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Ultrasound in Labor and Delivery

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Key Words
Ultrasound · Labor · Induction of labor · Progress of labor · Instrumental delivery

Abstract
Ultrasound may play an important role in the management of labor and delivery. Induction of labor is a common obstetric intervention, performed in about 20% of pregnancies. Pre-induction cervical length, measured by transvaginal sonography, has been shown to have a significant association with the induction-to-delivery interval and the risk for cesarean section. In the management of labor there is extensive evidence that digital pelvic examination does not provide accurate assessment of the position and descend of the fetal head both during the first but also in the second stage of labor. Several recent studies using both two- and three-dimensional ultrasound have now described objective measures of progression of the fetal head during labor. In instrumental deliveries an important determinant of a successful and safe use of vacuum and forceps is the correct determination of the fetal head position and appropriate application of the instrument. However, ultrasound studies have shown that digital examination before instrumental delivery fails to identify the correct fetal position in a high proportion of cases. The use of ultrasound is of crucial importance in performing a safe operative delivery and can help in the prediction of whether a vaginal delivery would be successful.

Extensive evidence over the last 30 years has demonstrated the value of ultrasound in the prenatal diagnosis of fetal abnormalities and in the assessment of fetal growth and wellbeing. Recent studies suggest that ultrasound may play an important role in the prediction of the time of onset and the progress of labor and in this article we review the evidence in favor of the use of ultrasound in the control of labor and delivery.

Ultrasound before Induction of Labor

Induction of labor is a common obstetric intervention, performed in about 20% of pregnancies [1]. However, about 20% of women having induction of labor need a cesarean section for delivery either because of failed induction, failure to progress in labor or fetal distress [2].

Several studies have examined a variety of maternal and fetal factors as well as screening tests to predict the outcome of labor induction. One meta-analysis by Crane [3] reported that certain characteristics of the woman (parity, age, weight, height and body mass index) and of the fetus (birth weight and gestational age) are useful predictors with parous young women who are tall and of low weight having a higher rate of induction success. Fetuses with a lower birth weight or increased gestational age are also associated with increased induction success. Pre-induction cervical length, measured by transvaginal so-

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nography, has been shown to have a significant association with the induction-to-delivery interval and the risk for cesarean section. There is evidence that pre-induction cervical length and the position of the fetal occiput in addition to maternal characteristics, including parity, gestational age, maternal age, and body mass index, provides useful prediction of the likelihood of cesarean section [4–6]. For example, the odds of cesarean section increases by about 10% with each increase of 1 mm in cervical length above 20 mm and the odds are about 75% lower in multiparae, compared to nulliparae with the same cervical length [7]. A series of models, incorporating sonographic and demographic characteristics, have been developed that can classify women into high and low risk groups for cesarean section and provide individual patient predictions for outcome of induction of labor [8].

The main indication for induction of labor is post-term pregnancy because in such cases the risk of intrauterine and postnatal death is increased from 2.4 per 1,000 pregnancies at 40 weeks to 5.8 at 43 weeks. In the management of the post-term pregnancies, induction of labor reduces perinatal mortality when compared with expectant management [9]. The traditional approach to the management of prolonged pregnancy is to undertake delivery during the 41st week of gestation. Rao et al. [10] reported the results of a new approach whereby an ultrasound-based assessment is undertaken at the end of the 40th week or during the 41st week of gestation and unless there is evidence of a specific medical or obstetric indication induction of labor is delayed by 7–10 days. The study demonstrated that a policy of delaying induction resulted in spontaneous onset of labor and delivery in more than 80% of cases. In addition, the rate of cesarean section for failure to progress or fetal distress was about 20% in the total population, including 15% in those with spontaneous onset of labor and 36% in those requiring induction of labor. The chance of spontaneous onset of labor was higher in parous than nulliparous women and was inversely related to maternal body mass index and cervical length. The chance of vaginal delivery was higher in those with spontaneous than induced onset of labor, in parous than nulliparous women, and in white than black women, and was inversely related to maternal body mass index and cervical length.

An ultrasound-based prolonged pregnancy clinic can identify previously undiagnosed problems, such as breech presentation that may benefit from elective cesarean section or oligohydramnios and fetal growth restriction for which early delivery with close intrapartum monitoring would be needed. In those with no specific medical indications for delivery during the 41st week a policy of delaying induction of labor by 7–10 days would reduce substantially the rate of induction for prolonged pregnancy. The extent to which such policy could reduce the overall rate of cesarean section without an increase in perinatal death can only be answered by randomized studies.

Ultrasound to Define Fetal Head Position and Progression during Labor

There is extensive evidence that digital pelvic examination for the determination of fetal head position during labor is not accurate. Sherer et al. [11, 12] reported a discrepancy in the assessment of the fetal occipital position of at least 45° between digital examination and transabdominal ultrasound in 53 and 39% of patients in the first and second stage of labor, respectively. Akmal et al. [13] reported that digital pelvic examination failed to determine the fetal head position in 34% of laboring women, and incorrectly determined head position in 51% of patients in whom the position could be defined. The rate of correct identification of the fetal position by digital examination increased with cervical dilatation, and if there was absence rather than presence of caput. Souka et al. [14] showed that assessment of the fetal head position by digital examination was not possible in 61% of cases in the first stage and in 31% in the second stage of labor. Difficulty in assessing the position was more likely if the occiput was posterior in comparison to anterior and in the maternal right in comparison to the left side. When assessment by vaginal examination was possible, fetal head position assessment by digital examination was accurate in 31% of the cases in the first stage and in 66% of cases in the second stage of labor.

The inaccuracy of clinical examination during labor has also been demonstrated in the descent of the head over the different planes of the maternal pelvis. Dupuis et al. [15] investigated the reliability of transvaginal assessment of fetal head station by using a newly designed birth simulator. A fetal head mannequin was placed in 1 of the 11 American College of Obstetricians and Gynecologists (ACOG) stations in a birth simulator equipped with real-time miniaturized sensor. The operators (32 residents and 25 obstetricians) then determined head position clinically. Mistakes in the ACOG position occurred in 50–88% of cases for residents and in 36–80% of cases for obstetricians, depending on the position. Regarding 'group' errors, classified as high, mid-pelvis, low and outlet, the mean 'group' error was 30% (95% CI 25–35%) for resi-

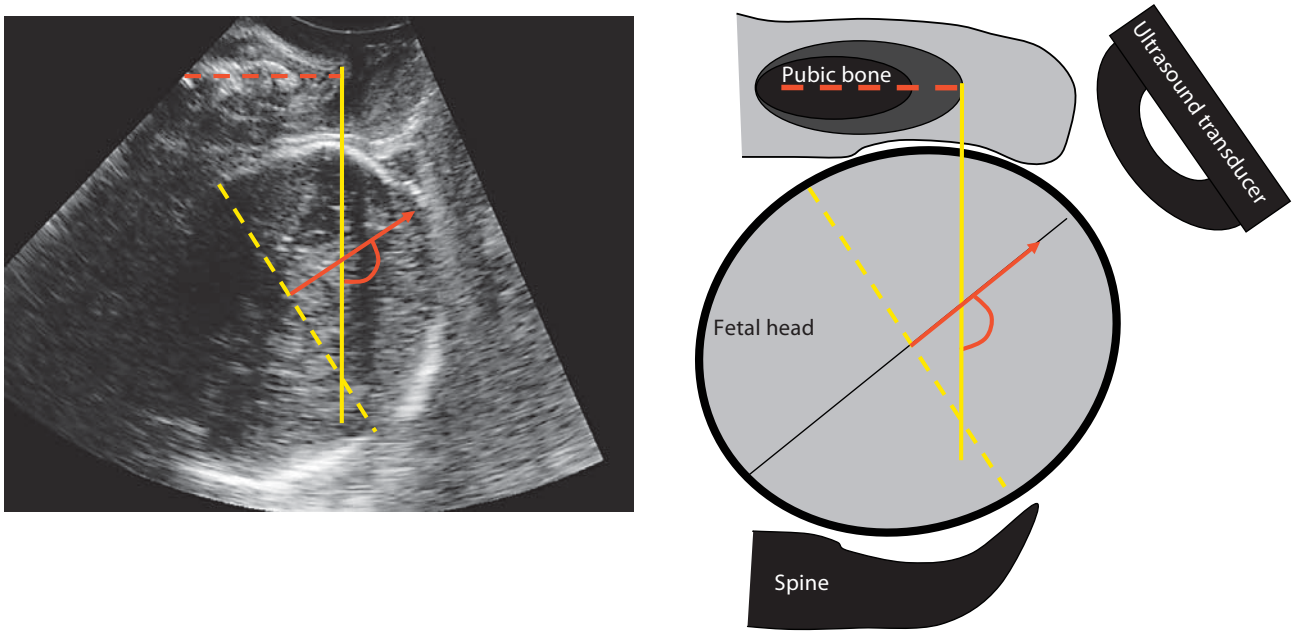

Fig. 1. Ultrasound image and drawing to demonstrate the fetal head direction described as the angle between a vertical line from inferior apex of the symphysis (yellow line) and another line drawn perpendicular to the widest diameter of the fetal head (red line).

dents and 34% (95% CI 27–41%) for obstetricians and alarmingly, from the group errors, the misdiagnosis of a station as representing a mid-pelvic station rather than a true high-pelvic station accounted for 88 and 67% of the errors made by residents and obstetricians, respectively. This can have major implications in the management of the patients in labor.

Several studies have used ultrasound to provide an objective measure of head progression in labor [16]. Head direction was defined by Henrich et al. [17] as the angle between the infrapubic line of the pelvis (a line perpendicular to the longer diameter of the pubis starting from the inferior border) and another line drawn perpendicular to the widest diameter of the fetal head (fig. 1). Using this technique, three types of head direction were determined: head down, horizontal and head up. 'Head up' is when the line drawn perpendicular to the widest diameter of the fetal head points ventrally at an angle of $\geq 30°$; head down is when this angle is $<0°$; all other angles are considered 'horizontal'. The head direction together with the descent in the maternal pelvis is a good indicator of successful vaginal delivery. An upward direction of the fetal head is a sign of good prognostic value for vaginal delivery contrary to a downward or horizontal direction of the head.

Ghi et al. [18] combined head direction with the degree of rotation of the middle line of the fetal head to establish the descent in the pelvis and the prognosis of a vaginal delivery. Using translabial ultrasound at the second stage of labor, they observed that patients with a downward direction of the fetal head would be eligible for an abdominal delivery because the presenting part of the fetus was above the mid-pelvis. A horizontal direction of the fetal head correlated in 90% of the cases with a mid-pelvis position of the fetal head and the management is unclear. Eventually, an upward direction indicated that the head was in the lower third of the pelvis in 89% of the cases. The combination of an upward direction of the fetal head with a rotation of $<45°$ indicated in 95% of the cases that the station of the fetal head was +3 cm or more and those patients could be delivered vaginally.

Another of these measurements is the angle of progression of the fetal head, described as the angle between a line through the midline of the pubic symphysis and a

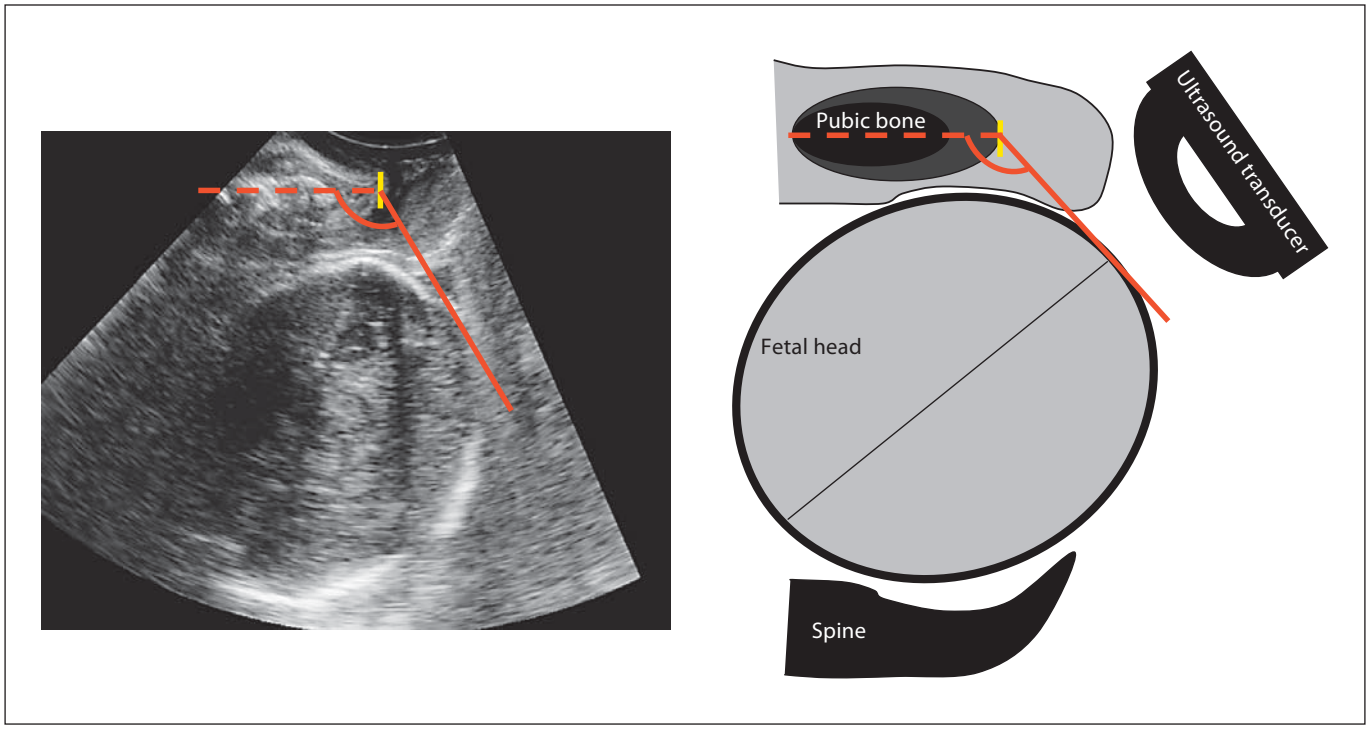

Fig. 2. Ultrasound image and drawing to demonstrate the angle of progression of the fetal head described as the angle between a line through the midline of the pubic symphysis (interrupted red line) and a line from the inferior apex of the symphysis to the leading part of the fetal skull (solid red line).

line from the inferior apex of the symphysis to the leading part of the fetal skull (fig. 2). An angle of progression of 120° or greater is an excellent predictor of a successful vaginal delivery. Kalache et al. [19] evaluated prospectively this measurement in women at term with failure to progress in the second stage of labor. Logistic regression analysis showed a strong relationship between the angle of progression and the need for cesarean delivery. When the angle of progression was 120°, the fitted probability of either an easy and successful vacuum extraction or spontaneous vaginal delivery was 90%. The same angle was measured by Barbera et al. [20] in 88 term laboring patients. He described a good intra- and inter-observer variability for the measurement that was less than 3°. Their data showed that an angle of at least 120° was always associated with subsequent spontaneous vaginal delivery. They also correlated the angle of progression with digital examination to determine head descent in the pelvis, finding a particularly poor correlation in mid-station (clinical station –2 to 0), reflecting how difficult it is for clinicians to accurately quantify clinical head station using the more subjective method of digital examination.

Dietz et al. [21] described the progression distance of the head as the minimal distance from a line through the infero-posterior symphyseal margin (parallel to the main transducer axis) and the leading edge of the fetal skull (fig. 3). This was described in 140 nulliparous pregnant women who were not in labor for the assessment of head engagement. The authors provided evidence that this method was highly reproducible and the progression distance correlated well with the station of the fetal head by a combination of abdominal palpation and vaginal digital examination. This measurement may also be of value in determining the progress of the head in the second stage of labor.

The three measurements, head direction, angle of progression and progression distance, together with the angle from the middle line of the head to the vertical line of the pelvis (as an indicator of the rotation of the fetal head to anterior position) have been incorporated in a 3D software called Sonography-based Volume Computer Aided Display, (SonoVCAD™labor. Voluson i, General Electric). The aim of SonoVCAD is to provide an objective measure of progression of the fetal head during labor.

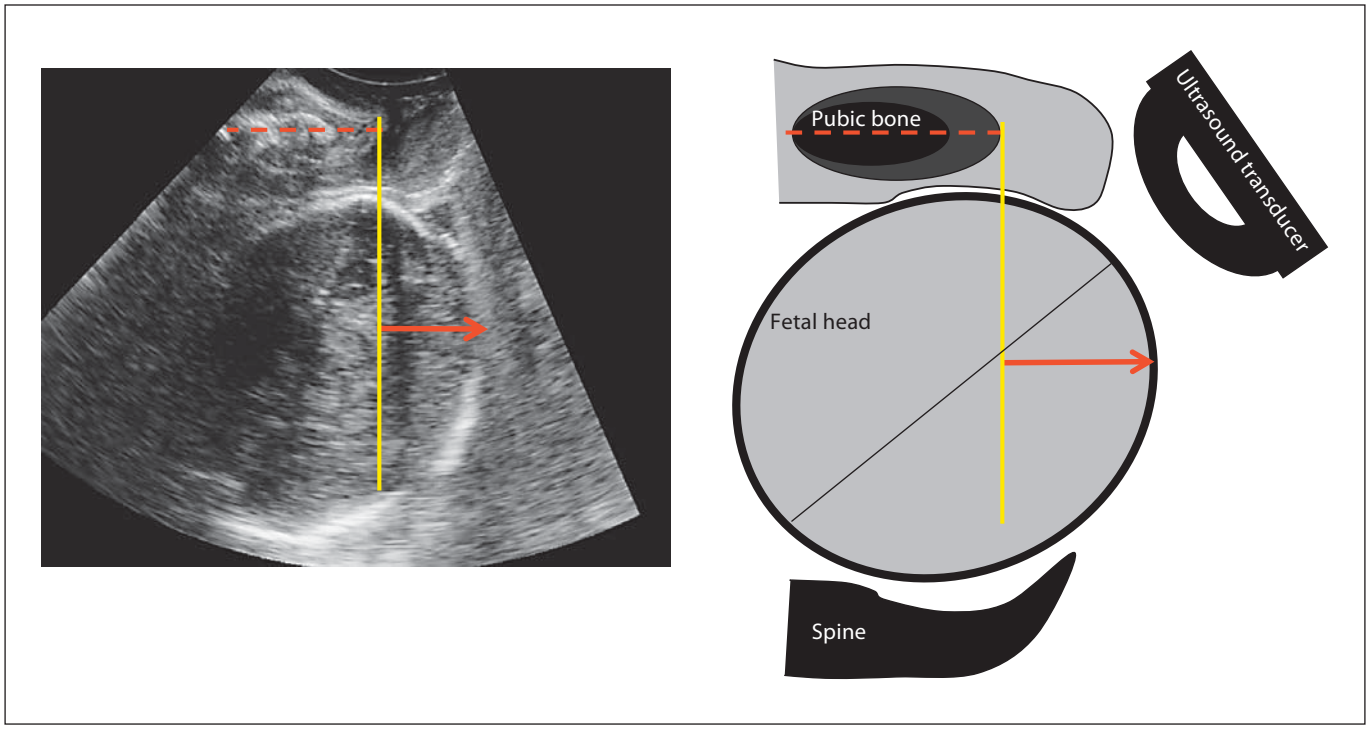

Fig. 3. Ultrasound image and drawing to demonstrate the progression distance of the head described as the distance (red line) between a vertical line from inferior apex of the symphysis (yellow line) to the leading edge of the fetal skull.

However, there are no prospective studies using this tool to establish which of the measurements is more reliable and accurate in the prediction of vaginal delivery and in general there is a limitation of these measurements to an anterior position of the fetal occiput.

Ultrasound to Define Fetal Head Position before Instrumental Delivery

Instrumental delivery is an integral part of obstetric care and is indicated for prolonged second stage of labor or fetal compromise or to shorten the second stage of labor for maternal indications, such as cardiac, pulmonary, cerebrovascular or neuromuscular disease.

Akmal et al. [22] carried out a study in 64 singleton pregnancies undergoing instrumental delivery. The fetal head position was determined by transvaginal digital examination by the attending obstetrician. Immediately after or before the clinical examination the fetal head position was determined by transabdominal ultrasound by a trained sonographer who was not aware of the clinical findings. The digital examination was considered to be correct if the fetal head position was within ±45° of the ultrasound finding. Digital examination failed to define the correct fetal head position in 27% of cases. The accuracy of vaginal digital examination was higher for occiput-anterior than occiput-lateral and occiput-posterior positions (83 vs. 54%) and for fetal head below than at the level of the ischial spines (77 vs. 33%).

An important determinant of a successful and safe use of vacuum and forceps is the correct determination of the fetal head position and appropriate application of the instrument. Thus, placement of the vacuum cup on the flexing point and placement of the forceps blades parallel to the sagittal suture are associated with high success rate and reduction in maternal and fetal morbidity [23, 24]. In contrast a deflexing or parasagittal placement of the vacuum on the fetal head, results in higher failure rate, cup detachment and fetal morbidity. In this study of vacuum extractions, incorrect cup placement was reported in about half of the procedures and an increase in neonatal injury from 5% for flexing median placement of the cup to 45% for deflexing paramedian application [23].

Wong et al. [25] have demonstrated that the accuracy of vacuum cup placement prior to vacuum extraction can be improved using transabdominal ultrasonographic assessment of the fetal head position. They randomly allocated 50 women with prolonged second stage to either digital examination (n = 25) or digital examination together with transabdominal intrapartum ultrasound (n = 25) prior to vacuum extraction by the attending obstetrician. The distance between the center of the chignon and the flexion point was then measured by a midwife immediately after delivery. The flexion point was defined as 6 cm posterior to the anterior fontanel or 3 cm anterior to the posterior fontanel. The mean distance between the center of the chignon and the flexion point was significantly lower in the group with digital examination and ultrasound assessment than in the group with digital examination alone (2.1 vs. 2.8 cm).

Assessment of fetal head station with regard to the narrowest part of the maternal bony pelvis is of crucial importance in performing a safe operative vaginal delivery. In this respect, Henrich et al. [17] defined easily obtainable sonographic criteria during maternal pushing immediately before vacuum extraction to predict successful operative vaginal delivery. They used mid-sagittal translabial insonation to determine the following maternal and fetal landmarks during maternal pushing: (i) the 'infrapubic line', perpendicular to the long axis of the pubic joint and extending dorsally from its inferior margin in a mid-sagittal plane; (ii) the widest fetal head diameter and its movement with regard to the infrapubic line during pushing, and (iii) the 'head direction'. They subsequently examined 20 pregnant women in spontaneous term labor in cephalic presentation immediately before vacuum extraction. Good prognostic signs for a successful delivery were the 'head-up' sign (head pointing ventrally) and objective descent of the fetal head below the infrapubic line, both noted at the height of pushing. Lack of descent or lack of passage below the infrapubic line and horizontal or downward head direction were poor prognostic signs.

The findings of the above studies demonstrate that ultrasound scanning for accurate determination of the fetal head position should be performed routinely before instrumental delivery.

References

1 RCOG: Induction of labor; in Evidence-Based Clinical Guideline Number 9. London, RCOG Clinical Support Unit, 2001.
2 Crowley P: Interventions for preventing or improving the outcome of delivery at or beyond term. Cochrane Database Syst Rev 2000;2:CD000170.
3 Crane JM: Factors predicting labor induction success: a critical analysis. Clin Obstet Gynecol 2006;49:573–584.
4 Fitzpatrick M, McQuillan K, O'Herlihy C: Influence of persistent occiput posterior position on delivery outcome. Obstet Gynecol 2001;98:1027–1031.
5 Sizer AR, Nirmal DM: Occipitoposterior position: associated factors and obstetric outcome in nulliparas. Obstet Gynecol 2000;96:749–752.
6 Gardberg M, Laakkonen E, Salevaara M: Intrapartum sonography and persistent occiput posterior position: a study of 408 deliveries. Obstet Gynecol 1998;91:746–749.
7 Rane SM, Guirgis RR, Higgins B, Nicolaides KH: Pre-induction sonographic measurement of cervical length in prolonged pregnancy: the effect of parity in the prediction of the need for Cesarean section. Ultrasound Obstet Gynecol 2003;22:45–48.
8 Rane SM, Guirgis RR, Higgins B, Nicolaides KH: Models for the prediction of successful induction of labor based on pre-induction sonographic measurement of cervical length. J Matern Fetal Neonatal Med 2005;17:315–322.
9 Darmstadt GL, Yakoob MY, Haws RA, Menezes EV, Soomro T, Bhutta ZA: Reducing stillbirths: interventions during labor. BMC Pregnancy Childbirth 2009;9(suppl 1):S6.
10 Rao A, Celik E, Poggi S, Poon L, Nicolaides K: Cervical length and maternal factors in expectantly managed prolonged pregnancy: prediction of onset of labor and mode of delivery. Ultrasound Obstet Gynecol 2008;32:646–651.
11 Sherer DM, Miodovnik M, Bradley KS, Langer O: Intrapartum fetal head position I: comparison between transvaginal digital examination and transabdominal ultrasound assessment during the active stage of labor. Ultrasound Obstet Gynecol 2002;19:258–263.
12 Sherer DM, Miodovnik M, Bradley KS, Langer O: Intrapartum fetal head position II: comparison between transvaginal digital examination and transabdominal ultrasound assessment during the second stage of labor. Ultrasound Obstet Gynecol 2002;19:264–268.
13 Akmal S, Tsoi E, Kametas N, Howard R, Nicolaides KH: Intrapartum sonography to determine fetal head position. J Matern Fetal Neonatal Med 2002;12:172–177.
14 Souka AP, Haritos T, Basayiannis K, Noikokyri N, Antsaklis A: Intrapartum ultrasound for the examination of the fetal head position in normal and obstructed labor. J Matern Fetal Neonatal Med 2003;13:59–63.
15 Dupuis O, Silveira R, Zentner A, Dittmar A, Gaucherand P, Cucherat M, Redarce T, Rudigoz RC: 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;192:868–874.
16 Yeo L, Romero R: Sonographic evaluation in the second stage of labor to improve the assessment of labor progress and its outcome. Ultrasound Obstet Gynecol 2009;33:253–258.
17 Henrich W, Dudenhausen J, Fuchs I, Kamena A, Tutschek B: Intrapartum translabial ultrasound (ITU): sonographic landmarks and correlation with successful vacuum extraction. Ultrasound Obstet Gynecol 2006;28:753–760.

18 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;33:331–336.
19 Kalache KD, Dückelmann AM, Michaelis SAM, 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;33:326–330.
20 Barbera A, Pombar X, Perugino G, Lezotte D, Hobbins J: A new method to assess fetal head descent in labor with transperineal ultrasound. Ultrasound Obstet Gynecol 2009;33:313–319.
21 Dietz HP, Lanzarone V: Measuring engagement of the fetal head: validity and reproducibility of a new ultrasound technique. Ultrasound Obstet Gynecol 2005;25:165–168.
22 Akmal S, Kametas N, Tsoi E, Hargreaves C, Nicolaides KH: Comparison of transvaginal digital examination with intrapartum sonography to determine fetal head position before instrumental delivery. Ultrasound Obstet Gynecol 2003;21:437–440.
23 Vacca A, Keirse MJNC: Instrumental vaginal delivery; in Chalmers I, Enkin M, Keirse MJNC (eds): Effective Care in Pregnancy and Childbirth. Oxford, Oxford University Press, 1989, pp 1216–1233.
24 Mola GD, Amoa AB, Edilyong J: Factors associated with success or failure in trials of vacuum extraction. Aust NZ J Obstet Gynaecol 2002;42:35–39.
25 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;98:120–123.