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OBSTETRICS

Prediction of spontaneous vaginal delivery in nulliparous women with a prolonged second stage of labor: the value of intrapartum ultrasound

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BACKGROUND: A limited number of studies have addressed the role of intrapartum ultrasound in the prediction of the mode of delivery in women with prolonged second stage of labor.

OBJECTIVE: The objective of the study was to evaluate the role of transabdominal and transperineal sonographic findings in the prediction of spontaneous vaginal delivery among nulliparous women with prolonged second stage of labor.

STUDY DESIGN: This was a 2-center prospective study conducted at 2 tertiary maternity units. Nulliparous women with a prolonged active second stage of labor, as defined by active pushing lasting more than 120 minutes, were eligible for inclusion. Transabdominal ultrasound to evaluate the fetal head position and transperineal ultrasound for the measurement of the midline angle, the head-perineum distance, and the head-symphysis distance were performed in between uterine contractions and maternal pushes. At transperineal ultrasound the angle of progression was measured at rest and at the peak of maternal pushing effort. The delta angle of progression was defined as the difference between the angle of progression measured during active pushing at the peak of maternal effort and the angle of progression at rest. The sonographic findings of women who had spontaneous vaginal delivery vs those who required obstetric intervention, either vacuum extraction or cesarean delivery, were evaluated and compared.

RESULTS: Overall, 109 were women included. Spontaneous vaginal delivery and obstetric intervention were recorded in 40 (36.7%) and 69 (63.3%) patients, respectively. Spontaneous vaginal delivery was associated with a higher rate of occiput anterior position (90% vs 53.2%, $P < .0001$), lower head-perineum distance and head-symphysis distance (33.2 ± 7.8 mm vs 40.1 ± 9.5 mm, $P = .001$, and 13.1 ± 4.6 mm vs 19.5 ± 8.4 mm, $P < .001$, respectively), narrower midline angle ($29.6° \pm 15.3°$ vs $54.2° \pm 23.6°$, $P < .001$) and wider angle of progression at the acme of the pushing effort ($153.3° \pm 19.8°$ vs $141.8° \pm 25.7°$, $P = .02$) and delta-angle of progression ($17.3° \pm 12.9°$ vs $12.5° \pm 11.0°$, $P = .04$). At logistic regression analysis, only the midline angle and the head-symphysis distance proved to be independent predictors of spontaneous vaginal delivery. More specifically, the area under the curve for the prediction of spontaneous vaginal delivery was 0.80, 95% confidence interval (0.69–0.92), $P < .001$, and 0.74, 95% confidence interval (0.65–0.83), $P = .002$, for the midline angle and for the head-symphysis distance, respectively.

CONCLUSION: Transabdominal and transperineal intrapartum ultrasound parameters can predict the likelihood of spontaneous vaginal delivery in nulliparous women with prolonged second stage of labor.

Key words: angle of progression, cesarean dystocia, fetal head position, fetal head station, head-perineum distance, head-symphysis distance, instrumental delivery, intrapartum care, labor dystocia, midline angle, operative delivery, parturition, prediction, prolonged second stage of labor, second-stage cesarean delivery, transperineal ultrasound, ultrasound in labor, vacuum extraction

A widely accepted definition of prolonged second stage of labor beyond which an operative delivery is mandatory is lacking and is matter of controversy.[1–9] The 2014 Obstetric Care Consensus of the American College of Obstetricians and Gynecologists (ACOG) and the Society of Maternal and Fetal Medicine (SMFM) states that "a specific absolute maximum length of time spent in the second stage of labor

EDITORS' CHOICE

beyond which all women should undergo operative delivery has not been identified."[2]

Several trials published over the last decade support the concept that the duration of the second stage of labor per se does not mandate delivery[10–14] and according to the ACOG/SMFM Obstetric Care Consensus "longer durations may be appropriate on individualized basis."[2] However, an increasing duration of the active pushing stage has been associated with a greater risk of complications, which include third- and fourth-degree tears, postpartum hemorrhage, and puerperal infections as well as an increase in adverse perinatal outcomes.[15–25]

On these grounds, fetal extraction by means of instrumental vaginal delivery or cesarean delivery is commonly performed in women with a prolonged second stage.[1] However, both instrumental vaginal delivery and cesarean delivery in the second stage are technically challenging and may be associated with risks for both the mother and the fetus.[26–28] Therefore, the accurate identification of those women with a prolonged second stage of labor who are still likely to accomplish spontaneous delivery is crucial to minimize the risk related to unnecessary obstetric intervention.

Such prognostic evaluation of woman during the second stage is traditionally based upon the digital assessment of the fetal head station, position, attitude, and progression. However, vaginal examination has been demonstrated to have

AJOG at a Glance

Why was this study conducted?
To evaluate the role of intrapartum sonographic findings in the prediction of spontaneous vaginal delivery among nulliparous women with prolonged second stage of labor.

Key findings
The midline angle and the head-symphysis distance are the only independent predictors of spontaneous vaginal delivery with a sensitivity of 81.8% (95% confidence interval [CI], 0.60–0.95) and 80% (95% CI, 0.64–0.91) and a specificity of 75% (95% CI, 0.60–0.87) and 63.2% (95% CI, 0.51–0.75), respectively.

What does this add to what is known?
Intrapartum ultrasound parameters can predict spontaneous vaginal delivery in nulliparous women with prolonged second stage of labor.

limited accuracy in the identification of the aforementioned parameters, particularly after 1 or more hours of active pushingl.[29–31]

In the last decade, the use of intrapartum ultrasound (US) has been widely introduced as a complementary tool for the physician in the management of abnormal labor course.[32] Because of its high reliability in assessing the fetal head station and position,[33-35] intrapartum US is currently endorsed in cases with slow or lack of progression in the second stage of labor to support clinical decisions.[32]

Several studies have addressed the role of intrapartum US in the prediction of the mode of delivery in women with a prolonged second stage of labor[36–46]; however, only a few of them have specifically evaluated in this subset of patients the role of US in anticipating the residual chance of spontaneous vaginal delivery (SVD).[36–38] The primary outcome of this study was to evaluate the relationship between transabdominal and transperineal sonographic findings in the prediction of SVD in nulliparous women with a prolonged active second stage of labor.

Materials and Methods
Study design
This was a prospective, observational, cohort study conducted at 2 tertiary maternity units in Italy (University Hospital of Parma and Sant'Anna Hospital of Turin) between December 2015 and March 2018. A nonconsecutive series of nulliparous women with nonanomalous singleton pregnancy at term as defined by gestational age >37+0 weeks of gestation, with no history of previous uterine scar and with a prolonged active second stage of labor (as defined by active pushing lasting more than 120 minutes, regardless of epidural administration) was evaluated for the study purpose.

According to the local protocol of the participating units, women diagnosed with protracted active pushing, unless the birth is imminent, are examined by the consultant obstetrician responsible for the patients care to exclude a labor arrest and to assess the need for obstetric intervention. For the present study, in the eligible cases, intrapartum US was performed following the clinical diagnosis of prolonged second stage of labor by 4 senior investigators with dedicated training on ultrasound in labor (T.G., B.M., A.D., and N.V.) who were blinded to the clinical findings and not involved in the clinical management of the patient but were available on request for research purposes.

The clinicians responsible for the intrapartum care of each patient were blinded to the US findings. In particular, the choice between expectant management and operative delivery, and in this latter case, the decision on how to perform fetal extraction was made by the physician on clinical basis and independently from the ultrasound parameters. According to the protocol for the management of active labor, for both of the participating units, the definition of prolonged second stage of labor was based on the ACOG/SMFM recommendations for the safe prevention of the primary cesarean section.[2]

In regard to the options for instrumental vaginal delivery, the use of forceps and trial of instrumental delivery are not performed as part of routine clinical practice in either of the participating inits. Patients submitted to obstetric intervention (cesarean delivery or vacuum extractor) purely because of suspected fetal compromise were excluded.

Clinical data were collected from patient case notes after delivery and included maternal age, ethnicity, body mass index, gestational age, induced or spontaneous labor, epidural analgesia, augmentation during labor, duration of I and II stage, US examination and delivery interval, digital head station, mode of delivery, perineal tears, estimated blood loss, birthweight, Apgar score at 5 minutes, and arterial pH.

Intrapartum ultrasound
Portable ultrasound devices equipped with low-frequency transabdominal probe were used for the study purposes. The enrolled women were lying in a semirecumbent position with an empty bladder, and measurements were performed in between uterine contractions and active pushing.

Transabdominal US was performed by placing the probe transversely over the maternal suprapubic region to assess the fetal head position, defined from the landmarks depicting fetal occiput position, which are the 2 fetal orbits for occiput posterior, the midline cerebral echo for occiput transverse and the occiput itself and the cervical spine for occiput anterior (OA) position. The position was described as a clock face with 12 hourly divisions; positions ≥10 o'clock and ≤2 o'clock were classified as OA, the remaining being classified as non-OA positions.[47]

Transperineal US was performed with the transducer placed in a transverse or longitudinal position between the labia majora or more caudally at the level of the fourchette to measure the currently described sonographic parameter for the assessment of fetal head station and descent. The midline angle was measured as previously described in an axial plane as the angle between the echogenic line interposed between the 2 cerebral hemispheres (midline) and the anteroposterior axis of maternal pelvis.[48] The head-perineum distance[49] was assessed placing the probe in the posterior fourchette and compressing the soft tissue against the pubic bone completely, without creating any discomfort to the women.

In the obtained frontal scan, the head-perineum distance was measured as the shortest distance from the bony limit of fetal skull to the perineum. Placing the transducer in a midsagittal position, we measured the angle of progression[50] previously defined as the angle between the long axis of the pubic bone and a line from the lowest edge of the pubis drawn tangential to the deepest bony part of the fetal skull.

The angle of progression was the only sonographic parameter that was measured at rest and at the peak of maternal pushing; the difference between the 2 measurements was defined as the delta angle of progression.[51] Head-symphysis distance was recorded in the same sagittal view as the distance between the lower edge of the maternal symphysis pubis and the fetal skull, along the infrapubic line.[51] All the images were obtained in the absence of uterine contractions or maternal pushes, with the only exception represented by the angle of progression measured at the peak of maternal effort, which was used also for the determination of the delta angle of progression.

Endpoints

The primary outcome of the study was to compare the sonographic findings between women who had SVD vs those who required obstetric intervention (OI), which included vacuum extraction and cesarean deliery. Furthermore, a comparison of the clinical outcomes between the 2 groups was undertaken.

Ethics approval

Ethics approval for this study was granted by the local Ethics Committee at the University Hospital of Parma (N 270/2018/OSS/UNIPR on March 12, 2018) and at the Sant'Anna Hospital of Turin (N 0061542 on June 21, 2017).

Statistical analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 20 (IBM Inc, Armonk, NY) and MedCalc Statistical Software version 18.11.6 (MedCalc Software, Ostend, Belgium). Normal or abnormal distribution of continuous variables was preliminary evaluated by means of the Kolmogorov-Smirnov and the Shapiro-Wilk tests, and data were shown as mean $\pm$ SD or as median (range) accordingly. Comparison of normally and nonnormally distributed continuous variables included the Student t test for independent sample and the Mann-Whitney U test, respectively.

Categorical variables were reported as number (percentage) and compared using the χ^2 or Fisher exact test. Logistic regression analysis was used to control for potential confounding variables,

TABLE 1
Demographic features, intrapartum findings, and perinatal outcomes of the included cases

Variables	Findings
Maternal age, y, mean $\pm$ SD	32.7 $\pm$ 6.9
Ethnicity n (%)	White, 90 (82.6%) African, 12 (11.0) Asian, 6 (5.5%) Others, 1 (0.9%)
Body mass index, kg/m^2, mean $\pm$ SD	28.5 $\pm$ 4.1
Maternal height, cm, mean $\pm$ SD	164 $\pm$ 6
Gestational age at last scan, weeks^{+days}, mean $\pm$ SD	$40^{+1} \pm 1^{+0}$
Fetal head position n (%)	Occiput anterior, 72 (66.1%) Nonocciput anterior, 37 (33.9%) - Occiput transverse, 13 (11.9%) - Occiput posterior, 24 (22.0%)
Mode of delivery n (%)	Spontaneous vaginal delivery, 40 (36.7%) Vacuum delivery, 40 (36.7%) Cesarean delivery, 29 (26.6%)[a]
Epidural n (%)	75/109 (68.1%)
Induction of labor n (%)	20/109 (18.3%)
Augmentation n (%)	71/109 (65.1%)
Duration I stage, min, mean $\pm$ SD	463 $\pm$ 118
Duration II stage, min, mean $\pm$ SD	156 $\pm$ 26
Digital fetal head station, median (range)	2 (−1 to −3)
Birthweight,g, mean $\pm$ SD	3434 $\pm$ 427
Apgar 1 min, median (range)	9 (2−9)
Apgar 5 min, median (range)	9 (7−9)
Arterial pH, mean $\pm$ SD, n = 70	7.24 $\pm$ 0.09

[a] n = 3 cesarean deliveries performed following failed instrumental delivery.

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TABLE 2
Demographic features, transperineal and transabdominal ultrasound parameters at diagnosis of prolonged second stage, and labor and perinatal outcomes in the spontaneous vaginal delivery and in the obstetric intervention group

Variables	Spontaneous vaginal delivery (n = 40/109, 36.7%)	Obstetric intervention (n = 69/109, 63.3%)	P value
Maternal age, y, mean ± SD	32.8 ± 5.7	32.9 ± 5.7	.94
Ethnicity, n (%)	White, 36 (90.0%) African, 3 (7.5%) Asian, 1 (2.5%) Others, 0 (0.0%)	White, 54 (78.3%) African, 9 (13.0) Asian, 5 (7.2%) Others, 1 (1.4%)	.43
Body mass index, kg/m^2, mean ± SD	8.6 ± 4.0	28.5 ± 4.1	.87
Maternal height, cm, mean ± SD	163 ± 6	164 ± 6	.34
Gestational age, wks^{+days}, mean ± SD	40^{+0} ± 1^{+0}	40^{+2} ± 1^{+1}	.26
First-stage length, min, mean ± SD	464 ± 224	463 ± 154	.96
Second-stage length, min, mean ± SD	135 ± 11	167 ± 24	< .001
Labor length, min, mean ± SD	586 ± 236	624 ± 163	.72
Ultrasound-delivery interval, min, mean ± SD	15 ± 11	47 ± 24	< .001
Birthweight, g, mean ± SD	3397 ± 363	3455 ± 461	.51
Epidural n (%)	Yes, 28 (70.0%)	Yes, 47 (68.1%)	.84
Induction of labor n (%)	Yes, 6 (15.0%)	Yes, 14 (20.3%)	.53
Augmentation n (%)	Yes, 25 (62.5%)	Yes, 46 (66.7%)	.79
Fetal head station, cm, median (range)	1 (−2 to 3)	0 (−2 to 3)	.002
Fetal head position n (%)	Non-OA 4 (10.0%)	Non-OA, 33 (47.8%)	< .001
Head-perineum distance, cm, mean ± SD	33.2 ± 7.8	40.1 ± 9.5	.001
Midline angle, degrees, mean ± SD	29.6 ± 15.3	54.2 ± 23.6	< .001
Angle of progression at rest, degrees, mean ± SD	137.2 ± 14.8	130.3 ± 20.0	.06
Angle of progression under pushing effort, degrees, mean ± SD	153.3 ± 19.8	141.8 ± 25.7	.02
Delta angle of progression, degrees, mean ± SD	17.3 ± 12.9	12.5 ± 11.0	.04
Head-symphysis distance, cm, mean ± SD	13.1 ± 4.6	19.5 ± 8.4	< .001
Estimated blood loss, mL, mean ± SD	422 ± 290	570 ± 328	.02
Episiotomy	17 (42.5%)	29 (42.02%)	.962
Perinatal tear			
Grade I/II	13 (32.5%)	18 (26.1%)	.474
Grade III/ IV	2 (5%)	1 (1.44%)	.275
Apgar 5 min, median (range)	9 (8−9)	9 (7−9)	< .001
Arterial pH, mean ± SD, n = 70	7.26 ± 0.09	7.29 ± 0.09	.27
Arterial base excess, mean ± SD, n = 70	7.2 ± 2.4	6.9 ± 2.4	.26
Neonatal trauma n (%)	0 (0.0%)	0 (0.0%)	—
Neonatal intensive care unit transfer n (%)	1 (2.5%)	2 (2.9%)	.90

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while the prediction of the mode of delivery by intrapartum sonographic parameters was determined by receiver operating characteristic (ROC) curve analysis. The method of DeLong et al[52] was used for the comparison of the ROC curves. A value of $P < .05$ was considered as statistically significant.

Results
Overall, 109 women were included. The transabdominal and transperineal US examination was successfully performed

in all the eligible cases. Baseline and obstetrical features of our cohort population are shown in Table 1, while the demographic characteristics and the intrapartum US parameters at diagnosis of prolonged second stage in the spontaneous vaginal delivery, instrumental delivery and cesarean delivery group are shown in the Supplemental Table. Forty women achieved SVD (36.7%), while OI was recorded in 69 patients (63.3%): among these, instrumental delivery was performed in 40 cases (36.7%) and cesarean delivery in 29 (26.6%), 3 of which was performed after a failed instrumental delivery.

Clinical findings
As shown in Table 2, no significant differences were noted in maternal demographics among the SVD and OI groups. With regard to the clinical characteristics, the digitally assessed fetal head station was significantly lower in the SVD compared with the OI group ($P = .002$), while a significantly longer second stage and US-to-delivery interval were recorded in the latter group (135 ± 11 vs 167 ± 24 minutes, $P < .001$, and 15 ± 11 vs 47 ± 24 minutes, $P < .001$, respectively).

Sonographic findings
Looking at the intrapartum sonographic findings, a lower frequency of non-occiput anterior position (4 of 40, 10.0%, vs 33 of 69, 47.8%, $P < .0001$), a shorter head-perineum distance (33.2 ± 7.8 mm vs 40.1 ± 9.5 mm, $P = .001$), a narrower mean value of the midline angle (29.6° ± 15.3 vs 54.2° ± 23.6°, $P < .001$) and a shorter head-symphysis distance (13.1 ± 4.6 mm vs 19.5 ± 8.4 mm, $P < .001$) were noted in the SVD compared with the OI group. The angle of progression at the acme of the pushing effort as well as the delta angle of progression were found to be wider in the SVD compared with the OI group (153.3° ± 19.8° vs 141.8° ± 25.7°, $P = .02$, and 17.3° ± 12.9° vs 12.5 ± 11.0, $P = .04$, respectively).

Ultrasound prediction of SVD
At the logistic regression analysis, the midline angle and the head-symphysis

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TABLE 3

Logistic regression analysis for intrapartum clinical, transperineal, and transabdominal ultrasound parameters at diagnosis of prolonged second stage and mode of delivery (spontaneous vaginal delivery vs obstetric intervention)

sariable	Adjusted OR	(95%CI)	p
Digital station	0.815	0.348—1.913	.639
Head-perineum distance	0.991	0.868—1.132	.896
Midline angle	1.075	1.014—1.139	.014
Angle of progression under pushing effort	1.058	0.978—1.144	.157
Head-symphysis distance	1.299	1.036—1.630	.024
Fetal head position	0.200	0.014—2.792	.231
Delta angle of progression	0.894	0.799—1.002	.054

CI, confidence interval; *OR*, odds ratio.

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distance proved to be the only parameters independently associated with the mode of delivery ($P = .013$ and $P = .024$, respectively) (Table 3). Areas under the curve (AUCs) for the prediction of mode of delivery were 0.81, 95% confidence interval (CI; 0.70—0.92), $P < .001$, and 0.74, 95% CI, (0.65—0.83), $P = .002$, for the midline angle and the head-symphysis distance, respectively (Figure 1).

The best cutoffs for the prediction of the mode of delivery were 34.75 degrees for the midline angle and 15.25 mm for the head-symphysis distance. More specifically, a midline angle below 34.75 degrees was recorded in 33 of 40 cases of SVD (82.5%) and in 17 of 69 of OI (24.6%), yielding an 81.8% sensitivity (95% CI, 0.60—0.95), a 75% specificity (95% CI, 0.60—0.87), a 62.1% positive predictive value (95% CI, 0.42—0.79), an 89.2% negative value (95% CI, 0.75—0.97), a 3.3 likelihood ratio (LR0-positive (95% CI, 1.89—5.66) and a 4.1 LR-negative (95% CI, 1.67—10.17) for SVD.

A head-symphysis distance below 15.25 mm was measured in 32 of 40 women who had SVD (80%) and in 25 of 69 who had OI (36.2%) and was associated with an 80% sensitivity (95% CI, 0.64—0.91), a 63.2% specificity (95% CI, 0.51—0.75), a 56.1% positive predictive value (95% CI, 0.42—0.69), an 84.3%

negative predictive value (95% CI, 0.71—0.93), a 2.2 positive likelihood ratio (95% CI, 1.54—3.08), and a 3.2 negative likelihood ratio (95% CI, 1.66—6.03) for SVD. At the ROC curve, a combined model that included both the midline angle and the head-symphysis distance (AUC, 0.81, 95% CI, 0.70—0.92, $P < .001$) did not yield a significant improvement of the accuracy in the prediction of the mode of delivery compared with the midline angle only ($P = .95$) and the head-symphysis distance only ($P = .78$).

Secondary outcomes
Looking at the secondary outcomes, a significantly higher estimated blood loss and a significantly lower 5 minutes Apgar score were noted in women in which OI was performed compared with those who had SVD (Table 2).

Comment
Principal findings
Our study has demonstrated that intrapartum ultrasound for fetal head position and station can be used to identify nulliparous women with a higher residual chance of SVD despite a lack of progression of the second stage of labor. The occiput position, the clinical station and all the transperineal sonographic parameters appeared

ROC curve analysis for head-symphysis distance and midline angle
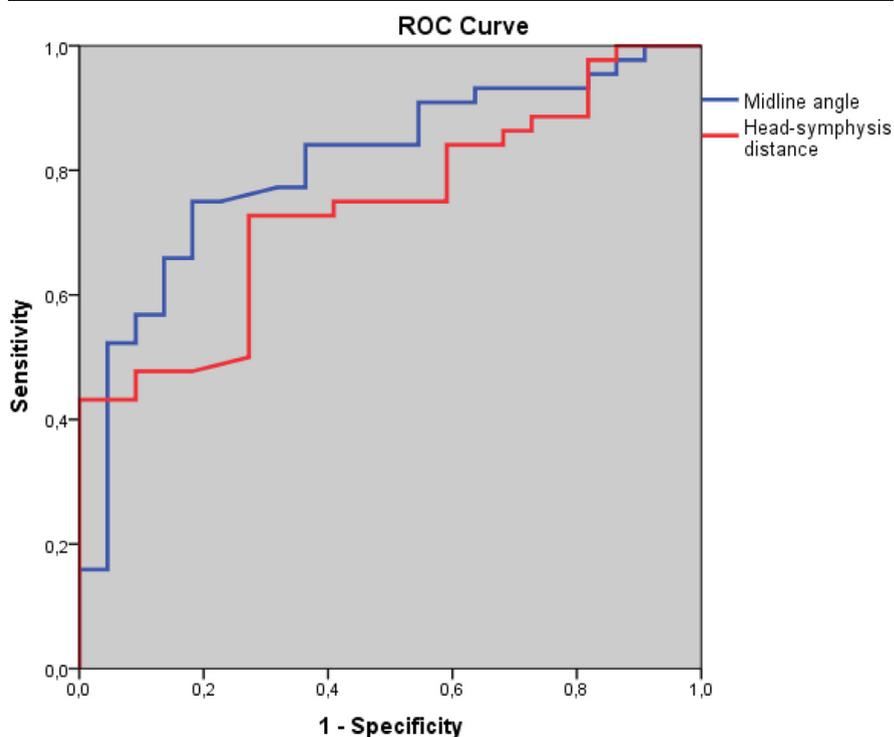
Receiver-operating characteristic curve analysis for head-symphysis distance and midline angle. AUCs for the prediction of mode of delivery were 0.81, 95% CI (0.70—0.92), *P* < .001, and 0.74, 95% CI (0.65—0.83), *P* = .002, for the midline angle and the head-symphysis distance, respectively.

AUC, area under the curve; *CI*, confidence interval; *ROC*, receiver-operating characteristic.

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significantly associated with the mode of delivery. However, the US findings, namely the midline angle and the head-symphysis distance, represented the only independent predictors of the mode of delivery.

Results in the context of what is known

There is much controversy in the literature and among experts on the maximum duration that should be allowed for the active second stage in healthy laboring women in the absence of suspected fetal compromise.[3—25] Several data support the concept that the increased duration of the second stage of labor is independently associated with an increased risk of adverse maternal and perinatal outcomes and with a progressively higher chance of operative vaginal delivery.[15—25,53,54]

In 2 large retrospective studies conducted either on nulliparous[53] or multiparous[54] women, Cheng et al[53] observed a direct relationship between the length of the second stage and the occurrence of postpartum hemorrhage, endometritis, third- and fourth-degree perineal tear, and low Apgar score at 5 minutes. Similarly, the results from a secondary analysis of a large randomized controlled trial conducted on nulliparous women with epidural analgesia also demonstrated a significant increase in the incidence of neonatal trauma and admission to neonatal intensive care unit for every hour of active pushing.[24] On this basis the prolongation of the second stage of labor has been considered a relatively common indication for obstetric intervention, either instrumental vaginal delivery or cesarean delivery, to minimize the risk of adverse events.[1,2,24]

Conversely, other evidence supports the concept that the slow progress of the second stage of labor per se does not mandate delivery.[11—14] Indeed, it has been recently demonstrated that extending the duration of the second stage beyond the conventional limits in the absence of fetal concerns may be safe for the mother and the baby and is associated with an increased likelihood of SVD.[10—15,24,55] A randomized controlled trial on the prolonged second stage of labor has demonstrated a greater than 2-fold reduction in the cesarean delivery rate with no worsening of the maternal and perinatal outcomes in women managed expectantly following the diagnosis of prolonged second stage.[10]

Of note, such findings were confirmed in other observational studies including larger numbers of cases.[11—14] In the light of these experiences, the previously reported higher risk of adverse maternal and perinatal outcomes in women with a prolonged second stage of labor is considered to be independent on the actual length of the pushing efforts but to be secondary to the underlying etiology and the obstetric management of the prolonged second stage itself.[12,18] On this basis, the recent ACOG/SMFM statement has affirmed that the length of the second stage alone "does not mandate delivery" and that allowing active pushing beyond the conventional threshold may be permitted "on an individual basis as long as progress is being documented."[2]

These recommendations have been recently challenged by a review work evaluating the available evidence on infant and maternal safety in relation to length of the second stage of labor.[3] The authors have scrutinized all the studies that have been pivotal in the ACOG/SMFM Obstetric Care Consensus. Of note, the revised upper limit of the second stage was based on the large *Eunice Kennedy Shriver* National Institute of Child Health and Human Development —sponsored study titled Consortium on Safe Labor,[9] which included only women that achieved a vaginal delivery and only infants with normal outcomes. Moreover, in most of

the studies supporting the safety of the prolongation of the second stage of labor, the infant outcome was corrected for the mode of delivery using logistic regression statistics.[21,24,53]

Such statistical correction would filter out adverse infant outcomes associated with the increased duration of the second stage of labor. Indeed, as this lengthens, the cesarean delivery rate incrementally increases not only because of the 3 hour threshold has been reached but also because the cesarean delivery becomes necessary because of the supervening fetal compromise.

Conversely, in the absence of statistical adjustment, the prolongation of the second stage beyond 3 hours was associated with serious infant complications as previously observed in other studies in which the data were not adjusted for the mode of delivery.[19,22,56]

Therefore, this review manuscript concludes that the evidence supporting the safety of a prolonged second stage for the fetus and for the woman requiring cesarean delivery is still lacking.[3]

Within this uncertainty, more recent studies specifically addressing the issue of birth outcome in relation to the adoption of the ACOG/SMFM guidelines on the second stage of labor have again provided conflicting results. Within a cohort of nulliparous women under epidural analgesia and with a prolonged second stage of labor, Thuillier et al[11] reported a reduction of the rate of cesarean delivery with no apparent increase in immediate adverse neonatal outcomes following the local implementation of the ACOG/SMFM recommendations.

On the other hand, albeit confirming a decreased incidence of obstetric intervention in cases in which more time for active pushing is allowed, the studies by Zipori et al[15] and Grantz et al[12] again confirm the major concerns in terms of maternal and neonatal safety related to the prolongation of the second stage of labor.

It is important to note that both instrumental vaginal delivery and cesarean delivery performed during the advanced second stage of labor are acknowledged risk factors for maternal and neonatal complications such as trauma, infection, hemorrhage, and potentially related long-term clinical sequelae.[11,12,14,26] This has been confirmed also in our study because a significantly higher risk of major complications including a lower Apgar score at 5 minutes and higher estimated blood loss were registered in the group in which OI was performed becaue of the prolonged second stage.

Notably, cesarean delivery performed during the second stage of labor is acknowledged to be associated with a higher likelihood of surgical complications and postpartum hemorrhage and infection compared with first-stage cesarean delivery[57–60] and may represent a potential determinant of complications such as preterm birth related to cervical incompetence in future pregnancies.[61–68] Moreover, a difficult or failed instrumental vaginal delivery either with vacuum or forceps is known to represent a major determinant of severe maternal and perinatal morbidity.[69–78]

For such reasons, the identification of the optimal modality of delivery in women at risk for OI is of paramount importance to optimize maternal and neonatal outcomes. Several studies have addressed the role of intrapartum US in the prediction of the mode of delivery in women with a prolonged second stage of labor.[36–46] In the vast majority of them, the angle of progression has been demonstrated to represent a reliable predictor of vaginal delivery and particularly of successful instrumental delivery.[36,39–41,43–45] Others have suggested a role of the head-perineum distance in the prediction of the mode of delivery in prolonged second stage.[41,42]

Our data, albeit showing an association between the head-perineum distance and the width of the angle of progression at rest and under pushing effort with the mode of delivery and between the head-perineum distance and the angle of progression under pushing effort with SVD, a multiparametric assessment could not demonstrate any role of the head-perineum distance and the angle of progression in the prediction of SVD.

Clinical implications

The aim of our work was not to predict the feasibility or the likelihood of success of an instrumental delivery, which was previously investigated by several other groups[40–42,44–46,79–82] but to evaluate the clinical role of US in the prediction of SVD despite slow progression of the second stage in nulliparous women. Within this selected cohort of women at risk of OI, the identification of those with a high residual chance of SVD may support an expectant management in cases with favorable sonographic findings, ultimately leading to the reduction of unnecessary OI that may be associated with maternal and neonatal risks.

Our results showed that the fetal head station either at clinical or sonographic assessment combined with fetal occiput position is significantly different between women with a prolonged second stage who end up in SVD vs those submitted to unplanned OI. However, at multivariable analysis only the ultrasound findings, namely a narrow midline angle and a short head-symphysis distance, were independent predictors of SVD.

Because of the mechanics of human labor, a midline angle below 45° is known to testify to the occurrence of the internal rotation that is required for the fetal head to negotiate the ischial spines plane. A narrow midline angle has been reported to be associated with a lower station and with a higher chance of SVD.[48] Moreover, because the progressive decrease of the space between the fetal skull and the maternal pubis is usually appreciated at digital examination during the fetal head descent, the sonographic measurement of the head-symphysis distance has been suggested as an additional index of fetal station.[46]

A short head-symphysis distance has been demonstrated to correlate with a low fetal station, with a wide angle of progression and with a high likelihood of SVD.[51,83] Interestingly, between 0 and +2 cm from the ischial spines, a shorter head-symphysis distance has been documented among fetuses in OA compared with those in occiput

Sonographic mechanics of human labor in occiput anterior and occiput posterior position
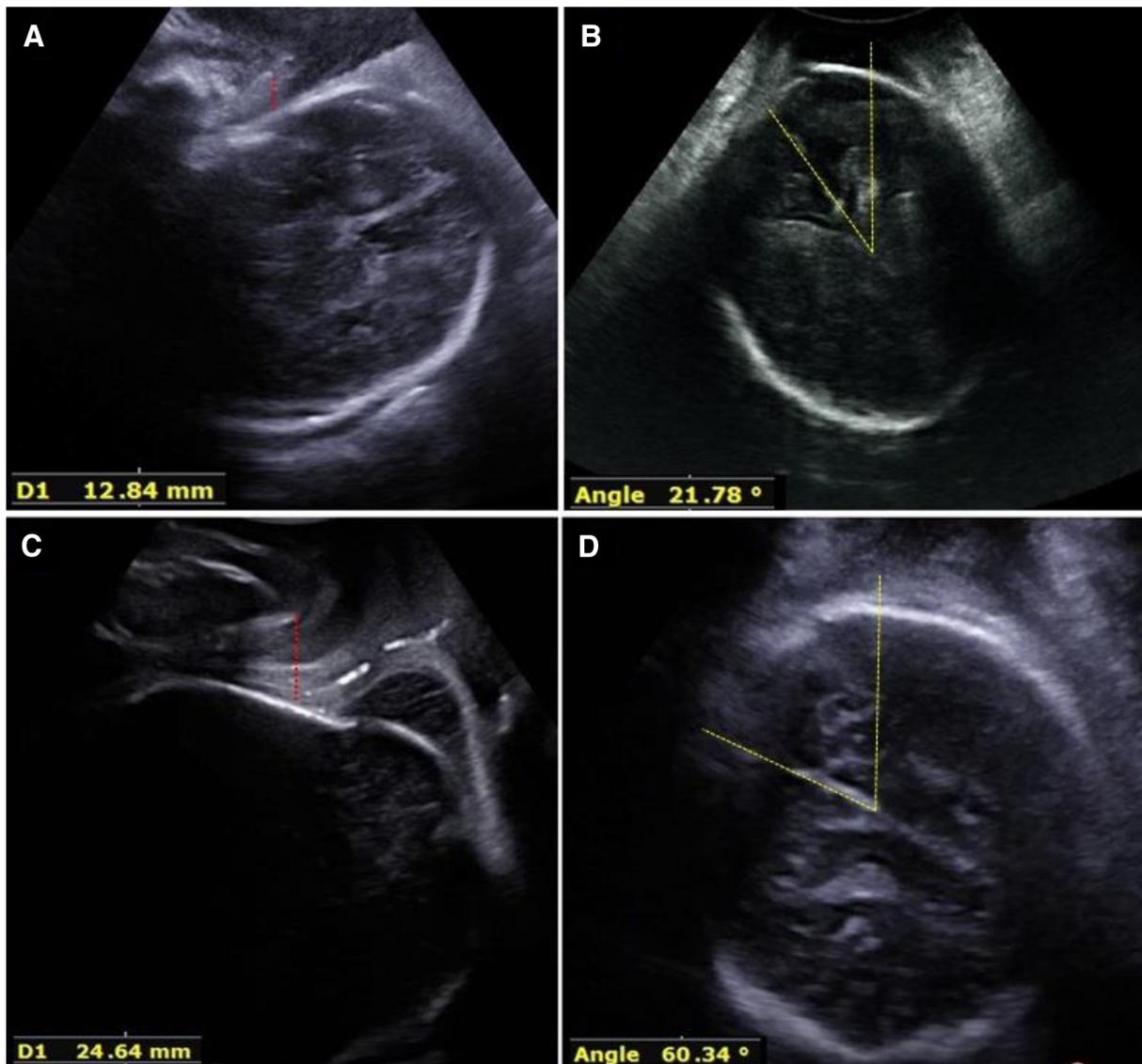
In the middle part of the birth canal, fetuses in the occiput anterior position show a horizontal-upward direction approaching the pubic bone, which is almost invariably associated with the occurrence of the internal rotation. In such cases a short head-symphysis distance **(A)** and a narrow midline angle **(B)** can be demonstrated by intrapartum ultrasound. Conversely, fetuses in the occiput posterior position show a downward direction toward the sacrum because the internal rotation has not occurred. These cases are usually associated with wide head-symphysis distance **(C)** and midline angle >45 degrees **(D)**.

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posterior position.[84] This seems to depend on the fact that in the middle part of the birth canal at transperineal US assessment, OA fetuses display a horizontal-upward direction approaching the pubic bone, while the occiput posterior fetuses show a downward direction toward the sacrum[38] and can eventually approach the symphysis after an upward head flexion only when reaching the outlet (Figure 2).

This may explain why in our work the midline angle and the head-symphysis distance turned to be the strongest predictors of the mode of delivery in a group of women with a prolonged active second stage. Indeed, the combination of a narrow midline angle together with a short head-symphysis distance can be considered as a surrogate of internal rotation and OA position, which are the 2 most favorable conditions for an imminent SVD.

Research implications

Intrapartum US has been demonstrated to perform better than clinical

examination in the assessment of the fetal head station[31,48,50,51,85–87] and position[79,88,89] and in the diagnosis of the malpositions and malpresentations of the fetal head,[90–92] among whom some require active intervention to safely accomplish a vaginal delivery.[92] On this ground, it is not surprising that the use of intrapartum US in prolonged second stage of labor is currently endorsed by the guidelines of the International Society on Ultrasound in Obstetrics and Gynecology with a level of evidence of 2+ grade of recommendation B[32].

Despite being mentioned in the previously cited guidelines, the use of the midline angle and the head-symphysis distance has not gained much popularity because these 2 sonographic parameters are not recommended as primary methods for the assessment of the fetal head station.[32] On the other hand, the usefulness of US in predicting the chance of SVD in women with prolonged second stage of labor has been addressed in a paucity of studies. Within a cohort of 62 women submitted to transperineal US, Masturzo et al[38] found that a favorable head direction (head up) was associated with SVD in the vast majority of cases (16 of 20, 80%), while significantly lower rates of SVD were observed for the downward (4 of 20, 20%) and the horizontal (9 of 22, 41%) head direction.

Another prospective study including 41 women with prolonged second stage, among whom only the 26 cases with OA position were evaluated, found that an angle of progression on or above 120 degrees was associated with a 90% fitted probability of either an easy and successful vacuum extraction or SVD.[37] Finally, a more recent research that involved more than 500 women recruited in the early second stage of labor found that the angle of progression and the midline angle are useful for estimating the remaining time in labor and have higher predictive value than digital vaginal examination.[93]

Our data also demonstrated that the angle of progression at the peak of maternal effort during pushing and the delta angle of progression were significantly narrower in the OI group. The finding that intrapartum US parameters recorded at the peak of pushing correlate with birth outcome and interval to delivery is not novel because Tutschek et al[35] previously found a significant association between the changes of the angle of progression during active pushing and the chance of vaginal delivery, and very recently also a smaller delta head-perineum distance has been related to a longer duration of operative vaginal delivery and a higher frequency of cesarean delivery in nulliparous women with prolonged second stage of labor.[94]

However, it is important to bear in mind that the width of the angle of progression may be falsely reassuring in the case of some types of fetal head malpresentations, which may preclude vaginal delivery[43,80,95]; therefore, we do envisage that the combination of multiple views (sagittal and axial at both the transabdominal and transperineal approach) may be required to assess properly the fetal head station and position to rule out malpresentations or malpositions and to optimally predict the mode of delivery.[95]

Within a population at high risk of operative delivery, the identification of those women with a good chance of achieving SVD is of paramount importance to minimize the risk of adverse maternal and perinatal outcomes associated with both instrumental extraction and second-stage cesarean delivery. On this basis, we strongly believe that intrapartum US may represent a promising tool to be included in newly developed protocols for the management of prolonged second stage of labor. Women with favorable conditions could be allowed more time for active pushing, while it seems reasonable to proceed with OI (either instrumental delivery or cesarean delivery) when the clinical diagnosis of prolonged second stage is made in presence of unfavorable sonographic findings. It is important to note, however, that sonographic parameters should not be considered outside the context of a thorough clinical assessment of the laboring woman and of the fetal head progression.

Stengths and limitations
To our knowledge, this is the first study evaluating the role of multiple sonographic parameters that can be measured with transabdominal and transperineal US for the prediction of SVD in women with a prolonged second stage of labor. This we believe can be considered among the major strengths of our work. Another strength is that this study was prospectively conducted at 2 referral centers for intrapartum US, which has allowed the collection of several US parameters within a selected population at risk of OI.

On the other hand, the main limitation is that our cohort was not powered enough to detect statistically significant difference in maternal and perinatal adverse outcomes; therefore, we could not assess the role of intrapartum US in minimizing maternal and neonatal risks in a prolonged second stage of labor.

Conclusion
In conclusion, our study has demonstrated the usefulness of intrapartum transabdominal and transperineal US in a prolonged second stage of labor for the identification of those women who have a good chance of achieving SVD. Further studies are needed to evaluate whether intrapartum US may play a role in the optimization of maternal and perinatal outcomes in cases of a prolonged second stage of labor. ■

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SUPPLEMENTAL TABLE
Demographic features and transperineal and transabdominal ultrasound parameters at diagnosis of prolonged second stage in the spontaneous vaginal delivery, instrumental delivery, and cesarean delivery group

Variables	Spontaneous vaginal delivery (n = 40/109, 36.7%)	Instrumental delivery (n = 40/109, 36.7%)	Cesarean delivery (n = 29/109, 26.6%)	P value
Maternal age, y, mean ± SD	32.8 ± 5.7	32.4 ± 5.9	33.6 ± 5.4	.64
Ethnicity n (%)	White, 36 (90.0%) African, 3 (7.5%) Asian, 1 (2.5%) Others, 0 (0.0%)	White, 33 (82.5%) African, 5 (12.5%) Asian, 2 (5%) Others, 0 (0.0%)	White, 20 (69%) African, 4 (13.8%) Asian, 4 (13.8%) Others, 1 (3.4%)	.24
BMI, kg/m^2, mean ± SD	28.6 ± 4.0	28.2 ± 4.4	28.6 ± 3.7	.96
Maternal height, cm, mean ± SD	163 ± 6	165 ± 5	163 ± 6.9	.21
Gestational age, wks$^{\pm days}$, mean ± SD	$40^{\pm 0} \pm 1^{\pm 0}$	$39^{\pm 0} \pm 1^{\pm 3}$	$39^{\pm 6} \pm 1^{\pm 0}$	.37
First-stage length, min, mean ± SD	464 ± 224	435 ± 152	499 ± 151	.37
Second-stage length, min, mean ± SD	135 ± 11	162 ± 23	176 ± 23	< .001
Labor length, min, mean ± SD	586 ± 236	598 ± 146	658 ± 181	.28
US-delivery interval, min, mean ± SD	15 ± 11	42 ± 23	56 ± 23	< .001
Birthweight, g, mean ± SD	3397 ± 363	3389 ± 525	3548 ± 352	.24
Epidural n (%)	Yes, 28 (70.0%)	Yes, 25 (62.5%)	Yes, 21 (72.4%)	.64
Induction of labor n (%)	Yes, 6 (15.0%)	Yes, 9 (22.5%)	Yes, 5 (17.2%)	.68
Augmentation n (%)	Yes, 25 (62.5%)	Yes, 27 (67.5%)	Yes, 19 (65.5%)	.89
Fetal head station, cm, median (range)	1 (−2 to 3)	1 (−2 to 1)	0 (−3 to 1)	< .001
Fetal head position n (%)	Non-OA, 4 (10.0%)	Non-O,A 14 (35%)	Non-OA, 20 (68.9%)	< .001
HPD, cm, mean ± SD	33.2 ± 7.8	36.7 ± 7	45 ± 9	< .001
MLA, degrees, mean ± SD	29.6 ± 15.3	47.6 ± 22	61.43 ± 23	< .001
AoP rest, degrees, mean ± SD	137.2 ± 14.8	136.1 ± 18.1	123.1 ± 20.4	.003
AoP pushing, degrees, mean ± SD	153.3 ± 19.8	149.5 ± 22	132.8 ± 27	.002
Delta AoP, degrees, mean ± SD	17.3 ± 12.9	13.9 ± 12	11.1 ± 10.3	.04
HSD, cm, mean ± SD	13.1 ± 4.6	15.7 ± 5.6	23.8 ± 8.7	< .001

Statistical analysis was as follows: an analysis of variance for continuous variables with normal distribution; Kruskal-Wallis test for continuous variables with nonnormal distribution; χ^2 test for categorical variables.

AoP, angle of progression; *BMI*, body mass index; *HPD*, head-perineum distance; *HSD*, head-symphysis distance; *MLA*, midline angle; *OA*, occiput anterior; *US*, ultrasound.

Dall'Asta et al. Predicting vaginal delivery in patients with a prolonged second stage. Am J Obstet Gynecol 2019.