

SONOGRAPHIC PARAMETERS FOR DIAGNOSING FETAL HEAD ENGAGEMENT DURING LABOUR

ABSTRACT

Purpose: To investigate the diagnostic performance of the Head-Perineum Distance (HPD), Angle of Progression (AoP) and the Head-Symphysis Distance (HSD) as intrapartum ultrasound parameters in the determination of an engaged fetal head.

Material and Methods 201 women in labour underwent both ultrasound and digital vaginal examination (digital VE) in the estimation of fetal head station. The transperineal ultrasound measured HPD, AoP and HSD for values correlating with digital VE head station. Using station 0 as the minimum level of head engagement, correlating cut-off values for HPD, AoP, and HSD were obtained. Receiver operating characteristics (ROC) were used in determining the diagnostic performance of these cut-off values for the detection of fetal head engagement.

Results With HPD of 3.6cm the sensitivity and specificity of sonographic determination of engaged fetal head were 78.7 % and 72.3% respectively. A HSD of 2.8cm also had sensitivity and specificity of 74.5% and 70.8 % respectively in determining engagement, whilst an AoP of 101° was consistent with engagement by digital VE with 68.1% sensitivity and 68.2 % specificity.

Conclusion Ultrasound shows high diagnostic performance in determining engaged fetal head at an HPD of $\leq 3.6\text{cm}$, HSD of $\leq 2.8\text{cm}$, and AoP of $\geq 101^\circ$.

INTRODUCTION

Establishing engagement of the fetal head is important in active labour, as non-engagement at some point of cervical dilatation would indicate the need for caesarean section ^{1, 2, 3}. It is therefore useful to know if head station is within the expected range of a given cervical dilation in the first stage of active labour ^{4, 5}. Where instrumental vaginal delivery is being considered in the second stage of active labour, confirming the engagement of the fetal head is also a requirement ^{6, 7}.

Conventionally, the determination of head station and engagement are done by digital vaginal examination (Digital VE). However, apart from the reported cases of maternal discomfort ^{8, 9} and the increased risk of infection associated with this traditional method ¹⁰, there are also reports of high levels of subjectivity and misdiagnosis ¹¹. A number of publications have reported sonographic parameters that could serve as an alternative non-invasive method for determining fetal head station, and with the potential of diagnosing fetal head engagement. The most commonly reported sonographic parameters for head station are the head-perineum distance (HPD) and the angle of progression (AoP) ¹². However, whilst the diagnostic value of HPD in determining a non-engaged fetal head had been reported, the HPD value for an engaged fetal head had not been reported. Again, in spite of the increasing number of publications reporting significant correlation between the sonographic AoP and the digital VE head station, we know from a recently published systematic review that, the diagnostic value of the AoP for detecting an engaged fetal head was not yet reported¹². In addition, other reported sonographic parameters for determining head station, such as the head-symphysis distance (HSD), had not been assessed for diagnostic performance in determining fetal head engagement.

The primary objective of this paper therefore was to investigate the diagnostic performance of the HPD, AoP and the HSD in the determination of an engaged fetal head.

METHODS

This is a prospective cross sectional study which was conducted at the labour and delivery ward of a Teaching Hospital in Ghana, between April and September 2016. The study was approved by the institutional ethics review board, and informed consent was obtained from all study participants. It included 201 consenting pregnant women at a gestational age of 37 to 42 weeks. The inclusion criteria was singleton gestation, cephalic presentation, and spontaneous labour. Women in labour with the following conditions were excluded: induction of labour, breech presentation, multiple pregnancy, polyhydramnios, sonographically detected fetal abnormalities, and previous caesarean section.

Digital VE was performed by the managing clinician on duty to determine the fetal head station of consenting participants, along with other routinely measured parameters for assessing labour progress. These examiners were specialists with at least 5 years of experience in intrapartum care. Station was estimated by assessing the relationship between the level of the ischial spines and the leading edge of the fetal head¹³. Engagement referred to the leading edge of the fetal head being at the level of the ischial spines or further below (i.e. stations 0 to +5)^{11, 13}. Therefore, non-engagement implied that the leading edge of fetal head was above the ischial spines (i.e. stations -1 to -5). All digital VEs were performed in the absence of uterine contraction.

Immediately after the digital VE, transperineal ultrasound was performed by an independent ultrasound investigator with over 10 years of experience, who was blinded from the digital VE findings, to measure the HPD, AoP and HSD. The ultrasounds were performed with a mobile ultrasound unit (P 300, Siemens-Acuson, Italy), using a 2-5MHz curvilinear transducer.

The transperineal ultrasound examination was performed by placing the curvilinear transducer at the perineal space between the labia and the anus. With the transducer held in the sagittal plane over the perineal region, the fetal head was displayed on the monitor often with part of

the symphysis pubis showing. The transducer was tilted slightly to direct the sound beam towards clear visualisation of the symphysis pubis in its longest axis (see figure 1). In some cases slight rotational manoeuvres were necessary for obtaining the longest axis of the symphysis pubis.

The image was frozen upon visualisation of the symphysis pubis to obtain measurements for the AoP. This was measured by drawing a line through the long axis of the symphysis pubis, using the 'distance' calliper on the machine. By clicking on another distance calliper, a second line was then drawn from the inferior edge of the symphysis pubis to form a tangent with the leading edge of the fetal head as shown in figure 2. Afterwards, a goniometer was then used in measuring the angle formed by the two drawn lines obtaining the AoP as described by Barbera et al¹⁴.

The HSD was also obtained from the same plane as the AoP by placing the distance calliper at the inferior edge of the symphysis pubis to obtain a perpendicular distance from the midline in the symphysis pubis to the fetal head in centimetres as described by Yousef et al¹⁵ (see figure 3).

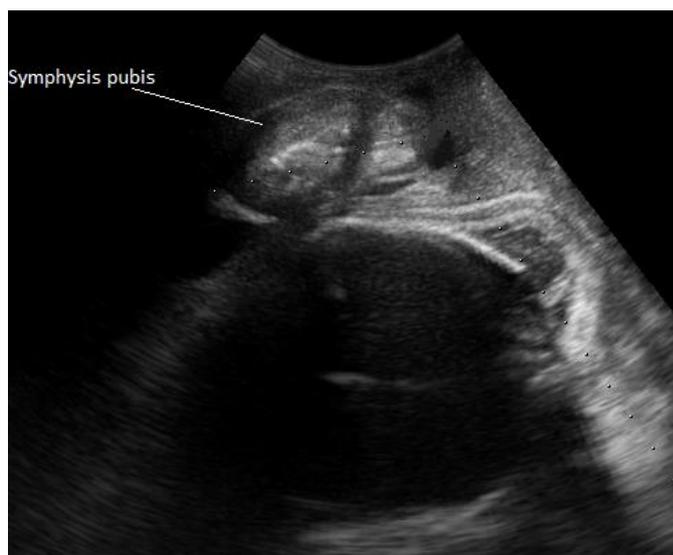


Figure 1: The symphysis pubis in long axis

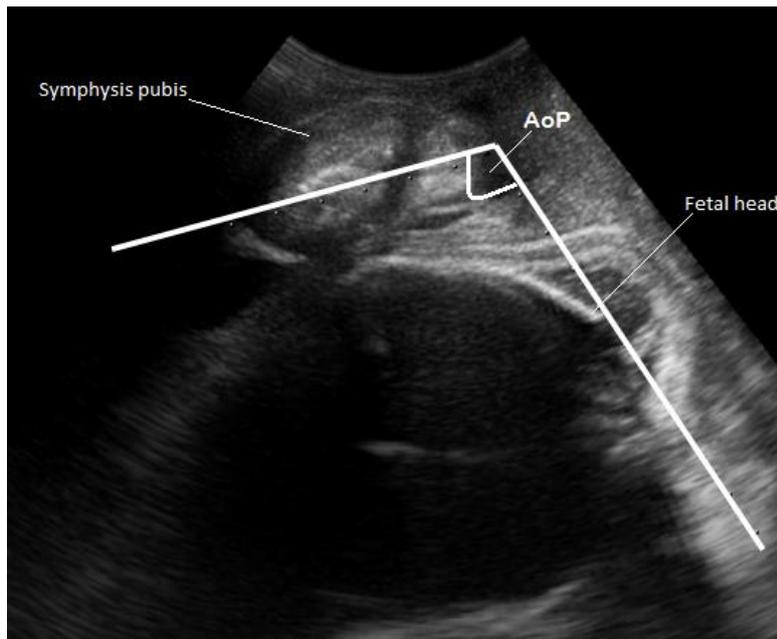


Figure 2: The AoP measurement

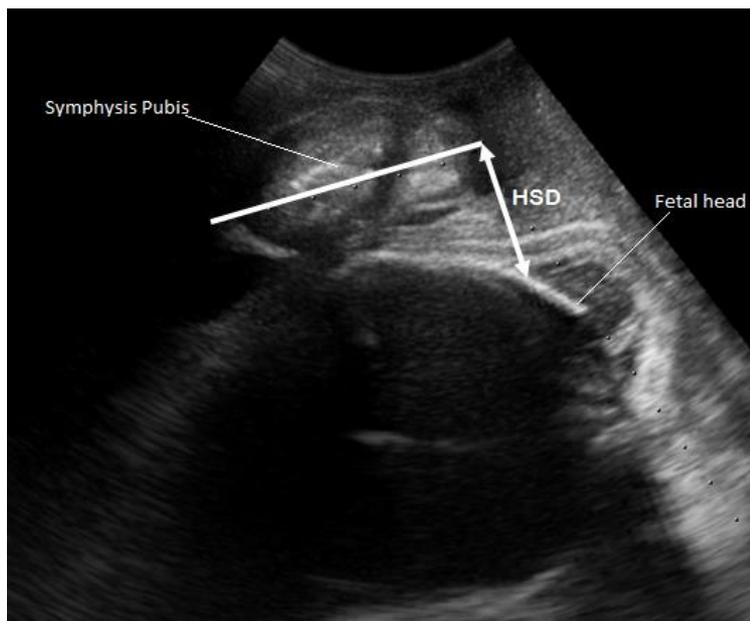


Figure 3: The HSD measurement

From the sagittal plane, the transducer was rotated 90° anti-clockwise for a transverse plane image. The transducer was gripped firmly to prevent it from sliding or tilting. Gentle pressure was then applied until the hard pelvic bone could be felt. The image was then frozen to measure

the HPD as the distance from the fetal head to the surface of the perineum as described by Eggebo et al¹⁶ (see Figure 4).

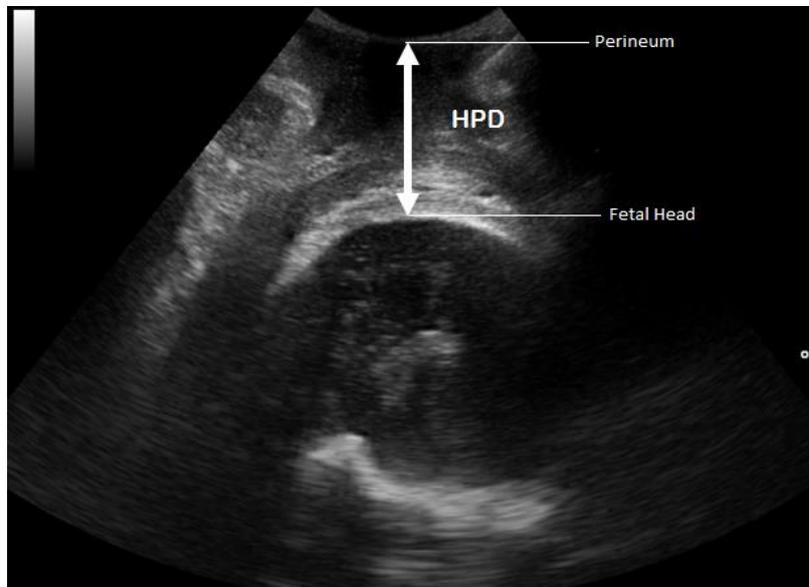


Figure 4: The HPD measurement

Data were entered into an Excel Spread Sheet. Data were then expressed as Mean \pm SD and 95% confidence interval. P-value less than 0.05 was considered for statistical significant difference. Receiver operating characteristics (ROC) curve was performed to assess the diagnostic performance of the HPD, AoP, and HSD in comparison with digital VE findings on fetal head station for the determination of engagement. Data analysis was done with XLSTAT version 2015 for windows.

RESULTS

Out of the total 201 parturients who participated in the study, data analysis was possible in 196 participants, due to some missing information on 5 participants. Participants were in the age range of 20 to 39 years, which included 47% nulliparous women, 22% primiparous, and 31% multiparous. Their average gestational age before spontaneous onset of labour was about 39

weeks + 4 days. Also, their body mass index (BMI) was in the range of 20kg/m² to 42kg/m² with the average being approximately 28kg/m².

188 out of the 196 participants which represents 96% were in the digital VE head station range of -2 to +2. The highest percentage of participants were diagnosed by digital VE as being at station 0, followed by station -1. Generally, 46 % were diagnosed by digital VE as non-engaged at various stations above the maternal ischial spines, whilst 54% were diagnosed as engaged at various stations below the maternal ischial spines.

Table 1 shows the average HPD, HSD and AoP values and the corresponding fetal head station reported by digital VE in the 188 participants whose head station ranged from -2 to +2. Generally, an HPD of 3.9cm was the upper-limit of station 0 whilst a HPD of 3.4cm was the lower-limit of station 0.

Also, a HSD of 3cm was the upper-limit of station 0, whilst an HSD of 2.6cm was the lower-limit of station 0. Lastly, an AoP of 98° was the lower-limit of station 0, whilst an AoP of greater than 105° was the upper-limit of station 0.

Table 1 Mean levels of HPD, HSD and AoP in relation to fetal head station by digital VE

STATION	-2	-1	0	1	2
N=196	N=27	N=57	N=62	N=29	N=13
HPD (CM)					
MEAN ± SD	4.42 ± 0.60	4.17 ± 0.86	3.64 ± 0.94	3.27 ± 0.60	3.08 ± 0.42
95% CI	(4.17 to 4.66)	(3.94 to 4.39)	(3.40 to 3.88)	(3.04 to 3.50)	(2.85 to 3.29)
HSD (CM)					
MEAN ± SD	3.47 ± 0.52	3.36 ± 0.64	2.83 ± 0.64	2.43 ± 0.74	2.13 ± 0.53
95% CI	(3.26 to 3.67)	(3.19 to 3.53)	(2.67 to 2.99)	(2.15 to 2.71)	(1.84 to 2.42)
AOP (DEG)					
MEAN ± SD	88.52 ± 7.23	91.92 ± 13.60	101.4 ± 13.4	108.2 ± 14.7	108.6 ± 8.58
95% CI	(85.6 to 91.3)	(88.3 to 95.46)	(98.0 to 104.8)	(102.6 to 113.8)	(104 to 113.1)

Figures 4, 5 and 6, and Table 2 show the diagnostic performance of HPD, HSD and AoP as sonographic methods of assessing fetal head engagement. Using the ROC curve, the threshold for HPD below which head engagement would be diagnosed was 3.6cm, as it was the average HPD value corresponding to station 0. On the basis of this threshold, AUC, the sensitivity, specificity, positive predictive value and negative predictive value of ultrasound of HPD for diagnosing engaged fetal head were 0.7946, 78.7%, 72.3%, 49.0% and 92.0% respectively.

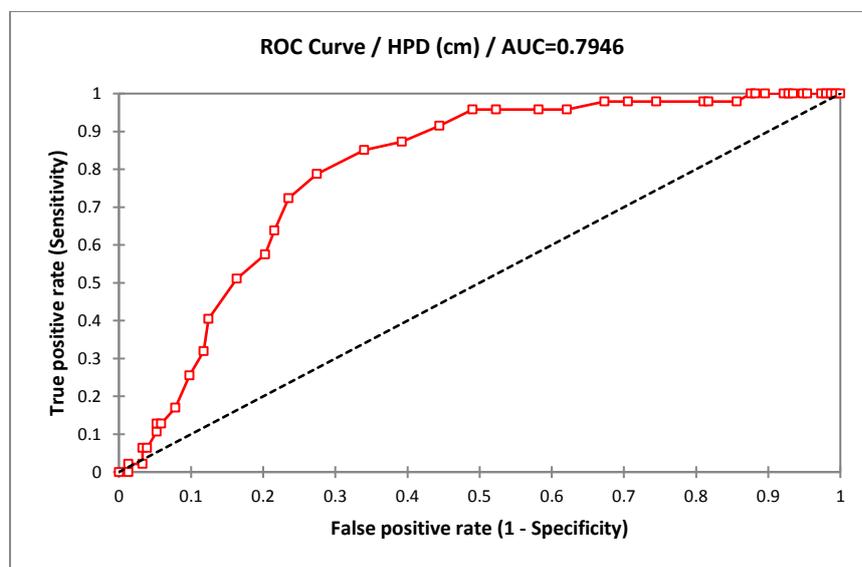


Figure 4 ROC Curve showing the diagnostic performance of HPD on engagement

Secondly, the cut-off value for HSD below which head engagement would be diagnosed was 2.8cm, as it was the average HSD value corresponding to station 0. On the basis of this threshold, AUC, the sensitivity and specificity of ultrasound for diagnosing engaged fetal head were 0.8265, 74.5% and 70.8%, respectively. The positive predictive value and negative predictive values for HSD were 44.0% and 90.0%.

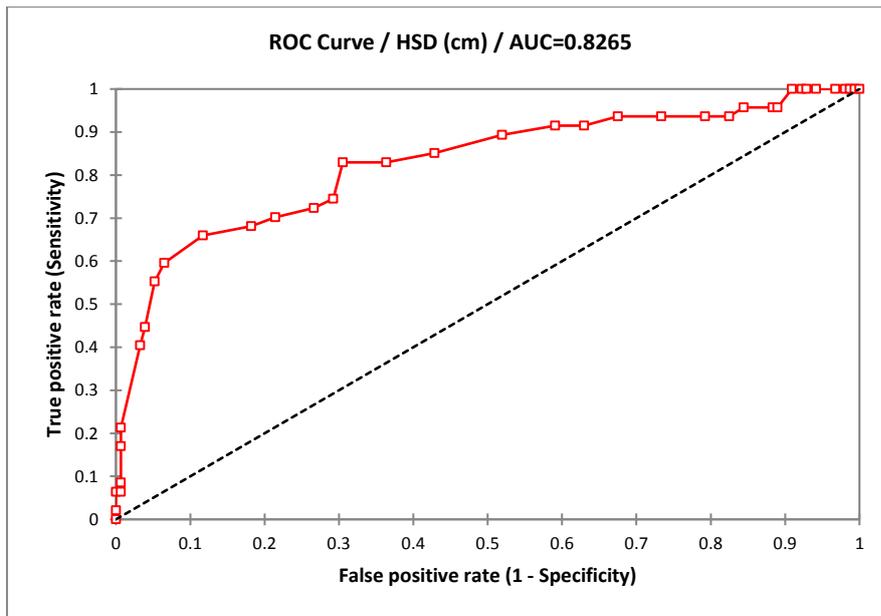


Figure 5 ROC Curve showing the diagnostic performance of HSD on engagement

Thirdly, the threshold for AoP above which head engagement would be diagnosed was 101°, as it was the average AoP value corresponding to station 0. On the basis of this threshold, area under ROC curve (AUC), the sensitivity and specificity of ultrasound for diagnosing engaged fetal head were 0.7729, 68.1% and 68.2%, respectively. The positive predictive value and negative predictive value were 39.5% and 87.5% respectively.

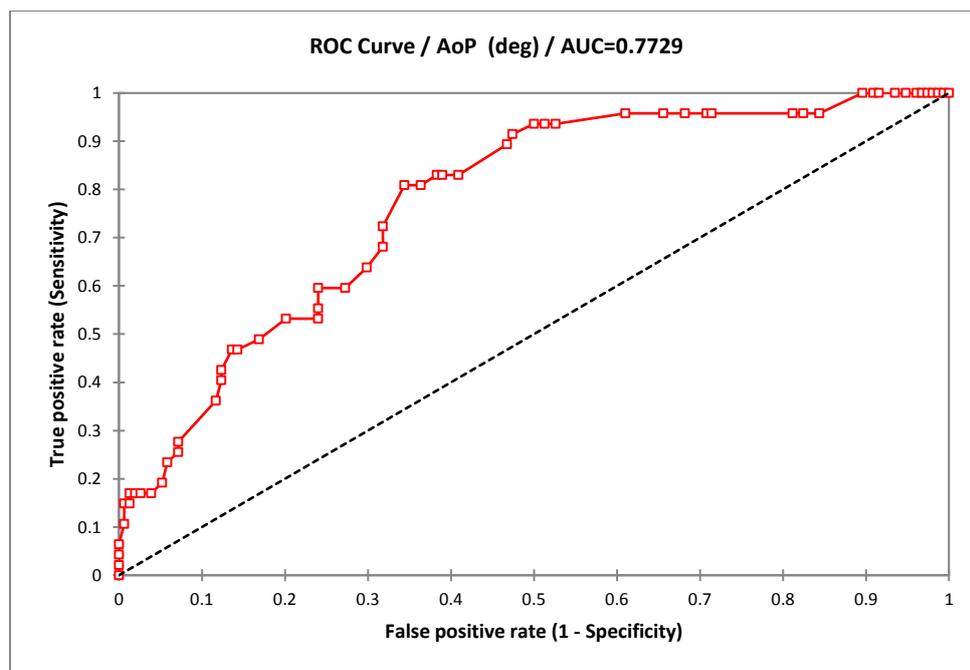


Figure Error! No text of specified style in document. ROC Curve showing the diagnostic performance of AoP on engagement

Table 2 Diagnostic performance of HPD, HSD and AoP on fetal head engagement

HPD(cm)	3.60	78.7(65.0-88.1)	72.3(65.0-79.0)	49.0	92.0	37	111	42	10	74.0
HSD cm)	2.80	74.5(60.0-84.0)	70.8(63.1-77.4)	44.0	90.0	35	109	45	12	71.6
AoP (deg)	101.0	68.1(54.0-79.6)	68.2(60.4-75.0)	39.5	87.5	32	105	40	15	68.2

DISCUSSION

This study investigated the diagnostic performance of sonographic parameters in detecting engaged fetal head. Earlier studies by Maticot-Baptista *et al*¹⁷ and Dimassi *et al*¹⁸ reported that a HPD of 5.5cm or higher was predictive of fetal head non-engagement with high sensitivity and specificity, but provided no HPD predictive for an engaged fetal head. Given that the distance from the perineum to the maternal ischial spines is reported to be 5cm apart^{16, 19}, an HPD value for an engaged fetal head would be expected to be ≤ 5 cm since engagement occurs around station 0 or at a station further below¹⁴. However in the 62 parturients whose digital VE

head station was 0, the HPD obtained was in the range of 3.4cm to 3.9 cm (Table 1). Consequently, the average HPD of 3.6cm was used as the cut-off value for high likelihood of predicting an engaged fetal head, just as a HPD of ≥ 5.5 cm was reported as being predictive of non-engagement. The 3.6cm average HPD for station 0 was in perfect agreement with Tutchek *et al*²⁰ who earlier reported that a HPD of 3.6cm corresponded with station 0 in their study population. However their study provided no information on the diagnostic performance in connection with fetal head engagement.

With regards to the AoP, this study noted that digital VE station 0 averagely corresponded with 101°. This AoP value obtained by this study in correlation with station 0 is apparently lower than the 123° reported by Chan *et al*²¹ in the Chinese study population, and the 116° reported by Tutschek *et al*²⁰ in the Norwegian study population. It is however closer to the 99° obtained by Barbera *et al*²² which compared the AoP to CT scan findings in a separate non-gravid population. In a related finding, this study also noticed that the 62 parturients with digital VE head station 0 had an AoP in the range of 98° to 105°, and that using an AoP of $\geq 99^\circ$ was a good predictive value for fetal head engagement as the findings indicate (table 2). It however implies that these studies all agree on station 0 typically corresponding to an AoP above 99° and therefore highly probable to be indicative of an engaged fetal head as the AoP gets wider above 100°.

Thirdly, although not as well-known as the HPD and AoP, the HSD was also investigated by this study because it is measured in the same plane as the AoP, and could therefore serve as an additional sonographic parameter that could complement the HPD and the AoP for determining an engaged fetal head. This suggests that all three parameters may be measured to confirm agreement, as in the use of fetal biometry for the estimation of fetal growth where it is standard to measure more than one parameter for comparability and verification. It also indicates that a

high agreement amongst the three may increase confidence in these intrapartum sonographic parameters if chosen as the method for determining fetal head engagement in a given parturient.

To the best of our knowledge, this is the first time the diagnostic performance of ultrasound in detecting engaged fetal head has been reported. Secondly, this study was performed in a black African population for the first time. The shape of the female pelvis might differ between populations. Thus this article also adds important knowledge about using ultrasound in labour in other populations.

REFERENCES

1. Murphy K, Shah L, Cohen WR. Labor and delivery in nulliparous women who present with an unengaged fetal head. *J perinatol*: 1998; 18(2):122-5.
2. Friedman EA, Sachtleben MR. Station of the fetal presenting part: III. Interrelationship with cervical dilatation. *Am J Obstet Gynecol*. 1965 Oct 15; 93 (4):537-42.
3. Segel SY, Carreño CA, Weiner SJ, Bloom SL, Spong CY, Varner MW, Rouse DJ, Caritis SN, Grobman WA, Sorokin Y, Sciscione A. Relationship between fetal station and successful vaginal delivery in nulliparous women. *Am J Perinat* 2012 Oct; 29(09):723-30.
4. Debby A, Rotmensch S, Girtler O, Sadan O, Golan A, Glezerman M. Clinical significance of the floating fetal head in nulliparous women in labor. *J Reprod Med*. 2003 Jan; 48(1):37-40.
5. Hamilton EF, Simoneau G, Ciampi A, Warrick P, Collins K, Smith S, Garite TJ. Descent of the fetal head (station) during the first stage of labor. *Am J Obstet Gynecol*. 2016 Mar 31; 214(3):360-e1.
6. Elisabeth KW, Ira MB. Operative vaginal delivery. *Up to Date (Guideline)*. 2006.

7. Sekia H, Takedab S. A review of prerequisites for vacuum extraction: Appropriate position of the fetal head for vacuum extraction from a forceps delivery perspective. *Medical & Clinical Reviews*. 2016.
8. Dixon L, Foureur M. The vaginal examination during labour. Is it of benefit or harm?. *New Zealand College of Midwives Journal*. 2010.
9. Lewin D, Fearon B, Hemmings V, Johnson G. Women's experiences of vaginal examinations in labour. *Midwifery*. 2005 Sep 30;21(3):267-77.
10. Maharaj D. Puerperal pyrexia: a review. Part I. *Obstet Gynecol Surv*. 2007 Jun 1; 62(6):393-9.
11. Buchmann E, Libhaber E. Interobserver agreement in intrapartum estimation of fetal head station. *Int J Gynecol Obstet*. 2008 Jun 1;101(3):285-9.
12. Wiafe YA, Whitehead B, Venables H, Nakua EK. The effectiveness of intrapartum ultrasonography in assessing cervical dilatation, head station and position: A systematic review and meta-analysis. *Ultrasound*. 2016 Nov 1;24(4):222-32.
13. Cunningham FG, Leveno KJ, Bloom SL, Hauth JC, Gilstrap III L, Wenstrom KD. *Williams Obstetrics*. 22nd ed. New York: McGraw-Hill; 2005. p. 409–41.
14. Barbera AF, Pombar X, Perugino G, Lezotte DC, Hobbins JC. A new method to assess fetal head descent in labor with transperineal ultrasound. *Ultrasound Obst Gyn*. 2009 Mar 1;33(3):313-9.
15. Youssef, A., Maroni, E., Ragusa, A., De Musso, F., Salsi, G., Iammarino, M.T., Paccapelo, A., Rizzo, N., Pilu, G. and Ghi, T., 2013. Fetal head–symphysis distance: a simple and reliable ultrasound index of fetal head station in labor. *Ultrasound Obstet Gyn*, 41(4), pp.419-424.
16. Eggebø TM, Gjessing LK, Heien C, Smedvig E, Økland I, Romundstad P, Salvesen KÅ. Prediction of labor and delivery by transperineal ultrasound in pregnancies with prelabor rupture of membranes at term. *Ultrasound Obstet Gyn*. 2006 Apr 1;27(4):387-91.
17. Maticot-Baptista D, Ramanah R, Collin A, Martin A, Maillet R, Riethmuller D. Ultrasound in the diagnosis of fetal head engagement. A preliminary French prospective study. *J Gynecol Obst Bio R*. 2009 Oct;38(6):474-80.
18. Dimassi K, Belghith C, Triki A. Ultrasound diagnosis of fetal head engagement. *Int J Gynecol Obstet*. 2014 Oct 1;127(1):6-9.

19. World Health Organization. Reproductive Health. Managing complications in pregnancy and childbirth: a guide for midwives and doctors. World Health Organization; 2003.
20. Tutschek B, Torkildsen EA, Eggebø TM. Comparison between ultrasound parameters and clinical examination to assess fetal head station in labor. *Ultrasound Obstet Gyn.* 2013 Apr 1;41(4):425-9.
21. 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 Maternal-Fetal Neo M.* 2015 Aug 13;28(12):1476-81.
22. Barbera AF, Imani F, Becker T, Lezotte DC, Hobbins JC. Anatomic relationship between the pubic symphysis and ischial spines and its clinical significance in the assessment of fetal head engagement and station during labor. *Ultrasound Obstet Gyn.* 2009 Mar 1;33(3):320-5.