Role of Intrapartum Ultrasound in Modern Obstetrics

Viola YT CHAN MBBS, MRCOG, FHKAM (Obstetrics and Gynaecology)
Winnie HUI MBBS, MRCOG
Wai-Lam LAU MBBS, FRCOG, FHKAM (Obstetrics and Gynaecology)
Department of Obstetrics and Gynaecology, Kwong Wah Hospital, Yaumatei, Hong Kong

Intrapartum ultrasound has become more popular over the last decade. It provides a more objective assessment of fetal head position and station than traditional digital vaginal examination, which is now known to be inaccurate. Correct identification of fetal head position is particularly useful before instrumental delivery, although it should not be used in the first stage of labour to predict successful vaginal delivery. Fetal head station can be assessed by determining the relationship between maternal and fetal structures transperineally, such as head-perineum distance and angle of progression. Intrapartum ultrasound has potential use before and during labour. Current evidence, however, shows it is most useful during the second stage of labour, especially when choice of optimal mode of delivery is not apparent. We believe that intrapartum ultrasound is a promising diagnostic tool that will ultimately improve the wellbeing of mothers and babies.
Hong Kong J Gynaecol Obstet Midwifery 2017; 17(2):134-40

Keywords: Embryology; Ultrasonography, prenatal

Introduction

Use of ultrasound in obstetrics and gynaecology first started in 1958 following the legendary publication by Ian Donald and his team in *Lancet* in which the physics, techniques, safety, and potential of ultrasound were described[1]. Since then, the development of ultrasound has accelerated and it has become indispensible in modern obstetrics.

Intrapartum ultrasound is a relatively new concept that has developed in the last 10 years, and is becoming more popular in developed countries as part of the assessment of labour progress. It is well established that clinical examination of fetal head position, station, and descent is often inaccurate, especially in the second stage of labour when the fetus may already have had significant caput succedaneum and moulding. With the help of transabdominal and transperineal ultrasound, the fetal spine, head position, station, and descent can be assessed objectively, thereby assisting clinical decision-making, such as choosing the optimal mode of delivery in a prolonged second stage.

In this article, we discuss the various ultrasound parameters proposed for labour assessment, and their current and future clinical applications.

Fetal Head and Spine Position

Traditionally, fetal head position is assessed by identifying the location of the posterior fontanelle by digital vaginal examination. Such clinical assessment is often inaccurate, with only 30% in complete agreement and 69% in agreement within 45 degrees when compared with actual fetal head position obtained by transabdominal ultrasound[2]. Fetal head position can be ascertained by transabdominal ultrasound according to the 'clock-face' method proposed by Akmal et al[3], as shown in Figure 1. Fetal occiput, cerebral midline, or the orbits in the transverse plane or fetal spine in the longitudinal plane can be used as markers to identify different fetal head positions (Figure 2). Accurate assessment of the fetal head position during labour is particularly useful when the fetus is in an occiput-posterior (OP) position, since certain manoeuvres can be performed to reduce maternal discomfort[4]. A local study[5] as well as a recent multicentre randomised controlled trial by Ramphul et al[6] have shown that compared with digital vaginal examination, determination of fetal head position with ultrasound prior to instrumental delivery reduces misplacement of the vacuum cup. Prediction of persistent OP position at delivery is also possible with a sensitivity of approximately 70% to 80%[7,8], although it is important to remember that fetal head position during the first stage of labour should not be used to predict successful vaginal

Correspondence to: Dr Wai-Lam Lau
Email: lauwl@hotmail.com

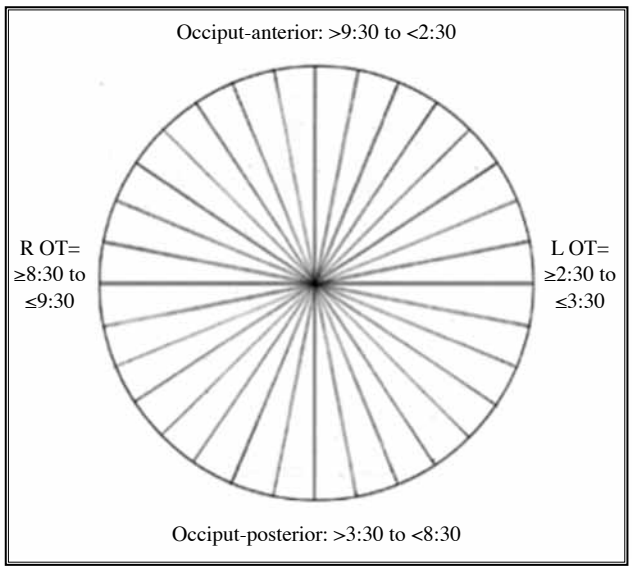

Figure 1. 'Clock-face' concept of fetal head position proposed by Akmal et al[3]

Abbreviations: L = left; OT = occiput-transverse; R = right

delivery. In a prospective cohort study by our group in which 100 assessments were obtained from 94 labouring women in the first and second stage of labour, the incidence of OP position was approximately 20%, 15%, and 4% during the first stage, second stage, and at birth, respectively[9].

Apart from fetal head position, fetal spine position can be ascertained using transabdominal ultrasound. Knowledge of both improves prediction of persistent OP position at birth from 70-80% to 100%[4].

Fetal Head Station: Head-perineum Distance and Angle of Progression

Fetal head station by digital vaginal examination of the relationship between fetal head and maternal ischial spine[10] has been proven to be subjective, inaccurate and poorly reproducible, with numerical errors occurring in 36% to 88% of cases, of which 20% were undiagnosed high

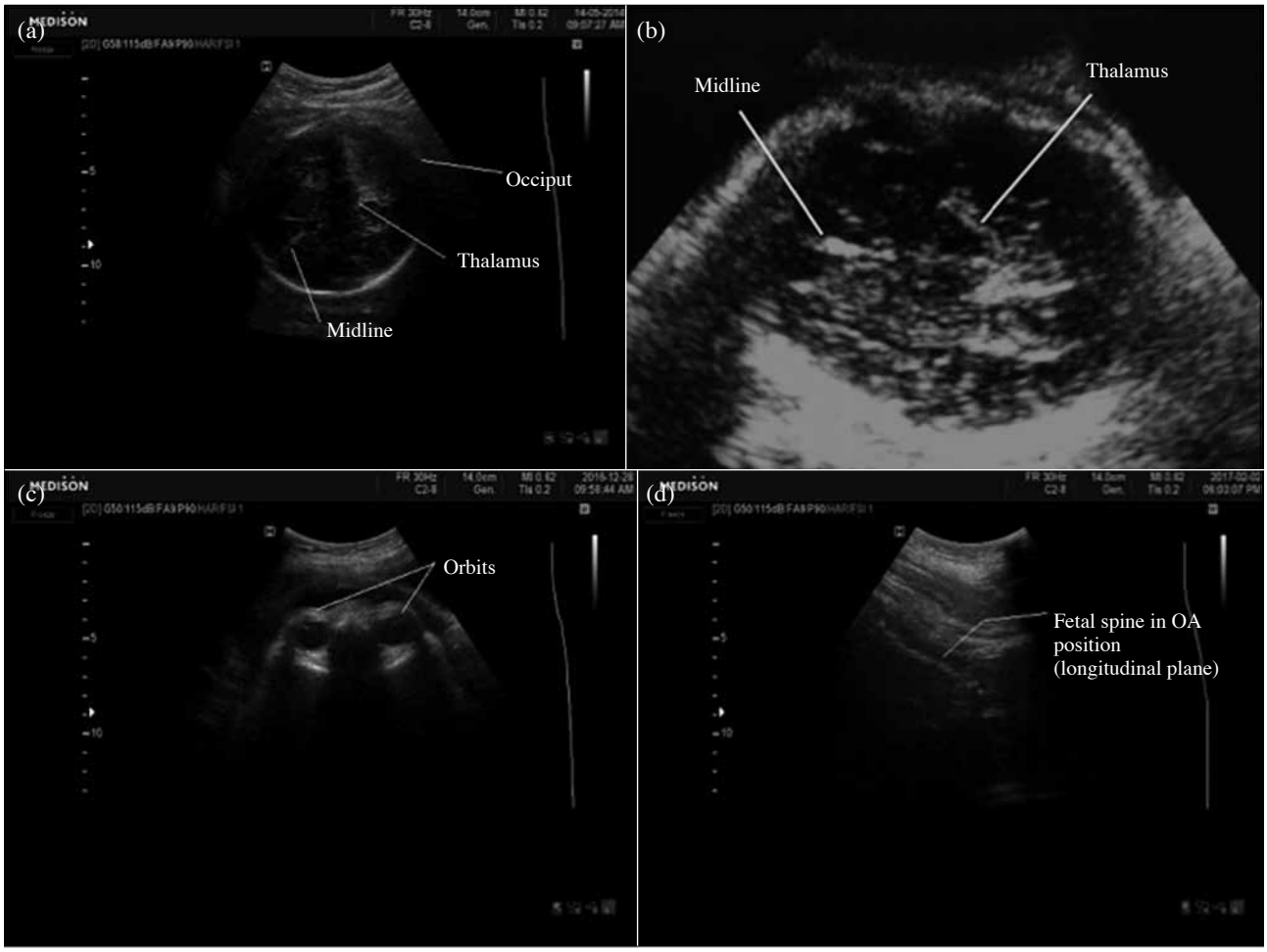

Figure 2. Images of fetal head position obtained by transabdominal ultrasound (transverse plane), with (a) occiput visualised anteriorly in OA position; (b) transversely positioned midline in OT position; (c) anterior pointing orbits in OP position; (d) spine (longitudinal plane) in OA position

Abbreviations: OA = occiput-anterior; OP = occiput-posterior; OT = occiput-transverse

stations[11,12]. Nonetheless, accurate assessment of fetal head station and descent is paramount to the assessment of labour progress as it enables the correct decision to be made about mode of delivery when labour is prolonged. Transperineal ultrasound allows visualisation and measurement of the relationship between the fetal head and maternal tissue, therefore overcoming the shortcomings of digital vaginal examination that is rather arbitrary. Different transperineal ultrasound parameters have been proposed and evaluated for their reproducibility, including head-perineum distance (HPD), angle of progression (AoP), head progression distance, head-symphysis distance, and midline angle[13]. They have been shown to be objective, highly correlated, and reliable in the assessment of fetal head station. These measurements are obtained by placing the ultrasound probe transversely or sagittally onto the maternal perineum as shown in Figures 3 and 4. HPD and AoP are discussed in detail below as they are easy to learn and extensively used. In brief, the shorter the HPD or the larger the AoP, the lower is the fetal head station.

Steps of Transperineal Ultrasound Examination

The following shows the steps of transperineal ultrasound examination:

1. The woman should lie in the lithotomy position, and her bladder should be empty.
2. Ultrasound gel should be applied to the transducer before covering it with a glove.
3. The ultrasound probe should be pressed firmly and transversely onto the perineum to obtain the HPD.
4. The ultrasound probe should then be rotated 90 degrees to a sagittal plane, to determine the AoP and head direction.
5. These measurements should be repeated during uterine relaxation and contraction with pushing.

Head-perineum Distance

HPD is the shortest distance from the outer bony limit of the fetal skull to the skin surface of the perineum[14]. It is obtained by simply pressing the ultrasound probe firmly onto the soft tissue between the labia majora until the probe can advance no further. After freezing the image, the HPD is measured on screen (Figure 3). The measurement should be taken during both uterine relaxation and contraction with pushing. A shorter distance indicates that the fetal head is closer to the perineum. In our previous study, HPD was correlated linearly with clinical head station (f= –0.497, p<0.001)[15]. A recent multicentre prospective cohort study of prolonged second stage by Kahrs et al[16] showed that the duration of vacuum extraction was shorter in women with HPD of 25 mm (log rank test <0.01). In women with HPD

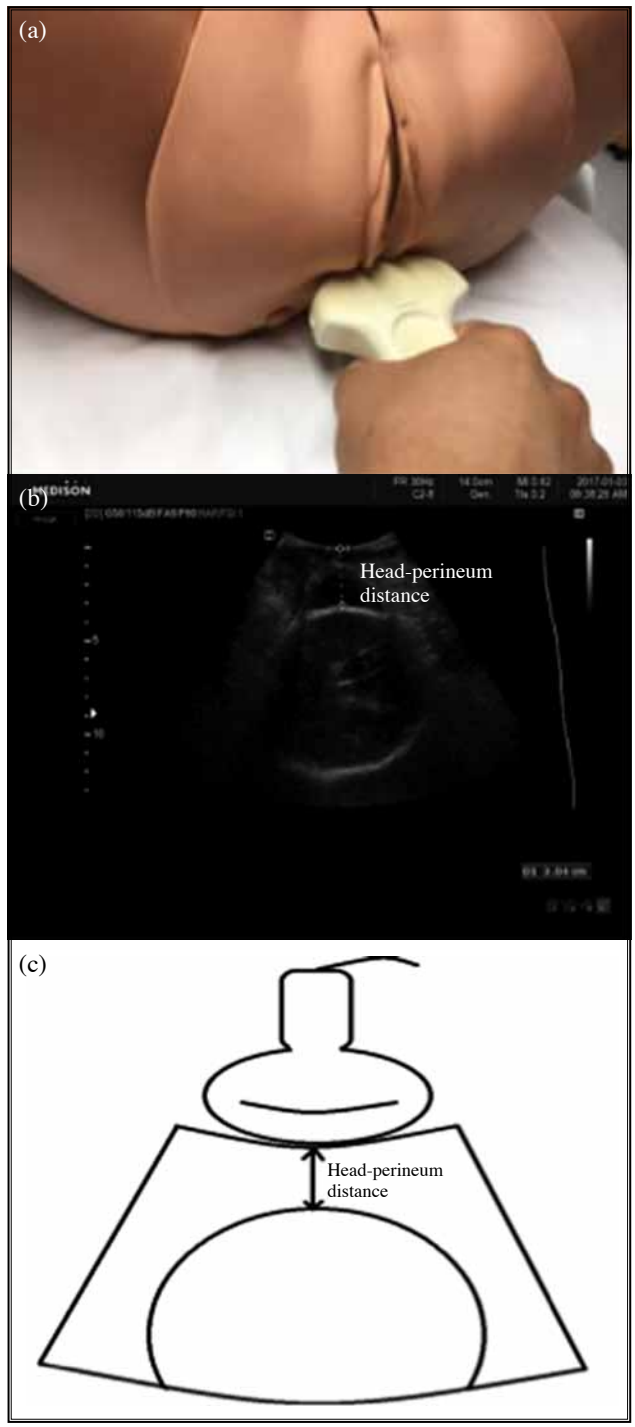

Figure 3. Placing the ultrasound probe transversely on the maternal perineum to obtain the head-perineum distance: illustrated by (a) manikin, (b) ultrasound image, and (c) schematic diagram

of ≤35 mm, 7/181 (3.9%) were delivered by Caesarean section compared with 9/41 (22.0%) in women with HPD of >35 mm (p<0.01). In addition, umbilical cord arterial pH was <7.10 in 2/144 (1.4%) women with HPD of ≤35 mm compared with 8/40 (20.0%) with HPD of >35 mm (p<0.01).

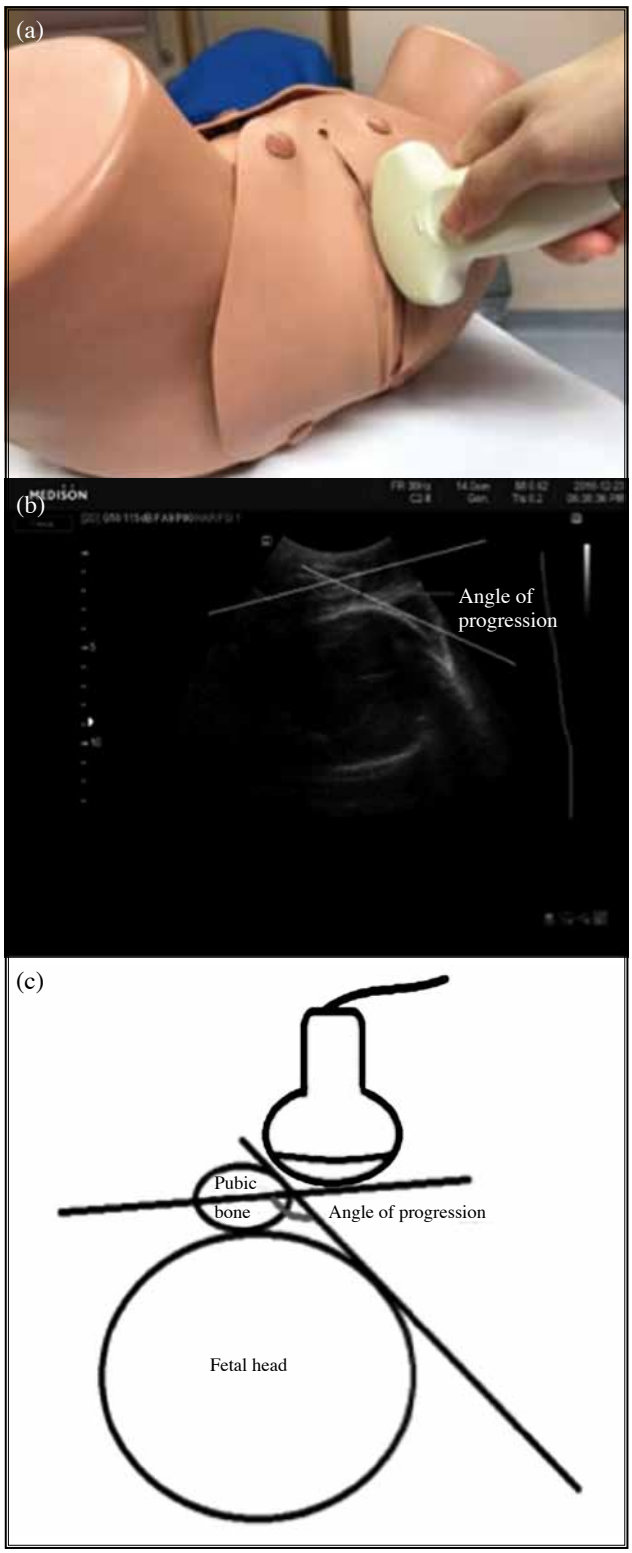

Figure 4. Placing the ultrasound probe sagittally on the maternal perineum to obtain the angle of progression: illustrated by (a) manikin, (b) ultrasound image, and (c) schematic diagram

Angle of Progression

AoP is the angle between the pubic symphysis and a line tangential to the fetal head contour[17] (Figure 4). Care must be taken to ensure both the long axis of the pubic symphysis and the fetal head contour can be ascertained on the sagittal image. The first line is drawn traversing two points identifying the long axis of the pubic symphysis, followed by a second line that extends from the most inferior portion of the pubic symphysis tangentially to the fetal skull contour (Figure 4). The angle can be measured directly on the screen or with a goniometer. In our previous study[15], AoP correlated linearly with clinical station (r=0.579, p<0.001); an AoP of about 120 degrees correlated with clinical head station 0, and echoes the findings of other groups[18,19]. Several studies suggested that a cutoff AoP of at least 120 degrees measured during the second stage of labour was associated with a higher chance of subsequent spontaneous vaginal delivery[17,20,21]. In our pilot study in 2009, using a cutoff of 150 degrees for AoP during contraction with pushing enabled us to predict 12 (80%) of the 15 successful vacuum extractions and all five Caesarean sections[22]. We postulated that the AoP during contraction with pushing probably reflects the combination of fetal head station as well as the dynamic change in fetal head descent against the birth canal. In a recent large single-centre prospective observational study of vacuum extraction at term by Bultez et al[23], AoP of >145.5 degrees was associated with a <5% vacuum extraction failure rate. The authors concluded that AoP may help to predict failure of vacuum extraction, especially among nulliparous women whose risk of failure is high.

Head Direction

Movement of the fetal head with pushing during uterine contractions can be visualised on real-time two-dimensional (2D) ultrasound in the sagittal view. Since the birth canal is curved, an upward head direction indicates the final stage of the fetal head descent. It has been shown that horizontal or downward head direction is associated with poor success of operative vaginal delivery[24,25]. Nonetheless the labour dynamic is different when the fetal head position is OP when absence of upward direction may be normal[26].

Clinical Applications

Before Onset of Active Labour

Cervical dilatation during active labour can generally be 'predicted' by partogram[27], but it remains difficult to predict onset of active labour. A recent systematic review and meta-analysis showed that cervical length measured by transvaginal ultrasound at term had moderate predictive value for the onset of spontaneous labour[28]. A short HPD of <45 mm at the time of prelabour rupture of membranes has also been associated with a higher chance of successful vaginal delivery and fewer Caesarean

sections[14]. In addition, Levy et al[29] suggested that narrow AoP of <95 degrees in nulliparous women at term before onset of labour is associated with a higher rate of Caesarean delivery. This was echoed by Jin et al[30] who showed that an AoP of >99 degrees in nulliparous women at term before onset of labour was associated with a higher rate of vaginal delivery. Some studies have also suggested that ultrasound before induction of labour may help to predict success of vaginal delivery and offer an alternative to the modified Bishop score[31,32].

First Stage of Labour

As discussed in the previous section, fetal head and spine position determined by transabdominal ultrasound might help predict persistent OP position. In addition, serial ultrasound examination of fetal head station, cervical length and dilatation combined with digital vaginal examination might provide a more objective assessment of labour progress. Hassan et al[33] proposed the concept of a 'sonopartogram', an ultrasound-based assessment of labour progress. In the study, cervical dilatation and fetal head descent were measured using both vaginal and ultrasound examination. Ultrasound assessment of labour progress was feasible in most cases, and there was good agreement between digital vaginal examination and ultrasound examination for cervical dilatation and head rotation. In our previous study, we found that HPD and AoP measured during uterine contractions correlated with time to normal vaginal delivery in primiparous women[15]. In the multicentre trial conducted on prolonged first stage, if the HPD was <40 mm the likelihood of Caesarean section was 7% but this increased to 82% if the HPD was >50 mm[21]. In the same study, if the AoP was >110 degrees the likelihood of Caesarean section was 12% but increased to 62% if the AoP was <100 degrees[21]. Therefore, intrapartum ultrasound may play a role when there is slow or lack of progress during the first stage of labour.

Second Stage of Labour

Ultrasound assessment is most useful when the mode of delivery is not apparent, such as in a woman with prolonged second stage and large fetal caput succedaneum. In this scenario, ultrasound can be useful to (1) determine the fetal head and spine position; (2) assess objectively the fetal head station with transperineal parameters such as HPD, AoP, and head direction; (3) visualise objectively the degree of caput and moulding[33]; and (4) avoid misplacement of instrument if an instrumental delivery is needed. Malpresentation or asynclitism can also be determined[34,35].

Use of transabdominal scan alone has been shown to reduce the misdiagnosis of fetal head position prior to instrumental delivery but not maternal or neonatal morbidity[5]. Recent studies that focused on the transperineal scan examination show that successful instrumental delivery is generally associated with AoP of >120-146 degrees or HPD of <35 mm[16,20,23]. We are currently analysing our 5-year data from women with a prolonged second stage, with an aim of determining the best cut-off value for HPD and AoP in triaging operative vaginal delivery or direct second-stage Caesarean delivery. A combination of both transabdominal and transperineal ultrasound findings should be more informative. As shown from the recent multicentre trial, only 3/138 (2.2%) fetuses in occiput-anterior position and HPD of ≤35 mm vs. 6/17 (35.3%) with non–occiput-anterior position and HPD of >35 mm were delivered by Caesarean section[16]. Further studies are needed to identify the optimal cutoff value of HPD or AoP below which a Caesarean delivery is a safer mode of delivery than operative vaginal delivery.

Other Benefits of Intrapartum Ultrasound

As both the woman and her partner can see the ultrasound images on screen, intrapartum ultrasound has the potential for coaching during active pushing[36]. Transperineal ultrasound has been shown to be well-tolerated, with close to 75% of pregnant women reporting no pain[37].

Conclusion

Intrapartum ultrasound provides an objective assessment of labour progress. It is easy to learn, with negligible intra- and inter-observer differences. Moreover, most of the parameters can be captured by 2D ultrasound and measured on the spot. When the optimal cutoff for ultrasound parameters is supported by evidence, it will also aid decision-making, especially when the choice of delivery mode is not straightforward such as slow or lack of progress in the second stage and possibly in the first stage too. With proper training and standardisation of technique, intrapartum ultrasound assessment will be the future diagnostic tool in active labour. Our group is currently exploring the possibility of midwifery-led intrapartum ultrasound serial assessment of labour progress. Meanwhile, clinical assessment by digital vaginal palpation should not become obsolete, but applied alongside sonography. A new algorithm that combines both the clinical and intrapartum ultrasound parameters should be the way forward.

Declaration

The authors have disclosed no conflicts of interest.

References

1. Donald I, Macvicar J, Brown TG. Investigation of abdominal masses by pulsed ultrasound. *Lancet* 1958; 271:1188-95.
2. Chan VY, Lau WL, Lo TK, Leung WC. Comparison of digital vaginal examination with intrapartum transabdominal ultrasound to determine fetal head position: a local experience. *Hong Kong J Gynaecol Obstet Midwifery* 2015; 15:23-8.
3. Akmal S, Tsoi E, Kametas N, Howard R, Nicolaides KH. Intrapartum sonography to determine fetal head position. *J Matern Fetal Neonatal Med* 2002; 12:172-7.
4. Guittier MJ, Othenin-Girard V, de Gasquet B, Irion O, Boulvain M. Maternal positioning to correct occiput posterior fetal position during the first stage of labour: a randomised controlled trial. *BJOG* 2016; 123:2199-207.
5. Wong GY, Mok YM, Wong SF. Transabdominal ultrasound assessment of the fetal head and the accuracy of vacuum cup application. *Int J Gynaecol Obstet* 2007; 98:120-3.
6. Ramphul M, Ooi PV, Burke G, et al. Instrumental delivery and ultrasound: a multicentre randomised controlled trial of ultrasound assessment of the fetal head position versus standard care as an approach to prevent morbidity at instrumental delivery. *BJOG* 2014; 121:1029-38.
7. Blasi I, D'Amico R, Fenu V, et al. Sonographic assessment of fetal spine and head position during the first and second stages of labor for the diagnosis of persistent occiput posterior position: a pilot study. *Ultrasound Obstet Gynecol* 2010; 35:210-5.
8. Gizzo S, Andrisani A, Noventa M, et al. Intrapartum ultrasound assessment of fetal spine position. *Biomed Res Int* 2014; 2014:783598.
9. Tang GP, Chan VY, Ng VK, Lau WL, Leung WC. Can intrapartum ultrasound assessment of fetal spine and head position predict persistent occiput posterior position at delivery? *Hong Kong J Gynaecol Obstet Midwifery* 2016; 16:102-7.
10. Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Gilstrap III LC, Wenstrom KD. Normal labor and delivery. In Williams Obstetrics. 22nd ed. *New York: McGraw-Hill*; 2005: 409-42.
11. Dupuis O, Silveira R, Zentner A, et al. Birth simulator: reliability of transvaginal assessment of fetal head station as defined by the American College of Obstetricians and Gynecologists classification. *Am J Obstet Gynecol* 2005; 192:868-74.
12. Dupuis O, Ruimark S, Corinne D, Simone T, André D, René-Charles R. Fetal head position during the second stage of labor: comparison of digital vaginal examination and transabdominal ultrasonographic examination. *Eur J Obstet Gynecol Reprod Biol* 2005; 123:193-7.
13. Molina FS, Terra R, Carrillo MP, Puertas A, Nicolaides KH. What is the most reliable ultrasound parameter for assessment of fetal head descent? *Ultrasound Obstet Gynecol* 2010; 36:493-9.
14. Eggebø TM, Gjessing LK, Heien C, et al. Prediction of labor and delivery by transperineal ultrasound in pregnancies with prelabor rupture of membranes at term. *Ultrasound Obstet Gynecol* 2006; 27:387-91.
15. Chan YT, Ng VK, Yung WK, Lo TK, Leung WC, Lau WL. Relationship between intrapartum transperineal ultrasound measurement of angle of progression and head-perineum distance with correlation to conventional clinical parameters of labor progress and time to delivery. *J Matern Fetal Neonatal Med* 2015; 28:1476-81.
16. Kahrs BH, Usman S, Ghi T, et al. Sonographic prediction of outcome of vacuum deliveries: a multicenter, prospective cohort study. *Am J Obstet Gynecol* 2017; 217:69.e1-10.
17. Barbera AF, Pombar X, Perugino G, Lezotte DC, Hobbins JC. A new method to assess fetal head descent in labor with transperineal ultrasound. *Ultrasound Obstet Gynecol* 2009; 33:313-9.
18. Tutschek B, Braun T, Chantraine F, Henrich W. A study of progress of labour using intrapartum translabial ultrasound, assessing head station, direction, and angle of descent. *BJOG* 2011; 118:62-9.
19. Bamberg C, Scheuermann S, Slowinski T, et al. Relationship between fetal head station established using an open magnetic resonance imaging scanner and the angle of progression determined by transperineal ultrasound. *Ultrasound Obstet Gynecol* 2011; 37:712-6.
20. Kalache KD, Dückelmann AM, Michaelis SA, Lange J, Cichon G, Dudenhausen JW. Transperineal ultrasound imaging in prolonged second stage of labor with occipitoanterior presenting fetuses: how well does the 'angle of progression' predict the mode of delivery? *Ultrasound Obstet Gynecol* 2009; 33:326-30.
21. Torkildsen EA, Salvesen KÅ, Eggebø TM. Prediction of delivery mode with transperineal ultrasound in women with prolonged first stage of labor. *Ultrasound Obstet Gynecol* 2011; 37:702-8.
22. Lau WL, Leung WC, Chin R. What is the best transperineal ultrasound parameter for predicting success of vacuum extraction? *Ultrasound Obstet Gynecol* 2009; 33:735.
23. Bultez T, Quibel T, Bouhanna P, Popowski T, Resche-Rigon M, Rozenberg P. Angle of fetal head progression measured using transperineal ultrasound as a predictive factor of vacuum extraction failure. *Ultrasound Obstet Gynecol* 2016; 48:86-91.
24. Henrich W, Dudenhausen J, Fuchs I, Kämena A, Tutschek B. Intrapartum translabial ultrasound (ITU): sonographic landmarks and correlation with successful vacuum extraction. *Ultrasound Obstet Gynecol* 2006; 28:753-60.
25. Ghi T, Farina A, Pedrazzi A, Rizzo N, Pelusi G, Pilu G. Diagnosis of station and rotation of the fetal head in the second stage of labor with intrapartum translabial ultrasound. *Ultrasound Obstet Gynecol* 2009; 33:331-6.
26. Ghi T, Maroni E, Youssef A, et al. Sonographic pattern of fetal head descent: relationship with duration of active second stage of labor and occiput position at delivery. *Ultrasound Obstet Gynecol* 2014; 44:82-9.

27. Friedman EA. The graphic analysis of labor. *Am J Obstet Gynecol* 1954; 68:1568-75.
28. Saccone G, Simonetti B, Berghella V. Transvaginal ultrasound cervical length for prediction of spontaneous labour at term: a systematic review and meta-analysis. *BJOG* 2016; 123:16-22.
29. Levy R, Zaks S, Ben-Arie A, Perlman S, Hagay Z, Vaisbuch E. Can angle of progression in pregnant women before onset of labor predict mode of delivery? *Ultrasound Obstet Gynecol* 2012; 40:332-7.
30. Jin H, Cho G, Hong H, et al. OP07.02: Prediction of delivery mode using angle of progression, before onset of labour in nulliparous women at term. *Ultrasound Obstet Gynecol* 2014; 44(S1):81.
31. Khazardoost S, Ghotbizadeh Vahdani F, Latifi S, et al. Pre-induction translabial ultrasound measurements in predicting mode of delivery compared to bishop score: a cross-sectional study. *BMC Pregnancy Childbirth* 2016; 16:330.
32. Eggebø TM, Heien C, Økland I, Gjessing LK, Romundstad P, Salvesen KA. Ultrasound assessment of fetal head-perineum distance before induction of labor. *Ultrasound Obstet Gynecol* 2008; 32:199-204.
33. Hassan WA, Eggebø T, Ferguson M, et al. The sonopartogram: a novel method for recording progress of labor by ultrasound. *Ultrasound Obstet Gynecol* 2014; 43:189-94.
34. Malvasi A, Stark M, Ghi T, Farine D, Guido M, Tinelli A. Intrapartum sonography for fetal head asynclitism and transverse position: sonographic signs and comparison of diagnostic performance between transvaginal and digital examination. *J Matern Fetal Neonatal Med* 2012; 25:508-12.
35. Lau WL, Leung WC, Chin R. Intrapartum translabial ultrasound demonstrating brow presentation during the second stage of labor. *Int J Gynaecol Obstet* 2009; 107:62-3.
36. Bellussi F, Youssef A, Ghi T, Margarito E, Salsi G, Pilu G. OP26.06: Traditionally coached versus sonographically coached second stage of labour: a randomised control trial. *Ultrasound Obstet Gynecol* 2016; 48(S1):136-7.
37. Chan YT, Ng KS, Yung WK, Lo TK, Lau WL, Leung WC. Is intrapartum translabial ultrasound examination painless? *J Matern Fetal Neonatal Med* 2016; 29:3276-80.