Research Article

The Value of Intrapartum Ultrasound in Predicting Mode of Delivery: a Prospective Cohort Study

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Abstract

Objective: The main aim of this study was to explore the value of several intrapartum ultrasonographic parameters in predicting mode of birth following spontaneous labor.

Methods: This prospective observational cohort study included two groups of primparous term singleton vertex presentation pregnant patients >18 years old admitted in the first stage of labor between January 2021 and May 2023: a cesarean section (CS) group and a normal vaginal delivery (NVD) group. All patients provided informed written consent. The investigation utilized both transabdominal and transperineal ultrasonography for comprehensive fetal and pelvic floor assessment. Transabdominal ultrasound evaluated standard parameters including fetal occiput position, biometry number, viability, presentation, and estimated fetal weight. Intrapartum transperineal ultrasonography, specifically performed during the first stage of labor, focused on the Levator Hiatus, measuring its anteroposterior diameter (APD) at rest and during Valsalva maneuver, as well as the angle of progression (AOP).

Results: The study population comprised 609 participants with a mean age of 22.8 ± 4.3 years and a high prevalence of being overweight and obesity (38.8% and 57.8%, respectively). When comparing patients who had an intrapartum CS to those who had a normal vaginal delivery (NVD). However, on logistic regression, age, BMI, gestational age, posterior occiput presentation, head circumference (HC), AOP (V) and APD (V) as significant predictors for both ICS and 2nd stage CS ($p<0.05$).

Conclusion: This study demonstrated that maternal age, BMI, gestational age, occiput posterior position, Angle of progression at Valsalva and levator hiatus anteroposterior diameter at Valsalva were independent significant predictors for Intrapartum cesarean section in primiparous women at term When the ratio between HC/APD at rest, BPD/APD at Valsalva and HC/APD at Valsalva is high, while the APD at Valsalva, AoP Valsalva values are low, cesarean section was more likely to be the mode of delivery.

Keywords: Angle of progression, Anteroposterior diameter of levator hiatus, Intrapartum cesarean section, Intrapartum ultrasound, Mode of delivery.

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INTRODUCTION

Normal vaginal delivery (NVD) is the preferred mode of childbirth for most mothers and infants due to its well-established benefits compared to cesarean sections (CS) [1]. NVDs are associated with faster recovery, shorter hospital stays, and a lower risk of complications [2]. Additionally, newborns born vaginally gain exposure to maternal microbiota, which seem to have immunological and respiratory benefits [3,4]. However, there has been a trend in recent decades towards an increasing CS rate, particularly those performed without a clear medical indication [5]. This not only strains healthcare resources but also carries potential risks for both mothers and neonates [6].

A crucial challenge to optimizing birth outcomes lies in the limitations of methods used for assessing labor progress, including traditional clinical examinations that can be subjective and lack consistency between practitioners [7, 8]. This highlights the need for more objective assessment tools to guide decision-making during labor [9]. Indeed, by providing a more objective and quantifiable assessment of fetal station and position within the birth canal, ultrasound has the potential to omit the subjectivity of such assessments [10].

Furthermore, precise determination of fetal head position and presentation are critical for a safe operative vaginal delivery. Similarly, distinguishing between a face and brow presentation is particularly crucial, as the larger engaging diameters of a brow presentation in a term neonates preclude vaginal birth [11]. Sonographic evaluation with trans-abdominal imaging in both sagittal and axial planes offers the optimal approach for this assessment. Several studies have demonstrated that intrapartum ultrasound offers superior accuracy and reproducibility compared to clinical examination in the diagnosis of fetal head station and position [12, 13]. However, there is paucity of information on any association between intrapartum ultrasound scan parameters performed early in labor and mode of birth. Moreover, there is no general agreement regarding, which measurements should be obtained and how useful they are if integrated with demographic and clinical parameters.

This was a nested study within the Reliability, Effectiveness and Acceptability of Sequential Stage Ultrasonographic Routine Examination (REASSURE) program. The main aim of this study was to explore the value of several intrapartum ultrasonographic parameters in predicting mode of birth following spontaneous labor.

METHODS

This prospective, single center, cohort study was conducted at Kasr Al Ainy Maternity Hospital, Cairo, Egypt between January 2021 and May 2023. A total of 609 pregnant primiparous participants presenting in the first stage of labor were enrolled into the study. All participants provided a written informed consent for participation. In addition, an ethical approval was obtained from Research Ethics Committee, Faculty of Medicine, Cairo University under No. MD-22-2021.

Primiparous term singleton pregnant patients aged 18 or older presenting in spontaneous labor with a baby in vertex presentation were considered potentially eligible for inclusion. Exclusion criteria for this study included individuals who were multiparous, had a history of preterm labor, presented with a non-vertex fetal presentation, were carrying a multiple pregnancy, had a planned elective Cesarean Section, had underlying medical conditions, or were unwilling to participate in the research. Patients were only recruited when at least one of the three obstetricians trained to measure the intrapartum ultrasonographic parameters of interest were available on labor ward. In addition, patients who developed prolonged labor were included in the study.

The primary endpoint of the study was the predictive accuracy of intrapartum ultrasound in predicting the need for cesarean section due to failure to progress in labor. Secondary endpoints included the rate of operative vaginal deliveries, (composite neonatal outcomes).

Both transabdominal and transperineal ultrasound scans were performed on all participants by trained operators on the use of both modalities. Transabdominal ultrasound was used to assess fetal presentation, biometry, and estimated fetal weight (EFW) (measured according to established protocols by Salomon et al., 2011) [14]. Intrapartum transperineal ultrasound was performed during the first stage of labor by experienced obstetricians who underwent standardized training on the measurement techniques. The anteroposterior diameter (APD) of the levator hiatus and angle of progression (AoP) were measured using a consistent protocol, with the transducer positioned at a specific angle and depth. To minimize intraobserver variability, measurements were performed by the same obstetrician for each patient. Additionally, a quality control process was implemented to regularly review and calibrate the ultrasound equipment.

Scans were performed by one of 3 trained operators. A single operator performed both the transabdominal and transperineal ultrasound scan measurements for each of the participants. A Samsung SONOACE R3 portable ultrasound machine was used to perform both transabdominal and transperineal scans on all participants. Transabdominal ultrasound was performed in the sagittal and axial planes and used as the primary method for evaluating fetal head position, following established protocols [14]. The probe placement on the maternal abdomen allowed visualization of the fetus spine and head. Ultra-sonographic identification of specific fetal landmarks, including the fetal orbits (occiput posterior presentation), midline cerebral echo (occiput transverse presentation), and the occipitocervical approximation (occiput anterior presentation), facilitated the determination of fetal head position. The choroid plexus further assisted in some cases. In situations with a low fetal head, where visualizing midline structures was difficult, a combined transperineal and transabdominal ultrasound approach ensured accurate positioning [15, 16]. Additionally, a transperineal ultrasound in the midsagittal plane was used to assess fetal head station. The symphysis pubis served as a landmark for quantitative assessments of the AoP [17]. The AoP, or the angle of descent, is 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 APD was measured as distance between the distal symphysis pubis and the proximal puborectalis muscle in line with previous reports [18]. Intrapartum transperineal ultrasound measurements were performed sequentially during the first stage of labor, with intervals determined by the clinical course and progress of labor.

The clinical labor ward team managed the patient's labor according to the unit's protocol and were blinded to any ultrasound scan findings related to this study. In addition to baseline demograhic details and ultrasonographic measurements, and mode of birth, we collected data on the clinical indication for CS if one was performed, the decision-making process for CS (e.g., based on maternal or fetal factors, failure to progress in labor, or other clinical indications), duration of second stage of labor, fetal sex, actual birthweight, any immediate adverse neonatal outcomes and/or need for NICU admission.

Descriptive statistics (means and standard deviations for continuous variables; frequencies and percentages for categorical variables) were calculated using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY). Chi-square or Fisher's exact tests were used to assess group differences for categorical variables. Due to skewed data, the Mann-Whitney U test was used to compare quantitative variables between groups. Multivariate logistic regression models with standard enter technique were used to identify independent predictors of both overall intrapartum caesarean section (ICS) and second-stage CS. Ultrasound parameters derived from more than one measurement (i.e ratios and delta measurements) were not included in the multivariate analysis. A p-value less than or equal to 0.05 was considered statistically significant.

In this study our main focus was to examine 8 ulatrsound scan intrapartum parameters for being potential candidate predictors for mode of borth in spontaneous labour in primaprous patients. These parameters were APD (R), APD (V), AoP (R), AoP(V), HC, BPD, occiput posterior position and estimated fetal weight. Simulation studies examining predictor variables for inclusion in logistic regression models suggest that approximately 10 events are necessary for each candidate predictor to avoid overfitting [19-21]. Therefore, we needed at least 80 patients with the primary outcome of interest (which is intrapartum caesarean section) in our cohort. Based on a recent study [22] the ICS rate from their large size multicentre study was 7-9% we assumed that 8% of our population will have an ICS and hence we estimated that 1000 would be required for 80 to have an ICS. Allowing a 15% attrition rate, we intend to recruit into the study till we have 92 ICSs or a total of 1150 patients recruited, whichever is reached first.

RESULTS

A total of 609 patients were enrolled into the study. The mean age of the study cohort was 22.8 ± 4.3 years and a mean BMI of 31 ± 3.9 kg/m² with 38.8% and 57.8% categorized as overweight and obese respectively. The full cohort charcateristics and, birth outcomes and sonographic paramters are presented in (Table 1).

Table 1. Population characteristics, ultrasound parameters and birth outcomes

Variable		Description (n=609)
Age (years)	Range	18 - 40
	Mean ± SD	22.8 ± 4.3
BMI (kg/m²)	Range	19.5 - 44.3
	Mean ± SD	31 ± 3.9
	Normal	21 (3.4)
BMI (kg/m²)	Overweight	236 (38.8)
	Obese	352 (57.8)
EFW by U/S (grams)	Range	2100 - 4600

	Mean ± SD	3242.3 ± 397
Gestational age (Weeks)	Range	37 - 42
	Mean ± SD	38.6 ± 1.3
HC (mm)	Range	279 - 359
	Mean ± SD	319.7 ± 12.2
BPD (mm)	Range	84 - 99
	Mean ± SD	92 ± 2.9
Occiput	Anterior	386 (63.4)
	Posterior	177 (29.1)
	Transverse	46 (7.6)
APD (R) (mm)	Range	45 - 75
	Mean ± SD	56.1 ± 5.7
BPD/APD (R)	Range	1.24 - 2.11
	Mean ± SD	1.66 ± 0.16
HC/APD (R)	Range	4.43 - 7.28
	Mean ± SD	5.75 ± 0.58
APD (V) (mm)	Range	50 – 80
	Mean ± SD	63.7 ± 6.2
BPD/APD (V)	Range	1.11 - 1.83
	Mean ± SD	1.46 ± 0.14
HC/APD (V)	Range	3.95 - 6.48
	Mean ± SD	5.06 ± 0.5
AoP (R) (Degrees)	Range	68 – 132
	Mean ± SD	98.5 ± 11.7
AoP (V) (Degrees)	Range	68 – 142
	Mean ± SD	109.3 ± 12
ΔAoP (Degrees)	Range	1 – 28
	Mean ± SD	11 ± 4.8
ΔAPD (mm)	Range	1 – 18
	Mean ± SD	7.7 ± 2.8
ΔBPD/APD	Range	0.02 - 0.49
	Mean ± SD	0.2 ± 0.08
ΔHC/APD	Range	0.07 - 1.66
	Mean ± SD	0.7 ± 0.27
Mode of delivery	CS	93 (15.3)
	NVD	516 (84.7)
CS stage (n=93)	1st stage	13 (14)
	2nd stage	80 (86)
	Obstructed labor	72 (77.4)
	Fetal distress	11 (11.8)
Cause of CS (n=93)	Antepartum hemorrhage	6 (6.5)
	Macrosomia	3 (3.2)
	Elderly primigravida	1 (1.1)
Duration of 2nd stage (min)	Range	20 – 150
	Mean ± SD	40.8 ± 21.7
Fetal sex	Male	293 (48.1)
	Female	316 (51.9)
Actual Birthweight weight (gram)	Range	2300 – 4500
	Mean ± SD	3232.5 ± 412.7
Adverse neonatal Outcomes	Yes	35 (5.9)
	No	573 (94.1)
Outcomes (n=35)	Respiratory distress	30 (86)
	Shoulder dystocia	1 (2.8)
	Hypoxic insult / convulsions	1 (2.8)
	Hypoglycemia	1 (2.8)
	Fracture clavicle	1 (2.8)
	Erbs palsy	1 (2.8)

SD: standard deviation, BMI: body mass index, EFW: estimated fetal weight, U/S: ultrasound. HC: Head circumference, BPD: Biparietal diameter. APD: Antero-posterior diameter of the levator hiatus, R: at rest, BPD: Biparietal diameter, HC: head circumference, V: at Valsalva, AoP: Angle of progression, Δ: Delta (The difference between the measurements at rest and Valsalva), CS: cesarean section, NVD: normal vaginal delivery.

There was no significant difference between patients who had an ICS compared to those who had an NVD with regards to APD (R) (p=0.964), BPD/APD (R) (p=0.082), AoP (R) (p=0.441). However, there were statistically significant difference between both groups with regards to HC, BPD, occiput posterior position, HC/APD (R), APD (V), BPD/APD (V), HC/APD (V), AoP (V), ΔAOP, ΔAPD, ΔBPD/APD, ΔHC/APD (0.001, 0.001, 0.011, 0.023, 0.004, 0.001, 0.001, 0.001, 0.001, 0.001, 0.001, 0.001 respectively). There were also differences between both groups in mean age, mean BMI, gestational age, estimated fetal weight and fetal sex (Table2).

Table 2. Comparison between ICS and NVD outcomes.

		ICS (n=93)	NVD (n=516)	*P-value*
Age (years)	Range	18 - 40	18 - 40	<0.001
	Mean ± SD	25.3 ± 6.3	22.4 ± 3.7	
BMI (kg/m²)	Range	23.9 - 43.9	19.5 - 44.3	<0.001
	Mean ± SD	33.1 ± 4	30.7 ± 3.8	
	Normal	1 (1.1)	20 (3.9)	
BMI	Overweight	19 (20.4)	217 (42.1)	<0.001
	Obese	73 (78.5)	279 (54.1)	
EFW by U/S (grams)	Range	2750 - 4600	2100 - 4270	<0.001
	Mean ± SD	3492.2 ± 412.9	3197.3 ± 377.2	
Gestational age (Weeks)	Range	37 - 42	37 - 42	0.001
	Mean ± SD	39.1 ± 1.5	38.5 ± 1.3	
HC (mm)	Range	307 - 358	279 - 359	<0.001
	Mean ± SD	327.4 ± 9.8	318.3 ± 12	
BPD (mm)	Range	87 - 98	84 - 99	<0.001
	Mean ± SD	93.7 ± 2.3	91.7 ± 2.8	
Occiput	Anterior	52 (55.9)	334 (64.7)	0.011
	Posterior	38 (40.9)	139 (26.9)	
	Transverse	3 (3.2)	43 (8.3)	
APD (R)	Range	45 - 72	46 - 75	0.964
	Mean ± SD	56.3 ± 6.5	56.1 ± 5.6	
BPD/APD (R)	Range	1.27 - 2.11	1.24 - 2.02	0.082
	Mean ± SD	1.68 ± 0.18	1.65 ± 0.16	
HC/APD (R)	Range	4.51 - 7.27	4.43 - 7.28	0.023
	Mean ± SD	5.88 ± 0.61	5.73 ± 0.57	
APD (V)	Range	50 - 79	52 - 80	0.004
	Mean ± SD	62.2 ± 7	64 ± 6	
BPD/APD (V)	Range	1.18 - 1.83	1.11 - 1.79	<0.001
	Mean ± SD	1.52 ± 0.16	1.44 ± 0.13	
HC/APD (V)	Range	4.08 - 6.48	3.95 - 6.44	<0.001
	Mean ± SD	5.33 ± 0.54	5.01 ± 0.48	
AoP (R)	Range	76 - 130	68 - 132	0.441
	Mean ± SD	97.9 ± 11.6	98.6 ± 11.8	
AoP (V)	Range	77 - 135	68 - 142	<0.001
	Mean ± SD	105.4 ± 12.2	110 ± 11.9	
ΔAOP	Range	1 - 22	4 - 28	<0.001
	Mean ± SD	7.7 ± 3.6	11.5 ± 4.8	
ΔAPD	Range	2 - 12	1 - 18	<0.001
	Mean ± SD	6.2 ± 2.2	8 ± 2.8	
ΔBPD/APD	Range	0.04 - 0.38	0.02 - 0.49	<0.001
	Mean ± SD	0.17 ± 0.06	0.21 ± 0.08	
ΔHC/APD	Range	0.15 - 1.31	0.07 - 1.66	<0.001
	Mean ± SD	0.59 ± 0.22	0.72 ± 0.27	
Fetal sex	Male	53 (57)	240 (46.5)	0.063
	Female	40 (43)	276 (53.5)	
Actual fetal weight (gram)	Range	2650 - 4500	2300 - 4300	<0.001
	Mean ± SD	3499.5± 488.9	3184.4± 378.4	
Adverse	Yes	6 (7.5)	29 (5.6)	0.473
neonatal outcomes	No	87 (92.5)	487 (94.4)	
Outcomes	Respiratory	5 (83.3)	25 (86.2)	0.152
(n=35)	Shoulder dystocia	0 (0)	1 (3.4)	
	Hypoxic insult/convulsions	0 (0)	1 (3.4)	
	Hypoglycemia	1 (16.7)	0 (0)	
	Fracture clavicle	0 (0)	1 (3.4)	
	Erbs palsy	0 (0)	1 (3.4)	

P values less than or equal to 0.05 were considered statistically significant, SD: standard deviation, BMI: body mass index, EFW: estimated fetal weight, U/S: ultrasound. HC: Head circumference, BPD: Biparietal diameter. APD: Antero-posterior diameter of the levator hiatus, R: at rest, BPD: Biparietal diameter, V: at Valsalva, AoP: Angle of progression, ICS: intrapartum cesarean section

On multivariate analysis, variables that continued to be significant were the mean maternal age (aOR: 1.111, 95% CI: 1.053-1.173; P<0.001), BMI (OR: 1.071, 95% CI: 1.001-1.146; P=0.047), gestational age (aOR: 1.265, 95% CI: 1.046-1.529; P=0. 015), posterior occiput (aOR: 3.187, 95% CI: 1.849-5.492; P<0.001), AOP (V) (aOR: 0.972, 95% CI: 0.950-0.995; P=0.016) and APD (V) (aOR: 0.925, 95% CI: 0.884-0.968; P=0.001) (Table 3). In addition, on multivariate analysis, mean maternal age (aOR: 1.116, 95% CI: 1.054-1.181; P<0.001), BMI (aOR: 1.083, 95% CI: 1.009-1.162; P=0.027), gestational age (aOR: 1.257, 95% CI: 1.029-1.535; P=0. 025), occiput posterior (aOR: 3.236, 95% CI: 1.842-5.686; P<0.001), and APD (V) (OR: 0.916, 95% CI: 0.872-0.962; P<0.001) continued to be significant (Table 3).

Table 3. Multi variate analysis to explore potential ICS predictors and 2nd stage CS.

Multi variate analysis to explore potential ICS predictors	***P-value***	**aOR**	**95% CI for OR**		
Age (years)	<0.001	1.111	1.053	-	1.173
BMI (kg/m²)	0.048	1.071	1.001	-	1.146
Gestational age (Weeks)	0.015	1.265	1.046	-	1.529
EFW by U/S (grams)	0.151	1.001	1.000	-	1.002
Occiput (posterior VS anterior or transverse)	<0.001	3.187	1.849	-	5.492
AoP (V)	0.016	0.972	0.950	-	0.995
APD (V)	0.001	0.925	0.884	-	0.968
Head circumference (mm)	0.091	1.033	0.995	-	1.072
Biparietal diameter (mm)	0.591	1.049	0.881	-	1.250
Multi variate ananlysis to explore the predictors of 2nd stage CS	***P-value***	**OR**	**95% CI for OR**		
Age (years)	<0.001	1.116	1.054	-	1.181
BMI (kg/m²)	0.027	1.083	1.009	-	1.162
Gestational age (Weeks)	0.025	1.257	1.029	-	1.535
EFW by U/S (grams)	0.254	1.001	1.000	-	1.002
Occiput posterior VS anterior or transverse	0<0.001	3.236	1.842	-	5.686
AoP (V)	0.198	0.984	0.961	-	1.008
APD (V)	<0.001	0.916	0.872	-	0.962
HC (mm)	0.392	1.017	0.978	-	1.058
BPD (mm)	0.328	1.097	0.911	-	1.322

P values less than or equal to 0.05 were considered statistically significant, OR= odds ratio, CI= Confidence Interval, BMI: body mass index, EFW: estimated fetal weight, U/S: ultrasound, AoP: Angle of progression, APD: Antero-posterior diameter of the levator hiatus, HC: Head circumference, BPD: Biparietal diameter. P values less than or equal to 0.05 were considered statistically significant, OR= odds ratio, CI= Confidence Interval, BMI: body mass index, EFW: estimated fetal weight, U/S: ultrasound, AoP: Angle of progression, APD: Antero-posterior diameter of the levator hiatus, HC: Head circumference, BPD: Biparietal diameter.

When comparing patients who had a 2nd stage CS and those who had an NVD, there were no significant differences in APD (R) and AoP (R) measurements. However, we found a statistically significant difference in mean maternal age, BMI, estimated fetal weight, gestational age, HC, BPD, occiput, HC/APD (R), APD (V), BPD/APD (V), HC/APD (V), AoP (V), ΔAOP, ΔAPD, ΔBPD/APD, ΔHC/APD, fetal sex, and birthweight (Table 4).

Table 4. Comparison between 2nd stage CS and NVD outcomes.

		2nd stage CS (n=80)	NVD (n=516)	*P-value*
Age (years)	Range	18 - 40	18 - 40	<0.001
	Mean ± SD	25.3 ± 6.1	22.4 ± 3.7	
BMI (kg/m^2)	Range	23.9 - 43.9	19.5 - 44.3	<0.001
	Mean ± SD	33.2 ± 4.1	30.7 ± 3.8	
BMI	Normal	1 (1.3)	20 (3.9)	<0.001
	Overweight	16 (20)	217 (42.1)	
	Obese	63 (78.8)	279 (54.1)	
EFW by U/S (grams)	Range	2750 - 4200	2100 - 4270	<0.001
	Mean ± SD	3462.8 ± 391.3	3197.3 ± 377.2	
Gestational age (Weeks)	Range	37 - 42	37 - 42	0.003
	Mean ± SD	39.1 ± 1.5	38.5 ± 1.3	
HC (mm)	Range	307 - 348	279 - 359	<0.001
	Mean ± SD	326.3 ± 8.9	318.3 ± 12	
BPD (mm)	Range	87 - 98	84 - 99	<0.001
	Mean ± SD	93.6 ± 2.3	91.7 ± 2.8	
Occiput	Anterior	43 (53.8)	334 (64.7)	0.011
	Posterior	34 (42.5)	139 (26.9)	
	Transverse	3 (3.8)	43 (8.3)	
APD (R)	Range	45 - 72	46 - 75	0.991
	Mean ± SD	56.2 ± 6.2	56.1 ± 5.6	
BPD/APD (R)	Range	1.27 - 2.11	1.24 - 2.02	0.085
	Mean ± SD	1.69 ± 0.18	1.65 ± 0.16	
HC/APD (R)	Range	4.51 - 7.27	4.43 - 7.28	0.040
	Mean ± SD	5.87 ± 0.61	5.73 ± 0.57	
APD (V)	Range	50 - 79	52 - 80	0.006
	Mean ± SD	62 ± 6.8	64 ± 6	
BPD/APD (V)	Range	1.18 - 1.83	1.11 - 1.79	<0.001
	Mean ± SD	1.53 ± 0.16	1.44 ± 0.13	
HC/APD (V)	Range	4.08 - 6.48	3.95 - 6.44	<0.001
	Mean ± SD	5.32 ± 0.54	5.01 ± 0.48	
AoP (R)	Range	80 - 130	68 - 132	0.982
	Mean ± SD	99 ± 11.6	98.6 ± 11.8	
AoP (V)	Range	77 - 135	68 - 142	0.006
	Mean ± SD	106.5 ± 12.1	110 ± 11.9	
ΔAOP	Range	1 - 22	4 - 28	<0.001
	Mean ± SD	7.7 ± 3.6	11.5 ± 4.8	
ΔAPD	Range	2 - 12	1 - 18	<0.001
	Mean ± SD	6.3 ± 2.2	8 ± 2.8	
ΔBPD/APD	Range	0.05 - 0.38	0.02 - 0.49	<0.001
	Mean ± SD	0.17 ± 0.07	0.21 ± 0.08	
ΔHC/APD	Range	0.18 - 1.31	0.07 - 1.66	<0.001
	Mean ± SD	0.6 ± 0.23	0.72 ± 0.27	
Fetal sex	Male	47 (58.8)	240 (46.5)	0.042
	Female	33 (41.3)	276 (53.5)	
Actual fetal weight (gram)	Range	2700 - 4500	2300 - 4300	<0.001
	Mean ± SD	3486.9±485.5	3184.4±378.4	
Adverse neonatal outcomes	Yes	5 (6.3)	29 (5.6)	0.796
	No	75 (93.8)	487 (94.4)	
Outcomes (n=35)	Respiratory	4 (80)	25 (86.2)	0.260
	Shoulder dystocia	0 (0)	1 (3.4)	
	Hypoxic insult/convulsions	0 (0)	1 (3.4)	
	Hypoglycemia	1 (20)	0 (0)	
	Fracture clavicle	0 (0)	1 (3.4)	
	Erbs palsy	0 (0)	1 (3.4)	

P values less than or equal to 0.05 were considered statistically significant, SD: standard deviation, BMI: body mass index, EFW: estimated fetal weight, U/S: ultrasound. HC: Head circumference, BPD: Biparietal diameter. APD: Antero-posterior diameter of the levator hiatus, R: at rest, V: at Valsalva, AoP: Angle of progression.

DISCUSSION

Our study included 609 primarous term singleton patients who had transabdominal and transperineal ultrasound examinations to explore parameters that could potentially be useful in predicting mode of birth in spontaneous labor. Participants who had a CS were older, had higher BMI and gestational age compared to those who delivered vaginally. On trasnsbdominal scan measurements, patients in the CS cohort had bigger HC, BPD and were more likely to have their baby in an occiput posterior position. While on transperineal ultrasound scanning, the levator hiatal APD and AoP were lower in the group of participants who had a CS compared to NVD. Nevertheless, these differences were only significant in measurements taken during a Valsalva maneuver. Additionally, multivariate analysis identified that maternal age, BMI, gestational age, occiput posterior position, AOP (V) and APD (V) to be independent factors associated with ICS. Notably, AOP (V) and APD (V) were inversely associated with CS risk. When comparing patients who had a CS during the 2nd stage to those who had an NVD, the findings were comparable, nonetheless, the difference in AOP (V) between the two group was not significant on multivariate analysis.

Traditionally, labor management heavily relies on a series of subjective clinical assessments to determine cervical evaluation, head descent and fetal position. However, the accuracy and reproducibility of these examinations are limited, particularly in the presence of caput [13]. Since the 1990s, ultrasound has emerged as a potential tool to improve labor management [23, 24]. Studies suggested it surpasses clinical examination in accuracy and reproducibility for fetal head position, station, and predicting arrest of labor [13, 25]. It has even been proposed that ultrasound may even hold promise in stratifying patients likely to achieve a spontaneous vaginal delivery from those requiring an operative intervention [24, 26]. However, despite these advantages, ultrasound currently remains a secondary tool in delivery room settings, with clinical evaluation still taking precedence [27]. Uncertainties persist regarding the optimal timing of ultrasound examinations, the most relevant parameters to assess, and how to effectively integrate sonographic findings into clinical practice to optimize patient management [13].

Our study population exhibited similar characteristics to those reported in comparable studies in terms of maternal BMI, estimated fetal weight, and gestational age. However, the mean maternal age in our cohort (22.8 ± 4.3) years was lower than other studies exploring the intrapartum ultrasonographic parameters [12,28, 29]. These differences are probably secondary to the potential influence of social background variations across the studied populations. Moreover, there was disparity in the use of epidural where none of our study cohort had an epidural compared to the 57.7% [29] and 93.4% [30] reported by other studies. The limited resources and high birth rate healthcare setting are the most likely reasons for this disparity. Among the 609 laboring women enrolled into the study, 93 (15.3%) had an ICS. This rate was much higher than that reported. [29] of 7.7% and (7-9%) [22]. We believe that an important reason for this discrepancy is related to the absence of operative vaginal deliveries in our cohort. This is mainly linked to limited availability of midwavies with the required skill to perform a vacuum extraction and limited resources to maintain the vacuum extraction equipment. An issue that is currently being addressed.

We were able to accurately determine the fetal head position in all of the studied labors via transabdominal ultrasound, which concurs with with the findings reported by other groups [13,27, 28]. Notably, a recent meta-analysis by Yaw Amo Wiafe et al. [31] encompassing 31 studies and 3,370

subjects reported that that ultrasound is preferred to digital vaginal examinationfor fetal head position assessment. Furthermore, our study identified a significant association between fetal head position and mode of birth. This association aligns with findings [32], our study also demonstrated significant associations between maternal age, sonographic fetal occiput position, and AoP as potential predictors for labor outcome. Nevertheless, Kamel et al investigated the use of these paramteres in the context of induced rather than spontaneous labor.

Our investigation innovatively assessed the AOP during both resting and Valsalva maneuvers, investigating its potential for predicting normal and abnormal labor progress. To our knowledge, this is the first study to explore this specific application. While prior research successfully measured AOP using transperineal ultrasound, their focus primarily remained on delivery mode rather than the entire labor process [28, 12]. Building upon the concept of a "sonopartogram" proposed by Hassan et al. [28],we aimed to establish AOP's predictive value. Unlike their study, however, we explored its correlation with normal or abnormal labor progression.

Previous studies have established a connection between AOP and vaginal delivery rates. reported a vaginal delivery rate of 87% when the AOP was ≥110° compared to 38% with an AOP <100° [33]. Found that 58% of vaginal deliveries had an AOP exceeding 110°.

Our study revealed a significant association between various cephalometric measurements obtained at rest and during Valsalva maneuvers with the mode of delivery. Specifically; HC to APD ratio at Valsalva, BPD to APD ratio at Valsalva, and HC to APD ratio at Valsalva were all significantly higher in women who underwent CS compared to those in NVD. Conversely, APD at Valsalva, AOP at Valsalva, AOP change (Delta), APD change (Delta), and the ratios and change values of BPD/APD were all significantly lower in the CS group. Notably, no statistically significant differences were observed between the groups regarding resting measurements of APD, the BPD/APD ratio, or AOP.

To address multicollinearity, or the interdependence between variables, our model selection process for multivariate analysis only included resting and Valsalva maneuver measurements, excluding other ratios and change values. While prior studies have employed multivariate analysis, none have investigated the combined influence of both APD and AOP. Existing research has focused on models incorporating AOP with other factors including, cervical dilation, fetal head position, and presence of caput [28, 12].

While numerous studies explored the potential of transperineal intrapartum ultrasound for predicting vaginal delivery, the optimal timing for its use during labor remains unclear [13]. Proposals range from utilizing TPUS in situations where vaginal exams are discouraged (e.g., PROM, preterm labor, placenta previa) [34] to incorporating it as part of pre-induction assessment in postterm pregnancies. Notably, Hassan et al. [28] proposed a "sonopartogram" involving repeated TPUS measurements during active labor, mimicking the clinical partogram. High-resource centers have even explored automated software for continuous TPUS monitoring throughout active labor [35].

Our study aimed to address this gap in knowledge by investigating the value of TPUS measurements of APD and AOP at rest and during Valsalva for implementing a clinical labor sonopartogram. This approach prioritizes situations where early intervention might be necessary due to potential deviations from normal labor progress.

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CONFLICT of INTEREST

None.

CONCLUSION

In conclusion, intrapartum ultrasound offers a more objective and reliable method for diagnosing fetal head position and station compared to clinical examination. Our findings indicate that specific ultrasound measurements, such as the anteroposterior diameter (APD) and angle of progression (AOP) during Valsalva maneuvers, in conjunction with head circumference (HC) to APD ratios, can effectively predict the need for cesarean section. Additionally, maternal age, body mass index (BMI), gestational age (GA), fetal occiput position, and AOP and APD measurements during Valsalva are significant independent predictors of instrumental cesarean section (ICS).

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Supplementary file 1

Code: **MD-22 -2021**

Cairo University
Faculty of Medicine
Research Ethics Committee

NOTICE OF APPROVAL

Date **28 -2-2021**
Protocol title **The value of intrapartum ultrasound in predicting mode of delivery**

Supervisor **Prof. Rasha A.M. Kamel**

Candidate: **Dr. Gamal Omar Abdel Ghany**
Institution **Cairo University**

Decision: APPROVAL

The Research Ethics Committee **(REC),** has reviewed and **approved** the above mentioned **protocol. You may begin your investigation**. Approval is granted for one year from the date of initial approval. At the end of this period, the principal investigator will submit the required documents for continuing review.

The principal investigator will need to:

- Notify the REC Chair immediately after any **serious adverse events** experienced by participants of the investigational study or as reported to you by the sponsor/manufacturer/co- investigators.
- Submit End of trial notification at the end of trial.
- Submit Clinical study report at the end of trial
- You may not initiate **changes** in approved research protocol without REC review and approval except where necessary to eliminate apparent immediate hazards to the human subjects.
- يحظر سفر أى عينات بشريه من المبحوثين خارج جمهوريه مصر العربية الا بعد موافقة الجهات الامنية .

Sincerely,

REC Subcommittee Chairman	**REC Chairman**
Prof. Maher Fawzy, MD	**Prof. M. Mohsen Ibrahim**
Professor of Anaesthesia,	Professor of Cardiology,
Cairo University	Cairo University