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Predictive value of head-perineum distance measured at the initiation of the active second stage of labor on the mode of delivery: a prospective cohort study.

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Abstract

Objective The objective was to assess the predictive value of head-perineum distance measured at the initiation of the active second stage of labor on the mode of delivery.

Material and Methods It was a prospective cohort study in an academic Hospital of Rennes, France, from July 1, 2020 to April 4, 2021 including 286 full-term parturients who gave birth to a newborn in cephalic presentation. A double-blind ultrasound measurement of the head-perineum distance was performed during the second phase of labor within five minutes after the onset of pushing efforts. The primary outcome was the mode of delivery (spontaneous vaginal delivery versus instrumental vaginal delivery or cesarean section). We performed a multivariate analysis to determine the predictive value of the head-perineum distance by adjusting on potential confounders.

Results Overall, 199 patients delivered by spontaneous vaginal delivery, 80 by instrumental vaginal delivery, and seven by cesarean section. The head-perineum distance measured at the beginning of pushing efforts was predictive of the mode of delivery with a threshold at 44 mm (crude: sensitivity = 56.8% and specificity =79.3%; adjusted: sensitivity =79.4% and specificity=87.4%). The risk of medical intervention is higher when the head-perineum distance is greater than 44 mm with an adjusted OR of 2.78 [1.38; 5.76].

Conclusion The head-perineum distance measured at the initiation of the active second stage of labor is predictive of the mode of delivery. Head-perineum distance below 44mm predicts a vaginal delivery with the best diagnostic performance, and optimizes the time to start pushing efforts.

Funding : None

Keywords: intrapartum ultrasound; transperineal ultrasound; head-perineum distance instrumental delivery; caesarean section; active second stage of labor.

Introduction

In some European countries, pushing efforts are usually starting after the diagnosis of engagement, during the second stage of labor, while in some other countries, pushing efforts usually start at diagnosis of complete cervix dilation at the beginning of the second phase. There is no clear difference in terms of spontaneous vaginal delivery between the two methods although delayed pushing tends to induce shorter pushing efforts, but longer second stage of labor^{1,2}.

Longer duration of the second stage of labor seems positively correlated with higher rate of chorioamnionitis, lower umbilical artery pH and higher risk of post-partum hemorrhage². Starting pushing efforts too late might induce unnecessary longer duration of the second stage of labor. On the other hand, starting pushing efforts too early might increase maternal exhaustion, and thus the risk of instrumental deliveries (forceps, vacuum, spatulas)². Instrumental deliveries cause greater perineal injuries³. On the neonatal side, instrumental deliveries may lead to short-term morbidity⁴, especially when combined with a sequential cesarean section⁵.

Today, the diagnosis of engagement is based solely on the digital examination by the midwife or the physician. However, studies have highlighted its subjectivity and its high inter and intra-observer variability^{6,7}. In contrast, ultrasound in labor has been found more accurate and objective in assessing fetal head station and position^{8,9}. The use of transperineal ultrasound in the delivery room has been used to intent reduce maternal-fetal morbidity¹⁰. It may help to confirm fetal presentation, but also the fetal head station in the pelvis¹¹.

The head-perineum distance measured in transperineal ultrasound is one of the parameters proposed as an aid in the diagnosis of fetal head station and as a predictor of successful instrumental delivery^{12,13,14}. Moreover, it is admitted that an instrumental delivery can be

realized only on engaged fetuses, under penalty of substantial risk excess of maternal-fetal morbidity¹⁵. Performing instrumental delivery on a fetal station greater than 55 mm on transperineal ultrasound has been described as more likely to result in failure and therefore in emergency cesarean section¹⁴.

We thus surmised that a reliable assessment of the fetal head station may help to assess the timing and likelihood of successful pushing.

Our primary objective was to determine whether the head-perineum distance measured at the beginning of pushing efforts is a predictive factor of the mode of delivery.

Methods

Design

We conducted a prospective, observational study at the University Hospital of Rennes, France from July 1, 2020 to April 4, 2021.

Population

Women at term (≥ 37 weeks of gestation) about to deliver singleton vertex-presenting fetuses were recruited to the study when they approached full cervical dilatation and before the beginning of pushing efforts.

Women were excluded from the study if the fetus was suspected of having major malformations. Data collection were obtained through the medical record: maternal age, gestational age, body mass index (BMI), mode of labor onset, oxytocin augmentation, length of the second stage, birthweight, and 5-minute Apgar score. Maternal and neonatal complications included intrapartum fever ($\geq 38^{\circ}\text{C}$), postpartum hemorrhage, need for blood transfusion, and third- or fourth-degree perineal tear. The study protocol was approved by an ethic committee approval « CPP ILE DE FRANCE V » (N°2020-A00633-36). Women received information on the study objectives and protocol when they entered the maternity ward. Their non-opposition was collected in their medical file. Women were free to discontinue their participation in the study at any moment, without justification.

Methods

The measurement of the head-perineum distance was performed for each patient at the beginning of pushing efforts. The head-perineum distance was measured in millimeters by transperineal ultrasound (model: "T-LITE" device, "sonoscanner" company, probe model PR50, frequency 2-5 MHz). An OB/GYN resident previously trained to the technique was called to perform the transperineal ultrasound just before the beginning of pushing efforts for

research purposes. It was agreed that the residents would be called only during working hours (8am-8pm).

The evaluation of the head-perineum distance was carried out in the dortholithotomy position, empty bladder, at the initiation of the active second stage of labor, within the five minutes preceding the onset of pushing efforts. The abdominal ultrasound probe, covered by a sterile glove, was placed transversally on perineum, without support, without compression and between contractions. The calipers were positioned "on to on" from the outer edge of the ultrasound probe marker to the outer edge of the fetal bone shelf. The result of the measurement was not communicated to the patient, nor to the midwife performing the delivery (double blind). The operator performing the measurement was not informed of the clinical diagnosis of fetal head station. If necessary, a senior obstetrician was called and the indication of an instrumental delivery or a caesarean section was left to his discretion.

Statistics analysis

The minimum number of subjects was estimated using NQuery software, taking into account a power of 80% to detect an $OR \geq 2$ when the head-perineum distance is at one standard deviation above the mean, assuming a normal distribution of this variable, a proportion of obstetrical intervention (instrumental delivery or/and caesarean section) of 12%, and a correlation coefficient (ρ) of the variables included in the model equal to 0.3. A sample size of 267 women met the objective. Assuming that approximately 5% of the measures could not be analyzed because of missing data, the number of women to be included was increased to 280.

The primary outcome was the mode of delivery (spontaneous versus instrumental/cesarean). To meet the primary objective, we performed a univariate analysis using the Student "t" test. The analysis was completed by a multivariable logistic regression model to determine the predictive value of the head-perineum distance.

The model included variables known a priori to influence delivery mode^{17,18,19,20,21}: pre-pregnancy BMI of the patient, parity, newborn's birth weight. Additional variables were explored as potential confounders: maternal age, past history of cesarean, induced labor, gestational age at delivery, oxytocin dose received, length of second labor phase, existence of fetal heart rate abnormalities during pushing efforts, fetal presentation at beginning of pushing efforts, abnormalities of cardiac fetal heart rate while pushing. These were manually selected when associated at $p < 0.25$ in univariate analysis with the exposure and the variable of interest. We then excluded some variables based on a backward selection, selected on the Akaike Information Criterion (AIC).

Variables finally included in the multivariable model were: pre-pregnancy BMI of the patient, parity, newborn's birth weight, maternal age at gestation, past history of cesarean, length of second labor phase and existence of fetal heart rate abnormalities during pushing efforts. The calibration of the model was evaluated by the Hosmer-Lemeshow test. The accuracy of prediction of the mode of delivery was determined by using a receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) was calculated with the 95% confidence interval (CI), and the best cutoff was derived from the discriminatory AUCs of those who delivered spontaneously and from those who had instrumental delivery/caesarean section. We performed an internal validation of the model by a 1000 resampling bootstrap corrected AUC calculation.

A second model adjusted for the same confounding factors was constructed by categorizing the head-perineum distance variable according to the threshold value obtained by the ROC curve (≤ 44 mm; > 44 mm).

A *p-value* < 0.05 was considered statistically significant. Data were analyzed using the R software (version 3.6.1).

Results

Descriptive analysis

We included 286 patients in our cohort (**Figure 1** Flow-chart). A total of 199 patients had spontaneous vaginal deliveries, 80 patients had instrumental vaginal deliveries, and 7 patients had cesarean deliveries. The demographic, clinical and ultrasonographic characteristics of these patients are presented in **Table 1**. Respectively 63 (72.5%) women and 85 (42.8%) women were nulliparous in the group « instrumental deliveries and cesarean » (IDC) and in the group « spontaneous vaginal delivery » (SVD) ($p < 0.001$). The average length of the second phase of labor was $157\text{min} \pm 57.7$ for IDC group and $112.5\text{ min} \pm 64.8$ for SVD group ($p < 0.001$). The duration of pushing efforts was significantly greater in IDC group ($45.4\text{min} \pm 17.2$) than in SVD group ($18.1\text{min} \pm 13.6$) ($p < 0.001$). There were no significant differences in mean birth weight between the two groups, $3469\text{g} \pm 390$ and $3388\text{g} \pm 441$ respectively ($p = 0.13$). The mean head-perineum distance measured at the beginning of pushing efforts in IDC group was $50.4\text{mm} \pm 9.6$ while it was $41\text{mm} \pm 13.4$ in SVD group ($p < 0.001$).

Primary outcome

Head-perineum distance measured at the beginning of the pushing efforts was associated with the risk of having instrumental or cesarean delivery (per 1cm increase: $\text{OR}_{\text{raw}} = 1.89$ [IC95%=1.50; 2.42]) (**Table 2**).

The variables selected for the multivariable analysis were: BMI, birthweight, maternal age, uterine scar, duration of second stage, abnormal fetal heart rate, as continuous or categorized variables as shown in Table 2. In multivariable logistic regression analysis, the head-perineum distance measured at the beginning of pushing efforts, as a continuous variable with a normal distribution, was still significantly associated with mode of delivery with an OR of 1.74 per

1cm increase [IC95% 1.27 ; 2.46] (**Table 2**). Parity, maternal age, history of caesarean section, length of second labor phase, as well as existence of fetal heart rate abnormalities during pushing efforts also remained statistically significantly associated with the delivery mode (**Table 2**).

Derived from the ROC curves, a cutoff in head-perineum distance at 44mm best discriminated women who delivered spontaneously and those who had instrumental deliveries of caesarean. (**Figure 2**. ROC curves). At the initiation of the active second stage of labor, the measurement of the head-perineum distance was greater than 44mm for 155 patients (54,1%).

In crude analyses, this threshold has a sensitivity of 56.8% [CI95% 49.9; 63.7], a specificity of 79.3% [CI95% 70.8; 87.8], a positive predictive value of 91.35 % [CI95% 87.3; 95.4] and a negative predictive value of 70.30% [CI95% 61.39; 79.21].

The corresponding area under the curve (AUC) was 71.62% [CI95% 65.6; 77.5] (Table 3). The AUCc obtained with the bootstrap was 87.58%. In fact, for a head-perineum distance at the beginning of pushing efforts of less than 44 mm, 86.3% of the patients gave birth by spontaneous vaginal delivery. Also, 44.5% patient with head-perineum distance greater than 44 mm had an instrumental delivery/caesarean.

After adjustment for potential confounders, the threshold value of 44mm showed an area under the curve of 89.7% [CI95% 86.1; 93.3], with a calculated Youden index of 0.67, a sensitivity of 79.4% [CI95% 73.9; 84.9] and a specificity of 87.4% [CI95% 80.5; 94.3]. (**Table 3**).

Using a dichotomized head-perineum distance (<44mm; ≥44mm), the association with mode of delivery remained statistically significant ($OR_{adjusted}=2.78$ [CI95% 1.38; 5.76]) in multivariate analysis (**Table 2**).

Using a subgroup analysis, in primiparous or multiparous women, the association between mode of delivery and head-perineum distance was also significant. For primigravid women,

adjusted OR was 1.70 [1.14; 2.60] $p= 0.008$ per 1cm increase ; for multigravida women it was adjusted OR = 3.51 [1.46 ; 11.31] $p= 0.003$.

We calculated the optimal cut off in those subgroups. In primiparous the optimal threshold was 38 mm (Se=90,5%; Sp= 43,5% ORa=3,32 [1.35; 8.70], $p= 0.0087$, AIC: 167.31). For Multiparous the best threshold was 46 mm (Se=91,6%; Sp=62,3%, ORa= 7.25 [0.84 ; 108.25], $p= 0.07263$. AIC: 67.33).

Discussion

In our cohort, the head-perineum distance measured at the beginning of pushing efforts was predictive of the mode of delivery. Our statistical analysis revealed a threshold value of 44mm, with a corresponding area under the curve of 89.7% [CI95% 86.06; 93.32].

Careful management of the second stage of labor is crucial to decrease maternal-fetal morbidity¹⁶. In practice, this means not starting pushing too early, so as not to risk maternal exhaustion and therefore the need for an instrumental delivery.

Other studies suggested that the head-perineum distance may be associated with the mode of delivery, but the measure was performed at different stages of labor. In a 2021 study from Iceland and Sweden, Hjartardottir et al. also found a significant association of head-perineum distance measured at the first and last clinical examination during labor with the mode of delivery¹⁷. In an Italian study by Dall'Asta et al., the head-perineum distance measured after 2 hours at full cervix dilation was also greater in cases of obstetrical interventions¹⁸. One of the notable differences between our study compared and the above-mentioned literature is the definition of the period to realize the ultrasound measurement, within 5 minutes before the beginning of active second phase. It facilitates the concrete application of our results as it may guide the midwives about when to start pushing¹⁹.

An Israeli study on 202 patients by Hadad et. al. also evaluated the interest of measuring the head-perineum distance at the beginning of pushing efforts, as well as other measures (the angle of progression, the head-symphysis distance, the head-perineum distance at rest and during pushing with contraction), in prediction of spontaneous vaginal delivery. In this study, only the angle of progression at rest and the delta AOP (difference in angle between the angle of progression during pushing and at rest) were significantly associated to the mode of delivery²⁰.

It is interesting to note that the digital examination does not present such good diagnostic performance. Torkildsen et al. in 2011 conducted a study in patients with prolonged first stage

of labor and found an area under the curve of 81% [CI95% 71; 91] for the prediction of vaginal delivery for a threshold value of head-perineum distance of 40mm, whereas it was calculated at 66% [CI95% 54; 79] for digital examination²¹. The question of a labor follow-up based on transperineal ultrasound arises. Indeed, some studies have investigated the acceptability to patients of ultrasound-based labor monitoring, and patients describe transperineal ultrasound as less unpleasant than digital examination^{22,23}.

We noted differences in the technique used by authors to measure the head-perineum distance. Indeed, some studies describe a soft tissue compression before measuring the head-perineum distance, which may be different from the technique used in our study. In other publications the transducer has been placed in the fourchette, and the soft tissue compressed until resistance against the pubic bone. In this way the influence of maternal obesity can be reduced^{17,24}. However, the level of compression can vary and may increase interoperator differences.

The prospective design of our study and the training of the resident ensured the good quality and homogeneity of the data collected. In addition, ultrasound measures were made in a double-blind manner using a technique in accordance with ISUOG recommendation²⁵. Occiput position or angle of progression could have been collected as well. However, head-perineum distance and angle of progression are independent methods and both methods gave similar mirror image patterns¹⁷. We chose the easiest measure to ensure its feasibility in our setting.

Our study also has some limitations. Indeed, we included only 14.2% of eligible patients, which led to a possible selection of patients (compared to the 2016 French national survey: more nulliparous women, more patients with induction of labor and prolonged second stage) which may have led to a higher rate of instrumental deliveries. Our rate of instrumental extractions was 27.9% in our population, and 12.1% in the French national survey. Since multiparous women give birth more quickly, we did not always have time to do our ultrasound measurement. However, the interest of predicting delivery mode by transperineal ultrasound at the beginning

of the pushing efforts is less interesting in women with a fast labor. Another limitation is that we did not collect the occiput position.

Conclusion

The head-perineum distance measured at the initiation of the active second stage of labor is predictive of the mode of delivery. Head-perineum distance below 44mm predicts a vaginal delivery with the best diagnostic performance. This measure provides women and staff additional information on whether to start pushing or to continue labor in countries practicing delayed pushing. Obstetrical teams could add this simple measurement to their routine practice to optimize the second stage of labor as a complement to vaginal examinations.

Disclosure of interests : none

Contribution to authorship :

MB participated in patient enrollment, data collection and manuscript writing

MP participated in the statistical analysis

EC participated in patient enrollment and data collection

PBP participated in the statistical analysis

LL participated in the conception of the study

RB participated in the proofreading

KNT participated in the proofreading

IE in the conception of the study, in statistical analysis, and proofreading

MLL in the conception of the study, manuscript writing and proofreading

Details of patient's consent : Women received information on the study objectives and protocol. Their non-opposition was collected in their medical file.

Funding : none

Details of ethics approval : The study protocol was approved by an ethic committee approval « CPP ILE DE FRANCE V » (N°2020-A00633-36)

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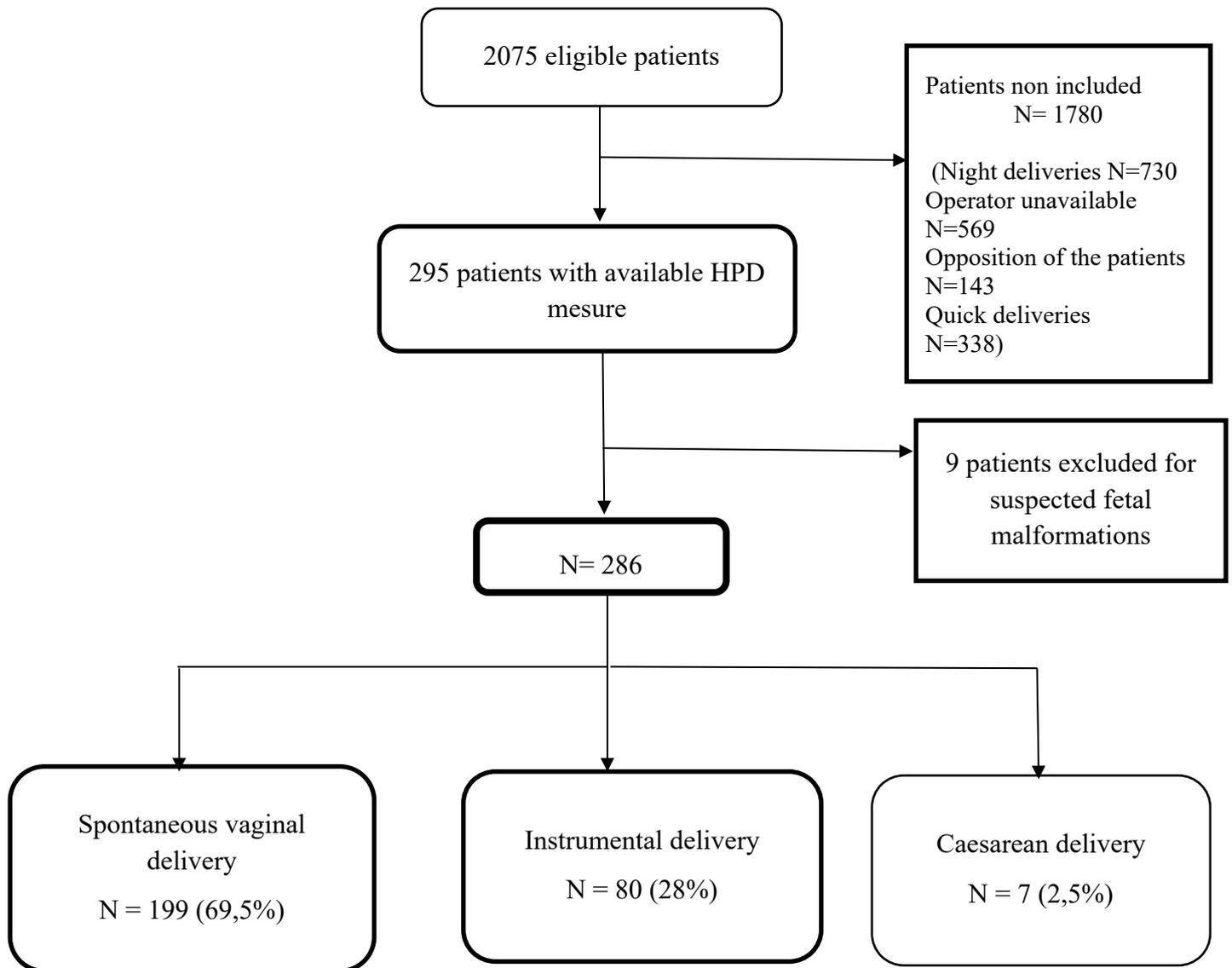


Figure 1. Flow chart

HPD: head-perineum distance

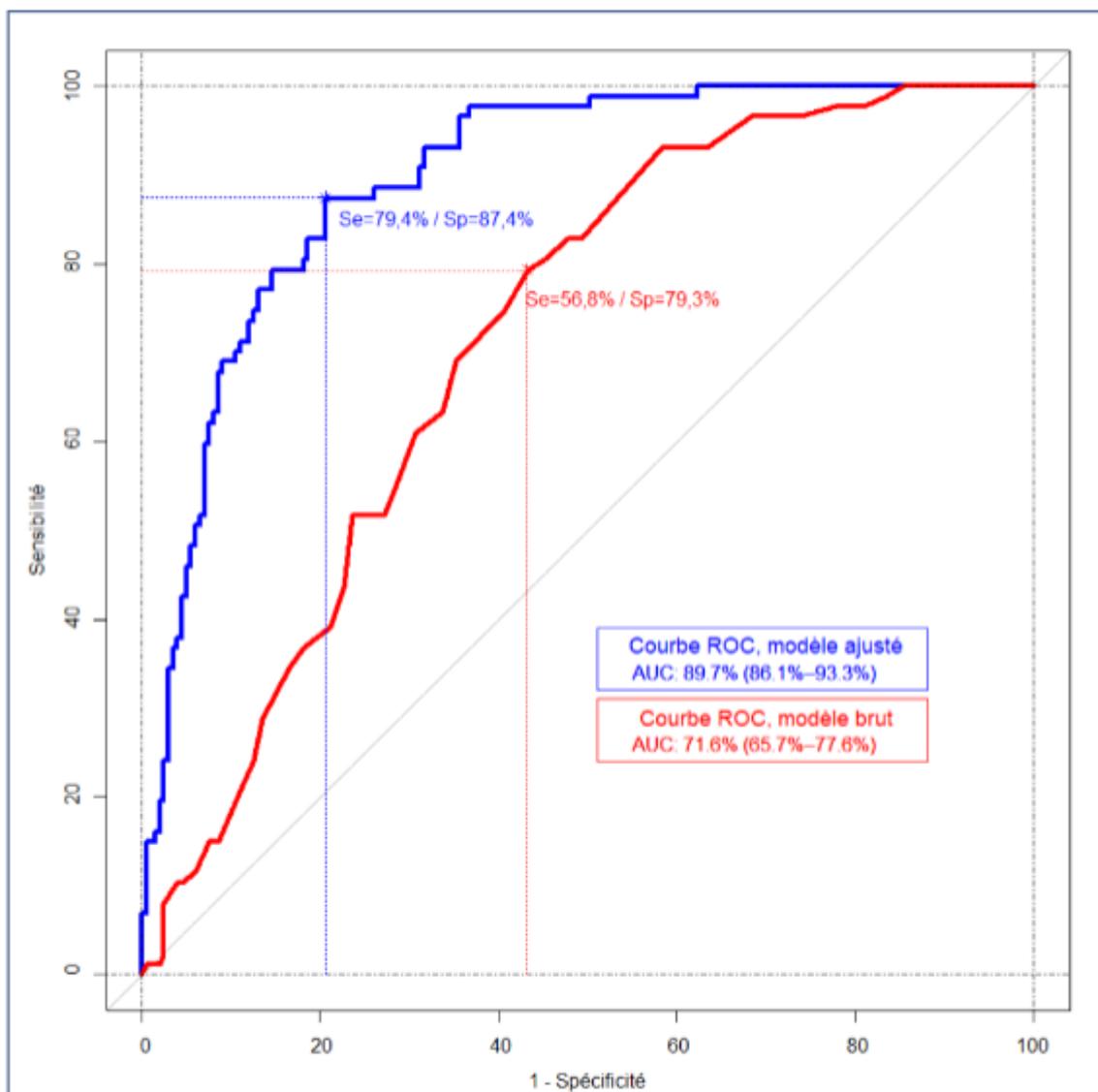


Figure 2. ROC curve analysis of head-perineum distance measured at the beginning of expulsive efforts for predicting spontaneous vaginal delivery. (n=286 women)

Model adjusted on: BMI (<30 kg/m²; >30 kg/m²), parity, birth weight, maternal age, history past of caesarean section, length of second labor phase, existence of fetal heart rate abnormalities during expulsive efforts

	Spontaneous vaginal delivery	Instrumental delivery and cesarean section	p value
	N (%) or mean (SD)	N (%) or mean (SD)	
	N= 199 (69.5)	N= 87 (30.5)	
Demographics			
Maternal age	29.2 (5.3)	31.3 (5.11)	0.002
Parity			<0.001
0	85 (42.8)	63 (72.5)	
≥ 1	114 (57.2)	24 (27.5)	
Previous cesarean	18 (9.0)	16 (18.4)	0.041
Pre pregnancy BMI (kg/m ²)			0.61
<25	4 (2.0)	2 (2.3)	
25- 30	114 (57.3)	55 (63.2)	
> 30	81 (40.7)	30 (34.5)	
Labor outcomes			
Gestational age at delivery	40.0(1.1)	40.3(1.1)	0.07
Labor induction	48(24.1)	28(32.2)	0.2
Total oxytocin dose (UI/L)	10.7(2.2)	11.5(3.2)	0.027
Birthweight	3388(441)	3469(390)	0.13
Duration of second stage	112.5(64.8)	157.4(57.7)	<0.001
Length of pushing phase	18.1(13.6)	45.4(17.2)	<0.001
3 and 4 degree perineal laceration	3(1.5)	10(12.5)	0.002
Post-partum hemorrhage	11(5.5)	13(14.9)	0.016
Fever during labor	13(6.5)	4(4.6)	0.52
Ultrasound measurement			

Head-perineum distance	41.0(13.4)	50.4(9.6)	<0.001
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Table 1. Demographic, clinic and ultrasound characteristics of the population and according to the mode of delivery.

Table 2. Parameters associated with spontaneous vaginal deliveries in multivariate analyses (n = 286 women).

Variable	Brut Model		Adjusted model (continuous HPD distance)		Adjusted model (dichotomized HPD distance)	
	pvalue	OR [IC]	pvalue	OR [IC]	pvalue	OR [IC]
Head Perineum Distance (cm)	6,64E-09	1,89 [1.50 2.42]	0,0004697	1,74 [1.27; 2.46]	0,0042315	2.78 [1.38 5.76]
BMI (kg/m ²)	–		0,1466142		0,1666889	
IMC ≤ 30		–		reference		reference
IMC > 40		–		0,47 [0.16 1.30]		0,49 [0.16 1.34]
Parity	–		6,60E-08		1,02E-07	
primiparous		–		reference		reference
multiparous		–		0,10 [0.03 0.24]		0,10 [0.04 0.25]

Birthweight		-	-	0,0545698	1,00 [1.00 1.00]	0,0282966	1,00 [1.00 1.00]
Maternal Age		-	-	0,0012201	1,12 [1.04 1.21]	0,0003011	1,13 [1.06 1.21]
Previous cesarean		-		0,0012188		0,0007445	
	no		-		reference		reference
	Yes		-		6,86 [2.11 24.05]		6,98 [2.23 23.47]
Duration second stage of labor(min)		-		3,01E-05		3,27E-05	
Between	(0, 74.2]				reference		reference
	(74.2, 135]		-		4,35 [1.21 18.35]		3,53 [1.04 13.70]
	(135, 185]		-		14.15 [4.07 60.67]		11.95 [3.62 47.26]
	(185, 300]		-		11.88 [3.44 49.94]		11.03 [3.35 43.03]
Abnormal fetal heart rate		-	-	9,82E-08	16.55 [5.42 60.45]	6,42E-08	16.84 [5.60 59.67]

Table 3. Predictive value of head-perineum distance measured at the beginning of expulsive effort on spontaneous vaginal delivery (n = 286 women).

	Youden index	Threshold value (cm)	Sensibility [CI 95 %]	Specificity [CI 95 %]	PPV [CI 95 %]	NPV [CI 95 %]	AUC [CI 95 %]
HPD, brut model	0,36	44	56,8 [49.9 % -63.7 %]	79,3 [70.8 %-87.8 %]	86.3 [80.4 %- 92.2 %]	44.5 [36.7 % - 52.3 %]	71,6 [65.7 %-77.6 %]
HPD, adjusted model*	0,67	-	79,4 [73.8 %-85 %]	87,4 [80.4 %- 94.4 %]	93.5 [89.8 % -97.2 %]	65 [56.3 %-73.6 %]	89,7 [86 %-93.3 %]

HPD: Head perineum distance; PPV: positive predictive value; NPV: negative predictive value; AUC: area under the curve.

*: Models adjusted on BMI (<30 kg/m²; >30 kg/m²), parity, birth weight, maternal age, history past of caesarean section, length of second labor phase, existence of fetal heart rate abnormalities during expulsive efforts.