REVIEW

The predictive role of uterocervical angle in labor outcomes: a narrative review

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ABSTRACT

INTRODUCTION: Uterocervical angle (UCA) is the angle between the anterior or posterior uterine wall and the cervical canal, and it has become an unique ultrasonographic marker in the recent years. The predictive role of the UCA in spontaneous preterm births (sPTB) has been examined by numerous authors, however few data are available on UCA as predictor of labor outcome at term of pregnancy. Therefore, the purpose of this review is to evaluate the effectiveness of transvaginal ultrasound measurement of UCA at term, and its clinical implications in obstetrics' practice.
EVIDENCE ACQUISITION: A literature search was conducted including all studies regarding the predictive role of ultrasonographic evaluation of the UCA on labor outcomes from 1990 to 2023.
EVIDENCE SYNTHESIS: A narrative synthesis was subsequently performed dividing studies that considered posterior and anterior UCA. Five studies were included for the anterior UCA, and ten for the posterior UCA. UCA was then evaluated as predictor of prolonged latent phase and predictor of the onset and mode of delivery.
CONCLUSIONS: It is likely that the combination of multiple cervical parameters, rather than UCA assessment alone, together with clinical information, can achieve higher levels of accuracy in predicting delivery outcomes. Future prospective studies are needed to define with greater certainty the role of UCA as a useful screening tool before laboring, but, until then, the use of UCA as a screening test to predict labor outcome should remain investigational.

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KEY WORDS: Labor, induced; Ultrasonography, prenatal; Uterus.

Introduction

The biomechanical role of the cervix during pregnancy is critical but not yet fully understood. The cervix is supported in the pelvis by the cardinal ligament and the utero-sacral ligament. Its role is to sustain the growing uterus and hold the fetus until the end of pregnancy.[1] This requires resisting multiple forces from the uterus, including the weight of the fetus and amniotic sac, as well as passive pressure from the uterine wall.[1] If the loads cannot be supported the balance breaks down, and the cervix softens considerably, shortening and dilating to allow the fetus to be delivered.

Therefore the structural change of the cervix as well as the angulation between the uterus and cervix, play a relevant role for the smooth progress of labor.[1] Throughout the pregnancy, a number of cervical examinations have been looked at in order to predict the risk of preterm delivery, the mode of delivery, and the outcome of labor induction or progression.[1] One of the most used techniques for evaluating the cervix and forecasting vaginal or cesarean birth is the Bishop Score (BS).[2] However, BS is subjective and has a poor predictive

value.[2] Several ultrasonic techniques have been examined in order to overcome the drawbacks of BS and identify objective predictors.[3] The assessment of cervical stiffness during pregnancy can be done using ultrasonographic models that predict successful delivery. These models include cervical length (CL), angle of progression (AoP), fetal head-perineum distance (HPD), fetal head-symphysis pubis distance (HSD), fetal head position prior to labor, cervical volume, cervical vascularization, sonoelastography, and shear wave velocity.[4] Despite the large number of studies using CL as a delivery method predictor, the findings are still debatable.[5-10] Sonoelastography was very recently developed, and research suggests that it may be helpful in anticipating the result of induced labor.[11] Nevertheless, due to high equipment costs and the need for specialized training, this technique is not appropriate for widespread usage.[4] The angle between the anterior or posterior uterine wall and the cervical canal is known as the uterocervical angle (UCA), and it has become a unique ultrasonographic marker in recent years.[6] The potential utility of UCA as a mechanical barrier for anticipating preterm birth has been examined by a number of writers. Preterm birth has a strong prognostic value, according to a broader UCA.[6, 9, 12] However most of the studies were focused on UCA measurement during the second trimester of pregnancy, and few data are available on UCA as predictor of labor outcome at term of pregnancy.[1, 13] Therefore, the purpose of this review is to evaluate the effectiveness of transvaginal sonographic measurement of UCA in pregnancies at term, and the clinical implications of this parameter in the obstetrical practice.

UCA: the physical basis

The cervix, which is sensitive to changes brought on by the pressure of the uterus and pelvic organs, is undeniably important in labor because of its high collagen content and ligamentous support.[14] Not only the cytoarchitectural changes with the remodeling of collage fibers, but also the structural changes of the angle between the uterus and cervix must be taken into account to fully understand the labor process. Cervical effacement shortens the cervix and stretches the lower uterine segment. Thus, women who have a favorable cervix should exhibit a shorter CL and a wide UCA during ultrasound screening.[14]

The correlation between UCA and labor prediction could be explained using the basics of physics.

The force that a gravid uterus applies on the cervix varies depending on the UCA.[14, 15] If a uterine contraction acts on a narrow angle, it will strengthen the closure of the endocervical canal; conversely, if the same force is expressed on a wide UCA, the result will be a faster opening of the endocervical canal. This would accelerate the emptying of uterine contents into the vagina.[14, 15] In addition, a wider UCA may allow the fetal head to exert more direct and effective pressure on the cervix; as a result, uterine emptying will be more linear.[14, 15]

Studies report that the risk of preterm labor increases as the UCA increases.[15] UCA has also undergone evaluation for predicting the success of mid-trimester pregnancy termination, demonstrating a high level of sensitivity and specificity.[16] CL and UCA were also examined to distinguish between true and false labor, and the results indicated that the true labor group had a shorter CL and a bigger UCA.[17] Recent studies have examined the relationship between effective labor induction and UCA.[1, 14, 18] A shorter CL might suggest more successful induction of labor, based simply on the assumption that the same force is exerted in a shorter distance.[1] However, it must be considered that the force changes depending on how the vector applicated is transmitted; and therefore, this is the reason why the UCA should be considered.[1] Moreover, compared with BS, which is based on cervical position or effacement, UCA could provide more detailed information and it considers the sum of multiple vectors from both directions, the anterior wall and the endocervical canal.[19]

Evidence acquisition

A literature search was performed using the National Center for Biotechnology Information (NCBI) PubMed database, and Scopus database. The considered timeframe was from 1990 to 2023. This search was focused only on papers published in English. Relevant keywords (uterocervical angle; posterior cervical angle; induc-

tion of labor, failure of induction; transvaginal ultrasonography; antepartum ultrasound; time of delivery; vaginal delivery) were used to gather articles regarding the predictive role of ultrasonographic evaluation of the UCA on labor outcomes. The first two authors independently assessed the eligibility of the studies. Due to the nature of the articles included in this review, a narrative synthesis was performed dividing studies that considered posterior and anterior UCA.

Evidence synthesis

Utero-cervical angle as predictor of failure of induction of labor

Induction of labor (IOL) is a frequently performed obstetric treatment, with over 20% of pregnancies undergoing IOL for several reasons such as post-term pregnancy, pre-labor rupture of membranes, elective labor, and other medical indications.[20] Assessing the condition of the cervix before delivery is an important factor to consider due to the major impact of IOL in obstetrics. While BS has been acknowledged as a valuable tool for prediction, there is a need for more objective and accessible forecasting methods. Currently, research is mostly focused on determining the predictive relevance of transvaginal sonographic findings.[15, 21]

CL is commonly employed as a sonographic parameter to assess the cervix. However, there is still disagreement among studies about the reli-

ability of sonographic measurement of CL in predicting the outcome of labor induction.[12] Although several authors have demonstrated higher sensitivity and specificity, CL has not been found to be superior to BS.[22] Therefore, it may be more acceptable to use more comprehensive approaches that include both sonography and digital examination.[21-23]

According to recent reports, UCA has been identified as a reliable indicator of IOL. Therefore, numerous studies have endeavored to assess alterations in the cervix resulting from the intensity of uterine contractions prior to manual examination. The accurate evaluation of such alterations can be done by measuring the angles between the cervix and the lower uterine region.[18]

Here, we have included a separate summary of the research that examined the angle between the posterior uterine wall and the cervical canal (posterior UCA) and the angle between the anterior uterine wall and the cervical canal (anterior UCA) (Supplementary Digital Material 1: Supplementary Table I, Supplementary Table II).[1, 3, 14, 18, 19, 23-32]

PCA

Several writers have extensively examined the posterior uterine cervical angle (PCA) in order to forecast the likelihood of a successful labor induction (Supplementary Table I).[3, 23-31] PCA is measured as the angle between the midsagittal line along the cervical canal and a line tangential to the posterior uterine wall[3] (Figure 1).
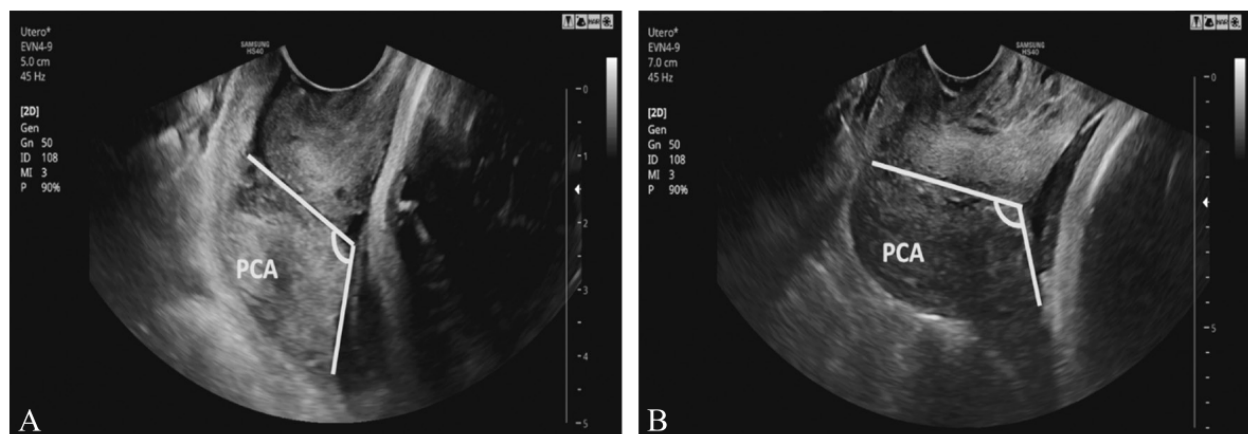

Figure 1.—Posterior uterocervical angle (PCA) is measured as the angle between the midsagittal line along the cervical canal and a line tangential to the posterior uterine wall. The two images represent angles with different widths: narrow angle (A) and wide angle (B) in yellow (colors in the online version).

Paterson-Brown *et al.* reported that PCA was more accurate than BS in predicting vaginal delivery.[24] Combining PCA>70° and BS>5 yielded the best accuracy in predicting successful IOL (sensitivity 88%, specificity 100%, k=0.68).[24]

Rane *et al.* performed transvaginal ultrasound in 604 patients whose PCA measurements of more than 120° was associated with a positive response to IOL within 24 hours.[3] PCA, in conjunction with preinduction CL measurements, occipital position, and certain maternal features, were determined to have substantial and separate predictive value for the duration between induction and birth, the probability of vaginal delivery within 24 hours, and the probability of cesarean delivery. These sonographic parameters were superior to BS in predicting the outcome of induction.[3]

According to Keepanasseril *et al.*, a PCA with a minimum angle of 100° can be used to predict the effective IOL in women who have not given birth before. This prediction method has a sensitivity of 65% and a specificity of 72%.[23] The authors demonstrated that the utilization of CL and PCA yielded superior results compared to standard BS in accurately predicting successful labor induction in nulliparous women.[23] Eggebo *et al.*, instead, considered an angle of 90° as a cut-off in the assessment of the PCA.[25] Their findings are similar to the study analyzed above, since the authors conclude that a PCA of >90° significantly predicted successful induction.[25]

Prado *et al.* carried on a prospective cohort study regarding 204 singleton vertex pregnancies, to predict the onset of labor within 12 hours, and vaginal deliveries regardless of the induction-to-delivery interval.[26] The authors found out that PCA≥114 ° was an ultrasonographic predictor associated with the success of IOL, and that values of PCA increased four times the likelihood of vaginal delivery, regardless the induction-to-delivery interval.[26]

Al-Adwy *et al.* found that a PCA angle greater than 99.5° had the highest accuracy in predicting the successful induction of labor, when compared to CL and BS.[27]

Furthermore, according to a study conducted by Gokturk *et al.*, a PCA angle greater than 120° was found to be a reliable indicator of successful labor induction.[28] PCA was statistically signifi-

cantly higher in a group of patients who delivered within 24 hours from IOL. However, in a multiple regression analysis this finding was not statistically significant.[28]

In another study which dismisses the role of PCA as a predictor of successful labor induction, the authors developed a pilot predictive model based on clinical and ultrasonographic parameters to show a significant association with the IOL result.[29] They considered a consistent number of ultrasonographic variables, such as CL, PCA, fetal HPD, cervical wedge, cervical dilatation and funneling. PCA was statistically significant different between women who delivered vaginally compared with women who underwent cesarean section after IOL (110° *vs.* 113°; P=0.048). Nevertheless, only fetal HPD, CL and BS showed significant association with the result of IOL.[29]

Hosoya *et al.* investigated cervical parameters predictive of vaginal delivery in elective labor induction among women at 40 to 41 weeks of gestation.[30] Higher BS, shorter CL, and changes in CL with dilatation are potential independent predictors of vaginal delivery following elective IOL in nulliparous women at 40 to 41 weeks of gestation. The PCA and other background characteristics showed no significant associations.[30]

A similar study was conducted by Uzun *et al.* including women beyond 41 weeks of gestation, and the findings were superimposable.[31] As a matter of fact, the authors concluded that BS predicts the need for cesarean delivery better than the ultrasonographic assessment of the cervix.[31]

Anterior UCA

Anterior UCA (aUCA) is measured as the angle between the midsagittal line along the cervical canal and a line tangential to the anterior uterine wall[6] (Figure 2). UCA has been proposed primarily as an ultrasound marker to predict spontaneous preterm delivery, with inconsistent results.[33] The authors of this latter, also focused on investigating this parameter as a predictor of labor induction outcome (Supplementary Table II).[1, 14, 18, 19, 32]

Eser *et al.* demonstrated that CL and aUCA, with respectively 27 mm and 97° as cut-offs, are good predictors of successful IOL.[18] The authors demonstrated also that labor induction-to-delivery
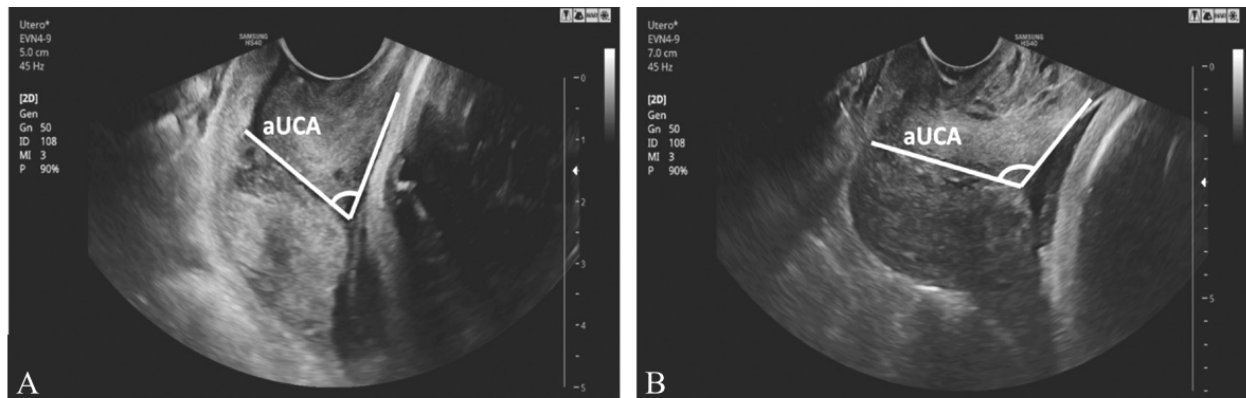
Figure 2.—Anterior UCA (aUCA) is measured as the angle between the midsagittal line along the cervical canal and a line tangential to the anterior uterine wall. The two images represent angles with different widths: narrow angle (A) and wide angle (B) in white.

time was significantly higher in a group with lower aUCA, suggesting that narrow angles may be associated with the prolonged latent phase of labor.[18]

Similar findings are described by Abdelhafeez *et al.*, considering a CL cut-off value of 32.3 mm, and 110.2° for the aUCA.[14]

In a study by Yang *et al.* the value of aUCA in predicting the success of IOL was evaluated, compared with BS and CL.[19] Women with successful IOL had significantly wider aUCA (P=0.012) and higher BS (P=0.001); however, the CL was not significantly different (P=0.130). aUCA alone did not perform better than the BS when predicting successful IOL. However, a combination of BS with aUCA was found to have higher performance in predicting IOL (combined UCA>108.4° and favorable BS achieve sensitivity of 44.6%, specificity of 96.0%, PPV of 96.2%, and NPV of 43.6%).[19]

Dagdeviren *et al.* reported that aUCA was not a useful predictor of IOL in a single-center study.[1] However, these results might be due to the number of multi-parity pregnancies and differences in IOL definition, as various centers use different protocols and definitions of successful IOL.[1]

Ileri *et al.*, nonetheless, found that there was no relation between failed IOL and cervical elastography, cervical volume, CL, and aUCA measurements in pregnant women with unfavorable cervix defined as a BS lower or equal to six.[32]

UCA as predictor of prolonged latent phase

UCA measurement was used to predict the latent phase duration in women with a post-term pregnancy.[34] aUCA significantly predicted prolonged latent phase duration, defined as a time >1200 min (AUC: 0.917, P<0.0001). The optimal cut-off value was obtained with UCA below 105° (sensitivity 100%, specificity 75%). Although CL was not effective in predicting latent phase duration, authors demonstrated that aUCA could be an independent risk factor for prolonged latent phase.[34]

The ultrasound measurement of aUCA has also been used to differentiate "false labor" from "real labor"[17]. False labor is a frequent obstetric situation affecting 5-12% of patients.[35] It involves painful uterine contractions that are almost regular, but not associated with significant progression of the cervical changes and absence of delivery in 24 hours.[36] The "true labor" group had shorter CL and larger UCA. The optimal cut off for UCA was, 123° (RR 6.7, sensitivity 50%, specificity 83%, PPV 10%, NPV 96%).[17]

Combining CL and UCA measured through transvaginal scan, together with a careful examination of patients, authors obtained the best specificity, yielding positive likelihood ratio that rich 13. This study investigated this innovative application of ultrasound to identify false labor avoiding unnecessary hospitalizations with negative obstetric and economic impacts.[17]

UCA as predictor of the onset and the mode of delivery

The study also examined the effect of UCA in predicting the occurrence of spontaneous birth in singleton pregnancies at full term. A transvaginal

ultrasound scan was used to acquire measurements of CL, posterior cervical angle (PCA), hardness ratio (HR), and mean strain from the internal os and external os in a group of 398 nulliparous singleton pregnancies at 37 to 38+6 weeks of gestation.[35] The main objective of the study was to explore the role of cervical sonoelastography in predicting the onset of spontaneous delivery within 7 days and to compare its diagnostic performance with the CL and PCA once. Almost 25% of the women included in the study delivered within one week. PCA was narrower (99° *versus* 102°; P=0.02) in women who delivered within 7 days from the assessment. However, CL and HR were the only variables independently associated with delivery within one week. A diagnostic model integrating these two parameters showed better diagnostic performance for imminent delivery.[35]

The authors conducted a study to assess the effectiveness of antepartum ultrasound in predicting the occurrence of spontaneous labor at 40 weeks of gestation in low-risk singleton nulliparous[37] and multiparous women.[38] Less than half of women delivered beyond 40 weeks (49.2% of nulliparous and 45.4% of multiparous). Women delivering beyond 40 weeks had a longer CL and HPD, higher HR, while PCA and AoP were narrower. PCA was wider (105° *vs.* 98° in nulliparous and 104° *vs.* 98° in multiparous, P≤0.0001) in women delivering before 40 weeks than those delivering later.[37, 38] Nevertheless, while doing multivariable logistic regression analysis, it was found that only CL and high placental density (HPD) were independently linked to birth beyond 40 weeks in the nulliparous cohort. In the multiparous cohort, CL, HPD, and high risk (HR) were independently connected with delivery beyond 40 weeks. A CL greater than 24 mm at 36 to 37 weeks of gestation demonstrated the best balance between sensitivity and specificity in predicting delivery after 40 weeks of gestation.[37] The combination of HPD and HR did not have a substantial impact on the diagnostic accuracy of CL alone in predicting delivery before 40 weeks.[38] The findings from these studies showed that antepartum ultrasound could reliably identify a subset of women at higher risk of delivering beyond 40 weeks of gestation, which represents the group of women who would ideally benefit from planned IOL at 39 weeks of gestation, in order to reduce perinatal complications.[37, 38]

In another study from the same authors, PCA was assessed immediately before membrane sweeping in 159 singleton term pregnancies, in order to predict spontaneous vaginal birth within 24 and 48 hours from the procedure.[39] PCA was higher (96.41±9.61 *vs.* 120.2±15.4; t=11.741; P≤0.0001) in women delivering within 24h from sweeping compared to controls. The best cut-off values to predict successful sweeping at 24 and 48h, calculated by ROC analysis, were 97.4° and 96° respectively. The combination of cervical parameters assessed on ultrasound (PCA and CL) together with parity and gestational age was retained a valuable tool in predicting spontaneous vaginal delivery after membrane sweeping by the authors.[39]

Kim *et al.* performed a retrospective cohort study to investigate the value of PCA in the prediction of successful vaginal birth before the labor beyond 34 weeks of gestation.[13] The study revealed that an increased pelvic circumference was linked to a greater likelihood of achieving a successful vaginal delivery, irrespective of body mass index (BMI) and parity.

Furthermore, the authors have shown that PCA is a distinct feature that is associated with successful vaginal delivery in women who have not previously given birth. The ideal PCA threshold was determined to be 96.5°, exhibiting a sensitivity of 73.5% and a specificity of 63.6%. For first-time mothers, the threshold value was determined to be 97.2°, with a sensitivity of 74.4% and specificity of 65%. Logistic regression analysis showed that increased maternal BMI, multiparity, and PCA exceeding 96.5° were independent factors linked to successful vaginal birth. Among the nulliparous group, a PCA exceeding 97.2° was identified as the sole independent predictor linked to achieving a successful vaginal birth.[13]

Contrary to this, the authors argue that aUCA is not useful in predicting successful vaginal birth because to the fact that pressure is typically exerted more on the posterior wall rather than the front wall.[13]

Discussion

The role of the cervix in labor is undeniable and studies surrounding the prediction of labor and/or induction failure are mainly focused on its sonographic parameters.[40, 41]

UCA emerged as a newer ultrasound parameter to predict labor outcome and basic physics play an important role in determining the UCA and its prediction of labor.[40, 41]

However, studies investigating UCA show conflicting results, identifying different cutoffs. This is attributable to non-uniformity of outcomes and great variability in methodology. Several studies have defined successful vaginal delivery as the primary goal, without considering additional criteria that may require a cesarean section, such as fetal distress. Previous research has characterized the primary result as the successful initiation of labor, determined by sufficient uterine contractions or cervical changes, without considering the method of delivery. Different induction protocol (involving different pharmacological methods), different skills level in performing digital and ultrasonography examination, the many different physicians who perform the measurement, the definition of failure of labor progress, the wide range of pregnancy durations considered, and the parity of women included, represent the main methodological criticalities in these studies.

Among different studies reviewed, the cervical angle was never analyzed alone, but always in association with other ultrasonographic parameters. The primary objective of evaluating the accuracy of UCA compared with other ultrasonographic parameters has been considered by only a few authors.[19, 27]

Therefore, we do not have sufficient evidence to establish the accuracy and superiority of uterocervical angles over other measurements, such as cervical length.

Both uterine cervical angles, anterior and posterior, have been used to assess labor outcomes. However, they have never been analyzed together and compared during the third trimester of pregnancy. This is another major limitation that makes it difficult to clarify the effectiveness of the two different ultrasound measurements.

It is important to note that the cervix is primarily composed of collagen fibers, which allow it to withstand the mechanical strain exerted by the surrounding organs and the enlarging uterus.[40, 41] Anatomical characteristics dictate the direction and density of collagen fibers. Furthermore, the alteration of collagen fibers fluctuates throughout the duration of pregnancy and may exhibit variations across different women.[40, 41]

UCA is presumably affected by the composition of the cervix and expresses its degree of rigidity;[40, 41] however, it is likely that the complexity of the cytoarchitecture of the cervix and its remodeling cannot be assessed by this ultrasonographic parameter alone.

Nonetheless, transvaginal ultrasound is a tool that clinicians should use to better identify women at risk of induction failure or those who will deliver beyond term. This tool would help physicians to provide individualized counseling to patients undergoing induction of labor, especially regarding its safety and effectiveness. In addition, antepartum ultrasound could help avoiding un-necessary obstetric interventions and possible related adverse outcomes, and consequently healthcare costs.

Conclusions

It is likely that the integration of multiple sonographic cervical parameters, rather than UCA assessment alone, together with clinical information such as parity and gestational age, could achieve higher levels of sensitivity and accuracy in predicting delivery outcomes.

Future prospective studies are needed to define with greater certainty the role of UCA as a useful screening tool before laboring. It would be necessary to evaluate the accuracy and superiority of UCA compared with other standard ultrasonographic measurements. In addition, anterior and posterior UCA are expected to be analyzed in more detail, comparing them with each other to better understand their differences and clinical implications.

Until prospective studies are completed, the use of UCA as a screening test to predict labor outcome should remain investigational.

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Conflicts of interest
The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions
Libera Troìa contributed to the study conception and design; material preparation, data collection and analysis were performed by Libera Troìa, Alessandro Libretti and Federica Savasta; The first draft of the manuscript was written by Libera Troìa and all authors commented on previous versions of the manuscript. All authors read and approved the final version of the manuscript.

SUPPLEMENTARY DIGITAL MATERIAL 1

Supplementary Table I.—Posterior utero-cervical angle as an ultrasound predictor of successful induction of labor.[3, 23-31]

	Type of Study	Patients	GA	Methods of Induction	US cervical measurements	Primary outcomes	Main results	PCA are good predictors of successful IOL
Paterson-Brown et al.[24] UK	Prospective observational study	50 singleton pregnancies	37-42 ws	Amniotomy + oxytocin or PGE2 gel	PCA, CL, cervical width, dilatation, position, lower segment thickness	To compare US assessment with the BS to predict IOL success	The overall accuracy in predicting induction outcome was greater with PCA than BS. Combining PCA >70° and BS>5 yielded the best accuracy in predicting successful IOL	Yes
Rane et al.[3] UK	Prospective study	604 singleton pregnancies	35-42+6 ws	ND	PCA, CL	To examine the value of CL, PCA and occipital position in the prediction of: 1. the induction-to-delivery interval within 24h 2. the likelihood of VD within 24h 3. the likelihood of CS	1. Prediction of the induction-to-delivery interval was provided by the OP, CL, PCA and parity 2. Prediction of the likelihood of VD within 24 h was provided by OP, CL, PCA and BMI. 3. Prediction of the likelihood of CS was provided by the OP, CL, parity, maternal age and BMI.	Yes
Keepanasseril et al.[23] India	Prospective observational study	145 singleton pregnancies,	34-41 ws	Misoprostol or PGE2 gel +	PCA, CL, funneling	To determine the usefulness of different US parameters in	CL and PCA are independent predictors of successful outcome of IOL, with 3cm as	Yes

2

Study	Design	Population	GA	Induction	US parameters	Aim	Results	IOL predicted
		nulliparous women		oxytocin	PCA, CL, cervix dilatation	predicting the successful IOL in nulliparous women	cut-off for CL and 100° for PCA	
Eggebø et al.[25] Norway	Prospective comparative clinical study	275 singleton pregnancies	>37 ws	Misoprostol or amniotomy + oxytocin	PCA, CL, cervix dilatation	To compare elements of the BS and corresponding US measurements before IOL, and assess how predictive factors can be used in a clinical setting.	Univariable regression: digital assessment of cervical dilatation, FHPD<40mm, CL>25 mm, PCA>90° were correlated with successful IOL. Multivariate regression: previous vaginal birth, maternal height and PCA>90° predicted successful IOL.	Yes
Uzun et al.[31] Türkiye	Prospective observational study	90 singleton pregnancies, nulliparous women, intact membranes	≥41 ws	Oxytocin	CL, PCA, quantification of the cervical stromal echogenicity by tissue histograms and funneling	To predict CS before IOL	BS predicts the need for CS better than the US assessment of the cervix	No
Gokturk et al.[28] Türkiye	Prospective observational study	178 singletons pregnancies, intact membranes, BS<5	37-42 ws	Oxytocin	PCA, CL	To evaluate US characteristics such as CL, PCA and fetal head position in predicting successful IOL within 24 hours as an alternative method to BS	Univariate analysis, labor was shorter when the PCA was greater (>120°), CL was shorter, BS was higher, other than multiparity. Multivariate regression: PCA was not statistically significant (whereas CL, BS and multiparity were).	No
Prado et al.[26] Brazil	Prospective cohort study	204 singleton, pregnancies, Intact membranes	37-42 ws	Misoprostol (±oxytocin)	PCA, CL	To predict the onset of labor within 12 hours, and VD irrespective of the induction-to-delivery interval.	PCA ≥114° are US predictors associated with the success of the IOL. PCA increased four times the likelihood of VD, regardless the induction-to-delivery interval	Yes
Al-Adwy et	Prospective	70 singleton	35-42	Oxytocin (±	PCA, CL	To determine the	PCA >99.5° had the best	Yes

3

Study	Study type	Sample	ws	Induction method	Parameters	Aim	Results	
al[27] Egypt	observational study	pregnancies	ws	misoprostol for cervical ripening)		accuracy of PCA compared with CL and the BS in predicting the outcome of IOL	accuracy in predicting successful IOL compared with the CL and BS.	No
De Miguel Manso et al.[29] Spain	Prospective observational study	231 singleton pregnancies	40 ws median (IQR 38-41 ws)	Vaginal dinoprostone or oxytocin (±amniotomy)	CL, PCA, FHPD, dilatation, cervical wedge, funneling, distance from the presentation edge to the EOC, elasticity or cervical deformation (strain)	To validate a pilot predictive model based on clinical parameters and US parameters that showed a significant association with the IOL result	Only HPD, CL and BS showed significant association with the result of IOL	No
Hosoya et al.[30] Japan	Prospective single-center cohort study	142 singleton pregnancies	40-41 ws	Intracervical balloon + oxytocin (±amniotomy)	CL, PCA	To evaluate the rate of VD after IOL	High BS, short CL, and changes in cervical length with dilatation are potential independent predictors of vaginal delivery following elective IOL. PCA showed no significant associations	No

BMI: Body Mass Index; BS: Bishop Score; CL: cervical length; CS: cesarean section; EOC: external cervical os; GA: gestational age; HPD: fetal head-perineal distance; IOL: induction of labor; IQR: interquartile range; OP: occipital position; PCA: posterior cervical angle; PGE2: prostaglandins; US: ultrasonographic; VD: vaginal delivery; ws: weeks.

Supplementary Table II.—Anterior utero-cervical angle as ultrasound predictor of successful induction of labor.[1, 14, 18, 19, 32]

	Type of Study	Patients	GA	Methods of Induction	US cervical measurements	Primary outcomes	Main results	aUCA as a good predictor of successful IOL
Dagdeviren et al.[1] Türkiye	Prospective cohort study	150 singleton pregnancies, nulliparous women, BS<6	>37 ws	PGE2	CL and aUCA	To investigate the role of aUCA in predicting successful IOL.	aUCA did not predict the outcome of IOL Broader UCAs are associated with shorter duration of active phase. CL and aUCA are inversely correlated with vaginal delivery after a successful IOL.	No
Eser et al.[18] Türkiye	Prospective cohort study	109 singleton pregnancies, nulliparous women	Prolonged pregnancy	Intracervical balloon	CL and aUCA	To determine whether aUCA correlates with satisfactory response to IOL (latent phase duration <720 min).	aUCA (97°) and CL (27 mm) significantly predicted satisfactory response to IOL. Labor induction-to-delivery time was significantly higher in a group with lower aUCA	Yes
Abdelhafeez MA et al.[14] Egypt	Prospective cohort study	150 singleton pregnancies, nulliparous women, intact membranes	≥ 38 ws	Misoprostol	CL and aUCA	To assess CL and aUCA measured by TVUS as predictors of successful IOL	CL (32.3mm) and aUCA (110.2°) are good predictors of successful IOL	Yes
Yang et al.[19] Korea	Retrospective study	205 singleton pregnancies	37-41 ws	PGE2 or oxytocin	CL and aUCA	To determine the value of aUCA in predicting successful IOL, compared to BS and CL	Successful IOL group had significantly wider aUCA and higher BS. CL was not significantly different. aUCA combined with the BS showed higher performance in predicting IOL than aUCA alone The mean time of the latent phase	Yes

4

| İleri et al.[32] Türkiye | Prospective observational study | 141 singleton pregnancies, BS≤6 | Term | PGE2 | CL, cervical volume, aUCA, cervical elastographic parameters. | To define US cervical measurements as candidate parameter predictive of successful of IOL | No significant differences between cervical elastography values, cervical volume, CL and aUCA. CL significantly predicted the time interval from induction to delivery. was statistically shorter in the wider aUCA group | No |

aUCA: anterior uterocervical angle; BS: Bishop score; CL: cervical length; GA: gestational age; IOL: induction of labor; PGE2: prostaglandins; TVUS: transvaginal ultrasound; US: ultrasonographic; ws: weeks.