MESTRADO INTEGRADO EM MEDICINA

Ultrasound in the second stage of labor-how, why and when should we use it?

Sofia da Silva Boavista

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Ultrasound in the second stage of labor - how, why and when should we use it?

A NARRATIVE REVIEW

MESTRADO INTEGRADO EM MEDICINA
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Autor

Sofia da Silva Boavista

Número mecanográfico: 201705771

up201705771@up.pt

Orientador

Prof. Doutora Inês Maria Moreira Guedes Maia Nunes de Melo Seco

Assistente Hospitalar de Ginecologia e Obstetrícia - Centro Materno-Infantil do Norte (CMIN), Centro Hospitalar Universitário de Santo António (CHUdSA)

Professora Auxiliar Convidada - Medicina da Mulher: Obstetrícia I, Mestrado Integrado em Medicina, Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto

Coorientador

Joana Silva Farhat

Interna de Formação Específica em Ginecologia e Obstetrícia

Centro Materno-Infantil do Norte (CMIN), Centro Hospitalar Universitário de Santo António (CHUdSA)

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Autor

Sofia da Silva Boavista

(Sofia da Silva Boavista)

Orientador

(Inês Nunes)

Coorientador

(Joana Farhat)

Dedication

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Resumo

Introdução: A gestão clínica da segunda fase do trabalho de parto é particularmente desafiadora. Durante a última década, a ecografia intraparto tem sido cada vez mais utilizada para determinar a posição, orientação e descida da cabeça fetal, bem como para estimar o tempo para o parto e distinguir mulheres candidatas a um parto vaginal daquelas que devem ser submetidas a uma cesariana.

Métodos: Foi realizada uma revisão da literatura com pesquisa nas bases bibliográficas Pubmed, SCOPUS e Web of Science. A seguinte questão de pesquisa foi usada: ("ultrasonography") AND ("Labor, obstetric" OR "vacuum delivery" OR "forceps delivery" OR "cesarean section" OR "stage labor, second" OR "labor presentation" OR "obstetric surgical procedures"). Esta revisão incluiu artigos originais e de revisão escritos em inglês ou português e publicados entre 2000 e 2022. Os artigos foram selecionados com base no título, resumo e texto completo. O objetivo desta revisão foi avaliar e sistematizar o papel da ecografia na segunda fase do trabalho de parto.

Resultados:

Como? Existem várias técnicas que podem ser realizadas para determinar a posição, orientação e atitude da cabeça do feto. Alguns parâmetros adicionais podem ser medidos, tais como ângulo de progressão, descida ecográfica da cabeça fetal, direção da cabeça fetal, distância cabeça-períneo ou ângulo da linha média.

Porquê? Vários estudos demonstraram a superioridade da ecografia com ou sem recurso ao exame digital na determinação precisa da rotação da cabeça fetal (diagnóstico incorreto - com ecografia em 1,6% dos casos vs exame digital em 20,2%). Em mulheres com progressão lenta do trabalho de parto, a determinação precisa da posição da cabeça fetal é importante, já que alterações na posição da cabeça fetal estão associadas a um maior risco de morbilidade materna e perinatal, a um parto vaginal instrumentado (14%) e a cesariana (59%). A ecografia pode distinguir grávidas candidatas a um parto vaginal espontâneo daquelas destinadas a um parto cirúrgico. Além disso, a ecografia intraparto pode auxiliar na previsão do sucesso de um parto vaginal instrumentado.

Quando? As indicações para o uso da ecografia intraparto são a progressão lenta ou a paragem de progressão da apresentação na segunda fase do trabalho de parto, auxiliando na definição da orientação da posição da cabeça do feto antes de se considerar ou de se realizar um parto vaginal. Porém, uma avaliação mais precisa da posição da cabeça fetal nem sempre é benéfico (aumento na taxa de partos instrumentados para 33.7% versus 27.1%, sem reduzir as morbilidades materna e fetal).

Conclusão: Apesar do uso da ecografia durante a segunda fase do trabalho de parto poder dar ao obstetra uma perspetiva mais precisa antes de tomar decisões clínicas cruciais relativamente à probabilidade de um parto vaginal ser bem-sucedido e reduzir a taxa de insucesso de um parto instrumentado, a literatura demonstra que um diagnóstico mais preciso através do uso da ecografia nem sempre é vantajoso. Estudos adicionais serão necessários para implementar o uso da ecografia como prática de rotina na sala de partos.

Palavras-chave: *Parto; Ecografia intraparto; Segunda fase do trabalho de parto; Prolongamento da segunda fase; Parto vaginal instrumentado; Parto vaginal espontâneo; Cesariana.*

Abstract

Introduction: In labor, management of the second stage is particularly challenging. During the last decade, intrapartum ultrasound has been increasingly used to determine fetal head position, station and descent, as well as to estimate the time to delivery and distinguish patients candidates for vaginal delivery from those that should be submitted to cesarean section.

Methods: a review of the literature has been conducted using Pubmed, SCOPUS and Web of Science. The query ("ultrasonography") AND ("Labor, obstetric" OR "vacuum delivery" OR "forceps delivery" OR "cesarean section" OR "stage labor, second" OR "labor presentation" OR "obstetric surgical procedures") was used. This review included original research and review articles written in English or Portuguese and published between 2000 and 2022. The articles were selected based on their title, abstracts and full text. The aim of this revision was to evaluate and systematize the role of the ultrasound in the second stage of labor**.**

Results:

How? There are several techniques that can be performed to determine fetal head station, position and attitude. Additional parameters can be measured such as the angle of progression, sonographic head station, fetal head direction, head–perineum distance or midline angle.

Why? Numerous studies have shown that ultrasound alone or in combination with digital examination is preferable for accurately determining fetal head rotation (incorrect ultrasound diagnosis in 1.6% of cases, compared with 20.2% in digital examination group). In women with slow labor progression, the accurate determination of fetal head position is important, as fetal head malposition is associated with a higher risk of maternal and perinatal morbidity (adverse outcome index score is significantly higher - 8.8% had ≥1 adverse outcomes), operative vaginal delivery (14%) and cesarean delivery (59%). Ultrasound examination can distinguish those women who are candidates for spontaneous vaginal delivery and those destined for operative delivery. Furthermore, ultrasound in labor may predict the outcome of instrumental vaginal delivery.

When? The indications for ultrasound evaluation are slow progress or arrest of labor in the second stage, definition of fetal head position before considering or performing instrumental vaginal delivery and objective assessment of fetal head malpresentation. However, a more precise ultrasound diagnosis of the correct fetal position does not always translate into a measurable outcome benefit (operative delivery rate increased to 33.7% vs 27.1% without lowering maternal and neonatal morbidity).

Conclusion: Although the use of ultrasound during the second stage of labor might provide the obstetrician with a clearer picture before making crucial clinical decisions regarding the likelihood of a successful vaginal delivery and lower the rate of failed instrumental delivery, literature shows that a more precise ultrasound diagnosis does not always improve the obstetric outcome. Additional research is therefore required to implement ultrasound as a routine clinical practice in the labor ward.

Keywords: *Labor; Delivery; Intrapartum ultrasound; Second stage of labor; Prolonged second stage; Instrumental vaginal delivery; Spontaneous vaginal delivery; Cesarean section.*

Abbreviations

ACOG - American College of Obstetricians and Gynecologists
AoP - angle of progression
HPD - head perineum distance
HRD - head ratio distance
HWPD - head widest part distance
ISUOG - International Society of Ultrasound in Obstetrics and Gynecology
MLA - midline angle
OAP - occiput anterior position
OPP - occiput posterior position
OVD - operative vaginal delivery
SMFM - Society for Maternal-Fetal Medicine

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Introduction

The second stage of labor is defined by the World Health Organization as the interval between the initiation of complete cervical dilatation and the delivery of the baby.[1] It is divided into passive and active. The passive stage refers to the progress of the fetal head in the maternal pelvis without expulsive efforts, while the active stage corresponds to the phase of active expulsive efforts. [2] Management of the second stage of labor is challenging and commonly based on duration and clinical findings. [3]

During the last decade, intrapartum ultrasound has been increasingly used. [1] As apart from being non-invasive and safe, it was proven to be more accurate in determining fetal head station, position and descent, as well as estimating the time to delivery and distinguishing patients destined for spontaneous vaginal delivery from those that should be submitted to operative delivery. As a result, it may give the obstetrician a better understanding of the global clinical picture, before making critical decisions, on the likelihood of a successful vaginal delivery, hence reducing the rate of unsuccessful instrumental delivery and its associated morbidity. [2]

Methods

Bibliographic research was performed through Pubmed, SCOPUS and Web of Science to conduct this review. The following query was used: (“ultrasonography”) AND (“Labor, obstetric” OR “vacuum delivery” OR “forceps delivery” OR “cesarean section” OR “stage labor, second” OR “labor presentation” OR “obstetric surgical procedures”). This review included original research and review articles written in English or Portuguese and published from 2000 to 2022. The articles were selected based on their title, abstracts and full-text. This review aims to evaluate the role of ultrasound in the second stage of labor.

Results

1. How to use intrapartum ultrasound – what should we measure?

A two or three-dimensional ultrasound machine equipped with a convex probe is used for intrapartum ultrasound.[3] This probe is similar to the one used throughout pregnancy to evaluate fetal biometry and anatomy. The equipment used in a delivery ward must have long-lasting batteries and an easy starting mechanism. The best ultrasonic probe to use during labor is a wide-sector probe with low-frequency (4 MHz) insonation.[4] A transabdominal or transperineal approach may be performed[1], depending on the clinical indication and the parameters being assessed.[3] During transabdominal imaging, fetal presentation, anatomy, placental location and volume of the amniotic fluid may be determined.[1] In a transperineal approach, the transducer is placed between the labia majora or at the level of the fourchette[1] with the woman in a supine position, with an empty bladder and with legs flexed.[3] This way, it enables us to capture images of the fetal head and measure parameters to calculate fetal head station, one of the most important markers for fetal descent and cervical dilatation that may help predict delivery mode.[1] Parameters used to determine fetal head descent include the angle of progression and head-perineum distance, which provide an objective evaluation of fetal head station with minimal variability between operators.[5]

1.1. Determine fetal head station

Several sonographic parameters can be used during labor to assess fetal head station.[3] Direct measures (using a midsagittal plane) include the angle of progression, progression distance and transperineal ultrasound head station. Indirect measures (using a midsagittal plane) include the head-symphysis distance and head direction. The head-perineum distance and the midline angle can also be used (using an axial plane obtained by rotating the transducer clockwise 90◦).[6] Although there are several ways to evaluate the fetal head station, the angle of progression and the head-perineum distance are the most frequently mentioned techniques[7] recommended by the guidelines of the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG).[3]

1.1.1. Angle of progression

One of the most researched transperineal ultrasound parameters for estimating the fetal head station is the angle of progression (AoP).[8] It is obtained using a transperineal approach in mid-sagittal scan[1] by measuring the angle between a line drawn through the long axis of the pubic bone and a line running from the inferior apex of the symphysis pubis tangentially to the deepest bony part of the fetal skull.[9] The technique involves placing the transducer longitudinally between the labia majora, mobilizing the probe to see the mid-sagittal plane, identifying the pubic bone landmark arranged horizontally and finally freezing the image.[1] (Figure 1)

The advantage of measuring the AoP is that it offers a trustworthy evaluation of head station[1], as it is comparable to head station measured in centimeters, ranging from -3cm to +5cm (direct translation is possible), and it has the ability to connect ultrasound data to conventional assessment by digital palpation.[3] An AoP between 110° and 120° degrees has been linked in numerous investigations to the digital assessment equivalent of the level of the ischial spines (zero). However, a correct visualization of the pubic bone imaging is necessary.[1]

1.1.2. Head perineum distance

The head perineum distance (HPD) is an easily obtained parameter[10] using a transperineal approach, but in the axial plane.[1] It is defined as the shortest distance from the transducer (perineum) to the fetal skull.[11] Once in the posterior fourchette, between the labia majora, the transabdominal transducer should be pressed on the pubic arches until resistance is felt.[10] The transducer must be at the right angle to visualize the skull counter clearly, demonstrating that the fetal skull and the ultrasound beam are perpendicular.[3] (Figure 2) The HPD represents the portion of the birth canal that the fetus hasn't yet travelled. However, it is measured in a straight line, not considering the curve of the birth canal.[12] Consequently, the fetal head station assessed clinically, from -5 to +5, cannot be directly compared to the HPD.[3] Studies have shown that a head station of 0 corresponded to a head perineum distance of 35 or 36mm.[10, 13] The head-perineum distance has the advantages of being quick to measure and easy to obtain, making it particularly helpful in emergency situations, such as before an instrumental vaginal delivery. The main disadvantage is how difficult it is to standardize the pressure exerted by the operator in fetal soft tissue.[1]

1.1.3. Progression distance

The progression distance is measured using a transperineal ultrasound in the midsagittal plane. It is described as the shortest distance between the presenting point and the line perpendicular to the long axis of the pubic symphysis.[14] It was first described by *Professor Dietz et al*. who proposed the head progression distance as an easy and highly reproducible way of measuring head station, with a good correlation with clinical examination.[15] (Figure 3 & 4)

1.1.4. Transperineal ultrasound head station

The transperineal ultrasonography head station combines the curvature of the delivery canal and expresses head station on the scale typically used for clinical assessment of labor progress. It involves the measurement of the head direction and the distance between the deepest presenting bony part in the direction of the head and the infrapubic plane, which is 3 cm above the ischial plane.[1,3] This fixed anatomical landmark was described by *Henrich et al.* through the reconstruction of the female pelvis using computed tomography, since the ischial spine is not visible through ultrasound examination.[14]

Apart from being a complex and time-consuming method for measuring head station, it has been discovered that sonographic ultrasound head station correlates linearly with the readily quantifiable AoP, and the link between these two parameters enables straightforward conversion of AoP measurements into centimeters on the traditional palpation scale.[1,3]

1.1.5. Head-symphysis distance

The head-symphysis distance is measured using a transperineal approach in the midsagittal plane. [13] It is defined as the distance along a line perpendicular to the long axis of the symphysis pubis between the lowest edge of the symphysis pubis and the closest point of the fetal skull.[14,16] (Figure 5)

1.1.6. Head direction

Head direction, first described by *Henrich et al* [3], is an easy and fast method to measure head station. As it increases with descent along the curved birth canal, it is considered an indirect marker of head station.[1] It's described as the angle, measured in a midsagittal transperineal view, between the pubic symphysis' long axis and the longest visible fetal head axis.[1,3] Three different head directions - head up (angle $>30^{\circ}$), head down (angle $< 0^{\circ}$), and horizontal (angle between 0° and 30°) - were identified using this method.[3,15] (Figure 6)

1.1.7. Midline angle

The midline angle is different from other ultrasound parameters as it refers specifically to fetal head rotation rather than descent as a sign of labor progress. It is measured through transperineal ultrasound in the transverse/axial plane. The midline angle is the angle between the echogenic line that separates the two cerebral hemispheres (midline) and the anteroposterior axis of the maternal pelvis. *Ghi et al*, who first described this parameter, discovered a substantial relationship between rotation as reflected by MLA and the head station as evaluated clinically.[1,3] (Figure 7)

1.2 Determine Fetal head position and attitude

The orientation of the presenting fetal head within the mother's pelvic inlet is known as the fetal head position.[1] Depending on the clinical indication, a transabdominal or transperineal approach may be used to perform an ultrasound assessment of fetal presentation and position in labor; [1, 4] however, most often, a combination of the two approaches is necessary.[17] Thus, according to the guidelines of the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG), it is best performed by a transabdominal approach in axial, sagittal[3] and transverse planes,[4] by placing the transducer in the suprapubic region.[1] The visualization of midline intracranial structures (such as the cavum septi pellucidi, falx cerebri, thalami, and cerebellar hemispheres), as well as anterior or posterior cranial structures (such as the orbits, nasal bridge, and cervical spine), allows an ultrasonographic representation of the fetal head position.[18, 19] Despite the fact that not all intracranial landmarks are visible with every fetal head position, every sonographic analysis will show enough structures to identify the head position.[18] The two fetal orbits can be used as landmarks for fetal occiput position; the midline cerebral echo for the occiput transverse position; the cerebellum, cervical spine and the fetal occiput itself for the occiput anterior position.[3, 20] Transverse suprapubic transabdominal sonographic examination takes little time and can usually be done easily in under two minutes to determine the position of the fetal head.[18] In low fetal head stations, some midline structures may be difficult to visualize. Therefore, the ISUOG suggests that a combination of a transabdominal and transperineal ultrasound approach may be necessary to precisely determine the fetal position.[3]

Obstetricians define fetal position using a methodical technique.[1] Firstly, it is crucial to identify the fetal spine[17] and the occiput, generally located within 180° of the spine.[20] These two structures are used as landmarks[1] and can be represented and noted using a clock face.[4] In an occiput anterior presentation, the fetal spine and occiput meet between 10 and 2 o'clock; if they're located between 4 and 8 o'clock then it's an occiput posterior position; if they're positioned between 2 and 4 o'clock it is a left occiput transverse position; if the fetus has a right occiput transverse position then those structures are positioned between 8 and 10 o'clock.[1, 3, 21] (Figure 8)

The fetal head attitude is defined as the relationship of the fetal head to spine.[3] It can be measured through transabdominal ultrasound at the suprapubic area by calculating the fetal occiput spine angle[22], which corresponds to the angle formed by a line drawn tangential to the occiput of the fetus and another one to the cervical spine.[1] The transducer is firstly placed in a longitudinal position at the suprapubic area and then moved and angled until the cervical spine and occiput are viewed.[1] (Figure 9) The fetus usually develops a distinctive attitude toward the end of pregnancy. It folds in on itself, making its back noticeably convex and bringing the chin close to the chest. Thus, abnormalities in this attitude may occur.[23] A visual evaluation of fetal head attitude and accurate identification of fetal head malpresentation during labor have been possible through ultrasound.[3]

The occiput-spine-angle refers to the degree of head flexion in an occipital anterior or occipital transverse fetal head position in the maternal pelvis. However, when the fetus has an occiput posterior position, the chin-to-chest angle is used as an alternative to define fetal head flexion. It is described as the angle formed when a line drawn tangential to the skin covering the inferior limit of the oral cavity up to the chin intersects with a line passing by the long axis of the sternum.[1] (Figure 10)

2. Why should we use intrapartum ultrasound?

2.1. Comparison with clinical examination

Ultrasound is a safe and non-invasive tool used throughout pregnancy[1] and may have a fundamental role in labor management.[24] During the past ten years, intrapartum ultrasound has been increasingly used[1] since there is evidence that manual examination may not provide accurate information about the position and descent of the fetal head, both in the first and second stages of labor.[24] Furthermore, manual examination is sometimes painful for women[1], increases the risk of infections for both the mother and the fetus[7] and is associated with higher maternal stress. Some complications may include iatrogenic amniotomy and increased bleeding in some women with placenta previa.[5]

Assessment and management of labor are mainly based on digital evaluation of cervical dilatation and fetal head station and position.[3] The fetal head station is usually evaluated using a numerical system that refers to a line connecting the ischial spines and measuring the distance from the presenting part in centimeters. A value of -1 means that the presenting part is 1 cm above the interspinal line and +1 means it is 1 centimeter below it.[14] A study that investigated the reliability of transvaginal assessment of fetal head station showed that numerical errors occurred in 50% to 88% of cases for residents and 36% to 80% for attending physicians.[25] Regarding the fetal head position, during vaginal examination, it is diagnosed by delineating the suture lines of the fetal skull and fontanelles. However, there is a 25 to 75% variability in the accuracy of this clinical diagnosis.[26] In a research by *Souka et al.*, the examiners incorrectly evaluated the head position in 30.8% of cases during the second stage of labor.[14] Furthermore, despite the examiner's experience, several studies have shown that in 20-40% of cases the prediction of the head position by digital vaginal examination is inaccurate.[27] A study comparing intrapartum sonography with transvaginal digital examination in determining fetal head position before instrumental delivery showed that digital examination failed to correctly identify the fetal head position in 26,6% of cases.[28] Additionally, research has shown that the accuracy of digital vaginal examination in occiput posterior and transverse positions was only 50%.[27] In 2015, a prospective, observational study of 43 women in labor that compared ultrasound measurements and clinical assessments of cervical dilatation, fetal head station and fetal head position, demonstrated a good agreement between clinical and ultrasound assessment of cervical dilatation, moderate agreement in assessing head station and low agreement assessing head position.[5] Furthermore, numerous studies have shown that ultrasound alone or together with digital examination is preferable for accurately determining fetal head rotation as compared to traditional digital examination alone.[3]

In women with slow labor progression, the accurate determination of fetal head position is of great importance, as fetal head malposition is associated with a higher risk of maternal and perinatal morbidity, operative vaginal delivery and cesarian delivery.[21] Thus, multiple studies have shown that when determining fetal head position, station and predicting an arrest of labor, ultrasound examination is more accurate and reproducible than digital examination.[3] Even among experienced doctors performing the transvaginal digital examination, it has been suggested that ultrasound should be used as the gold standard to accurately determine fetal head position and station during labor.[21]

2.2. Prediction of mode of delivery

For most pregnancies, a spontaneous vaginal delivery is the ideal outcome.[29, 30] The prediction of a successful spontaneous vaginal delivery in pregnant women may enhance neonatal and maternal outcomes by lowering the rates of prolonged, nonprogressive labors converted to cesarean deliveries.[9] It is commonly established that emergency cesarean deliveries have worse prognoses than elective cesarean deliveries, particularly when a prolonged vaginal delivery trial has failed.[31] Besides, a cesarean delivery when the fetal head is positioned deeply in the mother's pelvis is also linked with an increased risk of neonatal trauma, admission to an intensive care unit, and maternal morbidity.[32] It has been determined that certain abdominal and digital vaginal examination parameters can predict spontaneous vaginal birth both before and during labor. However, their accuracy in predicting the delivery mechanism varies and is not reliable enough for clinical usage.[25] Ultrasound examination may, to a certain degree, differentiate those women destined for spontaneous vaginal delivery and those destined for operative delivery.[3] Compared to physical examination, fetal head descent assessment accuracy has improved since introducing some ultrasound parameters such as the angle of progression, progression distance[33] and head direction.[29]

In some cases, an ultrasound check may indicate which women are expected to give birth naturally through vaginal birth and which ones will require surgical delivery.

The AoP has strong correlation with the mode of delivery when measured in laboring women.[8] In a systematic review and meta-analysis including a total of 8 studies reporting on 887 pregnancies, the AoP at the onset of the second stage of labor for the prediction of spontaneous vaginal delivery showed moderate diagnostic performance (with a sensitivity of 80%, specificity of 81%). For narrower AoP (between 108° and 119°), a sensitivity of 94% and specificity of 47% were found, compared with 66% and 82% for wider AoP (between 141°and 153°), respectively. Hence, in singleton, term, cephalic presenting pregnancies, the AoP measured by transperineal ultrasound at the start of the second stage of labor may predict spontaneous vaginal delivery.[9] In a prospective observational study including 197 nulliparous women, the AoP at rest, combined with the delta angle of progression (change between the AoP at rest and pushing), was found to predict spontaneous vaginal delivery in 86% of the women. A cut-off AoP of 138° (sensitivity of 71,6% and specificity of 83,7%) and a cutoff delta AoP of 11° (sensitivity of 87,3% and specificity of 45,1%) were considered for spontaneous vaginal delivery. 97% of women with an AoP of ≥138° and a delta AoP ≥11° had a spontaneous vaginal delivery. With these parameters being the most significant predictors, ultrasound conducted at the start of the active second stage of labor was found not only to help predict the mode of delivery and duration of pushing but also to perform better than the conventional digital exam.[34]

Furthermore, in a study including 221 women in labor, the authors observed a higher AoP in women who delivered vaginally. The mean AoP found in the second stage of labor of women who had a spontaneous vaginal delivery was 135.1° ± 19.90°, while in women who had an operative delivery was 119.1° ± 12.10°. The angle of progression cut-off point was 129.9°, with 85% specificity and 63% sensitivity. Similar results have been found in other studies, with slight variations in the mean cut-off points of the AoP.[35] A prospective observational study including 150 women concluded that an AoP with a cut-off of 110° predicts vaginal delivery, with a sensitivity of 68%. The AoP was ≥110° in 58% of women and out of these, 88% delivered vaginally.[36] Moreover, in a study by *Barbera et al*. including 23 women in the second stage of labor, women with an AoP greater than 120° delivered naturally, while those who had a cesarean delivery had an AoP of around 108°. Again, It has been shown that measuring the angle of progression translabially is an objective, reliable, and repeatable metric for determining whether the fetal head is engaged in the birth canal.[37]

The angle of progression may also play an important role in predicting cesarean deliveries. During the last decade, the rates of cesarean sections have been rising. Reducing these rates is very important to prevent associated morbidity.[38] In an observational prospective cohort study that included 575 women, it was found that the evaluation of maternal history and ultrasound parameters, such as the AoP, can predict around 70% of cesarean sections for a 20% positive rate - cesarean sections for maternal reasons were better predicted than those for fetal reasons, with a 77.5% versus 54.2% for a 20% false positive rate.[33]

By finding characteristics that predict a patient's risk of cesarean delivery, prelabor assessment may be improved. An independent risk factor for an unplanned cesarean delivery was found to be the sonographic fetal head circumference greater or equal to 35 cm measured within a week of delivery. Still, no significant trend was shown toward a higher chance of instrumental vaginal birth.[38] In a prospective cohort study of 200 nulliparous women, a fetal head circumference of greater or equal to 35cm was associated with more than two-fold the risk for operative delivery and a two-fold increased risk of cesarean section for dystocia. It concluded that ultrasound evaluation of the fetal head circumference at the beginning of labor might help identify women more likely to need an intrapartum intervention.[39]

Other parameters such as the head progression distance, head perineum distance and head-symphysis distance have also been used in the second stage of labor in the decision process regarding the mode of delivery. In a study including 68 pregnant women, these ultrasound parameters were different in women who delivered vaginally and had undergone cesarean delivery. The head progression distance was greater in those who delivered naturally, while the head perineum and head symphysis distance were smaller.[14] Additionally, *Carvalho Neto et al.*

in a study including 221 women, evaluated the head-perineum distance, which was higher among women who had an operative delivery, with a 69% specificity and 89% sensitivity for a cut-off of 43 mm for the cesarean endpoint.[35] In a study by *Eggebø et al*., of 150 women, 84 had a HPD of ≤40 mm and out of these 92% delivered vaginally, considering a cut-off of 40mm with a sensitivity of 69%.[36] Other studies had similar results. Regarding head symphysis distance, when comparing this parameter between women with spontaneous vaginal delivery and those with operative delivery, women with spontaneous vaginal delivery had shorter head symphysis distance than those who had undergone operative delivery. At the beginning of the active second stage of labor, a cut-off value of >17 mm was considered for operative delivery, with a 92.3% sensitivity and a 63.8% specificity. This concludes that measuring the head–symphysis distance through ultrasound may be used to predict operative delivery, with an accuracy of 81% at the beginning of the active second stage of labor.[40] (Table I)

2.3. Prediction of instrumental vaginal delivery outcome

Traditionally, a digital vaginal examination and clinical judgment are used to determine whether to perform an instrumental vaginal birth.[10] There is increasing evidence that ultrasound in labor may anticipate the outcome of instrumental vaginal delivery.[3] A failed operative vaginal delivery is associated with several risks for the mother and fetus and may become a traumatic experience.[10] Vacuum delivery has a lower risk of maternal and fetal morbidity when compared to forceps delivery. However, the risk of delivery failure is much higher.[41] Unlike a spontaneous birth or a successful vacuum extraction, failed instrumental vaginal delivery followed by cesarean section to complete fetal extraction is substantially more likely to result in subdural or cerebral bleeding, seizures,[42] prolonged hospitalization and admission of the baby to an intensive care unit.[41] Recent research has shown that intrapartum ultrasound is a safe technique for evaluating the position and staging of the fetal head and anticipating the outcome of delivery. It is also beneficial in analyzing phenomena associated with the fetus's passage via the birth canal. The position of the fetal occiput plays an essential role in the delivery outcomes.[35]

In a study that included all cases of operative vaginal deliveries in singleton pregnancies in cephalic presentation with a gestation time of >34 weeks from 2012 to 2015, researchers found that the perineum fetal skull distance measured by ultrasound is an accurate and reliable index of the difficulty of instrumental extraction, being a more precise predictor than digital examination. The greater the perineum to skull ultrasound distance, the higher the risk of a difficult or failed extraction. Thresholds of 40 and 60 mm were associated with a 2 and 3 times more significant chance for difficult extraction, respectively.[43] Another study by *Magnard et al.* showed that patients with measurements of >55 mm or 45 mm had a significantly greater extraction failure rate.[43] At the same time, *Tabard et al.* admitted a threshold of 50mm.[44] Furthermore, fetal head attitude may be important in predicting the outcome and progress of labor. A study by *Maged et al*., that included 400 women, found that an occiput spine angle of <126° was associated not only with a considerably longer duration of the first and second stages of labor, but also with complications for the mother and fetus.[23]

A study including 222 nulliparous women at term with prolonged second stage of labor in seven european maternity units from 2013 to 2016, showed that ultrasound has the potential to predict labor outcome in women with prolonged second stage of labor and help decide whether a cesarean delivery is the best option or if a vacuum delivery should be considered. The study confirmed that vacuum deliveries associated with fetal high stations are associated with an increased risk of failure. At the same time, with a head-perineum distance of <35 mm, there is a probability of 96% of vaginal delivery. Additionally, the duration of vacuum extraction was shorter in women with a head-perineum distance of <25 mm.[10]

Regarding vacuum deliveries, the angle of progression has been used as a predictive factor for failed vacuum extraction. Among the measurement of the AoP in 235 women, the angle of progression was higher in women who had undergone a successful vacuum delivery. A cut-off value of 145.5° was established and above this value the failure rate for vacuum extraction dropped below 5%.[41] Another study on 61 pregnant women at term observed that an angle of progression during the pushing phase of >128° has an 85% chance of easy vacuum delivery, defined as less than three vacuum pulls needed for fetal extraction, with a false positive rate of 9.3%.[42] *Sainz et al.* in his study reported that an angle of progression ≤120°, horizontal or down fetal head direction and a midline angle of ≥ 35% was associated with an 85% probability that the delivery will require more than 4 vacuum pulls and, therefore, will be more challenging.[45] Furthermore, another study found that the angle of progression and head direction are the best sonographic markers to predict the difficulties in forceps-assisted deliveries, being an AoP of >138° a good indicator for an easy forceps-assisted vaginal delivery.[42] Regardless of the ultrasound parameter used to measure fetal head station, a study has demonstrated that translabial ultrasound within the pushing phase is a better predictor than ultrasound at rest.[43]

Based on clinical operator's experience, integrating ultrasound data and all these characteristics should enable early assessment of the potential difficulties of a vaginal operative delivery and aid in the decision to perform a cesarean delivery.[43] (Table II)

3. When should we use intrapartum ultrasound?

3.1. Indications for ultrasound evaluation in labor

3.1.1. Slow progress or arrested labor in the second stage

When the second stage of labor exceeds a certain time threshold, it is considered a “prolonged second stage”. The prolongation of the second stage of labor may be caused by abnormal descent patterns, which can be classified into two types. A protracted descent is defined for multiparous women as a descent of less than 2cm per hour and for nulliparous women as less than 1cm per hour. In contrast, descent arrest is defined as no descent for more than an hour. These may indicate labor obstruction resulting in operative vaginal delivery or an emergency cesarian section.[46] In these cases, intrapartum ultrasound should be used to assess signs of obstructed labor, including poor pushing effort, inadequate uterine activity, malpresentation and/ or malposition of the fetal head and full bladder.[2]

A prolonged second stage of labor was redefined in 2014 by the ACOG and the SMFM consensus group statement for prevention of the primary cesarean birth, as no progress and rotation for >3 hours in nulliparous women without and >4 hours for nulliparous women with epidural analgesia. Also, for multiparous women, >2 hours without and >3 hours with epidural analgesia. Yet, they state that “A specific absolute maximum length of time spent in the second stage of labor beyond which all women should undergo operative delivery has not been identified” and that “longer durations may be appropriate on an individualized basis”.[47] Therefore, it is debatable and lacking consensus to what extent a prolonged second stage of labor should require an operative delivery.[48] Furthermore, even the exact start of the second stage of labor is difficult to define as the complete dilatation of the cervix may have occurred before the digital cervical examination takes place.[49]

It is challenging to diagnose and manage a prolonged second stage of labor and its complications.[2] Ideally, the management of the second stage of labor should aim to minimize the risks of maternal and neonatal morbidity and mortality while maximizing the probability of vaginal delivery.[50] A prolonged second stage of labor is generally associated with severe maternal and perinatal complications. In a retrospective study of 5,158 multiparous women, when the second stage of labor was prolonged for more than 3 hours, higher risks of operative vaginal deliveries, cesarean deliveries and maternal morbidity, including third and fourth-degree perineal tears, postpartum hemorrhage and chorioamnionitis were found. Neonatal complications included higher risks of 5-minute APGAR score less than 7, meconium-stained amniotic fluid, admission to the Neonatal Intensive Care Unit and longer hospitalization.[51]

Nowadays, diagnosing a prolonged second stage of labor is mainly based on digital assessment of fetal head station and position and cervical dilatation.[10] Vaginal examination, however, has shown limited accuracy in identifying these parameters, especially after one or more hours of active pushing.[48] An accurate assessment of these parameters is crucial as one of the reasons for a failed instrumental delivery and a higher rate of neonatal morbidity is the incorrect diagnosis or failure to correctly identify the fetal head position and station.[2] Long-term attempts at vacuum delivery are linked to perineal trauma and perinatal morbidity, particularly if the treatment is unsuccessful and a cesarean is required.[10]

In order to reduce unnecessary obstetric interventions, it is essential to accurately identify women who are still likely to deliver spontaneously despite a longer second stage of labor.[48] Several studies have supported the use of intrapartum ultrasound in prolonged second stage of labor to predict the mode of delivery. In a two-center prospective, observational, cohort study, conducted in Italy between December 2015 and March 2018, that included 109 nulliparous women with prolonged active second stage, transabdominal ultrasound was used to evaluate fetal head position and transperineal ultrasound was used to measure the midline angle, head-perineum distance and head-symphysis distance, in order to predict the likelihood of spontaneous vaginal delivery. Results showed that spontaneous vaginal delivery was associated with a higher rate of occiput anterior position, shorter head-perineum distance, shorter head-symphysis distance, narrower midline angle and wider angle of progression. These findings concluded that ultrasound may predict the likelihood of spontaneous vaginal delivery in nulliparous women with prolonged second stage of labor.[48] Furthermore, a study of prolonged labor in 150 women, found that 92% with a HPD of ≤40mm and 88% with an AoP 110° had a spontaneous vaginal delivery.[1] The AoP was found to be an objective parameter in the prediction of the delivery mode, in the prolonged second stage of labor, in cases of OAP.[37] In an analysis by *Kalache et al*, an AoP ≥120° was associated with a 90% possibility of a safe delivery, whether through vacuum extraction or spontaneously, demonstrating a strong correlation between an increasing "Angle of Progression" and a successful vaginal birth. *Masturzo et al*., in a study including 62 women with a prolonged second stage of labor, found that a head direction facing up, in 80% of cases was associated with a spontaneous vaginal delivery; a downward head direction with 20% and a horizontal direction with 41%.[52]

When labor progress is slow or an operative delivery is considered, ISUOG recommends measuring head position and descent.[3] In a study including 204 women, they found that when there was minimal or no fetal head descent, measured through head perineum distance, which may indicate labor obstruction or poor pushing technique, was associated with a longer duration of operative vaginal delivery and an increased frequency of cesarean section.[6] In a study by Y. *Gilboa et al*., including 45 pregnancies with a prolonged second stage of labor, it was demonstrated that fetal head descent during active pushing was the parameter that better predicted delivery mode. They assessed two additional new parameters: head widest part distance (the distance between the widest diameter of the fetal head and the infra-pubic line) and head ratio distance (corresponds to the head percentage beyond the infra-pubic line). They found that a HWPD > 1.2 cm and a HRD> 54 % increased the probability of a successful operative vaginal delivery.[53]

In summary, intrapartum ultrasonography aims to improve the diagnosis of protracted labor, to adequately choose the candidates for a trial of operative vaginal delivery and, as a result, to prevent unnecessary caesarean sections from being performed.[14]

3.1.2. Evaluation of fetal head position before instrumental vaginal delivery

Any fetal position not sacrum anterior for breech presentations or occiput anterior (OA) for cephalic presentations is considered a malposition.[4] The most common malposition is persistent occiput posterior position[4,19,54,55] with an incidence between 1.8% and 8.4%.[54] At the beginning of spontaneous labor, 15 to 20% of fetuses are in the OP position.[55] At the time of delivery, since many fetuses end up rotating to an occiput anterior position, only 5% of fetuses are in the OP position.[4] In a cross-sectional study including 918 women, even at 10cm of cervical dilatation, most of the occiput posterior positions during labor rotated to an anterior position.[56] An occiput posterior position may result from a malrotation during the second stage of labor from an initial non-OPP or from the persistence of this position throughout the entire labor, known as persistent OP position.[19] This mechanism is still a matter of debate. In a study by *D.Vitner et al*., they concluded that 100% of fetuses with an OP position at delivery were already in this position at station -2 and below, stating that most cases with OP position at birth result from a persistent OP position (absence of rotation from an initial OP position) instead of malrotation from an initial occiput anterior or transverse position.[57] Persistent OP is around two times more common in nulliparas.[4]

It is well known that the outcomes of delivery are significantly influenced by the fetal occiput's position.[35] Fetal cephalic malpositions frequently result in a failure of labor to progress.[17] A persistent OPP may result in obstructed labor in the first stage or a "deep transverse arrest" in the second stage. In most cases, delivery cannot be achieved through maternal pushing and requires an operative delivery.[19] A study by *Phipps H. et al.* confirmed that OP position is a strong predictor for an operative delivery after adjusting variables such as labor induction, gestational age, parity and the use of epidural analgesia.[58] Occiput posterior and transverse positions are linked to a high rate of maternal complications, including cesarean birth, operative vaginal delivery, third- and fourth-degree perineal lacerations, prolonged labor, and postpartum hemorrhage.[27,54,55,56] Furthermore, compared to newborns delivered in the occiput anterior position, a persistent occiput posterior position during delivery is linked to an increased risk of unfavorable neonatal outcomes, including high rates of 5-min Apgar score <7, meconium-stained amniotic fluid, meconium aspiration, umbilical artery pH of <7, neonatal trauma, longer hospital stays and admissions to neonatal intensive care unit.[27,18,54]

Notwithstanding the links between OP malposition and subsequent modes of delivery and maternal and newborn complications, detailed guidelines summarizing the management and decision-making in cases of occiput posterior delivery are lacking.[54] The management of fetal malposition is an ongoing debate - the role of instrumental and manual rotation of the fetal occiput and maternal positioning are always considered.[17] According to several studies, manual rotation is linked to a higher likelihood of spontaneous vaginal delivery and may be considered when an occiput posterior or transverse position is linked to dystocia; when effective, it appears to prevent adverse outcomes related to these positions.[27] Yet, interpreting these results is challenging because, as previously mentioned, prior research using intrapartum sonography indicates that most fetuses with a posterior or transverse occiput at full cervical dilatation will rotate naturally to an anterior position during the second stage. [17] However, it is consensual that a precise determination of fetal head position is necessary before instrumental delivery,[3] since the exact knowledge of the fetus's occiput is crucial for the appropriate positioning of the vacuum cup or forceps blades as well as the traction technique.[21]

As previously discussed, several studies have shown the inaccuracy of determining fetal head position through digital examination compared to ultrasound.[57] In cases of anomalous head position, like occiput posterior or transverse, when medical intervention is more likely required, clinical evaluation tends to be even less reliable. The existence of caput succedaneum and asynclitism, which are usually connected to obstructed labor, may exacerbate this lack of reliability.[3] Consequently, although not used as routine to monitor labor progression, intrapartum sonography is considered the gold standard for determining fetal head position.[57] Due to accurate identification of distinct fetal head landmarks, ultrasound helps diagnosing fetal malpositions, especially the OPP. In an investigation by *Blasi et al.*, diagnosing fetal occiput position through ultrasound in the second stage of labor presented 100% sensitivity, 78% specificity, a 26% positive predictive value, and a negative predictive value of 100%.[19] In a meta-analysis of RCTs, the accuracy of ultrasound diagnosis of occiput position was 98%, compared with vaginal examination (82%). However, the rate of unsuccessful OVD did not significantly differ between sonographic and clinical digital diagnosis of occiput position. Thus, they showed that before an operative vaginal delivery, sonographic knowledge of the occiput position does not appear to impact the incidence of failed OVD, or maternal or perinatal outcomes.[59] A study including 1903 women evaluated how the delivery mode and maternal and fetal outcomes were affected by ultrasound examinations to confirm the fetal head position during labor - although fetal head position could not be accurately determined by digital vaginal examination in 35% of cases, when correctly examined through ultrasound, it did not improve labor management and even increased the operative delivery rate (33.7% vs 27.1%) without lowering maternal and neonatal morbidity. These results were recognized as non-surprising - malpositions are underestimated by digital examinations; so it is expected that a more precise diagnosis by ultrasound led to increased interventions.[27]

Furthermore, *Ramphul et al*. randomized 514 women to determine whether ultrasound can decrease the incidence of incorrect diagnosis of the fetal head position at instrumental delivery and subsequent morbidity. Results showed that the incidence of incorrect diagnosis in the ultrasound group was 1.6%, while in the clinical assessment group was 20.2%. However, there was no discernible difference between the two groups in the prevalence of maternal and neonatal comorbidities, failed instrumental deliveries, or cesarean deliveries.[26] In a meta-analysis including 11 studies that investigated the use of intrapartum ultrasound to predict the mode of delivery in 5053 women, it was found that fetal head position determined by intrapartum sonography does not increase the likelihood that a cesarean section will be performed, concluding that it should not be used to predict delivery mode.[55]

Unfortunately, the literature on this topic is controversial and conflicting. Nevertheless, the complex process of labor depends on the interactions of three variables: the powers (forces produced by uterine musculature and maternal pushing efforts), the passenger (fetus), and the passage (bony maternal pelvis and resistance provided by soft tissues). Sonographically measuring the position of the fetus's head during the labor is just one aspect of what is, by nature, a complex and lengthy process.[18]

Discussion and Conclusion

Intrapartum ultrasound has the advantage of being a non-invasive and fast diagnostic technique that can be used during labor to monitor labor progress. However, it is still not fully understood how it may impact the management of labor and maternal and neonatal outcomes. Additionally, there are several limitations regarding this technique. It requires skilled operators trained in performing and interpreting ultrasound examinations, and it also relies on the availability of appropriate ultrasound equipment.

It has been proven that ultrasound is more accurate than digital clinical examination in providing information about the position and descent of the fetal head during labor. Furthermore, parameters obtained through intrapartum ultrasound can be used as predictors to assess whether a woman is more likely to have a spontaneous vaginal delivery rather than an operative delivery, and also to predict the outcomes of an instrumental vaginal delivery. However, evidence supporting the routine use of intrapartum ultrasound in all laboring women is limited, and its use should be based on clinical indication.

There are two key circumstances in labor where ultrasonography examination is likely to be particularly beneficial - slow progress or arrested labor and evaluation of fetal head position before an instrumental vaginal delivery. When suspecting a case of slow progress or arrested labor, intrapartum ultrasound may not only be used as a diagnostic tool through the assessment of cervical dilatation, fetal head station and position but also, to identify women who are still likely to deliver spontaneously. Fetal malposition is a common cause of labor arrest that may lead to the need for an instrumental vaginal delivery. Although it is consensual that a precise determination of fetal head position is essential before an instrumental vaginal delivery, as studied so far, a more precise ultrasound diagnosis of the correct occiput position does not always translate into a measurable outcome benefit. Additional research is required to explore potential modifications to clinical management during an operative vaginal delivery based on the use of intrapartum ultrasound.

In conclusion, intrapartum ultrasound may be used as part of a risk assessment tool that helps the obstetrician in the decision-making during labor and delivery, although the literature shows that a more precise ultrasound diagnosis does not always improve the obstetric outcome. Additional research is therefore required to implement ultrasound as a routine clinical practice in the labor ward.

Attachments

Table I. Summary of ultrasound parameters used to predict the mode of delivery

Parameter	Cut-off values for spontaneous vaginal delivery	Sensitivity (%)	Specificity (%)	Study
Angle of progression	**≥138°**	**71,6**	**83,7**	*Hadad et al.*[34]
	≥129.9°	**85**	**63**	*Carvalho Neto et al.* [35]
	≥110°	**68**	**----**	*Eggebø et al.*[36]
	≥120°	**----**	**----**	*Barbera et al.* [37]
Delta angle of progression	**≥11°**	**87.3**	**45.1**	*Hadad et al.*[34]
Head-perineum distance	**<43mm**	**89**	**69**	*Carvalho Neto et al.* [35]
	≤40mm	**69**	**-----**	*Eggebø et al.*[36]
Head -symphysis distance	**<17 mm**	**92.3**	**63.8**	*Youssef et al.* [40]

Table II. Summary of ultrasound parameters used to predict a difficult or failed extraction in instrumental delivery

Parameter	Higher risk of a difficult or failed extraction in instrumental delivery	Study
Perineum fetal skull distance	**≥ 40*-60**mm**	*Kasbaoui et al.* [43]
	45mm or >55mm	*Magnard et al.* [43]
	≥50mm	*Tabard et al* [44]
Angle of progression	**<145.5**	*Bultez et al.* [41]
	≤120º/ <128º (vacuum extraction)	*Sainz et al.* [42 45]
	< 138º (forceps extraction)	*Cuerva et al.* [42]
Midline angle	**≥ 35% (vacuum extraction)**	*Sainz et al.* [45]
Head widest part distante	**<1.2cm**	*Y. Gilboa et al.* [53]
Head ratio distance	**< 54%**	*Y. Gilboa et al.* [53]

*40mm: 2 times more chance of difficult extraction
**60mm: 3 times more chance of difficult extraction

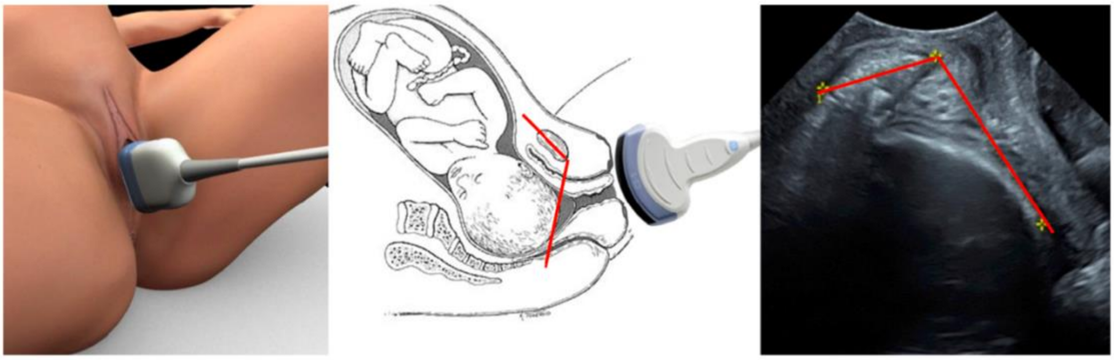

Figure 1. Measurement of the angle of progression *(Adapted from ISUOG Practice Guidelines: intrapartum ultrasound)* [3]

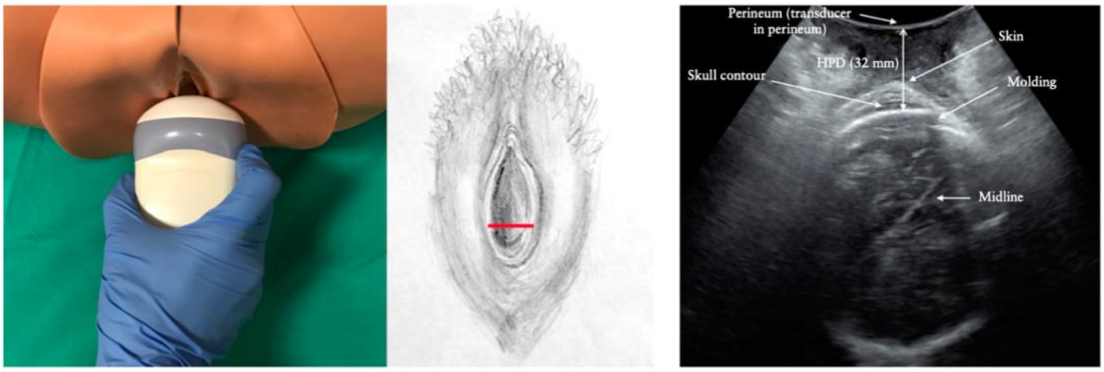

Figure 2. Measurement of head- perineum distance. *Showing placement of transducer and how distance is measured (adapted from ISUOG Practice Guidelines: intrapartum ultrasound)* [3]

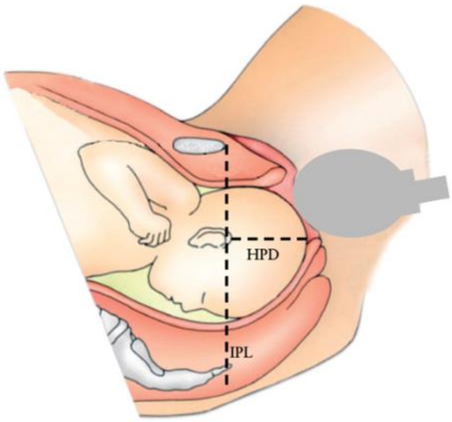

Figure 3. Measurement of head progression distance. *Showing placement of transducer on the sagittal plane, which must be tilted to demonstrate the pubic symphysis in a horizontal view (adapted from Kalache et al.)* [60]

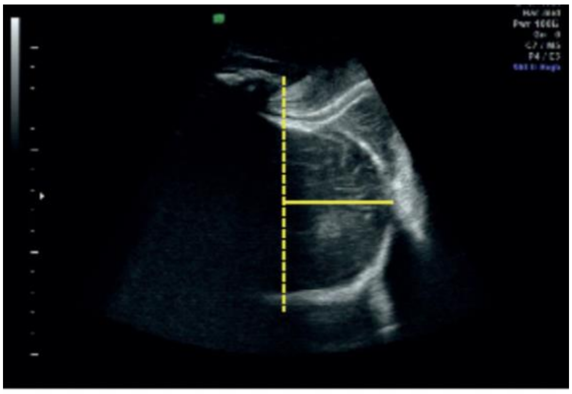

Figure 4. Sagittal transperineal ultrasound image showing head progression distance: solid line perpendicular to infrapubic line *(Adapted from Y. Gilboa et al.)* [60]

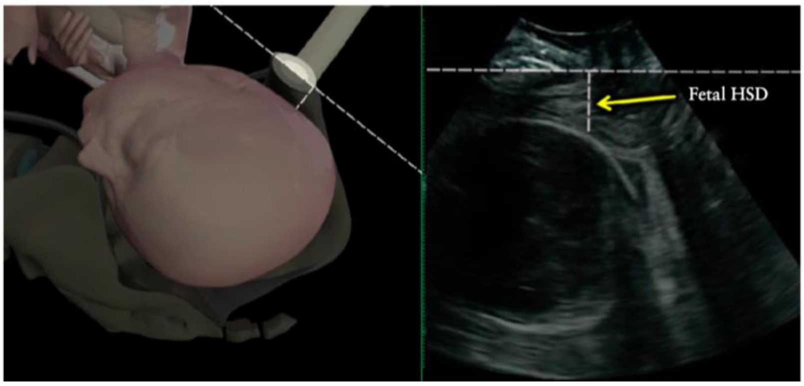

Figure 5. Measurement of head-symphysis distance *(Adapted from ISUOG Practice Guidelines: intrapartum ultrasound)*[3]

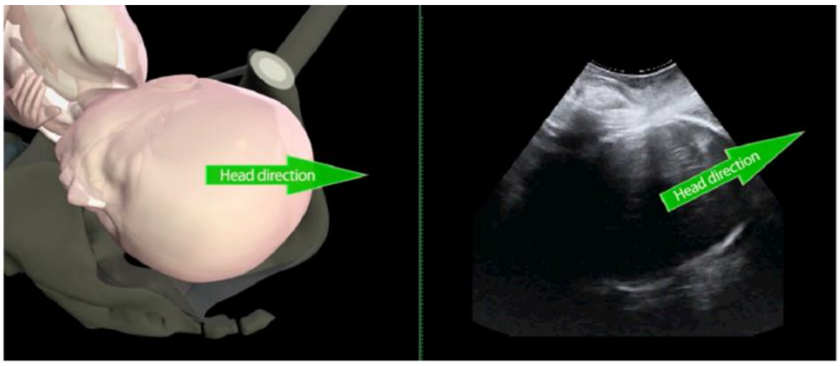

Figure 6. Measurement of head direction *(adapted from ISUOG Practice Guidelines: intrapartum ultrasound)*[3]

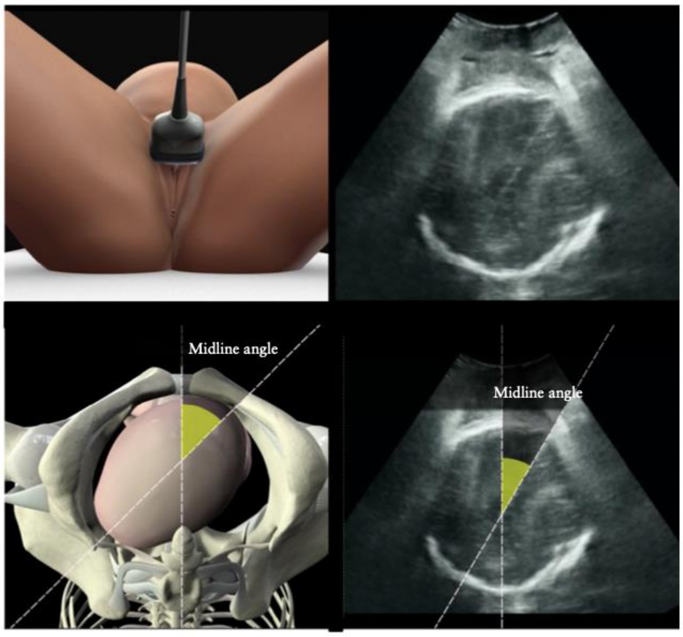

Figure 7.Measurement of midline angle. *Showing placement of transducer and how the angle is measured (adapted from ISUOG Practice Guidelines: intrapartum ultrasound)*[3]

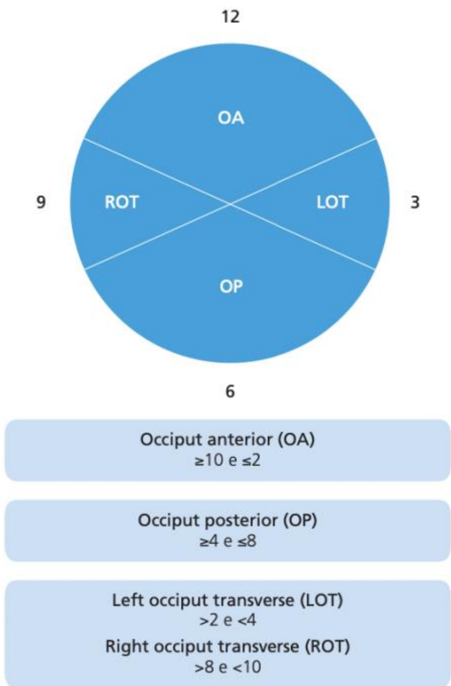

Figure 8.Classification of fetal occiput position (*Adapted from Ultrasound in labor: clinical practice guideline recommendation by the World Association of Perinatal Medicine (WAPM) and the Perinatal Medicine Foundation (PMF))*[1]

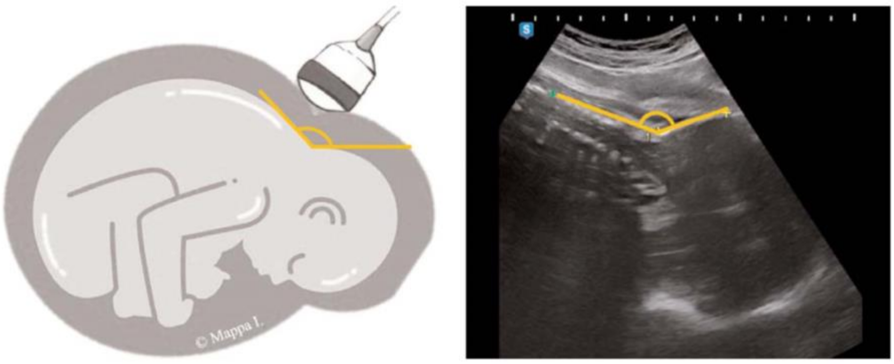

Figure 9. Measurement of occiput spine angle and corresponding ultrasound image *(Adapted from Ultrasound in labor: clinical practice guideline recommendation by the World Association of Perinatal Medicine (WAPM) and the Perinatal Medicine Foundation (PMF))*[1]

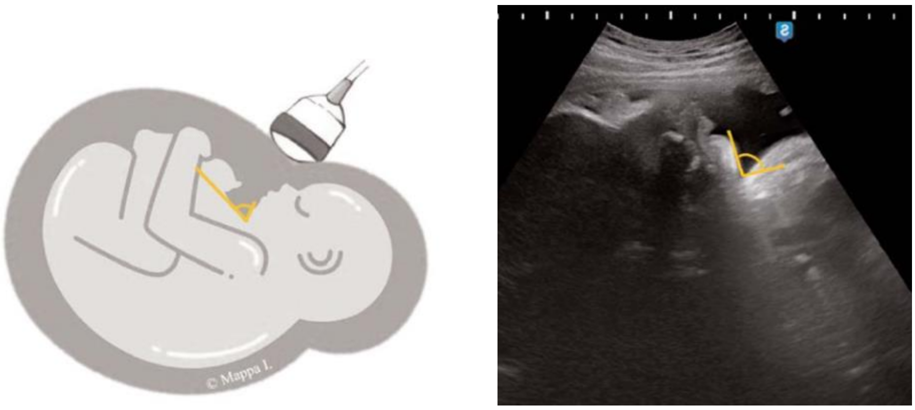

Figure 10. Measurement of chin-to-chest angle in fetuses with occiput posterior position and corresponding ultrasound image *(Adapted from Ultrasound in labor: clinical practice guideline recommendation by the World Association of Perinatal Medicine (WAPM) and the Perinatal Medicine Foundation (PMF))*[1]

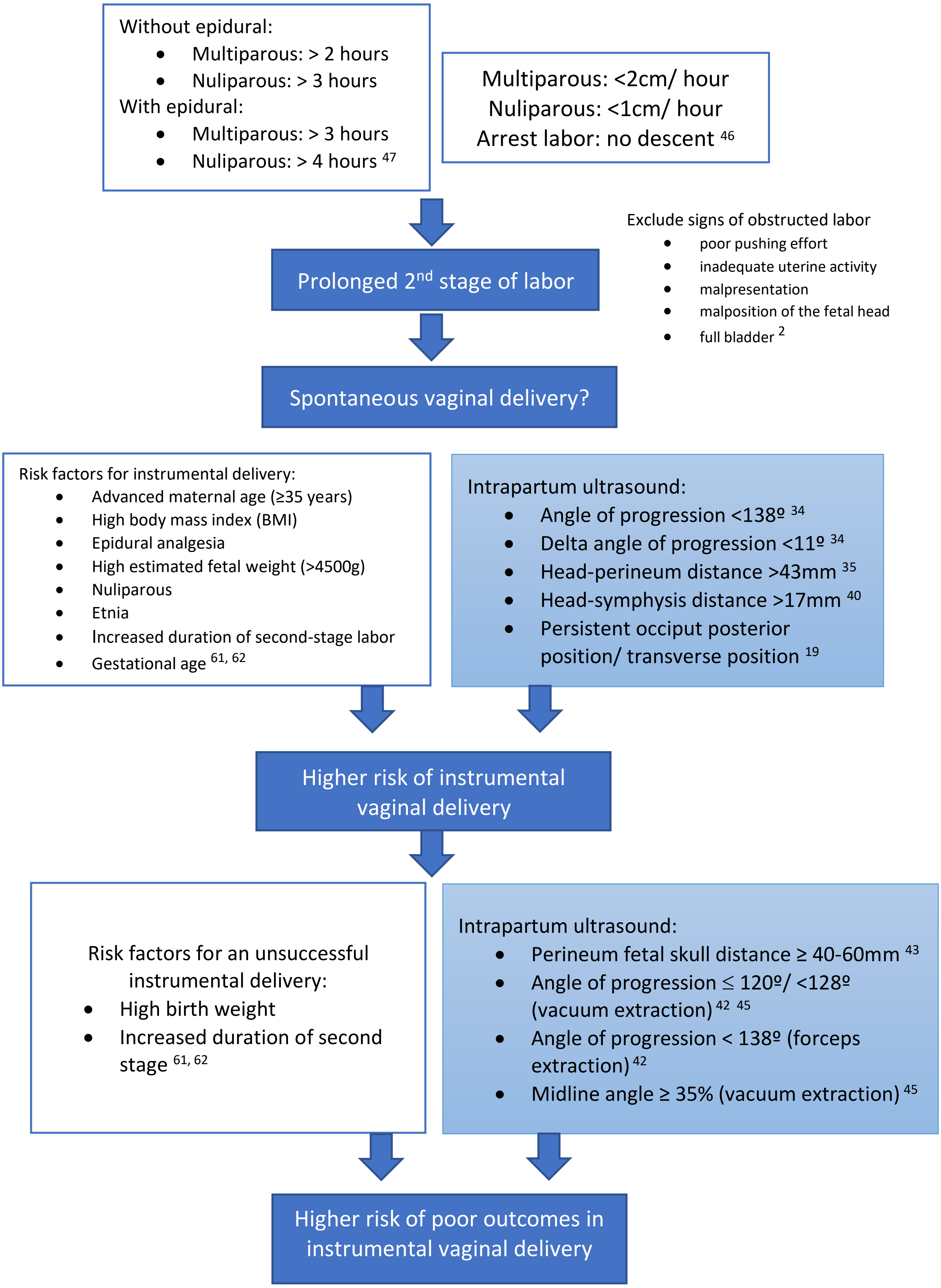

Figure 11. Flowchart summarizing ultrasound parameters and delivery outcomes in the second stage of labor.

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