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Prediction of Successful Normal Vaginal Delivery by Intrapartum Transperineal Ultrasonographic Measurement of the Angle of Progression

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ABSTRACT

Objectives: This study aimed to evaluate the angle of progression's predictive ability for successful normal vaginal delivery, establishing its cutoff value and clinical application.

Materials and Methods: In this prospective, diagnostic accuracy study, we enrolled pregnant women admitted to the labor room with term singleton cephalic presentation pregnancies, excluding those at risk of undergoing cesarean delivery with indications other than cephalopelvic disproportion. The angle of progression was measured using transperineal ultrasound during the active phase of labor.

Results: A total of 114 pregnant women were included in the study. Among these participants, 102 underwent vaginal delivery (89.5%), while 12 underwent cesarean delivery (10.5%). No significant differences were observed in age, body mass index, gestational age, cervical dilatation, amniotic membrane status, or fetal birth weight among the participants. However, multiparous women displayed a tendency towards higher vaginal delivery rates than nulliparous ones. The angle of progression's cut-off value, assessed by the area under the receiver operating characteristic curve, was 0.703. The optimal threshold on the curve, maximizing the area under the curve, was identified at 96.9 degrees, with a sensitivity of 82.4%, specificity of 58.3%, positive predictive value of 94.4%, and negative predictive value of 28% for predicting successful of normal vaginal delivery.

Conclusion: Transperineal ultrasound measurement of the angle of progression greater than 96.9 degrees showed good potential for predicting the success of normal vaginal delivery in pregnant women during the active phase of labor.

Keywords: angle of progression, intrapartum ultrasound, transperineal ultrasound, vaginal delivery.

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การทำนายความสำเร็จของการคลอดปกติทางช่องคลอดโดยใช้คลื่นเสียงความถี่สูงวัด angle of progression ผ่านภายนอกช่องคลอดในระยะการคลอด

เมธากวิน ตรีตรง, สุดถวิล ไกรนรา

บทคัดย่อ

วัตถุประสงค์: *เพื่อศึกษาความสามารถและค่ามุมที่เหมาะสมของ angle of progression ในการทำนายการคลอดปกติทางช่องคลอดและความสำคัญต่อการประยุกต์ใช้ในทางคลินิก*

วัสดุและวิธีการ: *บทความนี้เป็นการศึกษาในรูปแบบการศึกษาเชิงสังเกตไปข้างหน้าเพื่อหาความแม่นยำในเครื่องมือการตรวจวินิจฉัยโดยทำการวัดค่า angle of progression ในกลุ่มหญิงตั้งครรภ์เดี่ยวและมีส่วนนำของทารกเป็นศีรษะที่เข้าสู่ระยะเร่งคลอดในห้องคลอดโรงพยาบาลหาดใหญ่โดยแยกหญิงตั้งครรภ์ที่มีความเสี่ยงต่อการผ่าตัดคลอดด้วยข้อบ่งชี้อื่นนอกเหนือจากการผิดสัดส่วนของขนาดทารกและอุ้งเชิงกราน*

ผลการศึกษา: *หญิงตั้งครรภ์จำนวน 114 คนได้เข้าร่วมในการศึกษานี้ พบว่า 102 คน (ร้อยละ 89.5) สามารถคลอดบุตรทางช่องคลอดได้และ 12 คน (ร้อยละ 10.5) คลอดบุตรด้วยวิธีการผ่าตัดคลอด โดยไม่พบความแตกต่างในด้านของ อายุ, ดัชนีมวลกาย, อายุครรภ์, การเปิดของปากมดลูก, สถานะของถุงน้ำคร่ำ และน้ำหนักแรกคลอดของทารกระหว่างสองกลุ่มนี้ อย่างไรก็ตามพบว่าอัตราการคลอดบุตรปกติทางช่องคลอดพบในหญิงตั้งครรภ์หลายครั้งมากกว่า ค่า angle of progression ที่ 96.9 องศา มีพื้นที่ใต้เส้นโค้ง receiver operating characteristic (ROC) มากที่สุดที่ 0.703 ในการทำนายความสำเร็จในการคลอดปกติทางช่องคลอด โดยมีความไว้อยู่ที่ร้อยละ 82.4, ความจำเพาะร้อยละ 58.3, ค่าการทำนายเป็นบวกร้อยละ 94.4 และค่าการทำนายเป็นลบร้อยละ 28*

สรุป: *การวัด angle of progression ด้วยคลื่นเสียงความถี่สูงผ่านภายนอกช่องคลอดในระยะคลอดที่ค่ามุมมากกว่า 96.9 องศา มีความสามารถในการทำนายความสำเร็จของการคลอดปกติทางช่องคลอดในระยะเร่งคลอด*

คำสำคัญ: *angle of progression, การตรวจคลื่นเสียงความถี่สูงในระยะคลอด, การตรวจคลื่นเสียงความถี่สูงผ่านภายนอกช่องคลอด, การคลอดปกติทางช่องคลอด*

Introduction

Traditionally, the assessment of labor progression heavily relies on digital pelvic examinations, primarily considering cervical dilatation and fetal head station as crucial clinical indicators for diagnosing protraction and arrest of labor. However, evidence suggests that pelvic examinations can be prone to inaccuracy and subjectivity, particularly in cases involving the presence of caput succedaneum, which can obscure the determination of fetal head station and position[1]. These unreliable clinical findings may lead to misjudgments in the management of pregnancies experiencing a lack of labor progression, delays in transferring patients to higher-level healthcare facilities, an increased incidence of unnecessary cesarean deliveries, and potential maternal and fetal morbidity.

As a result, there is a growing demand for more accurate and objective tools to complement the assessment of fetal head descent. In recent years, the use of intrapartum ultrasound has gained prominence due to its capacity to provide quantitative measurements and its widespread availability in most labor rooms. Several intrapartum ultrasound parameters have been reported to correlate with fetal head descent, including head-perineum distance, head-symphysis distance, angle of progression, and progression distance[2]. Among these, the angle of progression has demonstrated the highest potential to represent fetal head descent[3-5]. First described in 2009(5), it is defined as the angle between the long axis of the maternal pubic symphysis and a line drawn tangentially from the most descended part of the fetal skull.

Since then, studies have reported that the angle of progression can also serve as a predictive indicator for the mode of delivery[6-11]. However, the cut-off values have shown variability across these studies. Currently, there is no consensus or established clinical practice guidelines regarding the utilization of the angle of progression in general medical practice.

In this study, our primary objective is to determine the diagnostic performance of the angle of progression measured during the active phase of labor in predicting the likelihood of a successful normal vaginal delivery. Additionally, we aim to assess the cutoff and diagnostic value of the angle of progression in predicting normal vaginal delivery, beyond its role in representing fetal head station.

Materials and Methods

Following approval from the Ethics Committee of Hatyai Hospital, Songkhla, Thailand, this prospective diagnostic accuracy study took place at Hatyai Hospital, a tertiary referral center, from February to August 2023. The study included pregnant women aged 20 years or older with a viable singleton, cephalic presentation, admitted to the labor room between 37 completed weeks of gestation and 41 weeks and 6 days of gestation. These women were either undergoing spontaneous labor or induction of labor and were initially planned for vaginal delivery. Pregnant women with diagnosed uterine anomalies, estimated fetal weight exceeding 4,000 gm, and prenatal diagnosis of fetal anomalies were excluded. This exclusion was based on their probability of undergoing cesarean delivery with indications other than cephalopelvic disproportion. In our center's clinical practice, clinicians may choose to perform operative delivery without strictly adhering to the criteria for prolonged labor such as in cases of poor maternal effort, which can result in an inaccurate evaluation of the actual outcome. Therefore, the authors decided to exclude cases involving operative vaginal delivery from the analysis.

A sample size of 114 was calculated based on the area under the receiver operating characteristic (ROC) curve from the work of Perez et al[10] with alpha of 0.05 and power of 0.8.

The author randomly recruited 114 nonconsecutive series of pregnant women during various periods of the day. All pregnant women who met our specified criteria were included, as shown in Fig. 1. Information about the study was provided to the pregnant women, and their consent was obtained before performing the transperineal ultrasound. A workshop on the transperineal ultrasonographic measurement of the angle of progression was organized by a Maternal-Fetal Medicine (MFM)

specialist before commencing data collection and the researcher performed measurements under expert supervision.

The ultrasonographic measurement of the angle of progression was conducted upon the pregnant women entering the active phase of labor. In our study, we employed the traditional criteria for defining the active phase of labor, as outlined in the Friedman study, characterized by cervical dilatation exceeding 4 cm along with regular uterine contractions. Notably, we excluded the deceleration phase, where rapid descent of the fetal head has already occurred. Consequently, our study focused on laboring women with cervical dilatation ranging from 4 to 8 cm.

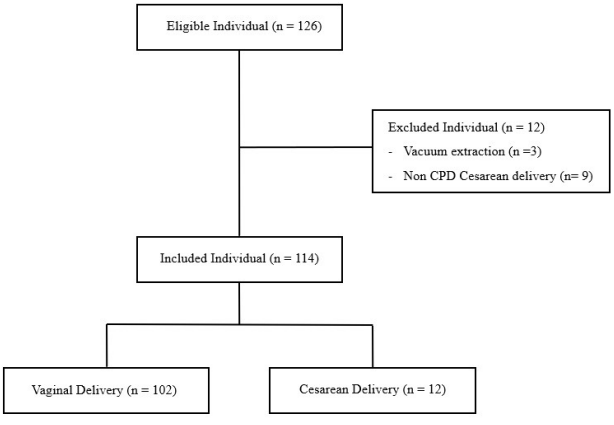

Fig. 1. A flow chart illustrating the process of inclusion and exclusion.

After bladder emptying, the pregnant women were positioned in a semi-recumbent posture[2]. Using a 5.5 MHz 4C-RS convex transducer from a 2D ultrasound device (GE LOGIQ V3), enclosed in a sterile glove, the transducer was gently placed vertically translabial. An image capturing the sagittal view of the long axis of the pubic bone and the lowest edge of the fetal skull was obtained in the same plane. Two caliper lines were drawn: one from the proximal edge of the pubic bone to the distal edge, and the other from the distal edge of the pubic bone to the lowest edge of the fetal skull, as shown in Fig. 2. The angle between these two calipers, automatically generated by the ultrasound machine and defined as the angle of progression, was recorded in the case record form.

Labor progression was monitored, and management decisions were made by the attending staff on duty at the time, who were unaware of the angle of progression data. In our center, there is no specific analgesia during labor except for intramuscular pethidine, and the management decision is based on the traditional criteria of secondary arrest of dilatation, as referenced from the Friedman study[12, 13]. Abnormal progression of labor is diagnosed when there is an absence of cervical progression for more than two hours, despite adequate uterine contractions. Pregnant women who underwent cesarean delivery for reasons other than cephalopelvic disproportion or those who delivered through operative vaginal methods, such as vacuum-assisted or forceps deliveries, were excluded from the study.

The data were analyzed using R-4.3.1 software. Demographic data were assessed, with continuous variables presented as mean, median and interquartile range while categorical data were shown as percentages. The cut-off value for the angle of progression was determined by calculating the maximum area under the receiver operating characteristics (ROC) curve, and sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratio were calculated.

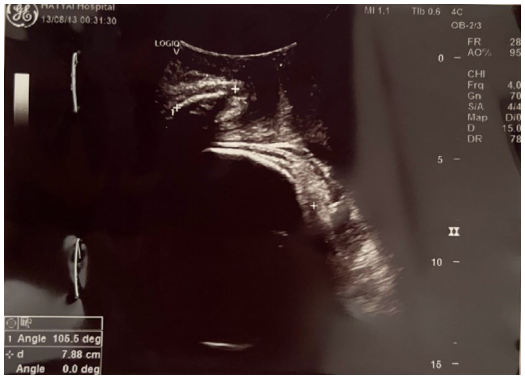

Fig. 2. Angle of progression

Results

A total of 114 nonconsecutive pregnant women were enrolled in the study. Among this group, 102 cases underwent vaginal delivery (89.5%), while 12 cases underwent cesarean delivery (10.5%). The demographic characteristics of the study group are detailed in Table 1. No significant differences were observed between the vaginal delivery and cesarean delivery groups regarding age, body mass index, gestational age, cervical dilatation, amniotic membrane status at the time of measurement, and fetal birth weight. However, multiparous patients showed a tendency toward a higher rate of vaginal deliveries when compared to nulliparous patients.

Table 1. Demographic data and obstetric outcomes.

Demographic	Total (n = 114)	Vaginal delivery (n = 102)	Cesarean delivery (n = 12)	p value
Age (median (IQR)), years	28 (24, 31)	28 (24.2, 31.8)	25.5 (22.2, 28)	0.098[a]
BMI at LR (median (IQR)), kg/m^2	27.7 (25.1, 30.9)	27.6 (24.9, 30.5)	30.2 (26.9, 32.8)	0.084[a]
Parity (%)				
Nulliparity	42 (36.8)	32 (31.4)	10 (83.3)	< 0.001[b]
Multiparity	72 (63.2)	70 (68.6)	2 (16.7)	
GA (median (IQR)), weeks	39 (38, 40)	39 (38, 40)	39 (39, 40)	0.045[a]
Cervical dilatation (median (IQR)), cm	5 (4, 6)	5 (4, 6)	4 (4, 5)	0.151[a]
Fetal head station (%)				0.256[b]
-3	1 (0.9)	1 (1)	0 (0)	
-2	42 (36.8)	34 (33.3)	8 (66.7)	
-1	43 (37.7)	41 (40.2)	2 (16.7)	
0	27 (23.7)	25 (24.5)	2 (16.7)	
+1	1 (0.9)	1 (1)	0 (0)	
Membranes status (%)				
Membranes intact	60 (52.6)	56 (54.9)	4 (33.3)	0.267[c]
Membranes ruptured	54 (47.4)	46 (45.1)	8 (66.7)	
Fetal birth weight (median (SD)), grams	3132 (373.5)	3110.7 (377.3)	3312.9 (293.4)	0.076[d]
APGAR (%)				0.105[b]
1 min				
8	1 (0.9)	0 (0)	1 (8.3)	
9	113 (99.1)	102 (100)	11 (91.7)	
5 min				
8	1 (0.9)	0 (0)	1 (8.3)	
9	113 (99.1)	102 (100)	11 (91.7)	

[a] = Ranksum test, [b] = Fisher's exact test, [c] = chi-square test, [d] = t-test
IQR: interquartile range, BMI: body mass index, LR: labor room, GA: gestational age, SD: standard deviation

The mean angle of progression in the study group was 106.3° (standard deviation (SD) 13.1). Specifically in the vaginal delivery group, the mean was 107.4°, while in the cesarean delivery group, it was 96.4°. Comparing vaginal and cesarean delivery group the angle of progression was significantly difference (Fig. 3).

The receiver operating characteristics (ROC) curve for the angle of progression (Fig. 4) demonstrated an area under the curve (AUC) of 0.751 (95% confidence interval (CI) 0.603-0.899). The optimized cut-off value for the angle of progression, which maximized the AUC, was determined to be 96.9°. This cut-off value for predicting successful normal vaginal delivery resulted in the sensitivity of 82.4% and specificity of 58.3%. The positive predictive value (PPV) was 94.4%, while the negative predictive value (NPV) was 28% (Table 2).

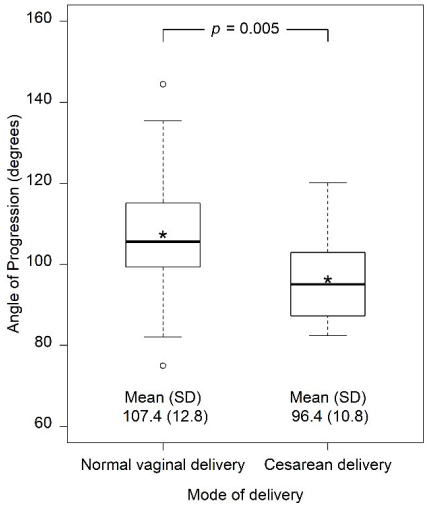

Fig. 3. Box plot of median and mean angle of progression in vaginal and cesarean delivery. (t-test).

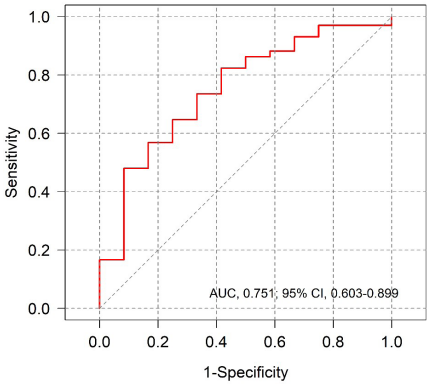

Fig. 4. The receiver operating characteristics (ROC) curve for the angle of progression.

Table 2. A two-by-two table presenting the optimized cut-off values along with their corresponding diagnostic values.

Primary Outcome	Vaginal delivery	Cesarean delivery	Predictive value	Total
AOP ≥ 96.9	84	5	0.94	89
AOP < 96.9	18	7	0.28	25
Sensitivity & specificity	0.82	0.58		
Total	102	12		114

AOP: angle of progression

Discussion

Based on the previous studies[14], our study affirms the reliability and reproducibility of intrapartum transperineal ultrasound measurements of the angle of progression in assessing fetal head descent during labor in pregnant women. Moreover, our findings supported the notion that the angle of progression serves as a valuable adjunctive tool to digital pelvic

examination, as it demonstrated predictive ability in determining the mode of delivery, with a validated cut-off point of 96.9°.

Our cut-off value aligned with findings from prospective study conducted in India by Vinutha et al[11], involving 185 laboring pregnant women in the early active phase of labor, it was determined that an intrapartum trans-labial ultrasound measurement of the angle of progression at 89° had the highest predictive value for predicting vaginal delivery. This measurement demonstrated an AUC of 0.789, a sensitivity of 79.3%, specificity of 65.6%, a PPV of 81.3%, and a NPV of 62.7%.

In contrast to the study by Perez et al[10] in Spain, which included 101 pregnant women and measured the angle of progression at the beginning of the active phase, it was found that the optimized cut-off value for the ROC curve was 125°, resulting in an AUC of 0.85, a sensitivity of 67.1%, and a specificity of 100%.

Eggebø[8] in the UK conducted a prospective study in two centers during 2013, which involved term singleton pregnant women experiencing prolonged labor according to the WHO and National Institute for Health and Care Excellence (NICE) guideline. The angle of progression was measured, with the finding that an angle of progression exceeding 110 degrees was a good predictor for vaginal delivery in the prolonged first stage of labor. However, it exhibited lower sensitivity and specificity compared to our study, with a sensitivity of 68%, specificity of 28%, a PPV of 88%, and a NPV of 43%.

The variation in cut-off values observed across studies can be attributed to numerous factors affecting the angle of progression, including fetal head station, fetal head position, and cervical dilatation at the time of measurement. As the angle of progression cannot be solely relied upon as the exclusive tool for predicting the success of vaginal delivery, fetal head position emerges as a crucial factor, as indicated by numerous prior studies[8, 9, 11, 15, 16]. Specifically, the occiput anterior position exhibits the higher probability of vaginal delivery, whereas the occiput posterior position is associated with the lower probability.

In our study, among the 12 cases that underwent cesarean delivery, a closer examination of the data revealed that five of these cases had an angle of progression exceeding the cut-off of 96.9°. Notably, among these cases, two were characterized by a fetal occiput posterior position, with angle of progression measurements of 120.1° and 103.7°, respectively.

Additionally, the fetal head station at the time the angle of progression is measured also influences the outcome. According to studies by Barbera et al[5], the angle of progression reflects the fetal head station, suggesting that a more positive or descending fetal head station theoretically increases the chances of a successful vaginal delivery.

In many of the previous studies, including our own, there is a lack of subgroup analysis for each of the factors mentioned above. This is because relying solely on a single value of the angle of progression may not be sufficient to accurately represent labor progression. As labor progresses over time, this dynamic process can introduce variability among the cut-off values observed in different studies.

Furthermore, the diagnostic criteria among the studies are also different. In our study, we employed the traditional criteria from the Friedman study, where the diagnosis of cephalopelvic disproportion was established after observing no cervical progression for two hours. In contrast, Eggebø et al[8] in the UK used diagnostic criteria from WHO and NICE, with a diagnosis threshold of 4 hours, potentially leading to differences in cut-off values. Perez et al[10] and Vinutha et al[11] did not specify the reference criteria for diagnosing prolonged labor in their respective studies. This variation in diagnostic criteria adds to the complexity of interpreting and comparing findings across different research studies.

The authors propose that the angle of progression can serve as an adjunctive tool to digital pelvic examination, enhancing the precision of labor progression assessment. Intrapartum ultrasound measurements of the angle of progression are not recommended as a standalone diagnostic tool for

cephalopelvic disproportion. Rather, they should be employed as a supplementary predictive tool for identifying cases with an elevated likelihood of experiencing challenges in achieving normal vaginal delivery. This approach aids practitioners in early detection, facilitating prompt management decision-making and minimizing delays in transfer of care.

The strength of our study lay in the absence of operator dependence. All measurements were exclusively conducted by the first author under expert supervision. Furthermore, there were no instances of missing data throughout the entire study period, enhancing the completeness and robustness of our findings. A limitation of our study was the lack of control for factors influencing the variation in the angle of progression, including fetal head station, fetal head position, cervical dilatation at the time of measurement, and parity of pregnant women, as mentioned earlier. A recommendation for future research is to improve the comprehensiveness and accuracy of objective parameter assessment in labor progression by incorporating serial measurements of the angle of progression or a combination of multiple intrapartum ultrasound parameters. Additionally, conducting subgroup analyses on factors that may impact the outcome could further enhance the depth of understanding.

Conclusion

Intrapartum transperineal ultrasound measurements of the angle of progression can serve as an adjunctive tool to digital pelvic examination, enhancing the precision of labor progression assessment. Due to its simplicity and reproducibility, intrapartum transperineal ultrasound measurements of the angle of progression can be widely used in primary health care centers after a simple training. Its implementation could be beneficial in management of cases with slow labor progression whether to reduce delayed decision to refer to a higher-level center or to reduce a hasty diagnosis of cephalopelvic disproportion leading to minimized unnecessary cesarean delivery.

Acknowledgments

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Potential conflicts of interest

The authors declare no conflicts of interest.

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