Ultrasound assessment of fetal head position and station before operative delivery: can it predict difficulty?

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Abstract

Objective – To evaluate whether ultrasound assessment of fetal head position and station though head perineum distance (HPD), is more predictive of a difficult operative vaginal delivery (OVD) than digital examination.

Methods – Retrospective, monocentric case control study including all singleton OVD at ≥34 weeks gestation. The principal criteria for a difficult OVD were based on a composite criterion of: an OVD considered "difficult" by the birth attendant, and/or two vacuum device detachments if a vacuum was used, and/or change of instrument, and/or a cesarean delivery for OVD failure.

Results – Two hundred eighty-six OVDs were included, among which 65 (22.7%) were difficult. The area under the curve (AUC) for predicting difficult OVD according to fetal position from digital examination or ultrasound was 0.62 (95% CI: 0.54–0.70) and 0.66 (95% CI: 0.58–0.73), respectively. Regarding fetal station, the AUCs of HPD without and with pressure were 0.59 (95% CI: 0.51–0.66) and 0.60 (95% CI: 0.51–0.68), respectively. Factors associated with difficult OVD were posterior and transverse positions (OR: 2.931, 95% CI: 1.640–5.239; p = 0.0003), HPD without pressure (threshold of 37 mm, OR: 2.327, 95% CI: 1.247–4.245; p = 0.0080), and HPD with pressure (threshold of 17 mm, OR: 2.594, 95% CI: 1.230–5.429; p = 0.0114).

Conclusion – Ultrasound assessment of fetal head position and station before OVD moderately predicts difficult OVD. Ultrasound assessment of posterior or transverse positions and HPD with a threshold of 37 mm (without compression of soft tissue) and 17 mm (with compression) were factors associated with difficult OVD.

Keywords

Head perineum distance; head position**;** head station; operative vaginal delivery; ultrasound

INTRODUCTION

Assessing the position and station of the fetal head during labor by digital examination remains the widely used method [1–5]. Many studies have shown that digital examination is subjective, with both intra- and interobserver variability [5-9]. The error rate in assessing position has been reported as ranging from 20 to 70% [5,7,9]. An error in assessing head position may result in inappropriate vacuum or forceps placement, increasing the potential for fetal injury and the failure rate of the procedure [10–12]. The superiority of ultrasound alone, or in combination with a digital examination, for determining fetal head position has been demonstrated compared with digital examination alone [2,4,13–16]. Thus, ISUOG guidelines recommend to systematically assess fetal head position by ultrasound before operative vaginal delivery (OVD) [7].

When OVD is required, assessing the fetal head station in the pelvis is mandatory. Vayssiere et al. showed that the level of fetal station in the pelvis is a predictor of successful vaginal delivery [17]. However, Dupuis et al. reported a rate of error from 30 to 34% with digital examination, especially in the presence of a caput succedaneum [5]. Several studies have assessed the utility of ultrasonography for measuring the degree of fetal head engagement and the probability of successful vaginal delivery [1,7,14,15,18–22]. Different methods have been proposed: angle of progression (AoP), also called the "angle of descent" [23,24], progression distance [25], head-perineum distance (HPD) [26], head–symphysis distance [27], and head direction [28].

Many studies have assessed predictions of delivery mode; however, assessing OVD difficulty is also of interest. Indeed, Kasbaoui et al. showed that an HPD $\geq$ 40 mm is significantly associated with a difficult OVD based on the composite criterion (operative vaginal delivery considered difficult by the operator, and/or more 2 vacuum device detachments, and/or need to apply a second instrument, and/or extraction duration of >10 minutes, and/or need for internal obstetrical maneuver to disengage the shoulders, and/or cesarean delivery for extraction failure), after adjustment for parity, fetal head position, and fetal macrosomia [20]. HPD was also a more accurate predictor of difficult OVD than digital examination. In their study, the abdominal probe was applied horizontally to the perineal body without pressing on tissues. Nevertheless, the ISUOG guidelines and other studies evaluating HPD have proposed measuring HPD by compressing soft tissue completely against the pubic bone without causing patient discomfort [7,18,29,30].

Therefore, the aim of this study was to evaluate whether ultrasound assessment of fetal head position and HPD measurement, is more predictive of a difficult OVD than digital examination

MATERIAL AND METHODS

Study and eligibility criteria

This retrospective, monocentric case control study was conducted from January 2019 to July 2019 in Lille, France. We included all OVD in singleton pregnancies of ≥34 weeks' gestation with cephalic position. Noncephalic positions, multiple pregnancies, singleton pregnancies <34 weeks' gestation, spontaneous deliveries, cesarean deliveries during labor, and patients lacking one measurement were excluded.

Operative vaginal delivery

In our center, all residents and obstetricians received theoretical and practical training on performing ultrasound-based HPD and position assessments. Before each OVD, the birth attendant performed a digital examination to determine fetal head position by palpating the sagittal suture and the anterior and posterior fontanels. Fetal head station was assessed based on the relationship between the most distal cranial point and the level of ischial spines. The presence of caput succedaneum was also recorded. Obstetricians and residents were asked to systematically perform, before each OVD, an assessment of fetal head position and station by ultrasound. The choice of appropriate delivery mode (vacuum, forceps, or cesarean section) was selected by the birth attendant, based on the digital examination with respect to national guidelines [31]. Indications of OVD could be abnormal fetal heart rate or failure to progress (defined as 30 minutes of pushing efforts with no progression according to national guidelines).

Bleeding was measured with a collection bag.

Measurement method

Ultrasonography was carried out via a portable machine (Samsung HM70A). The fetal position was determined by an abdominal approach to determine the head and spine positions

[7]. Then, the abdominal transducer was covered with a sterile glove and positioned horizontally on the perineum, between the labia majora in the posterior fourchette, to achieve a coronal view without intruding into the genital tract. Fetal head position and two HPD measurements were performed: without pressure (Figure 1a) and with firm compression of the tissues without causing patient discomfort, as recommended [7] (Figure 1b). The image obtained was a transverse view of the perineum and maternal pelvis, enabling visualization of the external bony limit of the fetal skull. HPD was the shortest distance measured between the ultrasonographic probe and the fetal skull, as previously described [7]. OVD and ultrasound measurements were performed by either a resident, under the supervision of the senior physician, or by the senior physician.

Assessment criteria

The principal criterion for OVD difficulty was based on the composite criterion proposed by Kasbaoui et al. [20].

- Birth attendant considered the OVD difficult
- And/or two vacuum device detachments if vacuum was used
- And/or a change of instrument
- And/or cesarean delivery for OVD failure

Statistical analysis

Data were recorded from medical file. Categorical variables are expressed as number (percentage). Quantitative variables are expressed as mean (standard deviation) for normally distributed data, or otherwise as median (interquartile range, IQR). Distribution normality was assessed using histograms and the Shapiro–Wilk test. Comparisons between the two study groups, defined by OVD difficulty, were made using the chi-square test or Fisher exact probability test for categorical variables, and using Student's *t* test or Mann–Whitney *U* test for quantitative variables. Diagnostic performance of digital examination and HPD was evaluated by calculating the area under the receiver operating characteristic (ROC) curve and compared using the nonparametric approach proposed by DeLong. Optimal threshold values were calculated for HPD, with and without pressure, based on the ROC curves, by maximizing the Youden index. Diagnostic and 95% CI values of the observed optimal and published thresholds were evaluated by calculating sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios. Finally, factors predicting difficult OVD were evaluated using univariate logistic regression models; OR and 95% CI values were calculated as effect sizes. Statistical testing was performed with a two-tailed α level of 0.05. Data were analyzed using the SAS software package, version 9.4 (SAS Institute, Cary, NC).

Ethics

The study was approved by the national committee of research in gynecology and obstetrics (CEROG #2020-OBST-0301, 01/05/2020).

RESULTS

During the study period, there were 2,635 live births at ≥34 weeks gestation and 383 (14.5%) OVD were performed. Among these OVD, 37 (9.7%) were excluded because HPD was assessed with only one measurement and ultrasound assessment was not performed in 63 cases (16.4%): 37 (9.7%) because head was on the perineum, 19 (4.9%) for fetal bradycardia, and 7 (1.8%) for unavailability of the ultrasound machine. Finally, 286 patients were eligible for the study. A flow diagram of patient enrollment is shown in Figure 2. Among the 286 patients with both HPD measurements: the birth attendant considered the OVD to be difficult in 26 (9.1%); 9 of the 167 (5.4%) in whom vacuum was used had two or more device detachments; 32 (11.2%) required a second instrument after vacuum failure; and 10 (3.5%) underwent cesarean deliveries for OVD failure. In total, 65 (22.7%) patients met the composite criterion for a difficult OVD.

The groups' demographic and clinical characteristics are presented in Table 1. Maternal characteristics were similar between the two groups. In difficult OVD cases, posterior and transverse positions determined by ultrasound were more frequently observed than anterior position (30 [46.2%] vs 50 [22.6%], $p < 0.001$) and duration was longer in the difficult OVD group (13.8 ± 6.3 vs 7 min ± 3.3, $p < 0.001$). Postpartum hemorrhage was also observed more frequently in the difficult OVD group (13 [20%] vs 11 [5%], $p < 0.001$). Vacuum devices were used less often in the difficult OVD group (10 [15.4%] vs 107 [48.4%], $p < 0.001$). Neonatal characteristics are also presented for the two groups (Supplementary data, Table S1). In the difficult OVD group, neonatal weight was significantly higher (3500 g ± 425 vs 3349 g ± 450, $p = 0.014$) and the rate of arterial umbilical cord pH < 7.10 was significantly higher (31.8% vs 14.0%, $p < 0.001$).

Regarding fetal head position, the concordance between digital examination and ultrasound was 66.8%. Figure S1 presents the concordance according to each fetal head position type. The area under the curve (AUC) for predicting difficult OVD according to fetal position obtained by digital examination or ultrasound was 0.62 (95% CI: 0.54–0.70) and 0.66 (95% CI: 0.58–0.73), respectively (Table 2 and Figure 3). There was no significant difference between the two AUC (p = 0.24).

The mean HPD without pressure was 41.0 ± 12.5 mm and 22.4 ± 9.3 mm with pressure. Difficult OVD was associated with a higher HPD measurement both without and with pressure (43.93 vs 40.14 mm, p = 0.024 and 25 vs 21.65 mm, p = 0.018, respectively). The AUC to predict difficult OVD for HPD without and with pressure was 0.59 (95% CI: 0.51–0.66) and 0.60 (95% CI: 0.51–0.68), respectively; the AUC for digital examination was 0.57 (95% CI: 0.50–0.63) (Figure 4). There was not a significant difference between the AUC for digital examination vs HPD without (p = 0.65) or with pressure (p = 0.78), or between the two HPD methods (p = 0.97). Sensitivity (Se), specificity (Spe), positive and negative predictive values (PPV and NPV), and positive and negative likelihood ratios for different thresholds of HPD with and without pressure are presented in Table 3. The optimal thresholds obtained with the best Youden index were 37 mm (Se 75.4%, Spe 43.2%, NPV 85.5%) without pressure and 17.1 mm (Se 83%, Spe 34%, NPV 87%) with pressure.

From bivariate analyses, the factors associated with a difficult OVD are presented in Table 4. Three criteria were significant: posterior and transverse positions (OR: 2.931, 95% CI: 1.640–5.239; p = 0.0003), HPD without pressure of 37 mm (OR: 2.327, 95% CI: 1.247–4.245; p = 0.0080), and HPD with pressure of 17 mm (OR: 2.594, 95% CI: 1.230–5.429; p = 0.0114).

COMMENTS

1) Main findings

Two HPD assessment methods are described in the literature: with and without soft tissue pressure [7,20]. This is the first study to compare these methods for the prediction of OVD difficulty. Fetal head position assessed by ultrasound had a higher AUC for predicting OVD difficulty. There was no difference between HPD with or without pressure, for which the optimal thresholds were 37 mm and 17 mm, respectively. As such, the choice of HPD measurement technique remains up to the birth attendant. Overall, factors associated with difficult OVD were posterior or transverse fetal head position assessed by ultrasound, and HPD measurement whatever the compression or not of soft tissue.

2) Results and interpretation

When OVD is required, it is essential to know the fetal head position and station in the pelvis. Clinical diagnosis remains the gold standard but is subjective [1,2,4,10] and remains an important source of error, with position diagnosis varying from 20 to 70% [7,9,16]. This error risk is higher after one or more hours of active pushing [2,4,26,32]. However, these notions of fetal head station and position are essential before performing an OVD. Indeed, OVD is associated with a higher risk of maternal and neonatal complications, especially when a second instrument is needed or a cesarean for failed vaginal delivery is necessary [33,34]. For the past 15 years, the use of ultrasound has been proposed for predicting the mode of delivery and complications during OVD.

One way of improving labor ward practices has been the use of ultrasound to ensure fetal head position before OVD. Indeed, posterior and transverse positions are associated with higher rates of perineal lesions and difficult OVD. In our study, we found more posterior and transverse positions in the difficult OVD group (46.2% vs 22.6%, $p < 0.001$). Missed posterior or transverse position diagnoses are higher than in anterior position [20,34]. Akmal et al. found an error rate of 17% for anterior position and 46% for posterior and transverse positions ($p = 0.002$) [14]. In our study, the concordance between digital examination and ultrasound was 66.8%, with a lower concordance in posterior (45.6%) and transverse (left occiput transverse 61.1% and right occiput posterior 37.5%) positions. In addition, we found that the position was more predictive of difficult OVD than was the station, using both ultrasound and digital examinations. Kasbaoui et al. used multivariate analysis to predict the occurrence of difficult OVD with different HPD (without pressure) thresholds (i.e., 40, 50, or 60 mm) to show that posterior or transverse position is an independent factor in difficult OVD [20]. Finally, the ISUOG recommends the assessment of head position by transabdominal ultrasound before OVD [7].

The correct diagnosis of the fetal head station is a prerequisite before instrumental delivery [15,19,20,33,35]. Several studies have assessed the utility of different ultrasonography methods for measuring the degree of fetal head station and the probability of vaginal delivery [1,7,14,15,18–22]. Kahrs et al. showed that HPD and AoP were significantly associated with spontaneous delivery (AUC = 0.83 [95% CI: 0.77–0.89] and 0.75 [95% CI: 0.66–0.85], respectively). HPD (with firm pressure) ≤ 20 mm is associated with a high probability of spontaneous vaginal delivery, whereas HPD > 35 mm was associated with cesarean delivery (AUC = 0.83 [95% CI: 0.74–0.92]) [1]. Similarly, Dall'Asta et al. showed that HPD (with pressure, threshold of 15 mm) is also predictive of spontaneous delivery (AUC = 0.74 [95% CI: 0.65–0.83]) [32]. To date, only one study has evaluated the prediction of a difficult OVD, in a prospective design that included 659 patients; using a composite criterion, this group found an association between the occurrence of a difficult OVD and HPD (without pressure), after adjustment for parity, fetal head position, and fetal macrosomia. With a threshold of 40 mm, the AUC was 0.63 (95% CI: 0.58–0.69; $p < 0.01$) with a sensitivity of 73.3% and specificity of 47.6% [20]. Our results are consistent with these. Indeed, the optimal HPD threshold without pressure for predicting difficult OVD was 37 mm. In our sample, we used the novel approach of comparing HPD with or without pressure. These AUC for predicting difficult OVD were similar (0.59 with pressure and 0.60 without). Thus, these data do not guide the clinician on whether to perform HPD measurements with or without pressure.

The HPD measurement is a linear method described as simple, easy, and reproducible [8,20,36]. Kasbaoui et al. found a strong correlation between ratings (0.96 [95% CI: 0.95–0.97; $p < 0.0001$]). Interobserver reproducibility remained high in patients with a body mass index (BMI) of 30–35 (severe obesity) and >35 (morbid obesity), with intraclass correlation coefficients of 0.97 (95% CI: 0.94–0.98; $p < 0.0001$) and 0.97 (95% CI: 0.94–0.99; $p < 0.0001$), respectively. Herein, we did not evaluate intra- and interrater variability for HPD measurements, which would be interesting to compare in future studies, especially in obese patients. The main limit of HPD is that it cannot be compared directly with the clinical assessment of fetal head station because it does not follow the curve of the birth canal [30]. Finally, the ISUOG suggests measuring the fetal head station by transperineal ultrasound before OVD because HPD and AoP are the most reliable sonographic parameters for predicting procedure outcomes [7].

In our study, we modified the composite criterion used by Kasbaoui et al., who included an OVD time >10 minutes in the composite criterion for “extraction difficulty” [20]. We also found that OVD time was longer in the difficult OVD group than in the control group (13.8 min ± 6.3 vs 7 min ± 3.3, respectively; $p < 0.001$). The cesarean section rate in our study for OVD failure was 3.5% (10/286). This is consistent with Dall’Asta et al. and Ramphul et al., who reported rates of 2.75% and 3.9%, respectively, in their nulliparous samples [15,32]. In contrast, Kasbaoui et al. reported only 3 cesareans for 659 OVD failure [20]. We also found a significant increase in immediate postpartum hemorrhage in the difficult OVD group (13 [20%], versus 11 [5%] in the control group, $p < 0.001$) and a significant increase in number with neonatal arterial pH < 7.10 (20 [31.8%] versus 31 [14%]; p < 0.001). Similarly, Dall'Asta et al. reported an increased rate of postpartum hemorrhage in their OVD group (p = 0.02) [32]. Kahrs et al. had more cases with umbilical arterial pH < 7.10 in their group with HPD > 35 mm (8/40 [20%] versus 2/144 [1.4%] in the HPD < 35 mm group; p = 0.01) [1]. Another important finding is the significant difference in cases with arterial pH < 7.10 in the difficult group. It also highlights the impact of difficult OVD on neonatal gasometric parameters and neonatal adaptation.

Finally, the clinical implication of those results could be to call for an experienced obstetrician (if not present) and delivery in the theater in cases with high risk of a difficult procedure, i.e with high measurement of HPD with or without compression.

3) *Strengths and weakness*

The major strength of this original study was that we assessed the prediction of difficult OVD by measuring HPD both without and with pressure. These two measurement techniques are described in the literature but to date have never been assessed simultaneously. One other strength is the evaluation in real practice, with the ultrasound before OVD not performed in 16.4% of cases due to head on perineum, fetal bradycardia and unavailability of the ultrasound machine. This notion is few described in previous studies.

However, there was a selection bias because fetal head position and station ultrasound evaluation before OVD was not performed in all patients. Further, the ultrasound measurements were not performed blind, which may have influenced the choice of instruments. In addition, the pressure placed on the ultrasound probe to perform HPD measurement is subjective, even though the method is described in the literature. Indeed, more than 98% of the patients in this study had epidural analgesia and in France, 82.2% of women had an epidural in 2016, compared with 60% in the USA and 30% in the UK [37,38]. Thus, the criteria for pressure should not be "until maternal discomfort," as has been proposed in many studies. This could question the external validity of the study in others centers with low rates of epidural. External validity could also be discussed regarding the body max index of our population, lower than in countries like USA or UK. We also found similar results whether compressing soft tissue or not. This finding was surprising because we suppose that obesity would influence the HPD measurements more when the soft tissue is not compressed. Occurrence of OASIS was also high in our population. It could be due to the use of forceps, but also due to repeated formation of diagnosis and management of OASIS improving its diagnosis. One last weakness is the subjectivity of the composite criteria. Indeed, the notion of “difficult OVD” depends on each birth attendant. However, in our study, we wanted to provide a reflect of “real life” in daily practice. We also decided not to include the neonatal weight in our multivariate even if there was a significant difference between the two groups. The first reason is a small clinical difference (151g), and the second one is the absence of the knowledge of this information before starting an OVD.

4) Conclusion

Ultrasound assessment of fetal head position and station before OVD moderately predicts difficult OVD. Ultrasound assessment of posterior or transverse positions and HPD, with a threshold of 37 mm (without compression of soft tissue) and 17 mm (with compression), were factors associated with difficult OVD. Nowadays, ultrasound assessment before OVD represents an important tool in a delivery room. However, further studies are mandatory to better handle this crucial tool and to better define its specific indications and different thresholds, especially in specific populations such as obese women.

DISCLOSURE OF INTEREST

The authors reports no conflicts of interest

FUNDING

No funding source was necessary for this work.

REFERENCES

1. Kahrs BH, Usman S, Ghi T, Youssef A, Torkildsen EA, Lindtjørn E, Østborg TB, Benediktsdottir S, Brooks L, Harmsen L, Romundstad PR, Salvesen KÅ, Lees CC, Eggebø TM. Sonographic prediction of outcome of vacuum deliveries: a multicenter, prospective cohort study. *Am J Obstet Gynecol*. 2017;217(1):69.e1-69.e10. doi:10.1016/j.ajog.2017.03.009

2. 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: Fetal head position. *Ultrasound Obstet Gynecol*. 2002;19(3):264-268. doi:10.1046/j.1469-0705.2002.00656.x

3. D. M. S, M. M, K. S. B, O. L. Intrapartum fetal head position I: comparison between transvaginal digital examination and transabdominal ultrasound assessment during the active stage of labor: Fetal head position. *Ultrasound Obstet Gynecol*. 2002;19(3):258-263. doi:10.1046/j.1469-0705.2002.00641.x

4. Chou MR, Kreiser D, Taslimi MM, Druzin ML, El-Sayed YY. Vaginal versus ultrasound examination of fetal occiput position during the second stage of labor. *Am J Obstet Gynecol*. 2004;191(2):521-524. doi:10.1016/j.ajog.2004.01.029

5. Dupuis O, Silveira R, Zentner A, Dittmar A, Gaucherand P, Cucherat M, Redarce T, Rudigoz R-C. 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(3):868-874. doi:10.1016/j.ajog.2004.09.028

6. Rivaux G, Dedet B, Delarue E, Depret S, Closset E, Deruelle P. Engagement de la tête fœtale : échographie transpérinéale, un nouvel outil diagnostique ? *Gynécologie Obstétrique Fertil*. 2012;40(3):148-152. doi:10.1016/j.gyobfe.2011.07.012

7. Ghi T, Eggebø T, Lees C, Kalache K, Rozenberg P, Youssef A, Salomon LJ, Tutschek B. ISUOG Practice Guidelines: intrapartum ultrasound. *Ultrasound Obstet Gynecol*. 2018;52(1):128-139. doi:10.1002/uog.19072

8. Simon E-G, Arthuis C-J, Perrotin F. Engagement de la tête fœtale : ce que l'échographie nous a appris. *Gynécologie Obstétrique Fertil*. 2014;42(6):375-377. doi:10.1016/j.gyobfe.2014.04.010

9. Tutschek B, Torkildsen EA, Eggebø TM. Comparison between ultrasound parameters and clinical examination to assess fetal head station in labor: Ultrasound parameters and fetal head station in labor. *Ultrasound Obstet Gynecol*. 2013;41(4):425-429. doi:10.1002/uog.12422

10. Dupuis O, Silveira R, Dupont C, Mottolese C, Kahn P, Dittmar A, Rudigoz R-C. Comparison of “instrument-associated” and “spontaneous” obstetric depressed skull fractures in a cohort of 68 neonates. *Am J Obstet Gynecol*. 2005;192(1):165-170. doi:10.1016/j.ajog.2004.06.035

11. Mola GDL, Amoa AB, Edilyong J. Factors associated with success or failure in trials of vacuum extraction. *Aust N Z J Obstet Gynaecol*. 2002;42(1):35-39. doi:10.1111/j.0004-8666.2002.00041.x

12. Gei A. Brachial Plexus Paresis Associated with Fetal Neck Compression from Forceps. *Am J Perinatol*. 2003;20(6):289-292. doi:10.1055/s-2003-42775

13. Sherer DM. Intrapartum ultrasound. *Ultrasound Obstet Gynecol*. 2007;30(2):123-139. doi:10.1002/uog.4096

14. 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: Intrapartum sonography. *Ultrasound Obstet Gynecol*. 2003;21(5):437-440. doi:10.1002/uog.103

15. Ramphul M, Ooi P, Burke G, Kennelly M, Said S, Montgomery A, Murphy D. 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 Int J Obstet Gynaecol*. 2014;121(8):1029-1038. doi:10.1111/1471-0528.12810

16. 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(2):193-197. doi:10.1016/j.ejogrb.2005.04.009

17. Vayssière C, Beucher G, Dupuis O, Feraud O, Simon-Toulza C, Sentilhes L, Meunier E, Parant O, Schmitz T, Riethmuller D, Baud O, Galley-Raulin F, Diemunsch P, Pierre F, Schaal J-P, Fournié A, Oury JF. Instrumental delivery: clinical practice guidelines from the French College of Gynaecologists and Obstetricians. *Eur J Obstet Gynecol Reprod Biol*. 2011;159(1):43-48. doi:10.1016/j.ejogrb.2011.06.043

18. Eggebø TM, Hassan WA, Salvesen KÅ, Lindtjørn E, Lees CC. Sonographic prediction of vaginal delivery in prolonged labor: a two-center study: Use of ultrasound in prolonged labor. *Ultrasound Obstet Gynecol*. 2014;43(2):195-201. doi:10.1002/uog.13210

19. 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: Angle of fetal head progression and vacuum extraction failure. *Ultrasound Obstet Gynecol*. 2016;48(1):86-91. doi:10.1002/uog.14951

20. Kasbaoui S, Séverac F, Aïssi G, Gaudineau A, Lecointre L, Akladios C, Favre R, Langer B, Sananès N. Predicting the difficulty of operative vaginal delivery by ultrasound measurement of fetal head station. *Am J Obstet Gynecol*. 2017;216(5):507.e1-507.e9. doi:10.1016/j.ajog.2017.01.007

21. Yonetani N, Yamamoto R, Murata M, Nakajima E, Taguchi T, Ishii K, Mitsuda N. Prediction of time to delivery by transperineal ultrasound in second stage of labor: Prediction of time to delivery by TPS. *Ultrasound Obstet Gynecol*. 2017;49(2):246-251. doi:10.1002/uog.15944

22. Ghi T, Youssef A, Maroni E, Arcangeli T, De Musso F, Bellussi F, Nanni M, Giorgetta F, Morselli-Labate AM, Iammarino MT, Paccapelo A, Cariello L, Rizzo N, Pilu G. Intrapartum transperineal ultrasound assessment of fetal head progression in active second stage of labor and mode of delivery: Second stage fetal head descent and mode of delivery. *Ultrasound Obstet Gynecol*. 2013;41(4):430-435. doi:10.1002/uog.12379

23. 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(3):313-319. doi:10.1002/uog.6329

24. 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(3):326-330. doi:10.1002/uog.6294

25. Dietz HP, Lanzarone V. Measuring engagement of the fetal head: validity and reproducibility of a new ultrasound technique. *Ultrasound Obstet Gynecol*. 2005;25(2):165-168. doi:10.1002/uog.1765

26. 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: Intrapartum translabial ultrasound. *BJOG Int J Obstet Gynaecol*. 2011;118(1):62-69. doi:10.1111/j.1471-0528.2010.02775.x

27. Youssef A, Maroni E, Ragusa A, De Musso F, Salsi G, Iammarino MT, Paccapelo A, Rizzo N, Pilu G, Ghi T. Fetal head-symphysis distance: a simple and reliable ultrasound index of fetal head station in labor: Head-symphysis distance. *Ultrasound Obstet Gynecol*. 2013;41(4):419-424. doi:10.1002/uog.12335

28. 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(6):753-760. doi:10.1002/uog.3848

29. 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 Gynecol*. 2006;27(4):387-391. doi:10.1002/uog.2744

30. 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(6):702-708. doi:10.1002/uog.8951

31. Collège national des gynécologues et obstétriciens français (CNGOF). [Instrumental extractions. Guidelines]. *J Gynecol Obstet Biol Reprod (Paris)*. 2008;37 Suppl 8:S297-300.

32. Dall'Asta A, Angeli L, Masturzo B, Volpe N, Schera GBL, Di Pasquo E, Girlando F, Attini R, Menato G, Frusca T, Ghi T. Prediction of spontaneous vaginal delivery in nulliparous women with a prolonged second stage of labor: the value of intrapartum ultrasound. *Am J Obstet Gynecol*. 2019;221(6):642.e1-642.e13. doi:10.1016/j.ajog.2019.09.045

33. Sainz JA, García-Mejido JA, Aquise A, Borrero C, Bonomi MJ, Fernández-Palacín A. A simple model to predict the complicated operative vaginal deliveries using vacuum or forceps. *Am J Obstet Gynecol*. 2019;220(2):193.e1-193.e12. doi:10.1016/j.ajog.2018.10.035

34. Ghi T, Dall'Asta A, Masturzo B, Tassis B, Martinelli M, Volpe N, Prefumo F, Rizzo G, Pilu G, Cariello L, Sabbioni L, Morselli-Labate AM, Todros T, Frusca T. Randomised Italian Sonography for occiput POSition Trial Ante vacuum (R.I.S.POS.T.A.). *Ultrasound Obstet Gynecol*. 2018;52(6):699-705. doi:10.1002/uog.19091

35. Murphy DJ, Macleod M, Bahl R, Strachan B. A cohort study of maternal and neonatal morbidity in relation to use of sequential instruments at operative vaginal delivery. *Eur J Obstet Gynecol Reprod Biol*. 2011;156(1):41-45. doi:10.1016/j.ejogrb.2011.01.004

36. Maticot-Baptista D, Ramanah R, Collin A, Martin A, Maillet R, Riethmuller D. Diagnostic échographique d'engagement de la présentation fœtale. À propos d'une série prospective préliminaire française. *J Gynécologie Obstétrique Biol Reprod*. 2009;38(6):474-480. doi:10.1016/j.jgyn.2009.04.001

37. Hu L-Q, Flood P, Li Y, Tao W, Zhao P, Xia Y, Pian-Smith MC, Stellaccio FS, Ouanes J-PP, Hu F, Wong CA. No Pain Labor & Delivery: A Global Health Initiative's Impact on Clinical Outcomes in China. *Anesth Analg*. 2016;122(6):1931-1938. doi:10.1213/ANE.0000000000001328

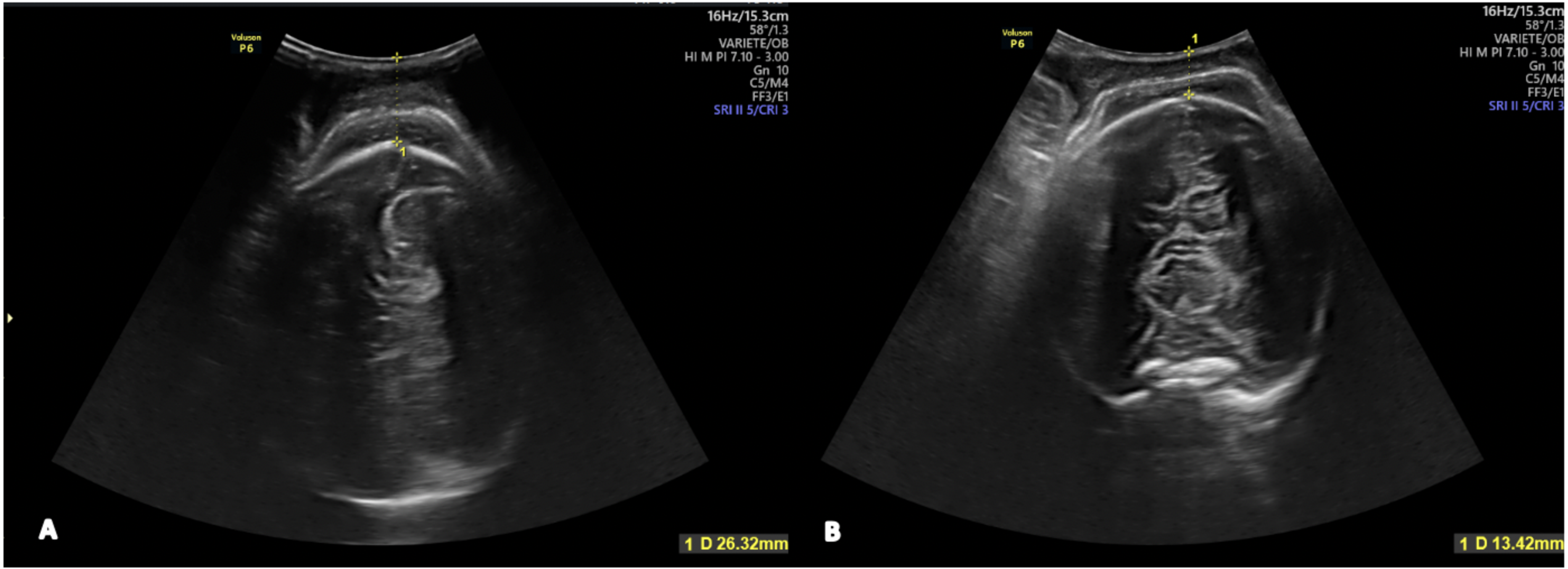
38. Grant EN, Tao W, Craig M, McIntire D, Leveno K. Neuraxial analgesia effects on labour progression: facts, fallacies, uncertainties and the future. *BJOG Int J Obstet Gynaecol*. 2015;122(3):288-293. doi:10.1111/1471-0528.12966

Figure 1: Fetal head station by transperineal ultrasound; A: HPD without pressure; B: HPD with pressure
HPD= head perineum distance.

Figure 3: Prediction of difficult OVD according to fetal presentation obtained though digital examination and ultrasound.

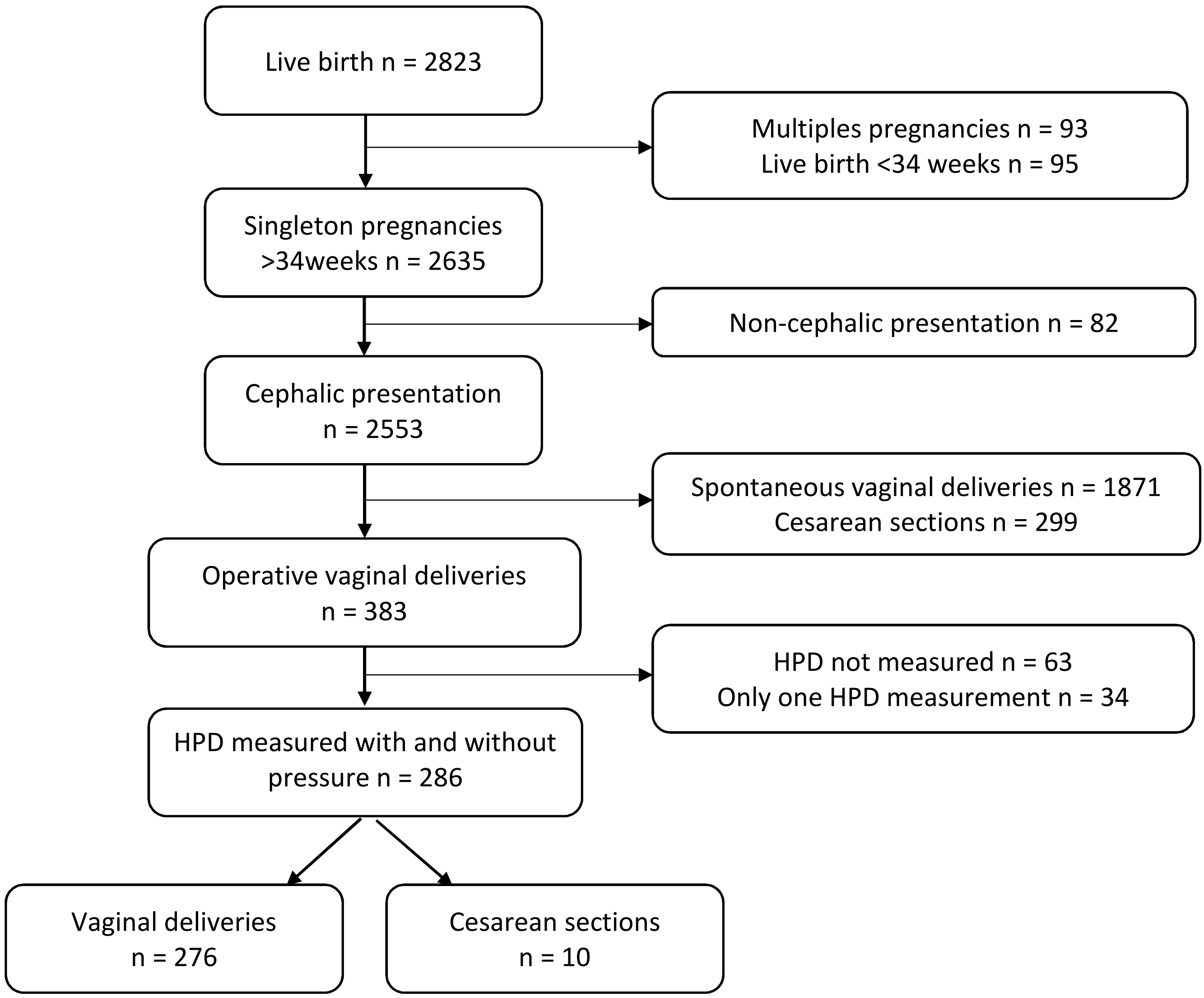
Figure 4: Prediction of difficult OVD according to fetal head station obtained though digital examination and ultrasound with and without pressure on tissues.

Figure S1: Concordance between digital examination and ultrasound for the diagnosis of fetal presentation

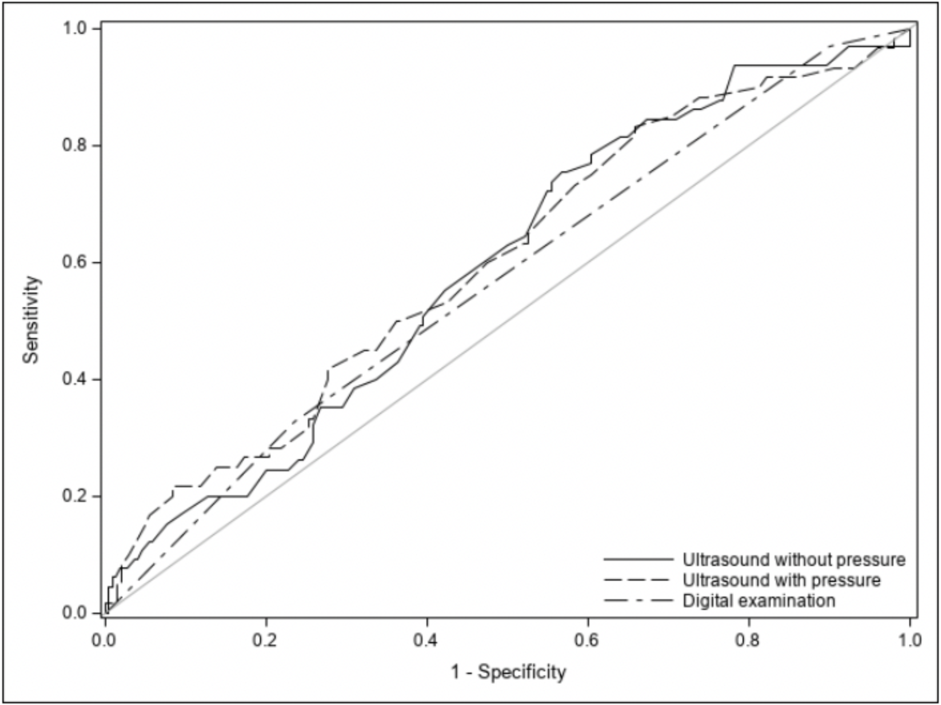


Voluson
P6
16Hz/15.3cm
58°/1.3
VARIETE/OB
HI M PI 7.10 - 3.00
Gn 10
C5/M4
FF3/E1
SRI II 5/CRI 3
1
A
1 D 26.32mm
Voluson
P6
16Hz/15.3cm
58°/1.3
VARIETE/OB
HI M PI 7.10 - 3.00
Gn 10
C5/M4
FF3/E1
SRI II 5/CRI 3
1
B
1 D 13.42mm

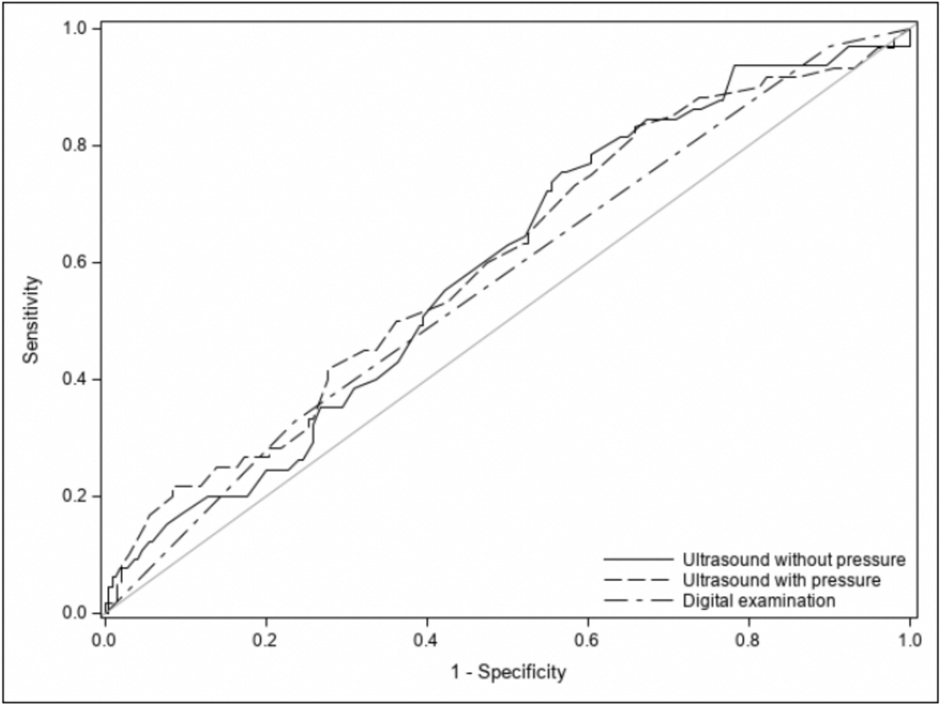
Figure 2: Flow chart of study population



Abbreviations: HPD= Head perineum distance



Sensitivity
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1 - Specificity
Ultrasound without pressure
Ultrasound with pressure
Digital examination



Sensitivity
1 - Specificity
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
Ultrasound without pressure
Ultrasound with pressure
Digital examination

	Control N=221	Difficult OVD n=65	p-value
Nulliparous	181 (81.9)	53 (81.5)	0.95
Age (years)	29.3 ± 5.1	29.5 ± 5.6	0.76
Body mass index (m/kg2)	24.6 ± 5.5	24.5 ± 4.9	0.89
Scarred uterus	17 (7.7)	7 (10.8)	0.43
Gestational age (weeks)	39 ± 1	39 ± 1	0.077
Induction labor	77 (34.8))	18 (27.7)	0.28
Epidural analgesia	218 (98.6)	64 (98.5)	NA
Oxytocin	97 (43.9)	32 (49.2)	0.45
Indication extraction			0.59
Abnormal FHR	132 (59.7)	35 (53.8)	
Failure of progress	54 (24.4)	20 (30.8)	
Both	34 (15.4)	10 (15.4)	
Posterior and transverse positions (US)	50 (22.6)	30 (46.2)	<0.001
HPD without pressure mean (mm)	40.1 ± 12.2	43.9 ± 13.0	0.024
HPD with pressure mean (mm)	21.6 ± 8.8	25.0 ± 10.6	0.018
Caput succedaneum	139 (62.9)	33 (50.8)	0.079
Instruments			
Forceps	113 (51.1)	23 (35.4)	0.072
Vacuum	107 (48.4)	10 (15.4)	<0.001
Vacuum + forceps	NA	32 (49.2)	NA
Extraction duration (min)	7 ± 3.3	13.8 ± 6.3	<0.001
OASIS III or IV	22 (10)	9 (13.8)	0.38
Bleeding (mL)	201.5 ± 179.5	307.1 ± 299.4	0.028
PPH > 500 mL	11 (5)	13 (20)	<0.001

Table 1: Comparison of maternal and obstetrics characteristics between the two groups

Results presented as number (percentage) or mean+/-standard deviation.

Abbreviations:; FHR: fetal heart rate; HPD: head perineum distance; NA: not applicable; OASIS: obstetric anal sphincter injuries; OVD: operative vaginal delivery; PPH: post-partum hemorrhage; US: ultrasound.

	Control (n=221)	Difficult OVD (n=65)	p-value
Shoulder dystocia	14 (6.3)	6 (9.2)	0.41
Neonatal weight (g)	3349 ± 450	3500 ± 425	0.014
5 minutes Apgar <7	2 (0.9)	3 (4.6)	NA
Umbilical arterial pH	7.17 ± 0.07	7.14 ± 0.07	0.004
Arterial pH < 7.10	31 (14.0)	20 (31.8)	< 0.001
Lactates (mmol/L)	5.8 ± 1.9	6.3 ± 2.3	0.051

Table 2 - Comparison of neonatal characteristics between the two groups.

Results presented as number (percentage) or mean+/-standard deviation.

Abbreviations: NA: not applicable; OVD: operative vaginal delivery

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
HPD without pressure:				
37mm	75.4	43.2	28.2	85.6
40mm	63.1	50	27.2	82.1
50mm	29.2	74.1	25	78
60mm	10.7	94.5	41.2	78.4
HPD with pressure:				
15mm	90	18.8	24.8	86.4
17mm	83.3	34.1	27.3	87.3
25mm	45	67.8	29.3	80.6
35mm	20	91.6	41.4	79.4

Table 3 : Diagnostic values of different thresholds of head perineum distance to predict difficulty of OVD

Results presented as percentage
Abbreviations : HPD : Head perineum distance

Criteria	Odd ratio	95% CI	P value
Posterior and transverse positions (US)	2.931	1.640-5.239	0.0003
HPD without pressure 37mm	2.327	1.247-4.345	0.0080
HPD with pressure 17mm	2.594	1.239-5.429	0.0114
Nulliparous	0.976	0.478-1.993	0.9467
Caput succedaneum	1.644	0.941-2.871	0.0806

Table 4 : Factor predictive of the difficulty of operative vaginal delivery in bivariate analyses.