ORIGINAL ARTICLE

Role of ultrasound parameters in the prediction of failure of induction of labor using Dinoprostone

Rôle des paramètres échographiques dans la prédiction de l'échec de l'induction du travail par Dinoprostone

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Abstract

Introduction-Aim: Labor induction is the artificial induction of uterine contractions in a woman who was not already in labor in order to achieve a vaginal birth. The main objective of our study was to analyze the role of ultrasound parameters in the prediction of failure of induction of labor.
Methods: This was a prospective observational study performed in a tertiary care maternity. For all the women who met our inclusion criteria, we measured these ultrasound parameters: Cervical length (CL), cervical dilation, cervical posterior angle (CPA), fetal head-perineum distance (FHPD), fetal occiput position, biparietal diameter (BPD) and estimated fetal weight (EFW). We defined failure of induction of labor as the occurrence of a cesarean section at any moment after the start of the induction.
Results: we collected 150 cases of induction of labor that met our inclusion criteria. Failure of induction rate was 45 %. Ultrasound parameters that were significantly associated to failure of induction were Cervical length (p=0.003), cervical dilation (p=0.002), cervical posterior angle (p<10-3), fetal head-perineum distance (p<10-3) and estimated fetal weight (p=0.006). Multivariate regression analysis found that posterior cervical angle and fetal head-perineum distance were the variables independently affecting the outcome of the induction of labor with respective thresholds of 105° and 55mm.
Conclusion: Ultrasound can be very useful in predicting the failure of labor induction. The threshold values that we found should be tested and validated in future studies to create a model to predict failure of labor.

Key words: induction, labor, ultrasound

Résumé

Introduction - Objectif: Le déclenchement du travail est l'induction artificielle des contractions utérines chez une femme qui n'est pas déjà en travail afin d'obtenir un accouchement par voie basse. L'objectif principal de notre étude était d'analyser le rôle des paramètres échographiques dans la prédiction de l'échec de l'induction du travail.
Méthodes: Il s'agissait d'une étude prospective observationnelle. Pour les femmes incluses, nous avons mesuré les paramètres échographiques suivants : Longueur cervicale, dilatation cervicale, angle cervical postérieur, distance tête fœtale-périnée, distance tête fœtale-périnée, la position de l'occiput fœtal, le diamètre biparié tal et le poids fœtal estimé. Nous avons défini l'échec du déclenchement du travail comme la survenue d'une césarienne à tout moment après le début de l'induction.
Résultats: nous avons recueilli 150 cas de déclenchement du travail. Le taux d'échec de l'induction était de 45 %. Les paramètres échographiques significativement associés à l'échec du déclenchement étaient la longueur du col (p=0,003), la dilatation du col (p=0,002), l'angle cervical postérieur (p<10-3), la distance tête fœtale-périnée (p<10-3) et le poids fœtal estimé (p=0,006). L'analyse de régression multivariée a révélé que l'angle cervical postérieur et la distance tête-périnée du fœtus étaient les variables affectant de manière indépendante l'issue du déclenchement du travail avec des seuils respectifs de 105° et 55mm.
Conclusion: L'échographie peut être très utile pour prédire l'échec du déclenchement du travail. Les valeurs seuils que nous avons trouvées devraient être testées et validées dans de futures études afin de créer un modèle permettant de prédire l'échec de l'accouchement.

Mots clés: déclenchement, travail, échographie

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Introduction

Labor induction is the artificial induction of uterine contractions in a woman who was not already in labor in order to achieve a vaginal birth [1]. Bishop score, which evaluates the uterine cervix through clinical examination, is the main tool that enables the obstetrician to choose the appropriate method of induction [2]. However, Bishop Score is subjective and its inter- and intra- operator variability is significant [3]. Furthermore, this score can't predict the result of the induction of labor [4]. And that's why the predictive role of other parameters, notably ultrasound parameters, is currently being evaluated.
The main objective of our study was to analyze the role of ultrasound parameters in the prediction of failure of induction of labor. We also aimed to propose cutoffs for the parameters that proved to be associated with failed induction of labor.

Methods

Study design and settings

A prospective, observational study was performed between January 1st of 2020 and June 30th of 2020 in a tertiary care maternity.

Inclusion criteria

We included all the patients who were scheduled for induction of labor and who met the following criteria: a single viable pregnancy with cephalic presentation, no previous C-section, a gestational age of 37 weeks of gestation or more, a fetus of normal weight and a Bishop score < 7 [5].
We defined failure of induction of labor as the occurrence of a cesarean section at any moment after the start of the induction. The definition of failed induction of labor is highly controversial, but we chose this definition because a cesarean delivery is the complication that we want to avoid the most when we decide to induce labor.

Ultrasound examination

We performed a transvaginal, transperineal and transabdominal ultrasound to measure these different parameters:
Cervical length (CL) was measured by transvaginal ultrasound. The calipers were used to measure the distance between the internal os and external os [6].
Cervical dilation was assessed by transvaginal ultrasound. The calipers were placed on both ends of the internal os to measure the funneling [7].
Cervical posterior angle (CPA) was measured by transvaginal ultrasound, obtaining a sagittal image. CPA is the angle between the lineused for the CL measurement and the posterior uterine wall [8].
Fetal head-perineum distance (FHPD)was measured by transperineal ultrasound. The patient was placed in lithotomy position with an empty bladder. The probe was gently placed on the perineum, at the ano-vulvar area. The distance between the probe and the external table of fetal skull was measured [9].
Fetal occiput position was determined by transabdominal ultrasound. The probe was placed on the patient's suprapubic region, visualizing the fetal head. The main landmarks depicting fetal occiput position are the cerebellum for occiput anterior position, and the fetal orbits for occiput posterior position [10].
Biparietal diameter (BPD) was measured by transabdominal ultrasound in an axial plane figuring the thalami, the midline falx, and the cavum septi pellucidi. The upper caliper was placed on outer border of upper skull and the lower caliper was placed on inner border of lower skull [11].
Estimated fetal weight (EFW): automatically calculated by incorporating biparietal diameter, abdominal circumference and femur length.
In our department, we used Prepidil© cervical gel containing 0.5 mg Dinoprostone. The cervix was reassessed 8 hours after the initial dose to decide whether to repeat the dose or to start oxytocin infusion. If no cervical ripening was achieved after 3 doses of Dinoprostone (at 8-hour intervals), the infant was delivered by cesarean delivery for absence of labor.

Statistical analysis

Statistical analysis was conducted with Statistical Package for Social Sciences (SPSS) version 20. Mann – Whitney test and Student test were usedfor univariate analysis. Multivariable logistic regression wasused to find the different parameters independently predicting failed induction of labor. Multivariate regression analysis was conducted on the variables that were significantly correlated ($P<0.2$) tofailed IOL in the univariate analysis to assess the independence of each variable in affecting the outcome. Relative Risks (RRs) with 95% confidence intervals (CIs) were calculated. Subsequently, Receiver operating characteristics (ROC) curve analyses were done to determine the AUCs, sensitivity, and specificity of the chosen cutoffs.
$P<0.05$ was considered statistically significant.
Consent: We obtained informed consent from patients for the use of their data in our work, subject to anonymity.

Results

During our study period, we collected 150 cases of induction of labor that met our inclusion criteria. The mean age of the patients was 27.5 years. Seventy percent of our population was nulliparous. Sixty-three women (42%) had a gestational age over 41 weeks of gestation.
The indications for induction of labor were the following: post-term pregnancy (39.3%), reduced fetal movements (12.6%), oligohydramnios (12%), pre-eclampsia (6%), premature rupture of membranes (5.3%), gestational diabetes (4%), growth restriction (2.6%) and other reasons, such as maternal illness or intrahepatic cholestasis (14.2%).
The ultrasound parameters were noted for every woman

in our population. Our findings are detailed in table 1.

Table 1. Ultrasound findings before induction of labor

Ultrasound parameter	Mean	Standard deviation	Median	Minimum	Maximum
Cervical length (mm)	25,8	8,1	26,4	1	46,2
Cervical dilation (mm)	4	1,6	4,10	0,1	7,6
Posterior cervical angle (%)	108,6	20	110	80	160
Fetal head-perineum distance (mm)	57,2	15,3	54	31	96
BPD (mm)	93,7	3,3	94,50	84	100
EFW (g)	3392	317,5	3400	2700	4000
Fetal occiput position	**Frequency**		**Percentage (%)**		
Anterior	125		83,3		
Posterior	25		16,7		

BPD: Biparietal diameter; **EFW**: estimated fetal weight

A c-section was indicated in 68 cases, which means that failure of induction rate was 45 %. C-section was indicated for absence of labor in 29 cases (42.7%).
Among the 7 ultrasound parameters that we studied, BPD and fetal occiput position were not significantly associated to failure of induction (p=0.15 and p=0.1 respectively) (Table 2).

Table 2. Associations between failure of induction of labor and ultrasound findings

Ultrasound parameter	Failure of induction		p
	Yes	No	
	Mean (SD)	Mean (SD)	
Cervical length (mm)	28 (7.5)	24.1 (8.2)	0.003
Cervical dilation (mm)	3.5 (1.9)	4.4 (1.3)	0.002*
Posterior cervical angle (%)	98.4 (17.7)	117 (17.9)	$<10^{-3*}$
Fetal head-perineum distance (mm)	68.5 (13.6)	47.8 (9.1)	$<10^{-3}$
BPD (mm)	94.3 (2.9)	93.1 (3.5)	0.15*
EFW (g)	3476.4 (298.3)	3321.9 (317.6)	0.006*
	Frequency (%)	**Frequency (%)**	
Fetal occiput position			0.1
Anterior	53 (42.4)	72 (57.6)	
Posterior	15 (60)	10 (40)	

* Mann-Whitney Test
BPD: Biparietal diameter ; **EFW**: Estimated fetal weight

Multivariate regression analysis was conducted on the variables that were significantly correlated with failed IOL in the univariate analyses, which were cervical length, cervical dilation, posterior cervical angle, fetal head-perineum distance, fetal occiput position, BPD and EFW, the variables that were independently affecting the outcome of the induction of labor were posterior cervical angle and fetal head-perineum distance (Table 3).

Table 3. Factors associated with failure of induction in the multivariate analysis

Covariables	RRa	IC95%	p
Posterior cervical angle	0,9	[0,8-0,9]	$<10^{-3}$
Head-perineum distance	1,3	[1,1-1,4]	$<10^{-3}$

We used ROC curves to define a threshold value for these two ultrasound parameters to predict failure of induction. The threshold value of the posterior cervical angle was 105°, corresponding to a sensitivity of 73% and a specificity of 72% (Figure 1).

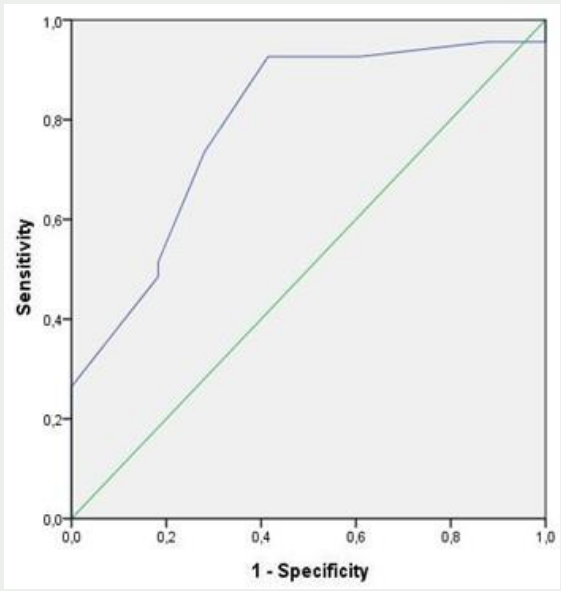

Figure 1. ROC curve for the posterior cervical angle

For the head-perineum distance, the threshold value was 55 mm, corresponding to a sensitivity of 82% and a specificity of 81% (Figure 2).

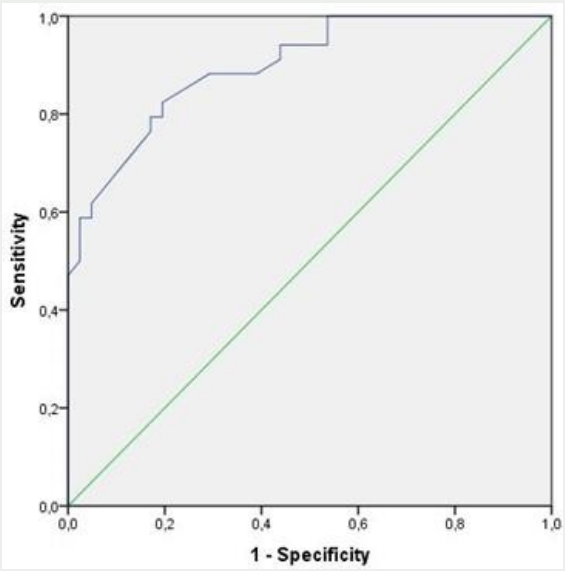

Figure 2. ROC curve for the head-perineum distance

Discussion

The main objective of our study was to identify the ultrasound parameters that can help predict the failure of induction of labor. This could be extremely helpful in the future of obstetrics. In fact, induction of labor is increasingly indicated worldwide for different causes [12]. This increase in incidence is partly caused by closer monitoring of pregnancies nowadays, resulting in more frequent discovery of gravid pathologies that used to go

unnoticed [13].
The only way currently at our disposal to decide how and when to induce labor is Bishop Score. This is a simple score that helps the obstetrician decide which method to use to induce labor depending on the situation at hand. However, Bishop Score does not permit to predict failure or success of the induction. In addition, this score is calculated based on five clinical parameters that suffer from significant inter- and intra- operator variability [3].
Ultrasound is one of the most important diagnostic technologies of our time. Its main qualities are safety and reproducibility. And it is thanks to these two qualities that ultrasound has acquired such a place in the world of obstetrics.
Using ultrasound to predict the outcome of induction of labor has always been a goal to reach for researchers. Many studies have focused on ultrasound parameters studying the cervix and fetal measurements, without a consensus being reached.
We will describe the different ultrasound parameters studied in the literature and compare the results of previous authors to ours.

Cervical length

Literature review reports that cervical length measured via transvaginal ultrasound is the most commonly used ultrasound parameter to predict the success or failure of labor induction. However, the established cutoffs differ from study to study, and no consensus is reached.
For example, Bila et al. [14] confirmed that ultrasound measurement of cervical length had an important role in predicting failure of induction of labor. The cutoff that was established in this study was 13 mm, with a sensitivity of 65.75% and a specificity of 75.34%.
Khalifa et al. [15] used a cutoff of 25.19 mm with a sensitivity of 51.28% and a specificity of 81.82%. Rane et al. [16] found a cutoff of 18.09 mm for cervical length, and stated that the probability of natural birth decreased by 11% for each additional millimeter for a cervix longer than 18 mm.
However, other studies have found different results. Indeed, Park et al. [17] showed, in a prospective study with 161 parturients, that cervical length could predict the probability of transition to the active phase within 24 hours after induction, but not the probability of a C-section delivery after induction of labor.
In our study, we found a significant difference between mean cervical length in women with failed induction (28 mm) and in others (24.1 mm) with p=0.003. However, in the multivariate study, cervical length was not associated with failure of induction of labor.

Cervical dilation

Cervical dilatation is not one of the most studied parameters in the literature to predict failure of induction of labor. Some authors measured the dilation, expressed in millimeters [18], while others simply reported whether or not there was a funneling [19].
Okitsu et al. [20] found that cervical dilation greater than 10 mm was detected by vaginal touch in only 38.5% of patients in whom ultrasound found a dilated cervix greater than 10 mm. The threshold value for ultrasound was determined to be 5 mm.
Bartha et al. [21] tried to assess the effectiveness of the ultrasound measurements of the cervix in predicting the success of induction of labor when compared to Bishop score. They concluded that when the induction decision was based on the presence of these associated criteria: Bishop score < 6, cervical length > 30 mm, and cervical dilation < 30% of cervical length, the need for prostaglandins was reduced by 35% compared to women for whom the decision to induce labor was made based on Bishop score only.
In our study, we found a significant difference between mean cervical dilation on ultrasound in women who had failed induction of labor (3.5 mm) and in those who succeeded (4.4 mm) p=0.002. However, in the multivariate study, ultrasound dilation of the cervix did not present a factor associated with the failure of the work initiation.

Posterior cervical angle

The posterior cervical angle is gaining more and more importance in studies dealing with the subject of predicting the success of induction of labor.
Al adwy [8] studied several parameters to verify their contribution in the prediction of failure of induction, including the posterior cervical angle. The threshold value proposed in this study was 99.5°. This parameter had the best sensitivity, specificity, PPV and NVP (91.84%, 90.48%, 95.70% and 82.60% respectively) compared to the cervical length and Bishop score. For Keepanasseril [22], the cutoffs with the best sensitivity and specificity were 90° and 110°. For Eggebo [23], these values were 90° and 120°.
Rane et al. [4] divided the 604 eligible women in their prospective study into two groups according to whether the posterior cervical angle was more or less than 120°, which he considered to be the best value that could predict the success of induction of labor. They proved that for the same specificity of 75%, the sensitivity of this ultrasound parameter in the prediction of caesarean delivery after induction of labor was 75% higher than Bishop score.
Our results are consistent with those found in the literature since we found a significant difference between the mean value of the posterior cervical angle in women who gave birth by caesarean section (98.4°) and those who gave birth naturally (117°) with p<10-3. In the multivariate study, the mean cervical angle was a factor associated with the failure of work initiation (ORa = 0.9 and p<10-3). The threshold value of the posterior cervical angle predicting failure of the trigger was 105° corresponding to a sensitivity of 73% and a specificity of 72%.

Fetal head-perineum distance

Very few studies have attempted to study the performance of this parameter in predicting the outcome

of labor induction.
Ancel [24], in a prospective study where he aimed to establish an ultrasonographic score to predict the outcome of labor induction, selected two thresholds: 51.5 mm for which the specificity was 93% and the sensitivity was 27%, and 90 mm for which specificity was 7% and sensitivity 100%.
Eggebo [23] selected his cutoffs based on other previous studies. These thresholds were 40 mm, 45 mm and 50 mm. He determined that a distance of 40 mm or less was predictive of natural birth within 24 hours.
Our results are consistent with those found in the literature as we found a significant difference between the mean fetal head -perineum distance in women who delivered by caesarean section (68.5 mm) and those who had a natural delivery (47.8 mm) with p<10-3. In the multivariate study, perineal-head distance was a factor associated with failure of work initiation (ORa = 1.3 and p < 10-3). The threshold value of the perineal head distance predictive of the failure of the trip was 55mm corresponding to a sensitivity of 82% and a specificity of 81%.

Fetal occiput position

Induction of labor is only done if the fetus is in cephalic presentation. But this presentation has several varieties, depending on whether the occiput is anterior or posterior, and oriented right or left. In our study we focused solely on the anterior or posterior occiput position as it is the most important element in the progress of the labor [25].
Ancel [24] found a higher percentage of natural births for anterior varieties (83%) than for posterior varieties, with a statistically significant difference. Akmal [26] reported a rate of caesarean section in the posterior variety group of 19% versus 11% in the anterior variety group.
However, a systematic review of literature by Verhoeven et al. [27] including 11 articles and 5,053 women who underwent induction of labor showed different results. All included studies reported disappointing values of specificity and sensitivity (71% and 39% respectively). They concluded that ultrasound determination of fetal occiput position prior to induction should not be used to predict delivery mode.
In our study, the fetal occiput position did not demonstrate a significant contribution to the prediction of failure of labor induction, nor in the univariate study (p=0.1) nor in the multivariate study.

Biparietal diameter

Few studies have chosen to study the role of biparietal diameter in predicting failure of labor induction. However, we chose to include this parameter in our study because of the crucial role of this diameter in the engagement.
Son et al. [28] investigated the role of BPD in the prediction of failure of labor induction in a retrospective cohort study with 276 nulliparous women undergoing induction of a post-term pregnancy. They found that the BPD average was significantly lower in the natural birth group compared to the group of caesarean section (9.43 ±0.35 cm versus 9.65± 0.42 cm, p < 0.01). After logistic regression in the multivariate study, they confirmed that BPD is a predictive factor of failure of labor induction.
However, Prado et al. [29] did not find a significant association between BPD and the outcome of labor induction.
In our study, BIP did not demonstrate a significant contribution to the prediction of work initiation failure in the univariate study (p=0.15) and in the multivariate study.

Estimated fetal weight

Estimated fetal weight is an ultrasound measurement routinely performed by obstetricians from the first months of their training.
In a prospective study involving 453 women admitted for labor induction, Kim et al. [30] demonstrated in their multivariate analysis that a high EFW was significantly associated with caesarean delivery (p<10-3).
In our study, we found a significant association between EFW and endpoint outcomes in the univariate study (p=0.006), but not in the multivariate study.

Study limitations and strengths
The main limitation of our study is the small sample size. This was due to the onset of the Covid-19 pandemic during the data collection period, which resulted in a drastic decrease in hospitalization rates in our department.
The primary strength of our study is that it was prospective, which gives it more statistical value than a retrospective study. Our study also has the advantage of relying on ultrasound. On the one hand, ultrasound measurements are more objective than clinical examination, and on the other hand, they are simple to do and can easily be taught to a resident in training. Finally, our study is the only one that focused on seven ultrasound parameters, whereas other similar studies only take on two or three parameters at most.

Conclusion

Prediction of failure of labor induction is possible through the ultrasound parameters detailed in our study. The threshold values that we found should be tested and validated in future studies in order to create a model to predict failure of labor.

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