicine Unit, Constable Wing, Colchester Hospital, East Suffolk and North Essex NHS Foundation Trust, Colchester, England (Dr Hassan); and Department of Development and Regeneration, Katholieke Universiteit Leuven, Leuven, Belgium (Dr Lees).

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Corresponding author: Christoph Lees, MD, FRCOG. c.lees@imperial.ac.uk

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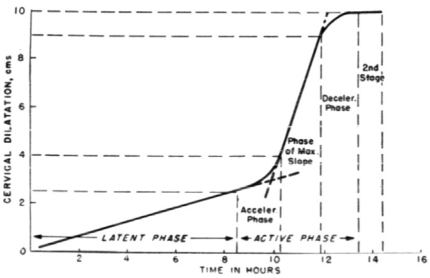
FIGURE 1
The mean labor curve based on 500 primigravid women at term[2]



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primary and secondary inertia.[1] Statistical analysis and evaluation of other factors, such as analgesia and oxytocin, led to the establishment of "mean" labor curves for cervical dilatation in nulliparous[2] and multiparous women.[3]

These were the first observations to allow labor progress to be empirically quantified. These observations were primarily based on representative samples of parturient from a database of personally examined women. Although the cervical dilatation at which active labor was considered to commence may be variable, the acceleration phase occurred at a variety of different cervical dilatations and differed between nulliparous and multiparous women.[2,3] Later work from Friedman and Sachtleben[4] reported labor progress in cephalopelvic disproportion (CPD) and other complications.

Developments of the partogram

Variations based on the principle of Friedman's labor curve were developed in the following decades.[5–9] In 1972, working in Zimbabwe (then Rhodesia), Philpott and Castle[7,8] developed a partogram from the cervicograph, which provided a method for recording additional intrapartum observations, not just cervical dilatation.[9] In a further prospective study of 624 women undergoing labor, an "alert line" was added to the partogram.[7] The alert line was a modification of the mean rate of cervical dilatation to represent the slowest cervical dilatation in 10% of primigravid women in the active phase of labor. This line represented a progress rate of 1 cm per hour; hence, a line showing slower cervical dilatation would cross the alert line. This might mean, for example, that, in remote settings, arrangements could be made to transfer a primigravid woman with prolonged labor from a community to a hospital setting. This was particularly pertinent to the setting in Southern Africa where distances among medical facilities are often great and rural hospitals may lack operative obstetrical facilities.

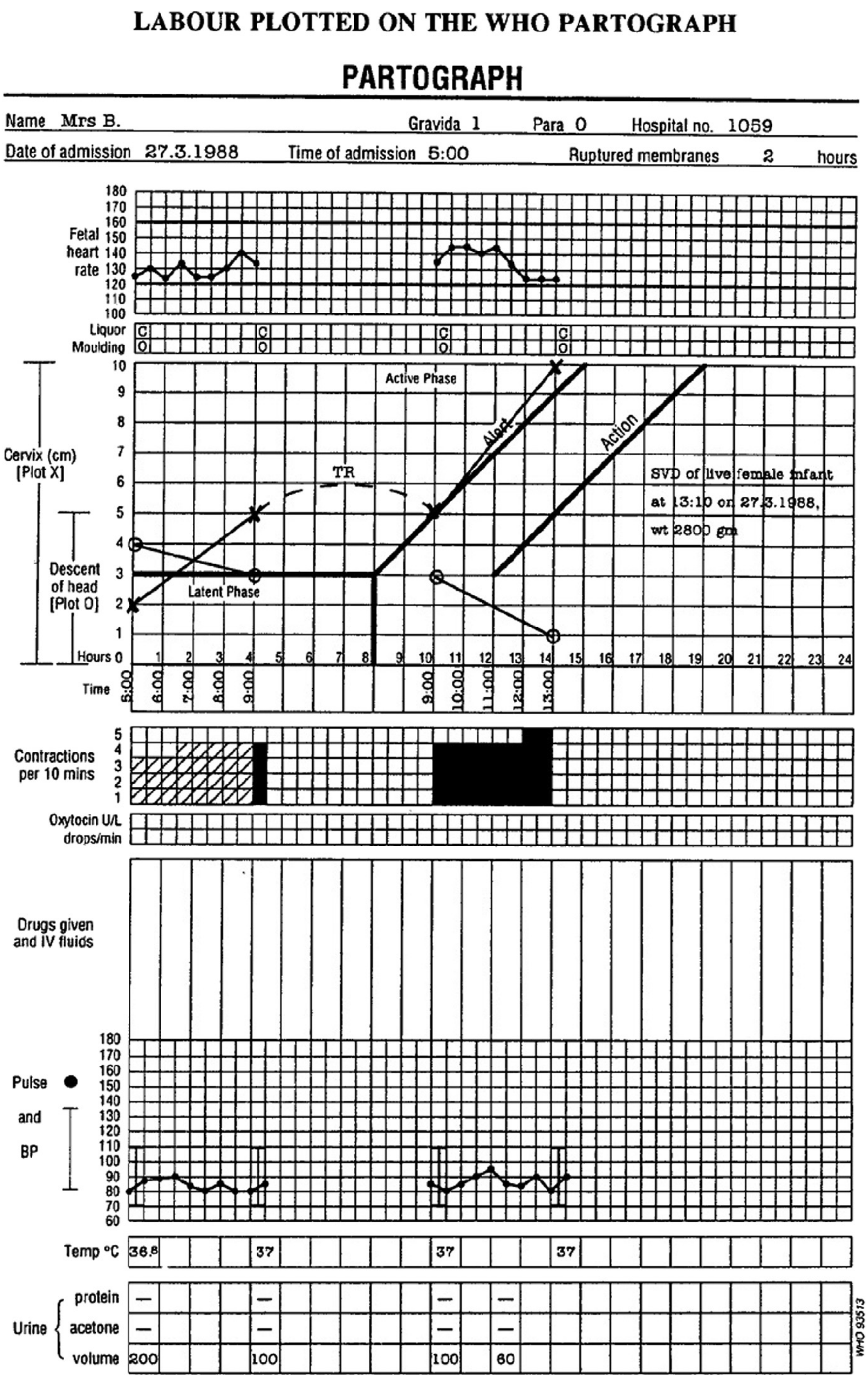
The next stage of partogram development was the introduction of an "action line," 4 hours to the right of the alert line.[8] This line was to identify primary inefficient uterine activity and trigger interventions, such as amniotomy (artificial rupture of membranes) or oxytocin infusion. This "active management of labor" was originally described to reduce the length of labor and the numbers of women who have cesarean delivery (CD), reporting the benefit of the intervention with oxytocin in women diagnosed with slow labor progress based on dilatation of the cervix.[10–12] In 1969, in Dublin, O'Driscoll demonstrated in 1000 women undergoing labor that active management lowered the CD rate and that there was less prolonged labor and more maternal satisfaction.[10,11,13] Subsequent studies have supported the reduction in the incidence of dystocia and the increase in the rate of vaginal delivery without increasing maternal or neonatal morbidity.[14–16]

In 1994, the World Health Organization (WHO) recommended the partogram to define slow labor progress because of concerns about the high level of associated maternal and fetal morbidity.[17] This partogram was reported to improve the management of labor and its outcome in the hospital setting.[18] Regular digital vaginal examinations (VEs) were undertaken to assess cervical dilatation, fetal head position, presence and absence of caput and molding, fetal head descent, and color of amniotic fluid while noting maternal observations and fetal heart rate. These assessments allowed labor progress to be monitored in the partogram concerning time (Figure 2). Although the partogram was not designed to predict the outcome of labor, its use has been shown to be associated with length of labor,[5,19] mode of delivery,[6,20–22] and short- and long-term perinatal outcomes.[10–12,23]

Several adaptations have been made to the original WHO partogram.[24] A simplified partogram begins in active labor and excludes the latent phase (Figure 3). Within this chart, the green area represents normal labor progress of 1 cm per hour. The junction between the green and yellow areas represents an "alert" line where if crossed, a review by a medical practitioner is recommended. The junction between the yellow and red areas represents an "action" line. When this is crossed, abnormal labor progress is inferred, and a medical intervention is recommended. These partograms have been described as more "user friendly" and hence preferable to medical and midwifery staff.[25,26]

As normal labor encompasses a wide variation in progress, "average" progress cannot be taken to be synonymous with normal progress in every parturient undergoing laboring. The recommendations included a new understanding that individual variability of labor progress could result in good perinatal outcomes and underlined the fact that many women do not experience a labor that conforms to the 5th and 95th percentile rates of labor progress on which the partogram design was based.[27,28] In 2018, the WHO updated its recommendations on global intrapartum care.[29] The updated WHO recommendations recognized a shift toward improving the experience of childbirth,[29] and this stimulated the design of a new labor monitoring tool: the WHO Labour Care Guide (LCG) (Figure 4).[30] Among other changes, this labor care guide defined the active phase of labor as starting from 5 cm of cervical dilatation, potentially missing important information about early labor, which would therefore not be plotted on the partogram. The fixed "alert" and "action" lines gave way to "evidence-based time limits" at each centimeter of cervical dilatation during the active first stage of labor. These time limits are derived from the 95th percentile of labor duration at different

FIGURE 2
Original partograph recommended by the WHO in 1988



The top panel shows fetal observations (heart rate monitoring), color of amniotic fluid, and fetal progress of labor. The fetal head station and cervical dilatation are plotted against time. The bottom panel displays maternal observations, frequency and strength of contractions, use of oxytocin, and medications in labor. Reproduced with permission from the study entitled "World Health Organization Partograph in Management of Labour."[17]

WHO, World Health Organization.

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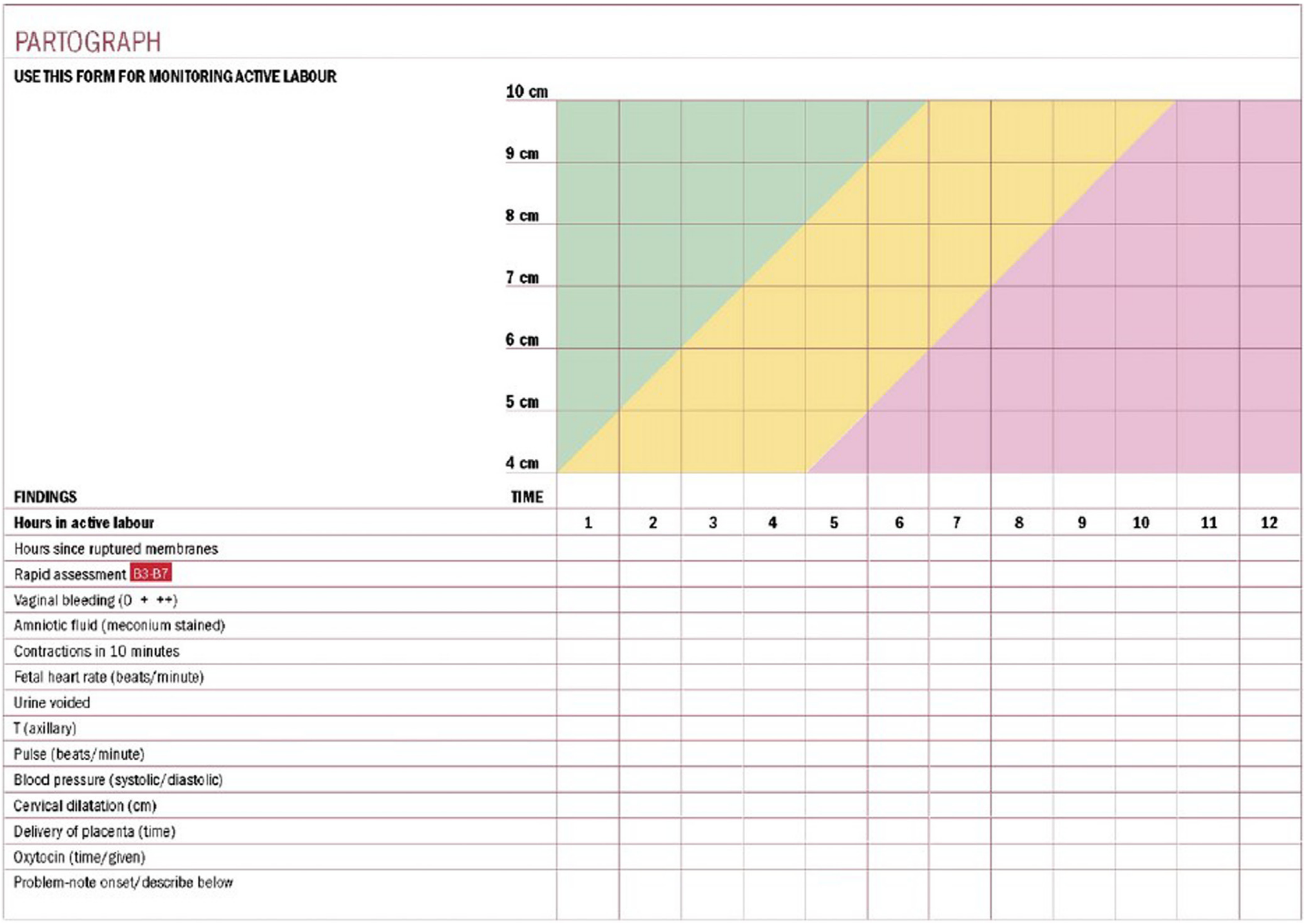
cervical dilatations in women with normal perinatal outcomes. This means that a nulliparous woman may, for example, take up to 18.5 hours (6 hours at 5 cm, 5 hours at 6 cm, 3 hours at 7 cm, 2.5 hours at 8 cm, and 2 hours at 9 cm) to progress from a cervical dilatation of 5 cm in "active labor" to full dilatation. These data are based primarily on evidence from a prospective cohort study of 5606 women in Nigeria and Uganda who gave birth vaginally. Following the onset of spontaneous labor, patterns of labor progression were examined concerning cervical dilatation. This was part of the WHO's "Better Outcomes in Labour Difficulty" project, which aimed to develop a new labor monitoring-to-action tool,[31] and thus, a redesign of the partogram seems to be based on a single scientific study and expert consensus.

In this same new section of the WHO LCG, the assessment of fetal head descent is described in fifths concerning the pelvic brim by abdominal palpation only. Describing the vertex concerning the ischial spines from VEs is no longer required (Figure 4). The transabdominal method of clinical assessment of fetal head descent was suggested by Crichton[32] in South Africa in 1974 as a more reliable method than the vaginal assessment of the ischial spine, especially in the presence of caput or molding. In 2007, Buchmann et al[33] found this clinical method to be unreliable with poor interobserver agreement. Despite this, it remains the only method for plotting fetal head descent in the new 2020 WHO LCG.[34]

The strength of uterine contractions was not included, recognizing that this was difficult to objectively measure, but the duration and frequency of uterine contractions were still recorded. It is noteworthy that the UK 2014 National Institute for Health and Care Excellence (NICE) guidelines, although updated in 2017,[35] continues to recommend the use of the 1994 WHO partogram with 4-hour action lines once labor is established in the first stage.[17] Despite many "high-tech" developments particularly in the imaging field of medicine, obstetricians and midwives continue to rely

FIGURE 3
The simplified partograph



Partograph developed to simplify the chart representation of cervical dilatation against time and track the rate of progress. It is used in active labor beginning from cervical dilatation of 4 cm plotted along the y axis and time in hours along the x axis. Maternal observations are recorded beneath this. Reproduced with permission from Mathews et al.[25]

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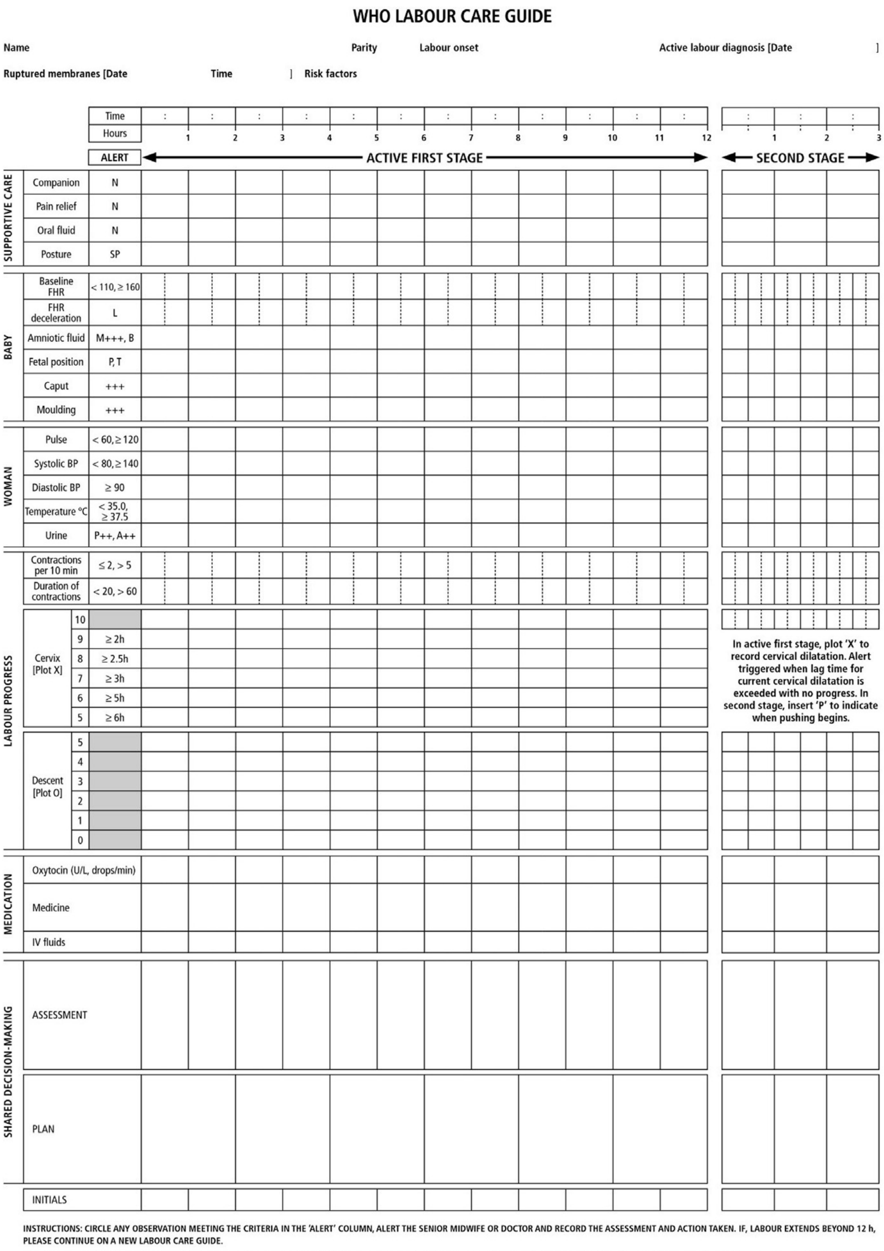
on subjective methods to assess and monitor labor progress. Digital VE is dependent on a tactile sensation of the examiner's fingers. In 1989, 36 midwives and 24 obstetricians were assessed blindly on a cervical dilatation simulator. Cervical dilatation was correct in 175 of 360 cases (49%) overall. Obstetricians were correct in 77 of 144 cases (53%) and midwives in 98 of 216 cases (45%) with no significant difference between them.[36] In 500 women, the researcher and clinicians agreed on the cervical dilatation in labor in 250 instances (49%) and differed by 2 cm or more in 56 instances (11.0%) (kappa, 0.40; 95% confidence interval [CI], 0.34—0.45). Accuracy was greater at low (3—4 cm) and high (8—10 cm) dilatations.[37]

In the same population, the interobserver agreement between 2 investigators for fetal head station was reported to be fair with a kappa statistic of 0.23 (95% CI, 0.17—0.29).[38] In a comparison of 32 residents and 25 attending physicians on a birth simulator for fetal head station, Dupuis et al[39] found errors that occurred in assessing head station in 50% to 88% of cases for residents and 36% to 80% of cases for attending physicians, depending on the position. The mean "group" error was 30% (95% CI, 25—35) for residents and 34% (95% CI, 27—41) for attending physicians.[38] Moreover, significant discrepancies are particularly noted for the assessment of fetal head position[40—43] and where there is an occiput posterior (OP) position.[44] Of note, 30% of babies presenting by the breech presentation are missed by palpation at or before labor.[45] Inconsistent results from those assessing cervical dilatation can subject women with prolonged labor to multiple examinations and delay the recognition of slow labor progress.

The partogram in modern clinical practice

Friedman's labor curve of 1954[1] still defines the principles on which labor

FIGURE 4
The WHO Labour Care Guide



The figure shows the graphical representation of labor progress—maternal and fetal observations—divided by the active first stage of labor, from 5-cm cervical dilatation, and second stage of labor, from 10-cm cervical dilatation. Reproduced with permission from Hofmeyr et al.[30]

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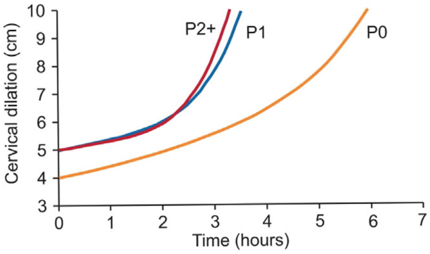
progress for most obstetricians and midwives is defined worldwide. The UK's NICE labor guidelines define the latent first stage of labor as "a period, not necessarily continuous, when there are painful contractions and there is some cervical change, including cervical effacement and dilatation up to 4 cm." The established first stage of labor is defined by "regular painful contractions and there is progressive cervical dilatation from 4 cm. If delay in the established first stage of labor is suspected, all aspects of labor progress should be assessed when diagnosing delay. In nulliparous women, this includes cervical dilatation of <2 cm in 4 hours, cervical dilatation of <2 cm in 4 hours, a slowing in labor progress for the second or subsequent labors, or a slowing in labor progress for multiparous women." Other factors associated with labor progress include "descent and rotation of the baby's head and changes in the strength, duration, and frequency of uterine contractions should also be evaluated."[35]

"Despite the Partogram forming the basis for most obstetrical intrapartum guidelines worldwide,[17,35,46] the authors of the 2018 Cochrane review were unpersuaded of the benefit of routine use of the partograph in labor management and care. They concluded that further trial evidence is needed on the efficacy of the partogram and which design is most effective."[44] In recent years, there has been much debate regarding the applicability of the partogram,[47] resulting in a joint consensus statement by the American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine, issuing new guidelines on labor management in 2014.[48] The guidelines suggested that contemporary labor progressed at a slower rate than previously thought, and thus, CD should be reserved only for women in whom labor arrest is diagnosed beyond 6 cm of dilatation.[48] These recommendations were based on moderate-quality evidence.[49,50]

In addition, the guidelines redefined labor dystocia based on retrospective data from 2010 in 62,415 single vertex vaginal deliveries with normal perinatal outcomes showing that contemporary labor progressed at a rate substantially slower than described by Friedman.[39,40] At more advanced cervical dilatation, labor proceeded more quickly. Cervical dilatation in nulliparous and multiparous women was similar between 4 and 6 cm. Beyond 6 cm, multiparous women's cervical dilatation was more rapid (Figure 5). In the active phase of labor, the maximum slope of the rate of change in cervical dilatation did not start until at least 6 cm. The study did not directly address an optimal duration for the

FIGURE 5
The "Zhang" curves



The graph shows consolidated labor curves differentiated by parity. These data were obtained from a population of singleton, term pregnancies with spontaneous onset of labor in which a vaginal delivery is achieved. P0 indicates nulliparous; P1 indicates women of parity 1; and P2+ indicates women of parity 2 or greater. Reproduced with permission from Zhang et al.[50]

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diagnosis of active phase or labor arrest but suggested that neither should be diagnosed before 6 cm of cervical dilatation.[42]

Critics of these new guidelines suggest that erroneous analyses of labor progress limited the generalizability of the results, including that the study excluded first-stage CD and was not adjusted for potential confounders, such as oxytocin use.[51] A recent study by De Vries et al[52] analyzed and compared the statistical methods used in the development of both Friedman's original labor curves with the defined latent phase and active phase[2] and progressive cervical dilatation charts created by Zhang et al.[47] Of note, 2 large databases were created, each with 500,000 simulated labor curves replicating the original populations. The statistical techniques used by Zhang et al[47,50] (repeated measures polynomial and interval-censored regression) were tested against the populations and were found not to accurately detect periods of rapid acceleration from the latent phase to the active phase in the first stage of labor.[52]

Interestingly, the "Labour Progression Study," a 14-site cluster randomized controlled trial (RCT) in Norway,[53] designed to compare the outcome of the ACOG guidelines with the WHO partogram, did not find a difference in the frequency of intrapartum CDs (ICDs). Here, 7 maternity units were randomly assigned to the control group, composed of 3305 participants (45.4%) (adhering to the WHO partogram), and 7 maternity units were randomly assigned to the intervention group, composed of 3972 participants (54.6%). There were 196 ICDs (5.9%) in women in the control group (WHO partogram) and 271 ICDs (6.8%) in women in the intervention group; thus showing no difference.[53]

A paperless interactive partogram was recently launched as an "app" to improve the ease and efficiency of use.[54] Within the app, a clinical decision support tool was created through an algorithm representing WHO labor guidance. Reminders were generated by the application for the practitioner to take maternal and fetal observations in labor. Visual and auditory alerts gave warning signals that an intervention in labor should be considered and subsequent interventions performed could be recorded. This electronic partogram (ePartogram) was evaluated in 842 women and compared with 1042 women monitored with the traditional paper partogram in Kenya (Figure 6).[54] Its use improved timeliness of care and compliance with recommended observations in labor. These findings pointed to the improvement of overall quality of care and reduction in adverse fetal outcomes; however, it needs additional evaluation in diverse maternity settings.

The "sonopartogram" and intrapartum ultrasound assessment

The assessment of labor progress by intrapartum ultrasound may play an important role in the management of labor and delivery. References to descriptions of intrapartum ultrasound are as early as 1977 when fetal head descent was objectively assessed. In this first known publication, an ultrasonic echograph measured the distance from the fetal head to the sacral tip before and during labor and compared this to the clinical evaluation of the fetal head station.[55] In a PhD program from Minsk in 1996, Voskresinsky[56] presented images of the fetal head at different stages of labor using transperineal ultrasonography.

Although the techniques of ultrasound assessment of labor progress have been extensively described and researched in the past decade, they are far from universally applied. Sonographic analysis of labor progress is a conceptually simple way of monitoring the key parameters of labor by ultrasound: cervical dilatation, fetal head descent, and fetal head position (rotation).

The concept of a comprehensive, multiparameter nonintrusive ultrasound-based assessment of labor progress known as the "sonopartogram" (Figure 7) was first introduced in 2014.[57]

FIGURE 6
Example of an ePartogram in modern use, an Android tablet-based application[54]

The figure shows the electronic input of labor progress: cervical dilatation and fetal head descent. The application stores all data of patients undergoing labor and reproduces it through graphical images. The dashboard display is shown in this figure representing all patients under the practitioner's care.

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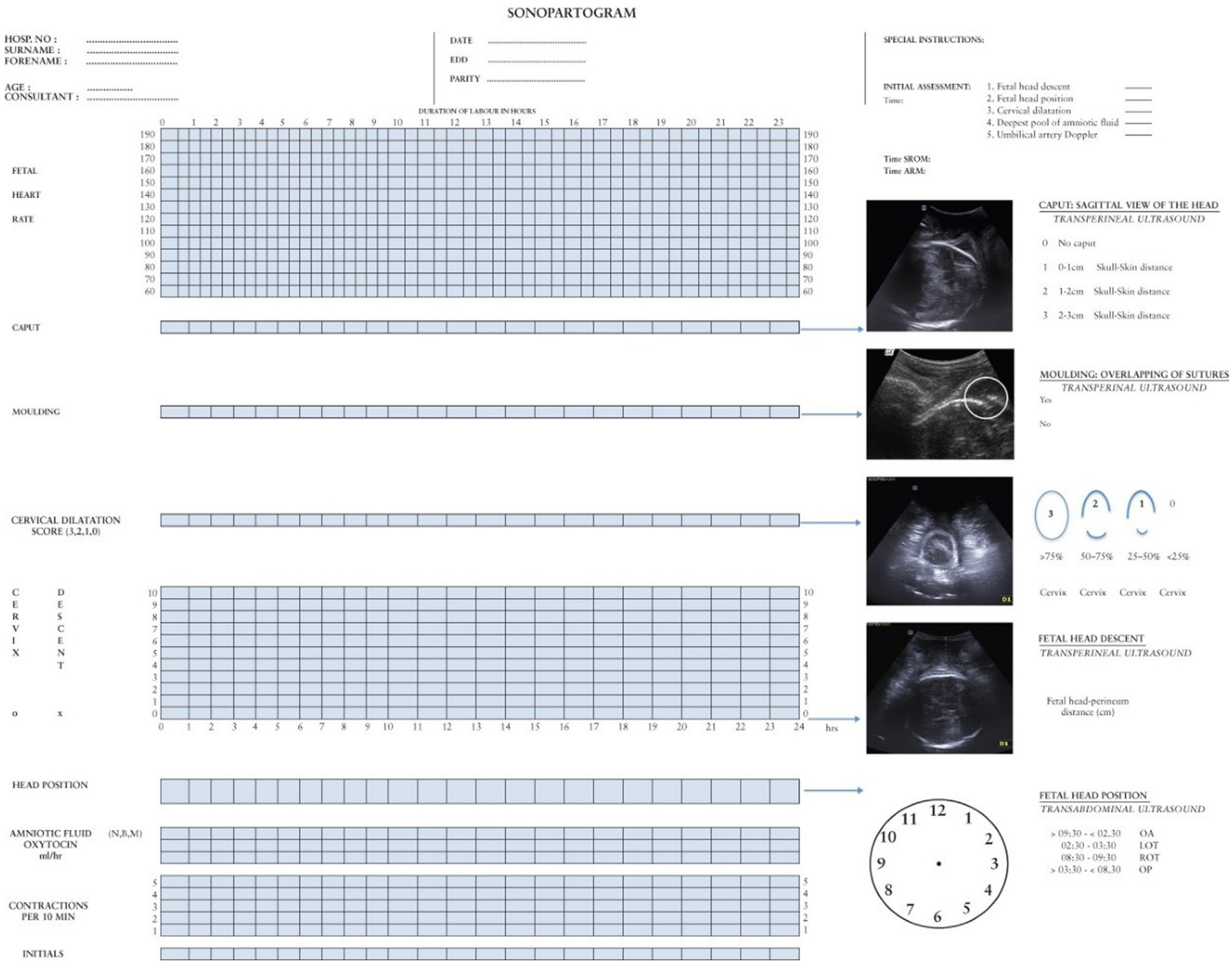
FIGURE 7

Prototype depiction of a sonopartogram



On the left side, the conventional tabulation of fetal observations (heart rate monitoring) and vaginal examination findings in labor are displayed. On the right side, the corresponding intrapartum ultrasound descriptor images are displayed. Reproduced with permission from Hassan et al.[57]

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A prospective pilot study of 20 women in the first stage of labor was carried out in 2 European maternity units. Almost simultaneous assessment of cervical dilatation, fetal head descent, and position was made by ultrasound and digital VE. Of note, 52 paired ultrasound and digital VE assessments, with a median of 3 per woman, were undertaken. Overall, 5% of parameters based on ultrasound were not obtained compared with 18% from clinical examination. The assessment of cervical dilatation was possible in 86.5% of ultrasound examinations and 100% of digital VEs (P=.02), there being a close correlation (r^2=0.68; P=.01). Cervical dilatation by ultrasound was greater than by digital VE by a mean difference of 1.16 cm (95% limits of agreement, −0.76 to 3.08). Fetal head descent was measured in all 52 cases by ultrasound-measured head-perineum distance (HPD) and digital VE, but the correlation between the 2 techniques was only moderate (r^2=0.33; P<.001). Head position was obtainable in 98% of ultrasound examinations and 46% of digital VEs, with a mean difference of −3.9° (95% limits of agreement, −144.1° to 136.3°).[57]

The sonopartogram study[47] described a proof of concept, based on a combination of labor parameters derived from both conventional examination and ultrasound. The data completeness was greater for ultrasound assessments than those based on clinical examination. Ultrasound assessment of labor progress was found to be feasible in most cases. Furthermore, the ultrasound technique described took no more than 5 minutes and was well tolerated by the women.[57]

The commonly used ultrasound techniques for assessing labor progress used in the sonopartogram are described in detail below, namely, transabdominal ultrasound to assess fetal head position and transperineal ultrasound to assess fetal head descent and caput succedaneum.

Intrapartum ultrasound: methods

In the following section, we described intrapartum ultrasound methods that are frequently described to determine the progress of labor, including those referred to in the original description of the sonopartogram.

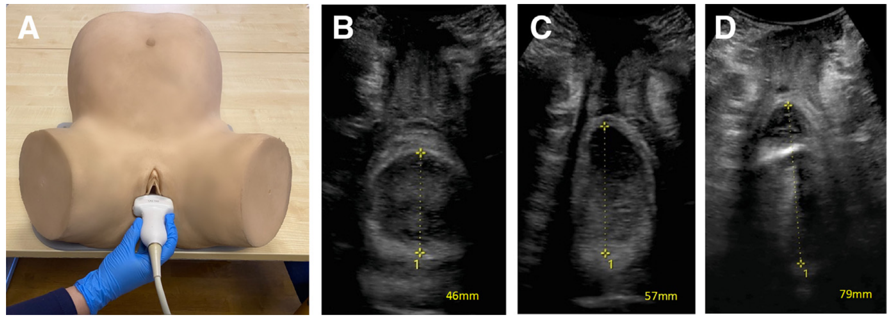
Cervical dilatation

Transperineal ultrasound assessment of cervical dilatation during labor by 2-dimensional ultrasound was first reported by Hassan et al,[58] who described a novel and simple technique. In the early stages of active labor, especially before rupture of the membranes, cervical dilatation can be seen and measured in its anteroposterior plane by holding the ultrasound transducer in the transverse plane at the vaginal introitus and angling gently up and down.

Ultrasound to measure cervical dilatation has been shown to be feasible, with fair agreement concerning VE, although the usefulness of ultrasound assessment of cervical dilatation attenuates at greater cervical dilatation (Figure 8).[59]

The cervix becomes difficult to visualize in more advanced labor and in all cases from a dilatation of 8 cm onward. This is explained by the fact that, at advanced cervical dilatations, the cervix is very thin, completely effaced, and retracted; furthermore, at this stage, the fetal head is low and may be lower than the cervical ring; hence, the fetal cranium can obscure the ultrasound assessment. The inability to visualize the cervix at advanced dilatation should not detract from monitoring labor progress by ultrasound as other parameters, such as fetal head descent, can also be observed to track progress of labor.[60]

FIGURE 8
Transperineal ultrasound images of the cervix



A, Transperineal ultrasound approach. Ultrasound probe orientation in the transverse plane. **B,** The cervical dilatation is measured at 46 mm. Both the anterior and posterior rims of the cervix are clearly visible. The anterior lip is the closest to the ultrasound transducer. **C,** The cervical dilatation is measured at 57 mm. The posterior cervical rim becomes obscured as fetal head descent occurs. **D,** The cervical dilatation is measured at 79 mm. Difficulty is encountered in obtaining clear imaging of the cervix in both anterior and posterior aspects because of shadowing from the fetal cranium.

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Fetal head descent (station)

Several transperineal ultrasound methods have been proposed to describe fetal head descent or station. Because of the difficulty of identifying the ischial spines on ultrasound, it is not possible to measure fetal head descent directly concerning the ischial spines as would be conventionally assessed when performing digital VE. We described the 2 most used methods to assess fetal head descent in the following section.

Head-perineum distance

A simple method to measure the descent of the fetal head using intrapartum ultrasound is to place the transducer transversely just above the posterior fourchette and measure the shortest distance from the transducer edge to the fetal skull: the HPD, which reflects the perineum-skull distance and is measured in millimeters (Figure 9).[61]

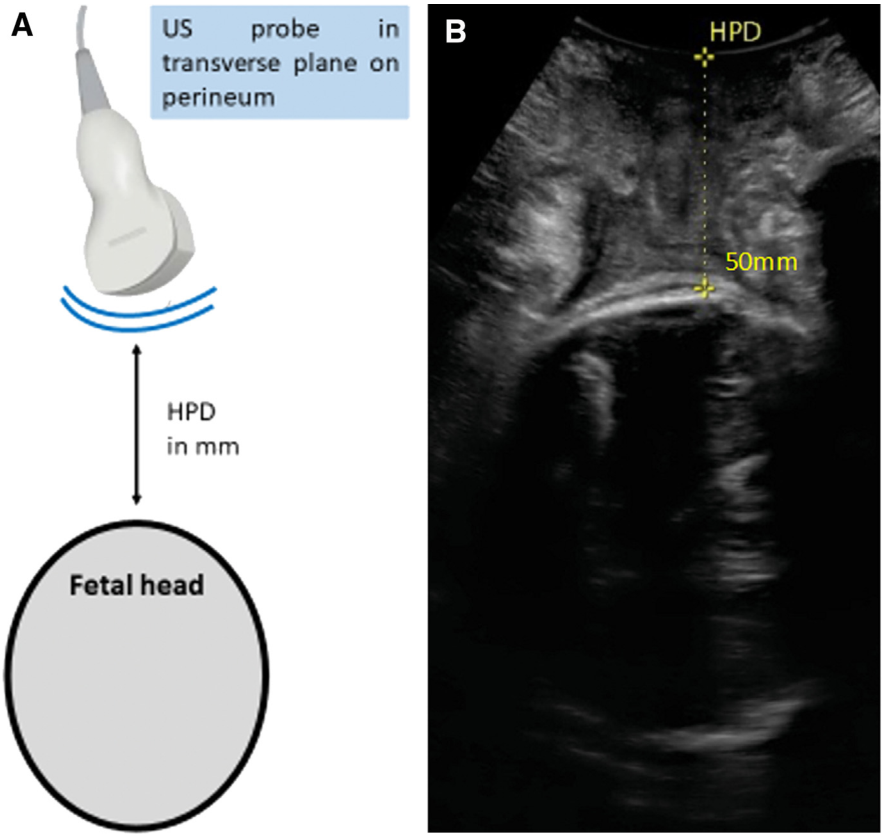
Concerning fetal head descent, the HPD measured by ultrasound is not directly comparable with head station measured by digital VE, and a substantial overlap is observed in the distributions of ultrasound-derived HPD measurements for any given fetal head station concerning the distance between the vertex and the ischial spines derived from digital VE. The coefficient of determination between ultrasound and digital VE head descent has been reported as r^2=0.33, indicating that although there was a significant association between the 2 methods, the level of correlation was only moderate.[57]

Angle of progression

The angle of progression (AoP) is measured by applying the ultrasound probe transperineally in the sagittal plane. The AoP constitutes the angle between a line through the long axis of the pubic symphysis and the tangent to the fetal skull (Figure 10). This can be calculated either manually or automatically, depending on the ultrasound equipment used. As the AoP increases, the further is the descent of the fetal head into the maternal pelvis during labor. The AoP has been found to be accurate and reproducible as a method of assessing the descent of the fetal head in labor.[62]

Many studies have demonstrated an association among HPD, AoP, and labor outcome in both the first and second stages of labor. Eggebø et al[63] assessed the sonographic prediction of vaginal delivery in prolonged labor in 150 women in 2 centers. They found that when HPD was ≤40 mm or AoP was ≥110°, most women had a successful spontaneous vaginal delivery, and when HPD was >40

FIGURE 9
Measurement of the head perineum distance (HPD)



A, Illustration of the measurement of the HPD. **B,** Transperineal ultrasound scan for obtaining the HPD in millimeters. An ultrasound probe orientation in the transverse plane is shown. The HPD measurement is 50 mm.

HPD, head-perineum distance.

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mm or AoP was <110°, approximately half of the women had a successful spontaneous vaginal delivery. Transperineal ultrasound was carried out by both midwives and doctors in this study.

Fetal head position (rotation)

Determining fetal head position is an important aspect of the labor assessment, with malposition contributing to labor dystocia. Digital VE has significant limitations when determining fetal head position, Akmal et al[64] found that clinicians erroneously assign OP position in almost 50% of cases. The assessment of fetal head position using transabdominal ultrasound is superior to digital VE, and ultrasonography has a higher success rate than digital VE in the determination of fetal head position.[59]

In the sonopartogram study, fetal head rotation was determined on the basis of the position of the posterior fontanel,[57] according to the originally described 12-hour clock face,[64] with the measurement rounded up or down to the nearest hour, in other words 30-degree segments.[57] The interobserver (Cohen's kappa, 0.727; $P<.001$) and intraobserver (Cohen's kappa, 0.845; $P<.001$) variabilities of this technique have suggested good agreement.[65] We described the different fetal head positions (Figure 11) and the use of transabdominal ultrasound for this assessment in labor below (Figure 12).

A systematic review and meta-analysis with a population of 3370 women undergoing labor favored ultrasound in determining fetal head position in the first stage of labor.[66] In addition to the assessment of fetal head position, the fetal spine position can be demonstrated with transabdominal ultrasound in the transverse plane at the level of the 4-chamber view of the heart (Figure 13). This supplementary additional ultrasound plane allows a better understanding of the fetal position. The 2020 Royal College of Obstetricians and Gynaecologists assisted vaginal birth guideline recommended the use of intrapartum ultrasound for fetal head position where there is clinical doubt.[67]

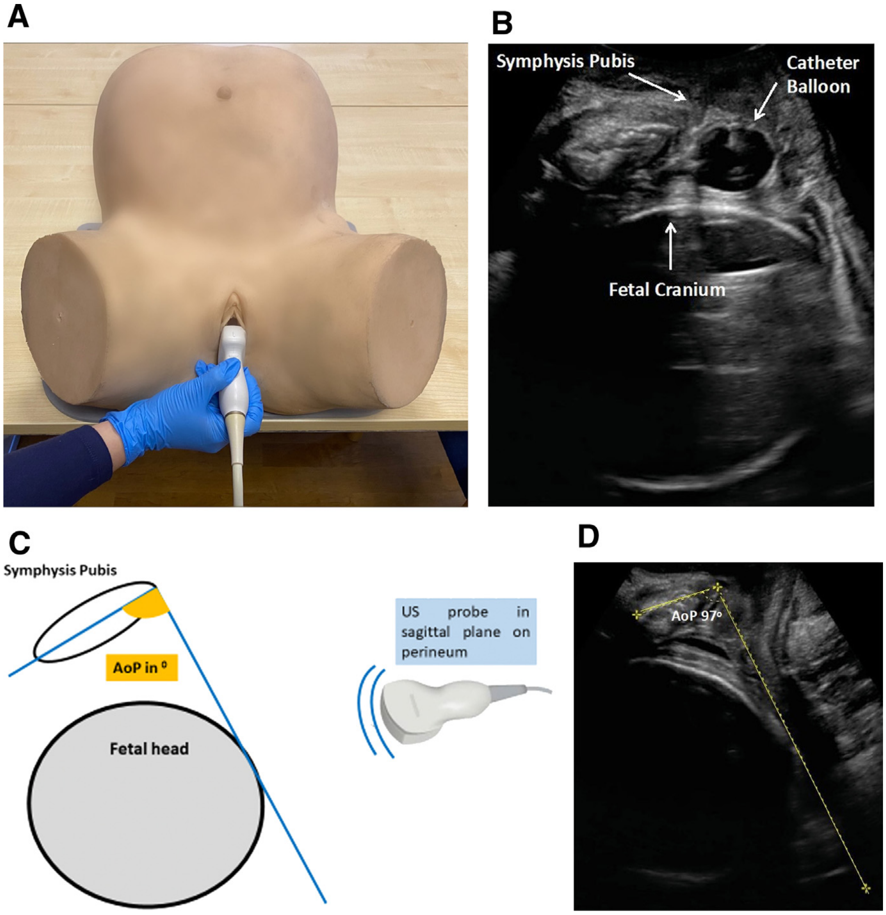
Caput succedaneum

The assessment of the caput succedaneum is particularly subjective. Described as a soft "bulge" of subcutaneous tissue, it is felt as a swelling against the fetal skull, and its degree is not possible to quantify objectively from digital VE. Barbera et al[68] demonstrated the identification of the caput succedaneum using transperineal ultrasound in the sagittal view of the fetal skull (Figure 14). Hassan et al[69] compared the clinical assessment and ultrasound assessment of the caput succedaneum in nulliparous women in the first stage of labor and also investigated the repeatability of ultrasound measurements. An objective method of measuring the caput is described by the skin-skull distance. This was defined as the maximum distance measured by ultrasound from the outer border of the fetal skin to the outer border of the leading arc of the skull. The caput was measured by ultrasound in most cases and correlated with digital assessment. The repeatability of ultrasound measurement of the caput was good, and its presence was associated with CD.[69]

Molding

Molding describes the change in fetal head shape occurring as a result of external compression forces on the cranial vault. It forms part of the vaginal assessment in labor. The first recognized ultrasound assessment of molding was in

FIGURE 10
Measurement of the angle of progression (AoP)



A, Ultrasound probe orientation in the sagittal plane. Transducer is placed on the outer aspect of the maternal labia. **B,** Ultrasound image depicting the landmarks for measuring the AoP. Identification of the maternal symphysis pubis and the contour of the fetal cranium. The maternal indwelling urinary catheter balloon can be seen in this image. It may resemble fetal caput succedaneum; however, it can be seen isolated from the fetal skin and in an anterior position. **C,** Illustration of the measurement of the AoP. **D,** The AoP demonstrated is 97°.

AoP, angle of progression.

Usman. The sonopartogram. Am J Obstet Gynecol 2022.

1991.[70] Molding can easily be visualized on sagittal view of the fetal head using transperineal ultrasound, of which the overlap of the skull bones can be measured (Figure 14).[71] Ultrasound can be used to classify the 3 different types of molding: occipitoparietal molding (occipital bone under the parietal bone at the lambdoidal suture), frontoparietal molding (the frontal bone under parietal bone at the coronal suture), and parietoparietal molding (overlap at the sagittal suture). Occipitoparietal molding, seen most in occiput anterior (OA) positions, is not associated with delivery mode as it is likely a physiological process. Parietoparietal molding is considered a warning sign for CPD. In a small study of 11 fetuses, frontoparietal molding was significantly associated with a failed vacuum. Of the 11 fetuses with either frontoparietal or parietoparietal molding, 10 underwent operative delivery.[71]

Asynclitism

Deflection of the sagittal suture to a more anterior or posterior position in the pelvis is called asynclitism. There are 2 varieties of asynclitism usually found in a fetus in the transverse head position. If the sagittal suture is closer to the sacral promontory, more of the anterior parietal bone can be felt during the VE; this is known as anterior asynclitism. In posterior asynclitism, the sagittal suture lies closer to the pubic symphysis, and more of the posterior parietal bone can be felt on VE. Asynclitism, particularly the posterior type, is a commonly reported cause of prolonged or obstructed labor.[72] Although ultrasound evaluation can determine fetal head position more accurately, the position of the sagittal sutures can only be determined by digital VE. Thus, ultrasound can be used as an adjunct in the clinical suspicion of obstructed labor, especially in the presence of the caput succedaneum.

Summary

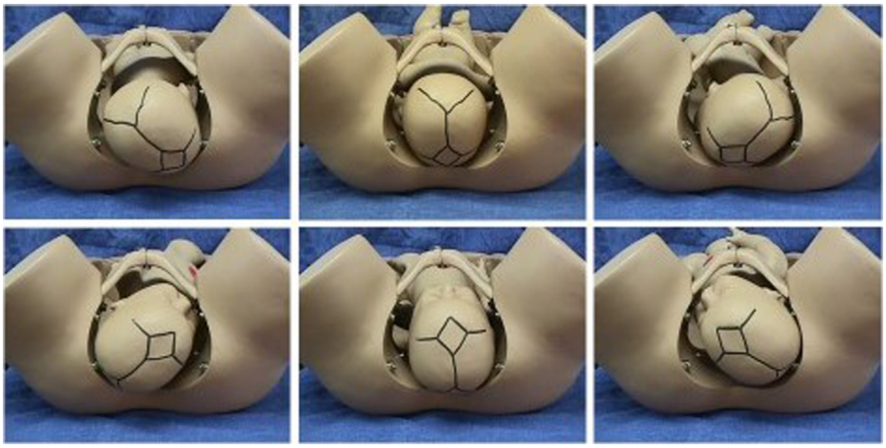
Ultrasound is considered to be superior to VE in the identification of fetal head position.[41–43,64,73–75] It is less evident that ultrasound is superior in the identification of the fetal head station[76–78] and cervical dilatation,[59,79,80] which is best assessed digitally in advanced labor.

Measuring fetal head descent by ultrasound is not analogous to the clinical assessment of fetal head station developed by Friedman and Sachtleben, the latter using the ischial spines and the leading fetal bony part as reference points.[81–85] The rate of longitudinal change in fetal head descent using HPD[86,87] and the AoP[86,87] as labor parameters have been described in the assessment of normal labor progress examined sonographically.

Prediction of labor outcomes using ultrasound

Of note, 1 key question in obstetrical practice is "Which women are likely to undergo unplanned operative interventions in labor?" Many researchers have attempted to combine clinical and sonographic predictors of operative delivery. Recent studies have suggested that ultrasound can, with varying degrees of

FIGURE 11
Representation of the fetal head position from palpation of the fontanelles



The larger *diamond shape* is bordered by 4 suture lines representing the anterior fontanelle, and the 3 suture lines represent the posterior fontanelle. The fetal head position is determined by the location of the posterior fontanelle. Top row from the left: right occiput anterior, occiput anterior, and left occiput anterior. Bottom row from the left: occiput posterior and left occiput posterior. Images courtesy of Akmal et al.[44]

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accuracy, predict the duration of labor[63,88] and labor outcomes.[63,86,89]

The multicenter Irish Genesis study of 2336 women showed that, before labor, the combination of maternal age, body mass index (BMI), height, fetal abdominal circumference, and fetal head circumference could be used to determine the overall risk of ICD in nulliparous women at term. This study used the sum of the individual factors to calculate the overall risk of CD using an intuitive risk assessment tool (Figure 15).[90]

Individual ultrasound parameters

Fetal head position (rotation)

Fetal OP position is associated with prolonged labor and difficult delivery.[91] Fetal head malposition is associated with an increased risk of ICD.[44] Of note, 38% of women with a fetus in the OP position were delivered by CD compared with 17% of women with a fetus in the non-OP position in a study in 2015 in nulliparous women with prolonged first stage of labor.[89] However, a systematic review reported that although sonographic assessment of the fetal head position before delivery was an easy approach and may be usefully applied in other settings (eg, before instrumental delivery), its assessment should not be used as the only predictive parameter for labor outcome.[92]

Fetal head descent (station)

In a study of 222 low-risk nulliparous women with a singleton pregnancy, the dynamic change of fetal head descent expressed as AoP was measured at rest, during pelvic floor contraction, and during Valsalva maneuver at term before the onset of labor. Wider AoP at rest and under pelvic contraction was associated with vaginal delivery, shorter labor duration, and shorter interval to delivery.[93] A narrow AoP (<95°) is associated with a high rate of ICD.[94] Moreover, HPD can predict vaginal delivery before the induction of labor (IOL).[95]

In the second stage of labor, the intraobserver interclass correlation coefficient (ICC) for AoP at rest was reported as 0.96 (95% CI, 0.89—0.99) and AoP with maternal pushing was reported as 0.98 (95% CI, 0.96—0.99). The interobserver ICC for the AoP at rest was 0.71 (95% CI, 0.31—0.9) and AoP with pushing was 0.93 (95% CI, 0.79—0.98).[96] Conducting a study on 50 women undergoing spontaneous labor, mainly in the second stage of labor, Tutschek et al[76] reported the AoP to have an intra- and interobserver variability of 13° and 14°, respectively.

Similarly, for HPD in the second stage of labor,[96] the intraobserver ICC was 0.96 (95% CI, 0.87—0.99) at rest and 0.96 (95% CI, 0.88—0.99) with maternal pushing. The interobserver ICC for HPD was 0.66 (95% CI, 0.18—0.89) at rest and 0.47 (95% CI, −0.12 to 0.81) with maternal pushing.

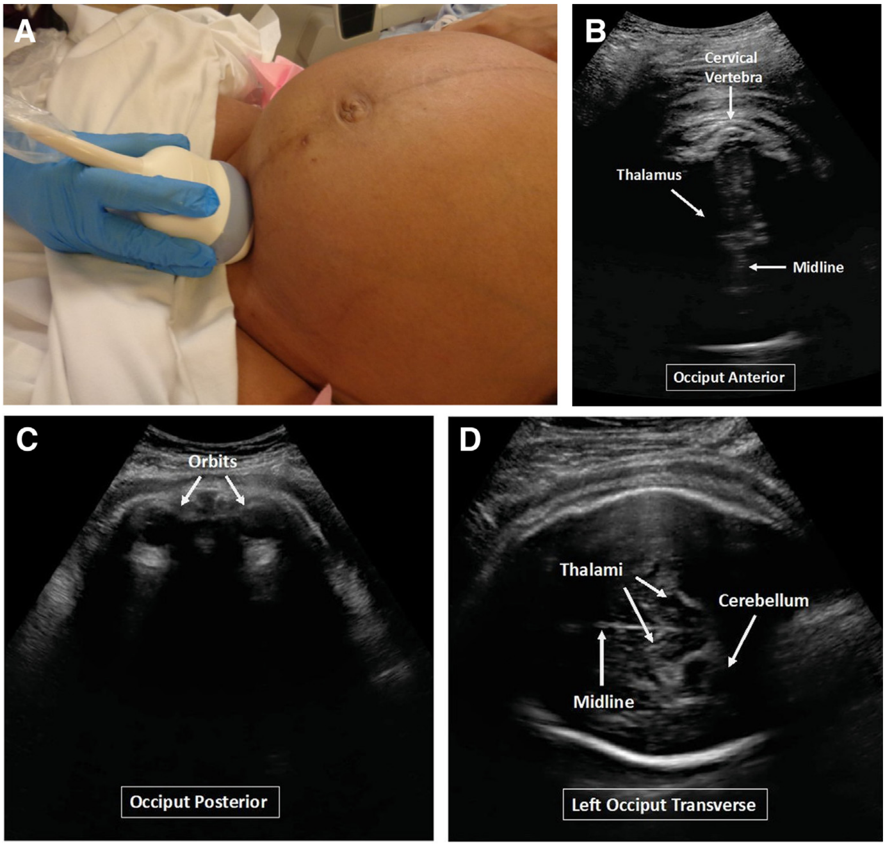
Cervical length and dilatation

In the mid-1960s, Bishop[97] introduced a standardized recordable scoring approach to assessing the cervix on digital VE. This "Bishop score" or cervix score was a prelabor scoring system to assist in predicting whether IOL will be required and to select those patients most suitable for induction. There has been variation in the clinical use of the Bishop score, with some studies indicating its use as a determinant of achieving vaginal delivery, and the score has been shown to be associated with induction-to-vaginal delivery time interval.[98,99] In others, the Bishop score is considered to have a poor predictive value[100] and has not been shown to be predictive of successful IOL.[101] As such, its use in routine clinical practice is becoming less widespread.

Cervical length (CL) can be assessed using the transvaginal[102] and transperineal ultrasound approaches.[103] CL assessed by ultrasound is better than the Bishop score in predicting the induction-delivery interval (IDI) and the success of the induction procedure.[104] There is a significant association between the IDI[102,104] and the risk of CD[105—107] with preinduction ultrasound measurement of CL.

CL has been used in combination with other maternal and ultrasound parameters to predict the outcome of IOL.[103,108] In 382 nulliparous women undergoing IOL, maternal parameters were recorded and transabdominal and transperineal ultrasound assessments were carried out at the start of the IOL. The independent predictive variables for CD include

FIGURE 12
Transabdominal ultrasound scan for fetal presentation



A, Ultrasound transducer orientation in the transverse plane on the maternal abdomen. The transducer position is above the symphysis pubis with probe angulation inferoposteriorly. Patient consent was obtained for image publication. **B,** Spinal vertebra seen at the 12-o'clock position demonstrating occiput anterior position of the fetal head. **C,** Both fetal orbits are seen at the anterior view at the 12-o'clock position; therefore, the occiput is at the 06-o'clock (occiput posterior) position. **D,** Midline cerebral echo is seen. On either side of the midline are the thalami, and the cerebellum is posterior and directly related to the occiput. This represents the left occiput transverse.

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maternal age (odds ratio [OR], 1.12; P=.003), CL (OR, 1.08; P=.04), AoP at rest (OR, 0.9; P=.001), OP position (OR, 5.7; P=.006) with an area under the curve (AUC) of 0.8 (95% CI, 0.71–0.87).[103] Using transvaginal ultrasound assessment of cervical dilatation, 822 women were assessed before IOL. The risk of CD was associated with preinduction CL (OR, 1.11; 95% CI, 1.07–1.14), parity (OR, 0.26; 95% CI, 0.15–0.43), gestational age (OR, 0.83; 95% CI, 0.73–0.96), and BMI (OR, 2.07; 95% CI, 1.27–3.37).

In 152 women with a single live fetus in cephalic presentation after premature rupture of membranes (PROM) at term, fetal head engagement assessed as the first measure of HPD and CL was used to predict the labor outcome. The ultrasound examination was performed before regular contractions had started. No VE was performed. CL was not associated independently with time to delivery. HPD was associated with the time from PROM to delivery (log-rank test, P<.001). Of note, 36 hours after PROM, 32% of women (95% CI, 15–49) with a short HPD defined as <45 mm and 43% of women (95% CI, 24–62) with a long HPD defined as ≥45 mm were still in labor. Women with an HPD of <45 mm had fewer ICDs, less use of epidural analgesia, and spent a shorter time in active labor.[61]

Intrapartum assessment of cervical dilatation by transperineal ultrasound during the latent and active phases is feasible and reproducible.[109] Cervical dilatation measured by ultrasound showed a good agreement with digital VE; however, the mean ultrasound measurement of cervical dilatation was nearly 1 cm less than clinical evaluation.[59,79]

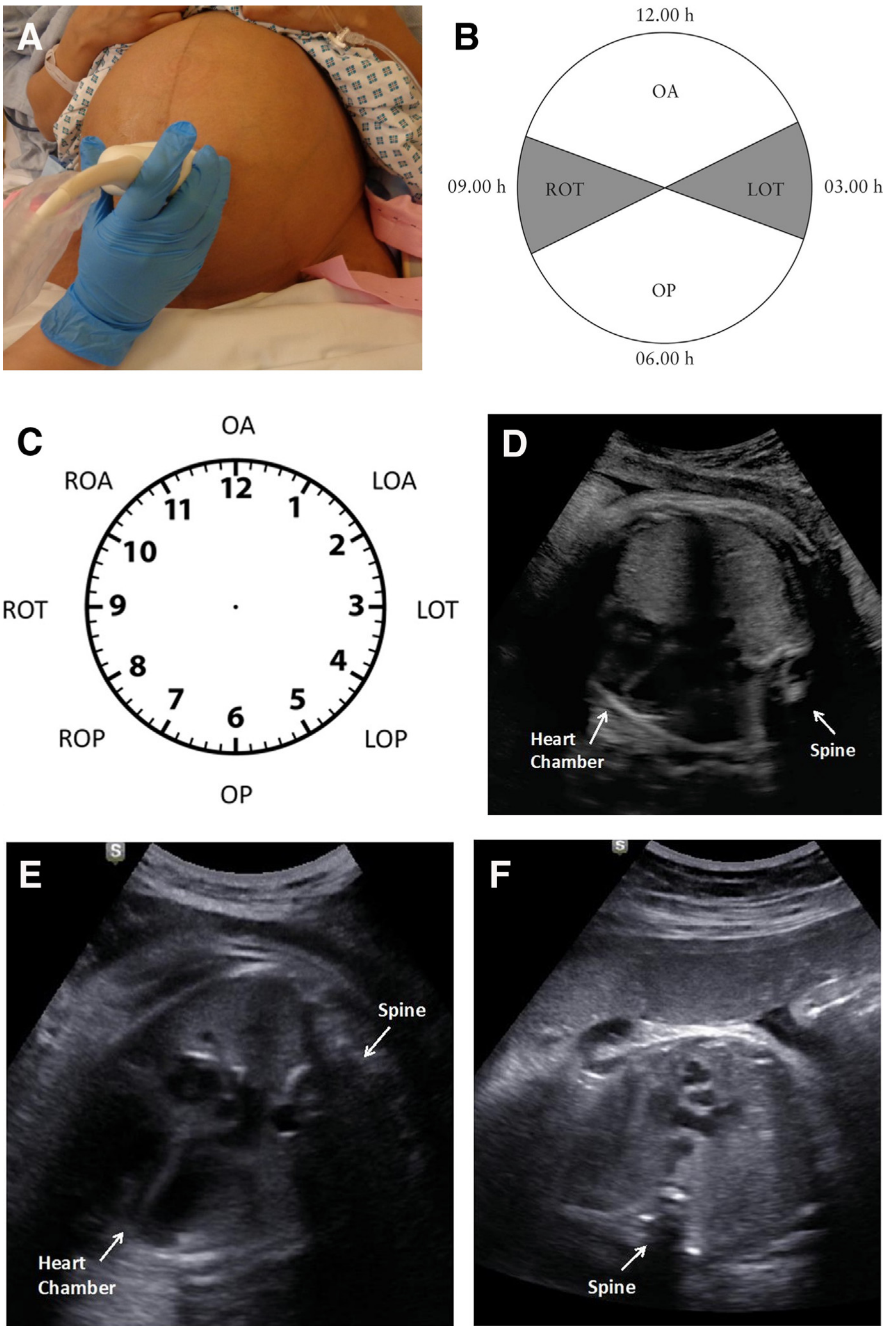
In 175 cases, Wiafe et al[110] describe an intraclass correlation coefficient of 0.76 (95% CI, 0.69–0.81) between digital VE and ultrasound-measured cervical dilatation.

Doppler assessment

Continuous electronic fetal heart rate monitoring through intrapartum cardiotocography (CTG) in labor aims to identify intrapartum hypoxic events experienced by the fetus at term, which are the leading cause of adverse perinatal outcomes.[111,112] Although this is the most common method of monitoring high-risk pregnancies in labor, it is subject to intra- and interobserver disagreement.[113] Cardiotocographs have limitations in predicting perinatal adverse outcomes,[114] and their use has not improved perinatal outcomes.[115] Thus, there is a need to better predict ICDs for fetal distress. A more robust marker of intrapartum fetoplacental perfusion, and hence acknowledgment of those fetuses that can withstand hypoxemic stress of labor, would be reassuring in 21st-century obstetrical practice.

In 1977, Fitzgerald and Drumm[116] reported the use of a novel noninvasive technique to image the fetal circulation, in particular the umbilical vein and umbilical artery. Sometime later, in 1984, Schulman et al[117] observed that fetuses that were small for gestational age had significantly higher umbilical artery resistance (systolic-to-diastolic ratios).

FIGURE 13
Transabdominal ultrasound scan for the fetal spine position



A, Ultrasound transducer orientation on the maternal abdomen at the level of the umbilicus giving a cross-sectional view of the fetus. Patient consent was obtained for image publication. **B,** Schematic diagram representing possible positions of the fetal spine when seen during a cross-sectional view of the fetal thorax. Reproduced with permission from Ghi et al.[73] OA at greater than or equal to the 10-o'clock position and less than or equal to the 2-o'clock position. LOT greater than the 2-o'clock position and less than the 4-o'clock position. ROT greater than the 8-o'clock position and less than the 10-o'clock position. OP greater than or equal to the 4-o'clock position and less than or equal to the 8-o'clock position. **C,** Schematic diagram representing possible positions of the fetal spine in correlation with a clock face. **D,** The spine position at the 4-o'clock position corresponding to the LOP fetal position. A 4-chamber view of the fetal heart is obtained to demonstrate the fetal thorax. **E,** The spine position at the 2-o'clock position corresponding to the LOA fetal position. **F,** The spine position at the 6-o'clock position corresponding to the OP fetal position.

LOA, left occiput anterior; *LOP*, left occiput posterior; *LOT*, left occiput transverse; *OA*, occiput anterior; *OP*, occiput posterior; *ROT*, right occiput transverse.

Usman. The sonopartogram. Am J Obstet Gynecol 2022.

Fetal Doppler assessment of the ratio between cerebral impedance and umbilical Doppler impedance has been suggested to have a role in the prediction of delivery for fetal distress in term babies.[118–120]

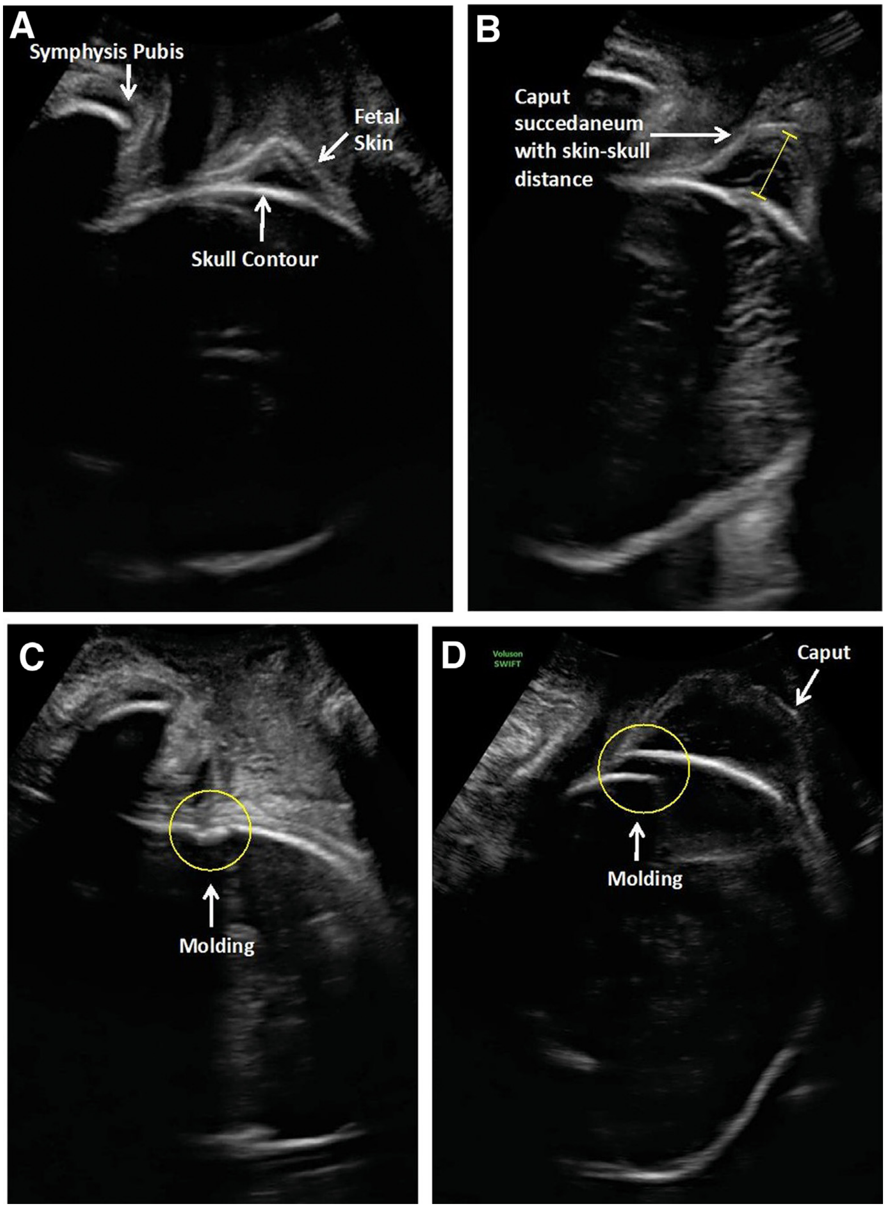
Cerebral umbilical or cerebral placental ratio

The cerebral umbilical ratio and cerebral placental ratio (CPR) are ratios of the middle cerebral artery pulsatility index (PI) to the umbilical artery PI. The CPR was first described by Arbeille et al[121] in 1987 and has since been used to describe the degree of fetal compromise in the growth-restricted fetus.[122] Fetal Doppler examination demonstrating cerebral distribution in term normally grown babies (low CPR) may be able to predict ICDs for fetal distress in nulliparous women just before delivery.[118–120] Prior et al[118] showed that a CPR on the 10th percentile was predictive of ICD, resulting in a sensitivity of 32.5%, specificity of 93.2%, and a positive predictive value of 36.4% for presumed fetal compromise. Fetuses with a low CPR in the context of low-risk pregnancies showed an increased risk of obstetrical intervention secondary to fetal distress, academia, and neonatal morbidity. The CPR may represent a marker of subclinical placental insufficiency[118]; however, its use as a predictive screening tool is poor.[120]

Umbilical cerebral ratio

The umbilical cerebral ratio (UCR) was described in 1992 by Hecher et al.[123] Although the UCR is the inverse of the CPR, its distribution may accentuate in

FIGURE 14
Transperineal ultrasound demonstrating caput succedaneum and cranial molding



A, Fetal and maternal anatomy landmarks portrayed. Maternal symphysis pubis can be seen and should be distinguished separately from the fetal structures. The fetal skull contour is demonstrated alongside the depiction of the fetal skin, which is elevated away from the skull in the presence of the caput succedaneum. **B,** The caput succedaneum is seen as a fluid soft tissue swelling of the scalp. This can be measured as the distance between the skull contour and the tip of the fetal skin in millimeters. **C,** Cranial molding is present as a discontinuity and nonalignment between 2 adjacent skull bones. **D,** Presence of marked caput succedaneum and cranial molding.

Usman. The sonopartogram. Am J Obstet Gynecol 2022.

the abnormal range, allowing better differentiation of Doppler deterioration.[124] A recent study has not found a difference between the UCR and CPR in predicting operative delivery for presumed fetal compromise.[125,126]

However, it is important to note that these studies were not conducted in labor. Although it is unlikely that fetal Doppler assessment will replace intrapartum CTG, this assessment may have a role in risk stratifying those that require intervention for fetal distress and presumed fetal hypoxia. Although associations have been demonstrated between intrapartum Doppler measurements and fetal distress, the results were inconsistent and should not be used in a predictive capacity in labor or inform current clinical practice.[127,128]

Intrapartum prediction models

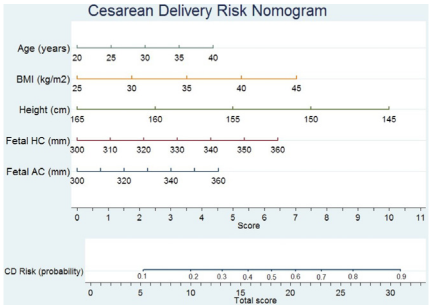
A model predictive for ICD was published in 2015 with 120 nulliparous women with prolonged first stage of labor in 2 European centers: Stavanger and Cambridge. The model was based on maternal characteristics and the results of intrapartum ultrasound. Clinical examinations, maternal characteristics, and ultrasound measurements, including fetal head position, fetal head station, and caput succedaneum, were evaluated. This model dichotomized the score and confirmed that the combination of maternal, clinical, and ultrasound characteristics could predict vaginal delivery effectively.[129]

A prospective observational study of 183 nulliparous women in early labor conducted in a tertiary obstetrical setting in Hong Kong investigated the feasibility of predicting labor outcomes using serial transperineal ultrasound. The study reported that it is feasible to predict ICD for obstructed labor in the early active phase.[130]

Another prospective longitudinal study performed on 315 women with a singleton pregnancy in the first stage of labor investigated the differences in labor progress between vaginal delivery and ICD (for failure to progress) using transperineal ultrasound assessment of the fetal head descent.[87] Women who achieved vaginal delivery had greater incremental AoP concerning fetal head station and cervical dilatation than those who achieved CD. Therefore, intrapartum ultrasound was potentially predictive of women who will require ICD because of failure to progress.[87]

In a single-center, prospective cohort study in Iceland, 99 nulliparous women

FIGURE 15
Cesarean delivery risk-assessment tool



The probability risk prediction score is calculated using maternal demographic factors (age, BMI, and height) combined with fetal biometry obtained by transabdominal ultrasound: HC and AC. Each parameter is given a score and combined to give a total score of probability of cesarean delivery. Reproduced with permission from Burke et al.[90]

AC, abdominal circumference; *BMI*, body mass index; *HC*, head circumference.

Usman. The sonopartogram. Am J Obstet Gynecol 2022.

with a single fetus in cephalic presentation and spontaneous labor onset at a gestational age of ≥37 weeks were reported.[131] VEs were undertaken at study entry and subsequently throughout labor, paired each time with a transperineal ultrasound examination by a separate examiner, with both examiners being blinded to the other's results. The measurements used to assess the fetal head station were the HPD and AoP. Cervical dilatation was examined by digital VE. The fetal head station at the first examination was the highest for the fetuses in the OP position. HPD was stable during the first stage, and fetal head descent accelerated late in labor.[131] This was consistent with findings from digital VE.[1,2,82]

In a secondary analysis of this prospective cohort study, ultrasound parameters were used to assess the duration of labor phases and the need for operative delivery.[88] Ultrasound measurement of cervical dilatation or position at inclusion was not significantly associated with spontaneous delivery. Here, AoP and HPD were the variables associated with operative deliveries.[88] Median times to spontaneous delivery were 490 minutes for HPD of ≤45 mm and 682 minutes for HPD of >45 mm. The median durations were 506 minutes for an AoP of ≥93° and 732 minutes for an AoP of <93°. HPD and AoP were associated with a spontaneous delivery with AUCs of 0.68 (95% CI, 0.55–0.80) and 0.67 (95% CI, 0.55–0.80), respectively. These descent patterns are the basis of the redesign of labor curves using ultrasound.[131]

The intrapartum "app"

The "intrapartum app" based on an intrapartum prediction model based on data from 2 European centers from 2015[129] was launched for research purposes only in 2017 for Apple[132] and Android mobile devices.[133] It is the first obstetrical birth prediction model app created and allows healthcare professionals to perform an "on-the-spot" analysis for the prediction of vaginal birth using single maternal and ultrasound parameters (Figure 16). Maternal characteristics and ultrasound data from 269 nulliparous women undergoing labor from a new population were entered into the app, and the likelihood of vaginal delivery and length of labor were calculated. When censoring for those patients who had CDs, the length of labor was shorter for those patients predicted to be at a high likelihood (≥75%) of vaginal delivery.[134]

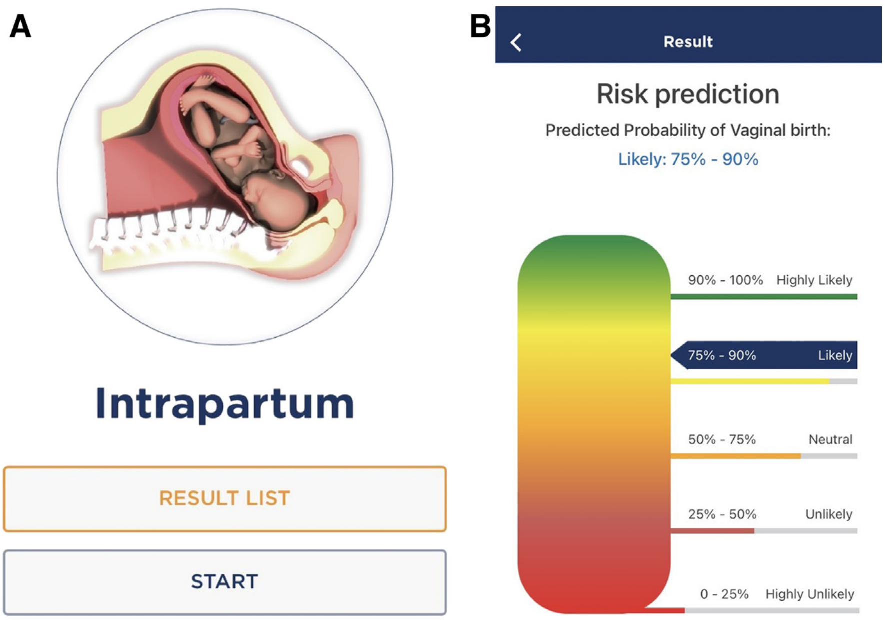
Prediction of labor outcome using ultrasound in the second stage of labor

The "ideal" management of the second stage of labor is a subject of ongoing debate. It is well known that a prolonged second stage of labor is associated with increased maternal and neonatal adverse outcomes, such as chorioamnionitis and low umbilical cord pH.[135] Moreover, it is recognized that prolonged active pushing phase is associated with a high rate of instrumental deliveries and adverse maternal and neonatal outcomes.[136,137] During the second stage of labor and when a decision is made for instrumental vaginal delivery, an essential element of a successful and safe use of an instrument is the correct determination of the fetal head position and station and an appropriate application of the tool.[73]

Ultrasound conveys objective and precise information on the relationship of the fetal head concerning maternal structures. The dynamics of the second stage of labor, in particular head station, position, and head direction, can be more accurately assessed than by digital VE. Using ultrasound in the second stage of labor may predict the labor outcome whether instrumental delivery should be attempted or if ICD is preferable.[138,139] The findings from ultrasound can identify cases of high risk of requiring instrumental deliveries[140] and instrumental delivery failure.[141] Notably, an HPD measurement of ≥40 mm taken in the second stage of labor has been suggested to be associated with a difficult instrumental delivery.[142] Importantly, high fetal head station and OP position are associated with a low pH at delivery.[139]

A systematic review and meta-analysis of RCTs using ultrasound assessment before operative vaginal delivery concluded that the fetal occiput position was more accurately identified using ultrasound compared with digital VE.[143] However, no study has shown that ultrasound before assisted delivery improves maternal or neonatal outcomes,[144,145] and 1 study reported a higher rate of CD in those women randomized to ultrasound.[145] With some justification, this is often cited by skeptics of intrapartum ultrasound to justify not undertaking ultrasound in this circumstance. However, it is important to note that no study is adequately powered to detect adverse maternal or neonatal outcomes.

FIGURE 16
The "Intrapartum app" for prediction of intrapartum cesarean delivery



A, Screenshot of the home screen. **B,** Description showing risk prediction. Reproduced with permission from Usman et al.[134]

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Rotational instrumental deliveries in fetal malposition can be challenging for the experienced obstetrician and pose difficulty in skill acquisition for trainee operators. Ultrasound monitoring of fetal head station and position can improve accuracy in determining the direction of fetal head rotation, enhancing operator confidence, and providing a new dimension to obstetrical training.[146]

A reliable assessment of the fetal head descent may inform the timing and likelihood of successful maternal expulsive contractions, consequently avoiding unnecessary obstetrical interventions. Fetal head descent assessed by transperineal ultrasound in the second stage of labor is associated with delivery mode[147–151] and duration of labor.[152,153] Predicting the mode of delivery from individual second-stage ultrasound parameters has led to considerable research in the last decade. Sonographic findings measured in 109 women at prolonged active pushing (120 minutes) in a study by Dall'Asta et al[120] observed OA position, short HPD and head-symphysis distance (HSD) distance, and narrower mean value of the midline angle to be associated with spontaneous vaginal delivery. A secondary analysis of a prospective cohort study of 204 nulliparous women with a prolonged second stage of labor conducted in 5 European countries during active pushing showed that minimal or no fetal head descent was associated with a longer duration of instrumental delivery and higher frequency of ICD.[154]

A prospective observational study conducted in Israel included 197 nulliparous women at full cervical dilatation and before the start of the active second stage of labor. In this study, prognostic ultrasound parameters included fetal head position, AoP, HPD, and HSD assessed through rest and active pushing. The outcomes of spontaneous vaginal delivery and shorter duration of pushing were significantly more common with a non-OP position, a wider AoP, and a shorter HPD and HSD.[155] A recent systematic review evaluating 8 prospective cohort studies established that an AoP at the beginning of the second stage of labor of between 108° and 119° predicted successful vaginal birth with a sensitivity of 94% and specificity of 47%.[156]

This research supported the potential for ultrasound-based prediction of the mode of delivery and duration of active pushing.

Conclusion

The integration of preexisting maternal factors, clinical assessment, and ultrasound measurements allows the fair prediction of ICD. Moreover, these assessments show promise in predicting the duration of labor, likelihood of success of assisted delivery, and poor fetal condition at delivery. It is still the case that these predictive models have not been externally validated in different populations sufficiently to allow their routine implementation. An unresolved question is whether the prediction of labor is useful to caregivers and women and whether such a prediction should influence clinical management. The incorporation of objective ultrasound measurements could improve confidence in clinical examination and therefore enhance the quality of information available to women and caregivers. ■

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