OBSTETRICS

The "occiput−spine angle": a new sonographic index of fetal head deflexion during the first stage of labor

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BACKGROUND: Fetal head "attitude" (relationship of fetal head to spine) in the first stage of labor may have a substantial impact on labor outcome. The diagnosis of fetal head deflexion traditionally is based on digital examination in labor, although the use of ultrasound to support clinical diagnosis has been recently reported.

OBJECTIVES: The aims of this study were: (1) to quantify the degree of fetal head deflection via the use of sonography during the first stage of labor; and (2) to determine whether a parameter derived from ultrasound examination (the occiput-spine angle) has a relationship with the course and outcome of labor.

STUDY DESIGN: This was a prospective multicentric, cross-sectional study conducted at the Maternity Unit of the University of Bologna and Parma from January 2014 to April 2015. A nonconsecutive series of women with uncomplicated singleton pregnancies at term gestation (37 weeks or more) were submitted to transabdominal ultrasound during the first stage of labor. If fetal position was occiput anterior or transverse, the angle between the fetal occiput and the cervical spine (the occiput-spine angle) was sonographically obtained on the sagittal plane. The measurements of the occiput spine-angle were performed offline by 2 operators who were blinded to the labor outcome. The intra- and interobserver reproducibility and the correlation between the occiput-spine angle and the mode of delivery were evaluated.

RESULTS: A total of 108 pregnant women were recruited, 79 of which underwent a spontaneous vaginal delivery and 29 were submitted to obstetric intervention (19 cesarean delivery and 10 instrumental vaginal deliveries). The mean value of the occiput-spine angle measured in the active phase of the first stage was 126° ± 9.8° (SD). The occiput-spine angle measurement showed a very good intraobserver ($r = 0.86$; 95% confidence interval [95% CI] 0.80−0.90) and a fair-to-good interobserver ($r = 0.64$; 95% CI 0.51−0.74) agreement. The occiput-spine angle was significantly narrower in women who underwent obstetric intervention (cesarean or vacuum delivery) due to labor arrest (121° ± 10.5° vs 127° ± 9.4°, $P = .03$). Multivariable logistic regression analysis showed that narrow occiput-spine angle values (OR 1.08; 95% CI 1.00−1.16; $P = .04$) and nulliparity (OR 16.06; 95% CI 1.71−150.65; $P = .02$) were independent risk factors for operative delivery. A larger occiput-spine angle width (i.e., >125°) showed to be significantly associated with a shorter duration of labor (hazard ratio = 1.62; 95% CI 1.07−2.45; $P = .02$).

CONCLUSION: We described herein the "occiput-spine angle," a new sonographic parameter to assess fetal head deflection during labor. Fetuses with smaller occiput-spine angle (<125°) are at increased risk for operative delivery.

Key words: dystocia, failure to progress, fetal attitude, first stage of labor, intrapartum ultrasound, labor, malpresentation, reproducibility

The arrest of labor progression is the leading cause of obstetric interventions, including cesarean delivery and instrumental vaginal delivery.[1,2] In the attempt to decrease the incidence of primary cesarean delivery, the classical definition of abnormal labor course[3-6] has been revised recently,[7-9] and a longer duration of the second stage has been declared as acceptable before diagnosing a labor arrest (up to 4 hours or more in nulliparous and to 3 hours or more in parous with epidural).[9] Some authors, however, have challenged this new statement claiming that, based on the available evidence, a second stage of labor beyond 3 hours is unsafe for the unborn infant.[10,11]

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EDITORS' CHOICE

Deflexed cephalic presentations are an important cause of obstructed labor[12,13] and account for one third of cesarean deliveries as the result of labor arrest.[1,2,7-9,14-17] Three varieties of deflexed cephalic malpresentations traditionally are described according to the degree of head extension, including sinciput, brow, and face.[18] In some of these cases, such as brow presentation, the achievement of vaginal delivery is not possible because the mean fetal head presenting diameter (mento-occipital diameter) is 13 cm, which is larger than the widest diameter of the birth canal (obstetric conjugate = 11 cm).[19-21] The diagnosis traditionally is based on digital examination during labor, although the use of ultrasound to support clinical diagnosis has been reported recently.[22-25]

Apart from these 3 varieties, minor degrees of fetal head deflexion in respect of the trunk but not clinically detectable may be sonographically documented at suprapubic ultrasound. It has never been established whether minor degrees of fetal head deflection are associated with disorders of labor progression. The aims of this study were: (1) to quantify the degree of fetal head deflection by the use of sonography during the first stage of labor; and (2) to determine whether a parameter derived from ultrasound examination (the occiput-spine angle) has a relationship with the course and outcome of labor.

FIGURE 1
The technique for the measurement of the occiput spine angle by means of transabdominal ultrasound

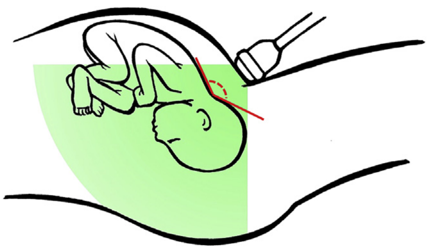

Image devised by Tullio Ghi, MD, University of Parma, and drawn by Simona Morselli, graphic designer, Bologna, Italy.

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Materials and Methods

A prospective, multicentric observational study with a sample of convenience was carried out at the Maternity Unit of the University Hospital of Bologna and Parma. The study was approved by the Institutional Review Board of the 2 istitutions. From January 2014 to April 2015 a nonconsecutive series of low-risk pregnant women in the first active stage of labor at or beyond 37 weeks of gestation were enrolled in this study. Patients were considered eligible for the study if 1 of the main investigators (T.G., F.B., or J.M.K.) was available in labor ward and if cervical dilatation was between 3 and 6 cm, the fetal head station was above the ischial spine (level 0), and regular uterine contractions were present. The patients provided a written informed consent to participate the study.

In these cases, the fetal head position was ascertained by mean of transabdominal sonography and described as on a clock face, as elsewhere reported [26] Cases in which fetal occiput was posterior (between the 4- and 8-clock position) were excluded. Additional exclusion criteria were prelabor rupture of membranes lasting more than 24 hours, obvious signs of deflexed presentation or asynclitism at digital examination, or abnormal cardiotocography at enrollment. In fetuses with anterior (right or left) or transverse (right or left) position, a 2-dimensional sagittal picture of the fetal head and upper spine was acquired (Figure 1) and stored in the ultrasound machine. On this image, the offline measurement of the angle formed by a line tangential to the occipital bone and a line tangential to the first vertebral body of the cervical spine (occiput-spine angle) was performed to quantify the degree of fetal head deflexion in respect of the trunk (Figures 2 and 3). For each case, the angle was calculated twice and independently by the 3 main investigators (J.M.K., F.B., and T.G.) to evaluate the intra- and interobserver agreement of this measurement.

Ultrasound did not alter labor management because the examiner was not involved in the patient's care. Furthermore, the results of ultrasound were not made available to the clinicians managing the patient. For each patient of the study group, the labor outcome and the mode of delivery was assessed retrospectively. Women submitted to obstetric interventions only due to nonreassuring fetal heart rate were eventually excluded because we sought to assess the relationship of the ultrasound findings with the risk of operative delivery due to prolonged or arrested labor. Prolonged first stage of labor was defined as cervical dilatation <1.2 cm/h in nullipara and 1.5 cm/h in multipara; arrest of the first stage was defined as nonprogression of cervical dilatation for >4 hours despite adequate uterine activity (3−5 contractions every 10 minutes) and rupture of membranes; prolonged second stage of labor was defined as fetal head descent <1 cm/h in nullipara and <2 cm/h in multipara; arrest of the second stage was defined as lack of fetal head descent after 2 or 3 hours of active pushing in nullipara (respectively without or with epidural) and after 1 or 2 hours in multipara (respectively without or with epidural).[12]

Statistics

Intraobserver agreement in occiput-spine angle measurements was determined with the use of the Pearson correlation coefficient (Pearson *r*); in addition, the repeatability coefficient was calculated as described by Bland and Altman[27]—this defines the range within which 2 measurements by the same observer will fall for 95% of subjects. Interobserver agreement in occiput-spine angle measurements was expressed as the Pearson correlation coefficient (Pearson *r*) and the 2-way mixed-effects intraclass correlation coefficient, with variance components being estimated by analysis of variance of replicate measurements. Agreement between the 2 observers also was assessed

FIGURE 2
The angle formed by the fetal occiput and the cervical spine (the occiput-spine angle) is measured on the sagittal plane at transabdominal ultrasound: the fetal head is almost completely flexed on the chest

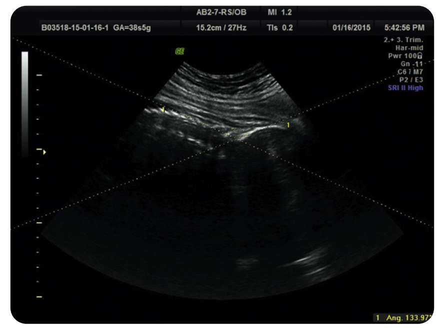

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FIGURE 3
The angle formed by the fetal occiput and the cervical spine (the occiput-spine angle) is measured on the sagittal plane at transabdominal ultrasound: the fetal head shows a mild degree of posterior deflexion in respect of the chest

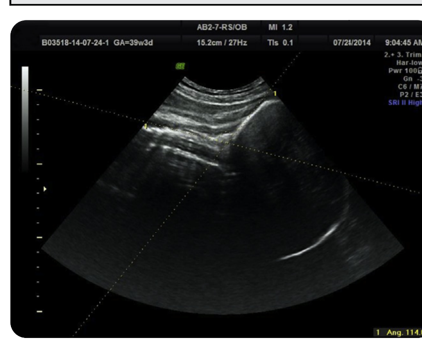

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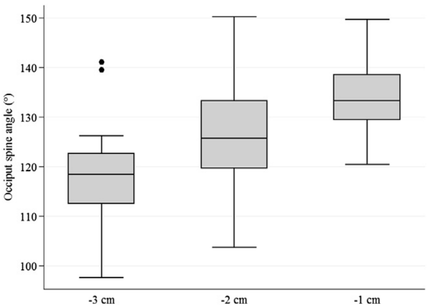
FIGURE 4
A box plot showing the distribution of occiput-spine angle values according to the fetal head station



The distribution of OSA values is described by displaying 5-number summary statistics. Any observation not included between the whiskers is represented as a dot.

OSA, occiput-spine angle.

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by calculating the limits of agreement as described by Bland and Altman[28]; the limits of agreement define the range within which 95% of the differences between 2 observers are likely to fall.

The first measurement by the expert operator was used for all subsequent analyses. The association between occiput-spine angle values and fetal head station was assessed graphically with the use of box plots (Figure 4). The χ^2 test, Fisher exact test, and Mann−Whitney *U* test were used, where appropriate, to compare the distribution of demographic and clinical characteristics of women who underwent spontaneous vaginal delivery with those of women submitted to an operative delivery (defined as caesarean delivery or instrumental vaginal delivery).

A multivariable logistic regression model was used to assess whether the occiput-spine angle affected the mode of delivery (spontaneous vaginal delivery vs operative delivery) after we accounted for possible confounding variables. The area under the receiver operating characteristic curve was calculated to assess the discriminatory power of occiput-spine angle. Lastly, we investigated in a secondary analysis the association of occiput-spine angle with overall labor duration using a multivariable Cox proportional hazards model. We tested proportionality of the hazards using the method of Schoenfeld.[29]

TABLE 1
Maternal, obstetric, and newborn characteristics stratified by type of delivery, after exclusion of cases in which obstetric intervention was performed due to nonreassuring fetal heart rate

Maternal, obstetric and newborn characteristics	All, n = 98	Spontaneous delivery (n = 79)	Operative delivery (n = 19)	*P* value
Maternal age, mean±SD	32.6 ± 5.8y	32.3 ± 5.9y	34.2 ± 5.4y	.22
Race (%)				>.99
White	88 (89.8%)	70 (88.6%)	18 (94.7%)	
Asian	8 (8.2%)	7 (8.9%)	1 (5.3%)	
African	2 (2.0%)	2 (2.5%)	0 (0.0%)	
Body mass index, mean	26.9 ± 3.6 kg/m²kg/m²	26.7 ± 3.6	27.9 ± 3.7	.16
Multiparity	35 (35.7%)	34 (43.0%)	1 (5.3%)	<.01
Gestational age, wk	39.6 ± 1.2	39.5 ± 1.2	39.7 ± 1.3	.44
Premature rupture of membranes	31 (31.6%)	22 (27.8%)	9 (47.4%)	.11
Epidural analgesia	49 (50.0%)	37 (46.8%)	12 (63.2%)	.31
Induction of labor	56 (57.1%)	42 (53.2%)	14 (73.7%)	.13
By				
Vaginal prostaglandines	11 (1.6%)	10 (23.8%)	1 (7.1%)	
Endovenous oxytocin	53 (94.6%)	39 (92.9%)	14 (100.0%)	
Length of stage 1, min	318.8 ± 209.2	274.1 ± 168.6	505.0 ± 259.4	<.001
Length of stage 2, min	44.2 ± 42.0	40.4 ± 32.9	60.4 ± 66.9	.69
Time between ultrasound and delivery (min)	234.5 ± 170.9	199.8 ± 139.8	378.5 ± 213.2	<.001
Occiput-spine angle, °	126 ± 9.8	127 ± 9.4	121 ± 10.5	.03
Station of the fetal head	−2.0 ± 0.1	−1.9 ± 0.1	−2.2 ± 0.1	.11
Birthweight, g	3393.3 ± 476.9	3335.1 ± 479.4	3635.0 ± 391.3	.01
Apgar score, 1 min	9.0 ± 0.8	9.1 ± 0.8	8.7 ± 1.0	.17
Apgar score, 5 min	9.9 ± 0.3	9.9 ± 0.2	9.7 ± 0.6	.04
Apgar score <7 at 1 or 5 min	4 (4.1%)	2 (2.6%)	2 (10.5%)	.17
pH[a]	7.2 ± 0.8	7.2 ± 0.9	7.3 ± 0.1	.70
Base excess[b]	−5.2 ± 3.4	−5.3 ± 3.3	−4.7 ± 3.9	.23

[a] n = 89; [b] n = 88. *y*, years.

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Results

Overall, 108 patients were included in the study group. Among these, spontaneous vaginal delivery occurred in 79, whereas cesarean delivery or vacuum were performed in 19 and 10, respectively. The indications for obstetric intervention were labor arrest in 19 patients and nonreassuring fetal heart rate in 10 patients. The mean value of the occiput-spine angle was 126° ± 9.8° with

TABLE 2

Results of the multivariable logistic regression in the prediction of operative delivery due to labor arrest

Maternal and obstetric characteristics	Odds ratio	*P* value	95% confidence interval
Narrower occiput-spine angle	1.08	.04	1.00–1.16
Nulliparity	16.06	.02	1.71–150.65
Maternal age	1.09	.13	0.97–1.22
Body mass index	1.13	.17	0.95–1.34
Premature rupture of membranes	2.66	.15	0.71–10.0
Induction of labor	0.76	.71	0.19–3.10
Station of the fetal head	0.72	.64	0.18–2.91

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comparable measurements among the different subtypes of fetal occiput position: anterior 9.3%; right-transverse 14.8%; right-anterior 7.4%; anterior-left 31.5%; and anterior-left transverse 37.0%. There was no significant difference in the occiput-spine angle among these groups (analysis of variance F-test = 0.78, *P* = .5). The occiput-spine angle measurement yielded very good intraobserver agreement (Pearson = 0.86, 95% confidence interval [95% CI] 0.80–0.90; repeatability coefficient ±10.1°) and fair-to-good interobserver agreement (Pearson = 0.64, 95% CI 0.51–0.74; intraclass correlation coefficient 0.63, 95% CI 0.50–0.73). The mean interobserver difference was 2.1°, and the limits of agreement were −15.7° to 20.0°.

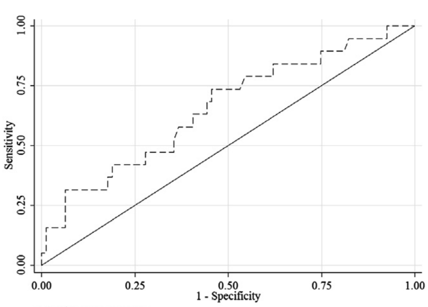
A significant direct correlation between the occiput-spine angle value and the fetal head station as assessed by digital examination was found. More specifically, the lower the fetal station was at the time of ultrasound assessment the wider the occiput-spine angle value appeared (Figure 4). A comparison between women who underwent an obstetric intervention (caesarean or vacuum delivery) as the result of labor arrest and those who underwent spontaneous vaginal delivery is shown on Table 1. In the operative group due to labor arrest, the following variables were significantly different in comparison with the women who underwent spontaneous vaginal delivery: lower parity (5.3% vs 43.0% *P* < .01), smaller occiput-spine angle (121° ± 10.5° vs 127° ± 9.4°, *P* = .03), lower 5-minute Apgar score (9.9 ± 0.2 vs. 9.7 ± 0.6 *P* = .04), increased duration of the first stage (8.4 ± 4.3 vs 4.6 ± 2.8 hours, *P* < .001), and increased birth weight (3635.0 ± 391.3 vs 3335.1 ± 479.4 g, *P* = .01). Interestingly, a higher fetal station at clinical assessment was not significantly associated to an increased risk of operative delivery due to labor arrest (OR 2.21, 95% CI 0.83–5.85, *P* = .11).

Narrow occiput-spine angle values were associated with a greater risk of operative delivery (OR 1.07; 95% CI 1.01–1.13; *P* = .02). Multivariable logistic regression analysis (Table 2) confirmed this result (OR 1.08; 95% CI 1.00–1.16; *P* = .04); more specifically, for each degree of decrease of the occiput-spine angle, an 8% increase of the risk of obstetric intervention due to dystocia was documented.

The receiver operator curve showed a fair accuracy of occiput-spine angle (area under the curve = 0.6566) in identifying the women who underwent operative delivery because of labor arrest (Figure 5). Univariable and multivariable Cox regression analysis (Table 3) showed that occiput-spine angle values greater than 125° were significantly associated with a shorter duration of labor (crude hazard ratio 1.46; 95% CI 1.00–2.14; *P* = .05; adjusted hazard ratio 1.62; 95% CI 1.07–2.45; *P* = .02). There was no evidence that the proportional-hazards assumption was violated ($\chi^2 = 7.48$, *P* = .381).

FIGURE 5

ROC for occiput-spine angle in identifying the women submitted to operative delivery because of labor arrest



The ROC curve is a plot of sensitivity vs 1−specificity that offers a summary of sensitivity and specificity across a range of cut points for a continuous predictor. The AUC ranges from 0.5 (no discrimination) to a theoretical maximum of 1 (perfect discrimination). Model 1: AUC, area under curve for model based on HDR variables; Model 2: AUC, area under curve for model based on HDR plus OPD plus medical charts variables. Dashed line refers to ROC curve analysis; dotted line refers to the reference line.

AUC, area under the curve; *HDR*, high dynamic range; *OPD*, observed predictive distribution; *ROC*, receiver operating characteristic.

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Comment

Principal findings

Our study demonstrates that (1) the sonographic measurement of the angle formed by the fetal occiput and the spine (occiput-spine angle) is feasible and reproducible; (2) the occiput-spine angle in the first stage of labor is positively correlated with the clinically established station; and (3) the occiput-spine angle measured in the first stage of labor correlates significantly with the risk of obstructed labor requiring an operative delivery.

Clinical and research implications

Fetal head attitude (the relationship of fetal head to spine) in the first stage of labor has a substantial impact on labor outcome, and this is the first study which has attempted to assess objectively the degree of fetal head flexion. The degree of fetal head deflexion was quantified accurately with the use of trans-abdominal 2-dimensional ultrasound and by measuring the angle formed by the occiput and the spine (occiput-spine angle). This new sonographic parameter has proven to be easy to obtain and highly reproducible. Moreover, in our series, the occiput-spine angle width in the first stage of labor seemed directly related to the clinically established station, being greater the deeper was the level of the head in the birth canal. These data are well correlated with the traditional obstetric concept that the fetal head descending through the birth canal undergoes a modification of attitude by progressively flexing towards the chest.[19]

Finally, we have noticed that the occiput-spine angle in the first stage of labor correlates significantly with the risk of obstructed labor requiring an operative delivery. Compared with spontaneous vaginal deliveries, cases that require obstetric intervention demonstrated a smaller occiput-spine angle at a similar station, suggesting diminished flexion of the fetal head. For nonocciput posterior fetuses, the greater the degree of fetal head deflexion, the greater risk of operative delivery it seemed due to labor arrest. Our data seem to support the obstetric notion that a deflexed fetal attitude may interfere with the fetal head descent because of an increase of the presenting diameter and a relative cephalopelvic disproportion, and this may ultimately increase the risk of arrested labor and obstetric intervention.[11,20] Lack of fetal head progression may actually present as a secondary arrest of cervical dilatation in the first stage or as an arrest of the second stage during active maternal pushing.

The relationship between the fetal head descent and the cervical dilatation in the active first stage of a normal labor has been mathematically described as linear in a very recent publication.[30] In obstetric textbooks, 3 main types of deflexed fetal attitude are described based on digital findings at vaginal examination, including sinciput, brow and face.[19] Our data seem to suggest that in the first stage of labor, a minor degree of fetal head deflexion, reflected by a smaller occiput-spine angle width, is able to be detected on transabdominal ultrasound but not clinical exploration that could increase the risk of labor arrest and obstetric intervention. We also found a significant inverse relationship between the occiput-spine angle and the duration of labor. More specifically, in fetuses with an occiput-spine angle <125°, the duration of labor was increased compared with those fetuses with an angle greater than that threshold.

TABLE 3
Results of the Cox model on time of delivery

	Final model		
Variables	Hazard ratio	*P* value	95% confidence interval
Occiput-spine angle >125°	1.62	.02	1.07–2.45
Multiparity	4.44	<.001	2.52–7.83
Maternal age	0.98	.322	0.94–1.02
Body mass index	1.34	.246	0.97–1.11
Premature rupture of membranes	1.17	.514	0.73–1.88
Epidural analgesia	0.89	.627	0.55–1.44
Station of the fetal head	1.58	.06	1.00–2.48

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Previous studies

Other authors have consistently shown that among women with a prolonged first stage of labor, the risk of caesarean delivery is inversely related to the depth of the fetal head level in the birth canal, as assessed by transperineal ultrasound. More specifically in this group of patients, either a greater distance between the fetal head and the perineum (head perineum distance) or a smaller angle of progression seem more accurate than digital assessment of fetal station in predicting the chance of abdominal delivery.[31] On the other hand, the accuracy and reproducibility of digital examination in assessing the fetal head station in the birth canal has been clearly shown to be poor.[25] We think that our data are consistent with the aforementioned observations[31] because a minor degree of fetal head deflexion in the first stage reflected by a smaller occiput-spine angle may in fact be expressed also by a greater head perineum distance or a smaller angle of progression.

The degree of fetal flexion had been sonographically assessed in a semi-quantiative fashion (more or less than 90°) among a group of women at term gestation with prelabor rupture of membranes.[32] In this specific context, the fetal head attitude was not proven to be clinically useful in predicting the occurrence of vaginal delivery; however, different from that study, we quantified the occiput-spine angle in each fetus and did not dichotomize the population in 2 groups according the degree of flexion. This difference may have allowed us to assess more genuinely the impact of the minor degree of fetal head deflexion on the fetal head descent and on the labor outcome. Furthermore, because the previous study included only women with prelabor rupture of membranes, we suspect that the degree of fetal head flexion in this series may have been to some extent conditioned by the decreased amount of amniotic fluid rather than reflecting the primary fetal attitude in spontaneous active labor. Finally, the degree of fetal flexion also was evaluated among those fetuses in direct occiput posterior position, but the reproducibility of the sonographic findings in such cases has not been reported. This may contribute toward explaining why in that study the fetal head attitude assessed by suprapubic ultrasound did not prove to be predictive of labor outcome.

It would be necessary to assess whether and to what extent the occiput–spine angle and the other parameters measured by transperineal ultrasound such as the head perineum distance or the angle of progression are related to each other.[32,33] Furthermore, it would be interesting to evaluate whether the occiput-spine angle width is an accurate predictor of labor outcomes among high-risk women, such as those with arrested or prolonged first stage of labor. We plan to address these issues in a future prospective study.

Strengths and limitations

The exclusion of fetuses in frank occiput posterior position may be considered as a limitation of this study. The occiput posterior position is extremely common in the first stage of labor and is sonographically documented in 30%−50% of fetuses.[28] Although most of the fetuses in occiput posterior position in the first stage of labor have been shown to convert to occiput anterior during the fetal head descent,[23,34] the sonographic diagnosis of occiput posterior in early active labor has been reported recently to be significantly associated with the risk of caesarean delivery.[35-38] Unfortunately, the sonographic measurement of the occiput-spine angle in these cases is not technically feasible because of the posterior position of the cervical spine of the fetus.

The interobserver reproducibility in obtaining the sonographic picture on which to measure the occiput spine angle has not been assessed. The scanning technique is a factor that may increase to some extent the variability of the occiput-spine angle measurement among different examiners, and this should be acknowledged as a further limitation of this study.

Conclusion

In conclusion, we have described a new sonographic parameter that correlates with the abnormal labor progress requiring obstetric intervention. The degree of fetal head deflexion in the first stage of labor may be quantified accurately in nonocciput posterior fetuses by means of transabdominal ultrasound. The occiput-spine angle width seems significantly related to the fetal head station and to the risk of obstetric intervention. ■

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