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Intrapartum ultrasound

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ABSTRACT

The use of intrapartum ultrasound has increased extensively over the last two decades. This increase is mostly driven by its higher accuracy, reliability and intra- and interobserver agreement compared to the traditionally-used vaginal examination for the assessment of several labor parameters. Moreover, it is less invasive, better tolerated by women and has a lower risk of pregnancy-related infections. The most important parameters that can be assessed by intrapartum ultrasound include the fetal head position, station and attitude. In the first section of this review, we explain how to use intrapartum ultrasound to assess these parameters, providing a broad overview of the different available techniques. The second section describes the indications of intrapartum ultrasound and provides some insight on how intrapartum ultrasound may help to improve management of abnormal labor. In the last section, we discuss the future perspectives of intrapartum ultrasound. This includes topics such as the incorporation of new labor parameters, such as maternal pelvimetry, molding and caput succedaneum; the development of "sonopartograms", and the use of artificial intelligence. This review is intended for obstetricians and midwives involved in daily practice in the labor ward.

1. Introduction

Over the past two decades, research on the use of ultrasound in labor ward has increased exponentially. Ultrasound is now recognized as more accurate than digital vaginal examination for assessing the fetal head position[1–3] and station [4], two critical parameters for labor management. Accurate assessment of these parameters may aid obstetricians in decision-making, potentially improving maternal and neonatal outcomes.

Ultrasound can also evaluate other key labor parameters, including fetal head attitude [5,6], the degree of head rotation within the birth canal [7], and the presence of asynclitism [8,9]. Furthermore, it is less invasive and better tolerated by laboring patients compared to vaginal digital examination [10,11]. In settings like prolonged rupture of membranes, repeated transperineal scans may reduce infection risks compared to frequent vaginal exams [12].

This review is focused on the application of ultrasound in labor ward for fetuses in cephalic presentation. We aim to provide

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clinicians with the knowledge to integrate ultrasound into labor management.

2. Assessment of labor parameters

2.1. Fetal head position

The fetal head position refers to the spatial relationship of the fetal occiput relative to the maternal pelvis. In normal labor, the occiput is typically oriented toward the maternal pubic bone, a position referred to as occiput anterior (OA) position. Early in labor, however, the occiput may be oriented laterally – right or left occiput transverse (OT) – or toward the sacrum – occiput posterior (OP) – often rotating spontaneously to OA as labor progresses [13]. When a non-OA position persists into the active phase of labor, it may contribute to arrest of labor, and is referred to as cephalic malposition [14].

The fetal head position is traditionally assessed through vaginal digital examination [14], but accuracy can be suboptimal, even among experienced clinicians, especially in the event of cephalic malpositions [1–3]. Conversely, ultrasound achieves nearly 100 % accuracy in determining the fetal head position during labor[15–18]. Consequently, several international guidelines now recommend ultrasound assessment of fetal occiput position, particularly when clinical uncertainty arises before considering or performing an operative vaginal delivery (OVD) [19,20].

Transabdominal ultrasound is considered the gold standard for the assessment of the fetal head position [19]. The operator first identifies the position of fetal spine on an axial view of the trunk and then moves the probe caudally to locate anatomical landmarks specific to each fetal head position. For occiput posterior (OP) fetuses, the orbits are the first structures visible below the ultrasound beam (Fig. 1A); for occiput transverse (OT) fetuses, the midline cerebral echo appears horizontally and perpendicular to the ultrasound probe (Fig. 1B). For OA fetuses, the fetal occiput and spine are demonstrated as the most anterior structures. Fetal occiput positions are reported clockwise: left OT is $\geq$ 02:30 and $\leq$ 03:30, right OT is $\geq$ 08:30 and $\leq$ 09:30, OP is $>$ 03:30 and $<$ 08:30, and OA position is $>$ 09:30 and $<$ 02:30 [21,19].

The fetal head position can also be assessed transperineally with a similar accuracy [22]. This approach is often preferred at lower fetal head stations, as it is not affected by the shadowing of the maternal pelvis and allows simultaneous assessment of head station and rotation. The probe is placed horizontally at the level of the fourchette, allowing the visualization of key intracranial structures in the axial plane: 1) the choroid plexus diverging toward the occiput, 2) the head shape (larger at the occipital pole than at the frontal one), and 3) the location of cranial molding (occipitoparietal for OA and frontoparietal for OP positions), as seen in Fig. 1C [23].

2.2. Fetal head descent

Fetal head descent is traditionally assessed by fetal head station, defined as the level of the fetal head relative to an imaginary line drawn between the maternal ischial spines [14]. At vaginal digital examination, the head station is classified as station 0 – i.e., head engagement – when the leading part of the fetal head reaches this imaginary line. Head stations above or below this line are expressed in centimeters, with negative values indicating stations above and positive values indicating stations below the interischial plane. However, this method is subjective and inaccurate, especially in the presence of caput succedaneum, molding, non-ruptured membranes, malposition, asynclitism and higher fetal head stations [24].

Contrarily, ultrasound offers greater objectivity, accuracy and intra- and interobserver agreement [25–27]. For sonographic assessment of the fetal head descent, transperineal ultrasound is the most recommended approach. The ultrasound probe may be placed longitudinally – in the midsagittal plane – between the two labia majora, allowing the visualization of the pubic symphysis joint and fetal skull. While the ischial spines cannot be directly visualized on this plane, studies using computer tomography showed that the interischial plane lies 3 cm caudal to the infrapubic line (perpendicular line tangent to the inferior border of the pubic symphysis) [28].

On this plane, the fetal head descent can be qualitatively assessed by evaluating the head direction relative to the maternal pubic axis (Fig. 2A) [29]. In fetuses in OA position, a downward head direction indicates that the head is at the pelvic inlet. A horizontal head direction suggests the head has reached the mid-section of the pelvis. An upward head direction ("head-up sign") indicates that the head has passed under the pubic symphysis, reached the lower pelvis and is extending towards the outlet (Fig. 2A and B).

At sagittal transperineal ultrasound, fetal head descent can be also quantified using the angle of progression (AoP), defined as the angle between a line along the long axis of the pubic bone and a tangent to the deepest bony part of the fetal skull (Fig. 2A and B) [30]. Bamberg et al., using magnetic resonance imaging, established that an AoP of 120° corresponds to a clinical head station of 0 [31]. Subsequent studies defined additional thresholds: an AoP of 130° corresponds to a head station of +1, and 140° to a station of +2 [31,32]. Similarly, one could measure the ΔAoP, which is the variation of the AoP between rest and maternal pushing [33].

Transperineal ultrasound can be also performed on the axial plane. Using a transverse probe orientation just above the posterior fourchette between both labia majora the fetal head station can be quantified by measuring the head to perineum distance (HPD). This is defined as the shortest distance between the outer bony limit of the fetal skull and the transducer edge (perineum) (Fig. 2C). Two methods are described: 1) the compressed HPD involves full compression of the soft tissues of the perineum against the pubic bone [34], 2) the uncompressed HPD does not involve any type of compression of the perineum [35]. There are discrepancies in studies regarding the reproducibility of the compressed HPD, with some of them showing an excellent reproducibility [36], while others show the contrary [25–27]. This may be related to the different levels of understanding on how much one should compress the perineum during the examination. To date, it is unclear if the uncompressed HPD might yield better results.

For practical purposes, a compressed HPD of 36 mm, 31 mm and 25 mm correspond to head stations of 0, +1, and +2, respectively [32]. Alternatively, the equivalent values for uncompressed HPD are 60 mm, 50 mm, and 40 mm [35,37,38]. The ΔHPD may be also

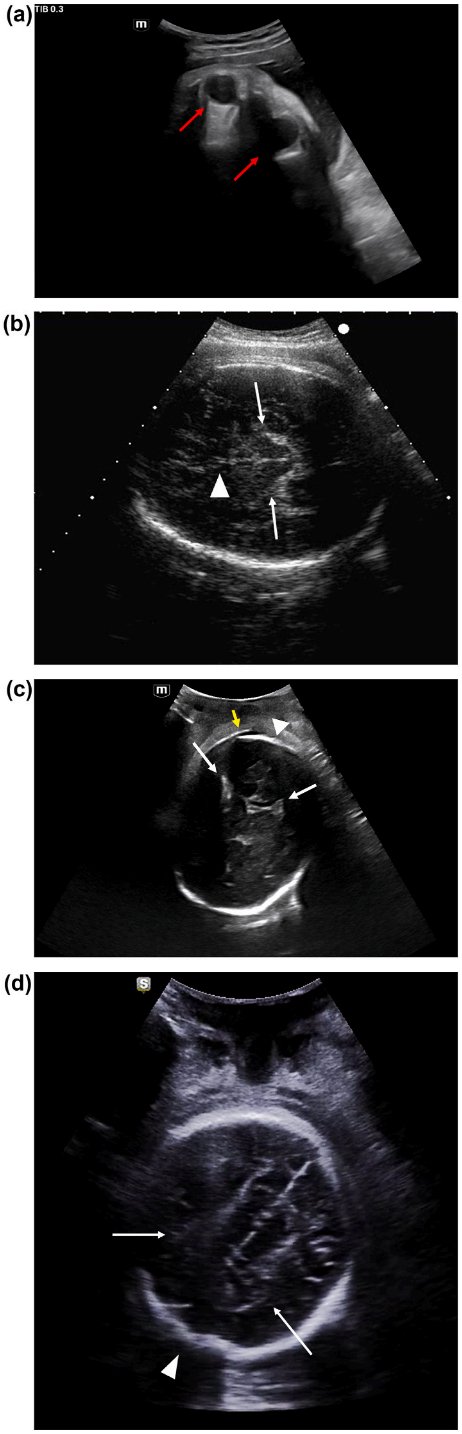

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Fig. 1. Intrapartum ultrasound to identify the fetal head position during labor.
A. Transabdominal ultrasound of a fetus in occiput posterior position. Note both fetal orbits (red arrows) appearing below the ultrasound beam.
B. Transabdominal ultrasound of a fetus in left occiput transverse position. The midline cerebral echo is visible horizontally with the fetal thalami alongside. Modified from Ramirez Zegarra R, Ghi T: Fetal cephalic malpresentation (deflexed presentations) and malposition (occiput transverse and posterior), VISUOG, www.isuog.org, February 2024.
C. Transperineal ultrasound of a fetus in occiput anterior position. Note the choroid plexus (white arrows) diverging toward the occiput (arrowhead), and the occitoparietal molding (yellow arrow).
D. Transperineal ultrasound of a fetus in occiput posterior position. Note the choroid plexus (white arrows) diverging toward the occiput (arrowhead) and the midline echo. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

assessed as the difference in HPD during rest and maternal pushing efforts [39].

The midline angle, calculated in the axial plane, is primarily used to assess fetal head rotation, rather than station [7]. It measures the angle between the anteroposterior axis of the maternal pelvis and the fetal brain midline, reflecting the degree of internal rotation during labor. As labor progresses, the fetal head typically rotates from a transverse to a vertical orientation before undergoing extension [14]. However, fetal head rotation can occur at various levels in the birth canal and at different stages of labor [40].

One observational study involving only OA fetuses suggested an association between the degree of fetal head rotation and station. The authors reported that a rotation of $\geq 45^\circ$ corresponded to a head station of $\leq +2$ in 98.6 % cases, while a rotation of $<45^\circ$ corresponded to a head station of $\geq +3$ in 83.7 % cases [7]. However, this study does not provide sufficient evidence to support the use of the midline angle as a direct measurement of fetal station, and further research is needed to validate this relationship.

The main limitation in ultrasound studies evaluating the fetal head descent is the lack of stratification by fetal head position. Descent patterns differ between OA and OP positions. OP fetuses do not follow optimally the curve of the birth canal and descend deeper into the maternal pelvis before extending their head [41]. Most studies included a vast majority of OA fetuses, making it unclear if the thresholds defined for the fetal head station (as mentioned above) equally and accurately apply to non-OA positions [42].

2.3. Fetal head attitude

Fetal head attitude indicates the degree of flexion or deflexion of the head [14]. In well-flexed vertex presentations, the posterior fontanelle is palpable during vaginal examination. In deflexed presentation, other anatomical landmarks such as the anterior fontanelle (sinciput presentation), forehead and brows (brow presentation) or nose and mouth (face presentation) are identified as the presenting part during vaginal examination [14,43].

Transabdominal ultrasound allows the assessment and quantification of the fetal head flexion/deflexion. For OA and OT fetuses, flexion is assessed on the sagittal plane using the occiput-spine-angle (OSA), the angle between a line tangential to the posterior cervical spine and a line tangential to the fetal occiput (Fig. 3A) [5]. A flexed OSA in vertex presentations measures $\geq 109^\circ$ [5,44].

For OP fetuses, flexion is assessed on the sagittal plane using a qualitative approach [45,46] or measuring the chin-to-chest angle (CCA) [6]. This angle is formed by lines tangential to the longest axis of the fetal sternum and the skin covering the inferior part of the fetal chin (Fig. 3B). Well-flexed OP fetuses typically present CCA values $< 35^\circ$. Measuring the CCA requires experience with intrapartum ultrasound; therefore, we recommend that inexperienced operators first become familiar with the qualitative assessment of fetal head deflexion in OP fetuses before attempting quantitative measurements [45,46].

Deflexed presentations in non-OP or OP fetuses usually demonstrate a narrower OSA ($<109^\circ$) or larger CCA ($>35^\circ$), respectively, both associated with labor dystocia and operative deliveries [5,6]. While no established thresholds exist to classify subtypes of fetal head deflexion, qualitative assessment using transabdominal ultrasound is possible [45]. Evidence on this topic remains limited, mainly coming from small case series. In OP or OT fetuses, transperineal midsagittal ultrasound might distinguish between brow and face presentations: brow presentations show the fetal orbit below the maternal symphysis pubis[46–48], while face presentations reveal the nasal bridge in this location [49]. Additionally, transperineal axial ultrasound in face presentations can document the fetal mouth and cheeks and determine the mentum position [50].

Asynclitism is defined as a malalignment of the fetal head in the birth canal where one parietal bone precedes the sagittal suture and it is more often found in OT positions. It can be identified using transperineal axial ultrasound, where the midline echo of the fetal brain (which corresponds to the sagittal suture of the skull) cannot be clearly visualized with a perpendicular insonation [51]. Tilting the ultrasound probe posteriorly towards the sacrum/rectum or anteriorly towards the pubic symphysis may allow to visualize the midline echo in anterior asynclitism or posterior asynclitism, respectively [9,52].

Lateral asynclitism has been recently described among unengaged fetuses with slow labor progress and it is characterized by a lateral (right or left) tilting of the sagittal suture [53]. It may be suspected on transabdominal axial ultrasound, when the fetal chest displaying the four-chamber heart view and face profile are visualized simultaneously, suggesting a lateral twisting of the fetal head into either one of the shoulders [54].

3. Indication for intrapartum ultrasound

3.1. Protracted or arrest of the first stage of labor

Labor arrest in the first stage is associated with adverse maternal or neonatal outcomes [55]. Management often involves the use of

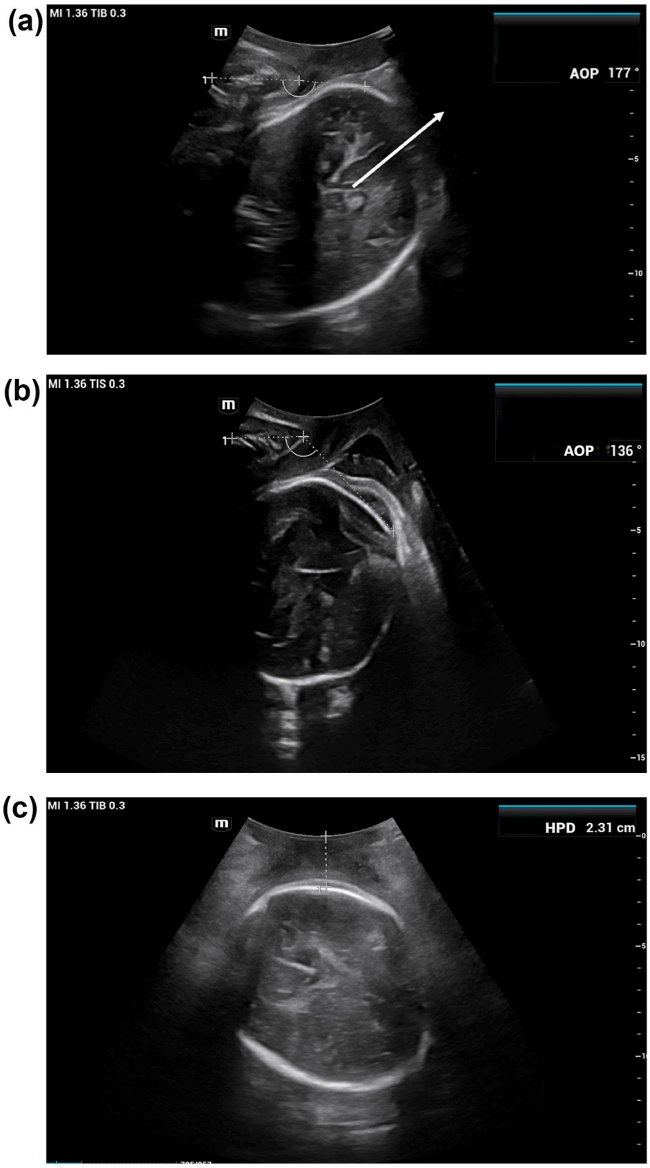

Fig. 2. Transperineal ultrasound for the assessment of the fetal head descent during labor.
A. Midsagittal view of the fetal head in the second stage of labor. Note the "head-up" direction (white arrow). The angle of progression (AOP) is the angle between a line through the pubic bone's long axis and the tangent to the deepest bony part of the fetal skull. In this case, the angle of progression is 177°, indicating a clinical station lower than +3.
B. Midsagittal view of the fetal head in the second stage of labor. The angle of progression (AOP) is 136°, indicating that the fetal head is almost reaching a clinical station of +2.
C. Axial view of the fetal head in the second stage of labor. The head-to-perineum distance (HPD) is measured as the shortest distance between the outer bony limit of the fetal skull and the transducer edge. In this case, the head-to-perineum distance is 23.1 mm. Additionally, note the choroid plexus diverging towards the occiput and the site of the occipitoparietal molding, indicating that the fetus is in right occiput anterior position.

oxytocin and amniotomy to accelerate labor progress, or cesarean delivery for failed progression [56]. Intrapartum ultrasound can aid in identifying which fetuses may achieve vaginal delivery versus those who may benefit from early cesarean delivery [57].

The assessment of the fetal head position is the first step in evaluating labor progression. In fetuses in OA or OT positions, the degree of fetal head flexion using the OSA should be evaluated. An OSA of less than 109°, indicative of malpresentation, has been independently associated with prolonged labor and an increased risk of cesarean delivery [5,6]. In cases where the fetal head is well flexed (OSA ≥109°), the next step is to evaluate fetal head station.

Persistent high fetal head stations, defined as a compressed head-perineum distance (HPD) greater than 50 mm or an angle of progression (AoP) less than 100°, have been linked to prolonged labor and an increased likelihood of cesarean section [58,59].

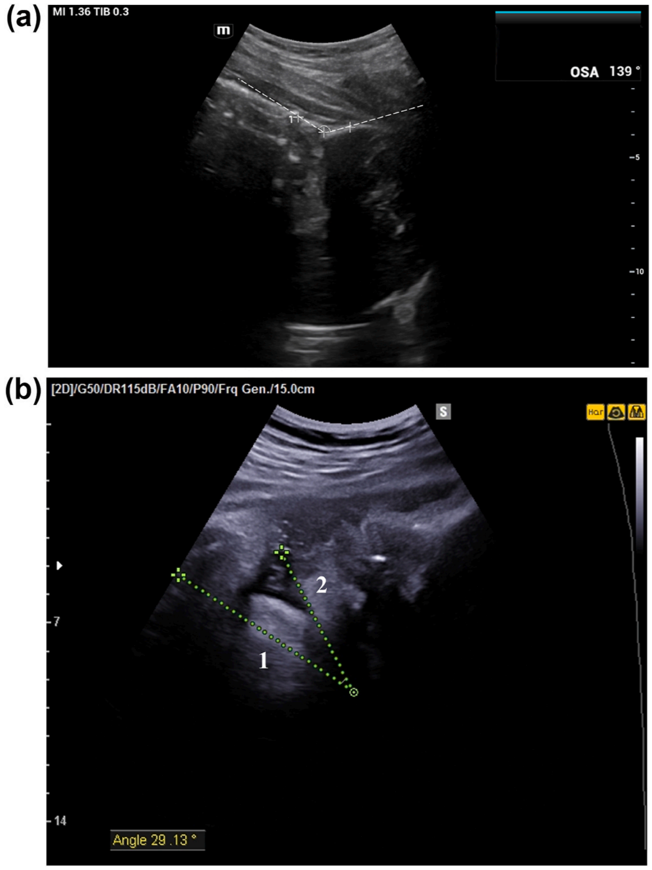

Fig. 3. Transabdominal ultrasound for the assessment of the fetal head attitude during labor.
A. Midsagittal view of a fetus in occiput anterior position displaying anteriorly the fetal occiput and the cervical spine. The occiput-spine-angle (OSA) is the angle between a line tangential to the posterior cervical spine and a line tangential to the fetal occiput. In this case, the occiput-spine-angle is 139° indicating a well-flexed head.
B. Midsagittal view of a fetus in occiput posterior position displaying anteriorly the fetal face profile. The chin-chest-angle is formed by lines tangential to the longest axis of the fetal sternum (1) and the skin covering the inferior part of the fetal chin (2). In this case, the chin-chest-angle is 29° indicating a well-flexed head.

Similarly, OP position is associated with higher risk of cesarean section [63]. The presence of fetal head deflexion, characterized by a chin-to-chest angle (CCA) greater than 35°, further increases the risk of labor dystocia and cesarean delivery and can be reliably identified using ultrasound [6,44].

3.2. Protracted or arrest of the second stage of labor

Managing a protracted second stage of labor remains controversial, as slow progress does not always necessitate expedited delivery. While prolonged second stage is associated with increased rate of operative delivery (both cesarean and instrumental vaginal delivery) and related adverse outcomes for mother and infant [64,65], many fetuses still accomplish spontaneous vaginal delivery [66], potentially improving outcomes and patient satisfaction [71,68].

Ultrasound can help identify fetuses likely to achieve spontaneous delivery, making expectant management a reasonable option [69]. Favorable indicators include OA position and good fetal head descent – AoP ≥120°, ΔAoP ≥15°, “head up” direction, and a midline angle <35° – all of which correlate with higher rates of spontaneous vaginal delivery [7,29,70–72] and shorter second stage duration [73].

Persistent OP position is strongly associated with slow progression or arrest of the second stage of labor [63,74], but its optimal management remains controversial. Prophylactic manual rotation has shown no clear benefit in improving vaginal delivery rates or outcomes[75–78], most likely because most OP fetuses spontaneously rotate to OA and deliver vaginally without intervention.

Identifying fetuses at higher risk of persistent OP position – who are more likely to benefit from manual rotation and face adverse outcomes – could improve management [24,56,63]. Intrapartum ultrasound can detect risk factors, such as posterior spine position, high fetal head station (narrow AoP), or head deflexion (CCA> 36.5°)[79–81]. Fetuses with such risk factors may benefit from timely interventions, such as manual rotation of the occiput [24,56,63], while a policy of expectant management may benefit more those fetuses without risk factors.

3.3. Prior to an instrumental vaginal delivery

Deciding between instrumental vaginal delivery or a cesarean section in cases of second stage labor arrest or intrapartum fetal compromise is challenging. Often, this decision is based on the clinical assessment of the fetal head station and position, as both are considered strong predictors of OVD success [82,83]. Given the subjectivity and inaccuracy of the vaginal examination [1,4], intrapartum ultrasound may serve as an ancillary tool to predict the feasibility of OVD. A management algorithm is proposed in Fig. 4.

Nowadays, several international guidelines recommend ultrasound evaluation of the fetal head position prior to instrumental vaginal delivery [19,20,84]. This recommendation is supported by randomized clinical trials demonstrating the superiority of ultrasound in terms of accuracy for the diagnosis of fetal head position over digital vaginal examination[15–18]. Of note, these studies did not show significant improvements in OVD success, or maternal or neonatal outcomes; however, they were underpowered for these outcomes. Additionally, ultrasound may also guide optimal instrument placement – either forceps [85] or vacuum extractor [86] – improving traction orientation and potentially enhancing success rates and neonatal outcomes [83,87,88].

Fetal head engagement (i.e., station 0) is another main requisite for OVD [20,89]. Mid-cavity OVD – referred to as instrumental extraction when the fetal head is at a station at 0 or +1 – is associated with a higher failure rate and adverse outcomes [82,83]. Ultrasound appears to identify an engaged fetal head – AoP ≥120°, compressed HPD ≤36 mm or uncompressed HPD ≤60 mm – better than vaginal digital examination [32,35,38,90,91]. Values outside these thresholds may indicate an unengaged fetal head and OVD should generally be avoided due to high failure rates [38].

In case of mid-cavity OVD, assessing the delta of the head descent at rest and during contractions is also helpful. A ΔAoP ≥15° or a ΔHPD ≥ 2 mm correlates with higher OVD success rates [33,39]. Decisions in case of fetal head malposition should involve senior obstetricians and individualized assessment, due increased risk of failure and adverse outcomes [92,93].

Low-cavity OVD – referred to as instrumental delivery of fetal head stations of +2 or lower – is usually easy to perform and success rates are high [82,83]. Favorable sonographic findings such as an AoP ≥140° [94,95], compressed HPD ≤25 mm, or uncompressed HPD ≤40 mm are associated with easy instrumental extractions [96,97]. Qualitatively, a fetal "head up" direction correlates well with successful OVD [29].

While observational studies overwhelmingly support ultrasound use for assessing head station and position prior to OVD [98], the only randomized controlled trial failed to show an improvement in maternal, neonatal or labor outcomes [18]. However, this study was stopped early due to futility after the enrolment of 222 patients (planned 600 patients); thus, making it underpowered to evaluate maternal and neonatal morbidity as a primary outcome [99].

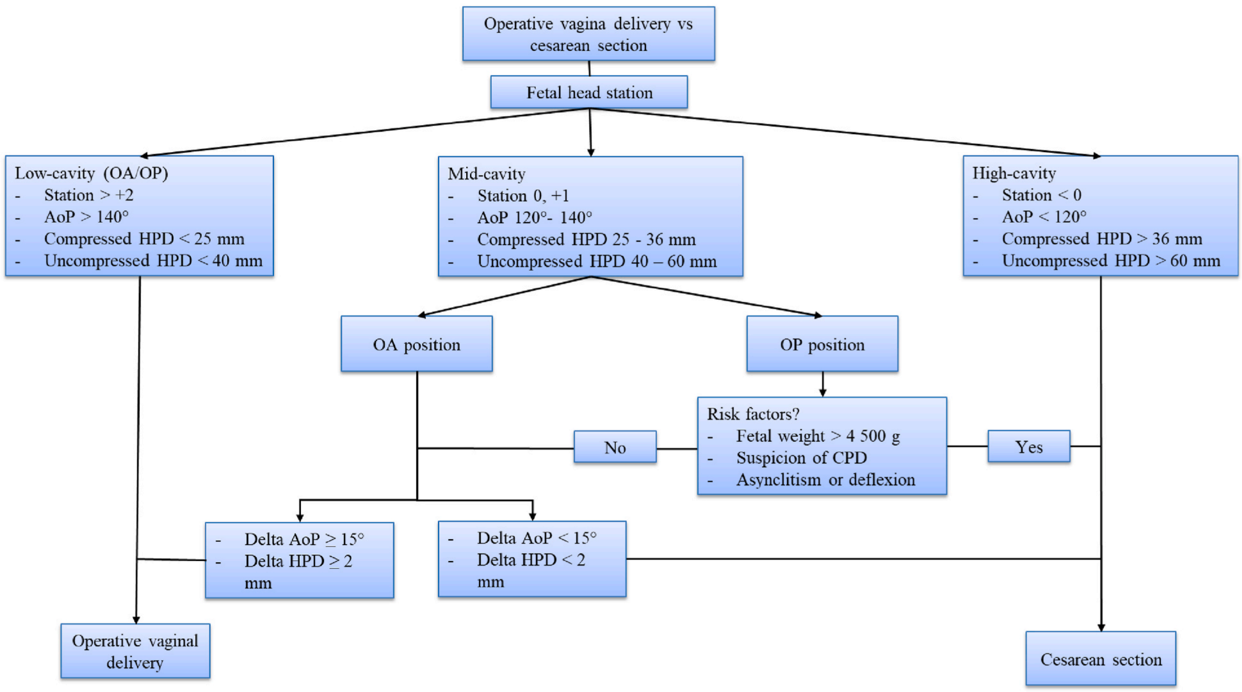

Fig. 4. Flowchart for the management of fetuses with an indication for operative delivery using intrapartum ultrasound.
AoP, angle of progression. HPD, head-to-perineum distance. OA, occiput anterior. OP, occiput posterior.

4. Future perspectives

4.1. Intrapartum ultrasound in normal labor

Monitoring normal labor with intrapartum ultrasound is feasible [100] and has led to the concept of a "sonopartogram" [103]. Potentially, the "sonopartogram" could replace traditional partograms by providing more accurate and reliable labor parameters [102,103]. Ultrasound assessment of labor parameters is more objective and reproducible, better tolerated by pregnant patients [10,11], and less invasive than digital vaginal examination, with reduced infection risks, especially after rupture of membranes [12]. Future research should aim to develop sonographic labor curves, compare their performance with traditional methods [104], ensuring that they do not lead to unnecessary interventions or adverse maternal or neonatal outcomes [105,106].

4.2. Etiology of labor arrest

The classification of labor dystocia remains a challenge due to its multifactorial etiology. Intrapartum ultrasound offers a more precise approach to identifying the underlying cause by integrating assessments of fetal head position, station, and attitude into a structured algorithm to guide labor management. As an example, we present an algorithm developed for the classification of first-stage labor dystocia on data from multiple studies. However, this algorithm is intended for research purposes only and has not yet been validated for clinical use (Fig. 5).

Certain labor parameters such as OP position and deflexed fetal heads are independently associated with first-stage labor dystocia. However, Dall'Asta et al. proposed that combining fetal head station and attitude may provide further insights into the etiology of labor arrest. Their study found that a well-flexed fetal head at a high station—defined as OSA/AoP >1.19 or OSA/HPD <2.72—is likely indicative of cephalopelvic disproportion, as these cases often involve a higher birthweight-to-maternal ratio [60,61]. Conversely, well-flexed fetuses at lower stations—defined as OSA/AoP ≤1.19 or OSA/HPD ≥2.72—are more likely to achieve vaginal delivery [58,62], suggesting that suboptimal uterine contractions are the primary cause of dystocia [60,61]. In such cases, augmentation of labor could potentially improve labor progression [24,43,62].

4.3. Additional labor parameters

The use of intrapartum ultrasound may extend to other labor parameters such as the cervical dilation, caput succedaneum [107,108], and fetal head molding [23,109]. This approach is feasible and may allow a more objective and repeatable measurement compared to vaginal digital examination. Sonographic maternal pelvis measurements, such as obstetrical conjugate [110,111] and subpubic arch angle [112,113] may help in the antenatal prediction of labor dystocia [114]. However, there is a lack of studies evaluating the maternal pelvis size as an intrapartum predictor of labor dystocia or failed OVD. Further studies are needed to assess the usefulness of these additional parameters and in the clinical management of labor.

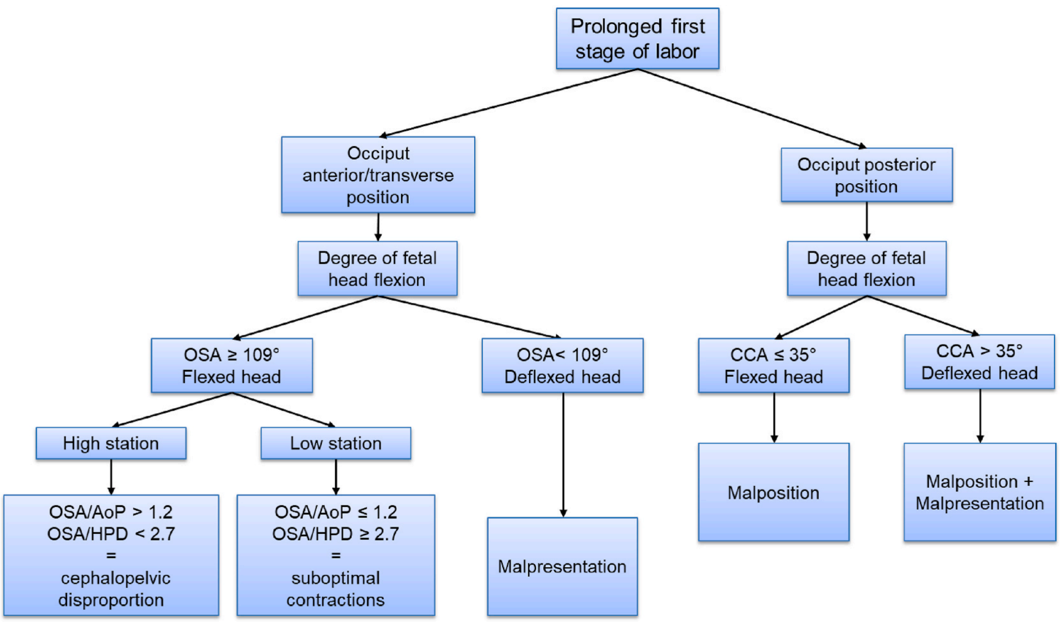

Fig. 5. Proposed algorithm for the classification of the etiology of protracted first stage of labor using intrapartum ultrasound. AoP, angle of progression. CCA, chin-to-chest angle. HPD, head-to-perineum distance. OSA, occiput-spine angle.

4.4. Artificial intelligence

Artificial intelligence, especially deep learning, is expanding rapidly in obstetrics, with significant applications in ultrasound imaging [115]. Recently, deep learning models are becoming available to assess various labor parameters such as fetal head position [116,117] and station [118,119]. These models may offer obstetricians – especially those with less experience – a reliable and efficient tool for recognizing key features during intrapartum ultrasound. Future artificial intelligence models should automatically analyze and integrate multiple sonographic parameters to provide birth attendants with a decision support in managing labor arrest, particularly when opting between OVD and cesarean section for expedited delivery in the second stage.

5. Conclusions

Intrapartum ultrasound has revolutionized obstetrics, offering an objective and reproducible method to assess labor progression. By providing precise information on the main labor parameters (fetal head position, station, and attitude), it surpasses traditional clinical methods in diagnostic accuracy and facilitates timely, individualized interventions which are likely to optimize maternal and neonatal outcomes.

Over the past two decades, there have been major advancements in the field of intrapartum ultrasound, especially in managing labor dystocia and predicting failed OVD. Incorporation of ultrasound into routine clinical practice represents a major step forward in modern obstetrics, with the potential to improve outcomes and prioritize patient-centered approaches.

Future research should focus on validating predictive models, standardizing sonographic thresholds, and exploring novel labor parameters. The development of "sonopartograms" and AI-assisted diagnostic tools could further improve intrapartum care, enabling precise monitoring of labor progression while minimizing unnecessary or potentially harmful interventions.

6. Practice points

- Ultrasound provides more accurate assessments of fetal head position, station and degree of flexion compared to digital vaginal examination.
- Fetal head station can be evaluated using the angle of progression, head-to-perineum distance, and head direction.
- Fetal head attitude can be assessed using the occiput-spine angle for non-occiput posterior fetuses and the chin-to-chest angle for occiput posterior fetuses.
- Ultrasound is better tolerated, less invasive, and associated with a lower risk of infections than digital vaginal examination.
- The main indications for intrapartum ultrasound are labor dystocia and assessment prior to operative vaginal delivery.

7. Research agenda

- How can intrapartum ultrasound be implemented for monitoring normal labor without increasing unnecessary interventions?
- How can multiple labor parameters be integrated into multivariable models to enhance the prediction of labor abnormalities?
- How can artificial intelligence be incorporated into routine clinical practice in labor ward to improve decision-making and outcomes?

CRediT authorship contribution statement

Ruben Ramirez Zegarra: Writing – original draft, Methodology, Conceptualization. **Esteban Lizarraga Cepeda:** Writing – original draft, Resources, Conceptualization. **Tullio Ghi:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors report no conflict of interests.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bpobgyn.2025.102617.

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