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by mohammedelnomrosy87@gmail.com
mohammedelnomrosy87@gmail.com

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Cervical Volume Assessment to Predict the Result of Induction of Labor: a Prospective Observational Study

Amira Emam Ahmed1, Ahmed Mostafa Sadek1, Ebrahim Ebrahim Swidan1, Nada Mohamed Abdelsamae Elsheikh2

1Department of Obstetrics and Gynecology, Faculty of Medicine, Benha University, Benha, Egypt

2Department of Obstetrics and Gynecology, Faculty of Medicine, Benha University, Benha, Egypt

***Correspondence:**

Dr. Nada Mohamed Abdelsamae Elsheikh,

E-mail: Nadaelsheikh96@gmail.com

ABSTRACT

Background: However, other researchers have questioned the Bishop score's predictive value for the outcome of labor induction due to its highly subjective nature, which is influenced by a doctor's clinical expertise. The purpose of this study was to assess the relationship between the frequency of deliveries within a day and the cervical volume as determined by ultrasonography and the Bishop score. **Methods:** This study involved the prospective observational correlation of 68 pregnant patients who were receiving care at Benha University Hospital. Transvaginal ultrasonography and the Bishop score were both used in the pre-induction cervical assessment. The cervix's anteroposterior diameter was measured, and the cervical volume was computed using the geometric view assumption that the cervix is a cylinder ($V = \pi r2h$). **Results:** The present study found that successful induction of labor correlated significantly with the Bishop score (p value 0.002), posterior cervical angle (p value <0.001), and cervical volume (p value 0.022). The mean cervical volume in patients delivered vaginally was 29.8±7.38mm, while in patients delivered by C.S., it was 23.99±6.04mm. **Conclusion:** Transvaginal ultrasound assessment of cervical length and volume holds promise as a reliable and patient-friendly tool for monitoring labor progression during IOL and predicting its success.

Keywords: Cervical Volume; Induction of Labor

Introduction

One of the obstetric treatments used most commonly in modern obstetric practice is induction of labor **(1)**.

Numerous studies have indicated that the digital cervical examination with Bishop Score has a low prognostic value for the induction outcome. Additionally, the assessment is subjective **(2)**.

In contrast to Bishop scoring, a number of recent investigations have shown that transvaginal sonographic measurement of the cervical length can produce a more sensitive prediction of effective induction **(3)**.

The use of transvaginal sonography over traditional digital vaginal examination in pre-induction cervical ripening has not been shown to be supported by sufficient data, according to the Cochrane review on "methods for assessing pre-induction cervical ripening." Consequently, it is crucial to research the possibility of influence from assessing the cervical volume to determine cervical favorability **(4)**.

The cervical length and Bishop Score are two features of cervical scoring systems that may be covered by the cervical volume calculation, which takes into account both the length and diameter of the cervix **(5)**.

The cervical volume used to measure pre-induction cervical ripening is not well documented in the literature.

Subjects and methods:

In this prospective observational correlational investigation, 68 pregnant patients of Benha University Hospital were included. Transvaginal ultrasonography and the Bishop score were both used in the pre-induction cervical assessment. Using the assumption that the cervix is a cylinder in a geometric view ($V = \pi r2h$), the anteroposterior diameter of the cervix was measured, and the cervical volume was computed.

Pregnant ladies over the age of eighteen who were ≥37 and <41 weeks along with a single intrauterine pregnancy and vertex presentation met the inclusion criteria.

Women under the age of eighteen who had multiple fetuses and non-vertex presentation, any obstetric contraindications to vaginal birth, evidence of fetal compromise, or a history of uterine scarring, such as from a cesarean delivery or myomectomy, were excluded.

Sampling method

Systemic random sample

Sample size

The study was conducted on 68 women

Sample size justification

Using Power Analysis and Sample Size Software (PASS 2020) from NCSS, LLC in Kaysville, Utah, USA (ncss.com/software/pass), the sample size was determined. According to a previously published study (Athulathmudali et al., 2021) (6), the median (IQR) Bishop score was 5 (3–6), and the mean (SD) cervical volume was 27.5 (10.4) cm3. Cervical volume appears to be a significant predictor of the likelihood of a vaginal delivery [aOR-1.10 (1.01, 1.17); 0.01]. The optimal cervical volume cut-off value for determining the likelihood of a vaginal delivery within 24 hours was less than 28.5 cm3, with a sensitivity of 72% and a specificity of 74%. Based on this, a two-sided proportional Z-test with a 5% margin of error, a 95% level of confidence, and an effect size of 1/1000 require a minimum total hypothesized sample size of 62 suitable women. 68 patients were enrolled in the trial after the sample size was expanded by 10% to account for a potential dropout rate.

Study procedures

Every woman underwent a clinical examination, a sonographic cervical assessment, and a history taking.

Transvaginal ultrasonography and the Bishop score were both used in the pre-induction cervical assessment.

Evaluation of cervical volume: By choosing the shortest measurement among the three, the ultimate cervical length was ascertained. Anteroposterior diameter of the cervix was measured at its midway, the angle that forms a right angle with the endocervical canal. By considering the cervix as a cylinder from a geometric perspective, the cervical volume was calculated ($V = \pi r2h$).

Using a protractor, PCA was to be measured at the internal os level on the sagittal plane of the cervix. It was described as the angle, in circumstances of a funneled or overly curved cervix, between a line between the posterior uterine wall and the endocervical canal.

Protocol for induction of labor

The clinical guidelines provided by the National Institute of Clinical Excellence (NICE) for labor induction

Women were given one dose of Dinoprostone 3 mg (a prostaglandin E2 vaginal tablet), and after six hours, they were evaluated. Depending on the results, if the cervix was unfavorable (Bishop score less than 6), another dose of a 3 mg Dinoprostone tablet was inserted (a maximum of two tablets giving rise to one cycle).

Women were scheduled for amniotomies if the cervix was good (Bishop score greater than 6). When uterine contractions were insufficient after two hours of observation following amniotomy in the labor ward, oxytocin augmentation was initiated. If induced labor began prior to the scheduled amniotomy, the woman could proceed with the procedure. In cases where the first cycle of Dinoprostone induction proved unsuccessful, either a

second cycle of prostaglandin-assisted induction or a cesarean delivery were carried out. Every woman was given the option of ongoing CTG monitoring during childbirth.

The frequency of delivery within 24 hours served as the major end measure.

Bishop Score, cervical length, and cervical volume were examples of independent variables (test variables) that were used as additional outcome measures. The frequency of deliveries within 24 hours and the interval between induction and delivery were dependent variables (outcomes). The two baseline factors (potential confounders) were mother age and parity. The information was utilized in a later statistical study.

STATISTICAL ANALYSIS

The recorded data was assessed using SPSS Inc.'s statistical program for social sciences, version 23.0 (Chicago, Illinois, USA). For the quantitative data, the ranges and mean± standard deviation were shown. Numbers and percentages were also used to display quantitative information. Utilizing the Shapiro-Wilk and Kolmogorov-Smirnov tests, the data were checked for normalcy.

RESULTS

The range of age “years” was 19–35 with a mean of 25.73 ± 5.02; the range of BMI (kg/m2) was 20–31 with a mean of 26.86 ± 3.12; the range of EFW “gm” was 2500–3950 with a mean of 3181.50±303.45; and the range of gestational age “weeks” was 37–41 with a mean of 38.94±1.39, **table 1**.

Total of 4 women (5.9%) were gestational hypertension, 5 women (7.4%) were gestational DM, 11 women (16.2%) were preeclampsia, 13 women (19.1%) were decrease fatal kicks, 18 women (26.5%) were ROM, 13 women (19.1%) were postdate, and 4 women (5.9%) were oligohydraminos, **table 2**.

There were 40 pregnant women who were delivered vaginally and 28 who were delivered by cesarean section (**table 3**).

The mean cervical volume in patients delivered vaginally was 29.8±7.38mm, while the mean cervical volume in patients delivered by C.S. was 23.99±6.04mm. While the mean posterior cervical angle in patients delivered vaginally was 119.07±12.76 degrees and the mean posterior cervical angle in patients delivered by C.S. was 93.31±12.08 degrees, it was found that cervical volume and PCA are significantly correlated to successful induction (p values of 0.022 and <0.001), respectively (**table 4**).

There was a statistically significant higher frequency of cervical volume ≥27 in CS (71.4%) compared to NVD (27.5%), with a p-value of 0.016. Also, statistically significant higher frequency of PCA ≥100 in NVD was 51.5% compared to C/S was 5.9%, with p-value (p<0.001), **table 5**.

There was a statistically significant higher frequency of Bishop Score 7-8 in NVD, which was 23 women (33.8%) compared

to C/S (5.9%), with a p-value of 0.002, **table 6**.

The higher median Bishop score in patients delivered vaginally was 4 (3-5) compared to C/S was 3 (3-4), with p-value ($p<0.05$), **table 7**.

Bishop score, intact membrane, cervical volume, and PCA(o) have a significant effect on the affecting NVD, with a p-value ($p<0.001$) at univariate analysis and statistically significant PCA only in multivariate analysis, with a p-value ($p<0.001$), **table 8**.

Bishop Scores greater than 4 showed sensitivity of 36.9% and specificity of 93.1%, while the posterior cervical angle greater than 100 degrees showed sensitivity of 89.80% and specificity of 87.3%, and cervical volume less than 27 showed sensitivity of 68.5% and specificity of 63.3% (**table 9**).

From previous data, the most common cause of induction was rupture of membrane (18 patients), which represents 26.5% of patients, and the least common cause was gestational hypertension (2 patients), which represents 2.9% of patients in each indication. There is no significant correlation found between the cause of induction and successful induction (**Table 10**).

There was no statistically significant relation between age, BMI, neonatal weight, gestational age, and successful outcome, with a p-value > 0.05 (table **11**).

There were 40 patients who delivered by NVD (successful outcome), which represents 58.8% of patients, 35.3% of them with rupture of membrane, and 23.5% with intact membrane. It was found that membrane status is significantly related to the successful outcome. P value (0.009), **table 12**

This table shows that the mean of the 1st stage was 16.08±2.59 and the mean of the 2nd stage was 0.70±0.17, **table 13**.

It was found a significant correlation between cervical volume and duration of the first stage of labor (high measures of cervical volume correlated with long duration); also, it was found that PCA and bishop score have no significant correlation with duration (**table 14**).

Table 1: Descriptive analysis of the whole study group

Total (n=68)	Min.– Max.	Mean ± SD.
Age(years)	19 – 35	25.73±5.02
BMI(kg/m2)	25 – 38	26.86±3.12
EFW(gm.)	2500 – 3950	3181.50±303.45
Gestational age (weeks)	37 – 41	38.94 ± 1.39

Table 2: Distribution of the studied cases according to indication of labor (n =68)

Indication	Total(n=68)	
	No.	%
Gestational hypertension	4	5.9%
Gestational DM	5	7.4%
Preeclampsia	11	16.2%
Decrease fatal kicks	13	19.1%
ROM	18	26.5%
Postdate	13	19.1%
Oligohydraminos	4	5.9%

Table 3: Distribution of the studied cases according to mode of delivery

Outcome	No.	%
C/S	28	41.2%
NVD	40	58.8%
Total	68	100.0%

Table 4: Association between cervical volume and PCA and successful induction (mode of delivery)

	C/S (n=28)	NVD (n=40)	Test value	p-value
Cervical volume				
Range	20 - 39	16 - 32	2.343	0.022*
Mean ± SD	29.8±7.38	23.99±6.04		
PCA (o)				
Range	73 - 133	91-135	8.373	<0.001**
Mean ± SD	93.31±12.08	119.07±12.76		

Table 5: Association between cervical volume and PCA and successful induction (mode of delivery)

	C/S (n= 28)		NVD (n= 40)		x2	p-value
	No.	%	No.	%		
Cervical volume <27 ≥27	 8 20	 28.6% 71.4%	 29 11	 72.5% 27.5%	6.415	0.016*
PCA(o) <100 ≥100	 24 4	 35.3% 5.9%	 5 35	 7.4% 51.5%	33.164	<0.001**

Table 6: Association between bishop score and successful induction (mode of delivery)

Bishop score	Total (n=68)		C/S (n=28)		NVD (n=40)		Test of sig	p-value
	No.	%	No.	%	No.	%		
Score 3-4	13	19.1%	8	11.8%	5	7.4%	12.919	0.002*
Score 5-6	28	41.2%	16	23.5%	12	17.6%		
Score 7-8	27	39.7%	4	5.9%	23	33.8%		

Table 7: Association between bishop score and successful induction (mode of delivery)

Bishop Score	C/S (n=28)	NVD (n=40)	Test value	p-value
Median (IQR)	3 (3-4)	4 (3-5)	2.852	0.024*
Range	3-5	3-5		

Table 8: Univariate and multivariate analysis for the parameters affecting NVD cases

2 NVD cases	Univariate		#Multivariate	
	P	OR(95%C.I)	p	OR(95%C.I)
Bishop score	0.020*	2.869(1.285-6.407)	0.288	2.209(0.638-7.652)
Intact membrane	0.013*	0.294(0.106-0.820)	0.149	0.319(0.063-1.612)
Cervical volume	0.024*	0.910(0.780-1.062)	0.088	1.307(1.066-1.602)
PCA(o)	<0.001*	1.287(1.191-1.392)	<0.001*	1.327(1.197-1.470)

Table 9: Agreement (sensitivity, specificity) for different parameters to predict successful outcome

	AUC	p-value	95%C.I	Cutoff	Sensitivity	Specificity	PPV	NPV
Bishop score	0.678	0.037*	0.549-0.821	>4	36.9	93.1	84.0	51.9
Cervical volume	0.691	0.025*	0.559-0.835	<27	68.5	63.3	73.9	57.3
PCA	0.903	<0.001*	0.836-1.000	>100	89.8	87.3	97.2	90.0

Table 10: Indication of labor and mode of delivery among the study group

Indication	C/S (n=28)		NVD (n=40)		p-value
	No.	%	No.	%	
Gestational hypertension	2	2.9%	2	2.9%	FEp=1.000
Gestational DM	3	4.4%	2	2.9%	FEp=0.429
Preeclampsia	6	8.8%	5	7.4%	0.355
Decrease fatal kicks	6	8.8%	7	10.3%	0.490
ROM	5	7.4%	13	19.1%	0.067
Postdate	2	2.9%	11	16.2%	FEp=0.082
Oligohydraminos	4	5.9%	0	0.0%	FEp=0.105

Table 11: Relation between demographic data and successful outcome (mode of delivery)

	C/S (n=28)	NVD (n=40)	Test value	p-value
Age (years)	26.17±5.18	24.57±4.69	0.164	0.780
BMI (kg/m2)	26.99±2.94	25.89±3.09	0.171	0.639
GA (weeks)	39.01±1.50	39.33±1.50	0.513	0.546
EFW (gm.)	3195.15±320.25	3172.05±295.05	0.955	0.132

Table 12: Relation between membrane status and successful mode of delivery

Membrane	Total (n=68)		C/S (n=28)		NVD (n=40)		χ2	p-value
	No.	%	No.	%	No.	%		
Ruptured	31	45.6	7	10.3	24	35.3	6.784	0.009*
Intact	37	54.4	21	30.9	16	23.5		

Table 13: Descriptive analysis of the studied cases according to duration of first stage of labor

Duration (hours)	Total (n=68)
1st stage	
Mean ± SD	16.08±2.59
Range	8-19
2nd stage	
Mean ± SD	0.70±0.17
Range	0.5-1

Table 14: Correlation between different parameters and duration of first stage of labor

Duration (hours)	Cervical volume		PCA(o)		Bishop score	
	R	p	r	p	r	p
1ststage	0.403	0.009*	–0.167	0.275	–0.072	0.758

DISCUSSION:

The current investigation was a prospective observational study that was conducted at the Benha University Maternity Hospital. The purpose of this study was to assess the predictive value of effective labor induction and pre-induction ultrasonography measurements. Of the 68 individuals in our study, 58.8% were delivered vaginally and 41.2% by cesarean section (C.S.). The study found no statistically significant difference in the mean maternal age (24.57±4.69 vs. 26.17±5.18) or body mass index (25.89 ± 3.09 vs. 26.99 ± 2.94) between the vaginally delivered women and the C/S group. The average fetal weight (3172.05 ± 295.05 kg vs. 3195.15 ± 320.25 kg) and gestational age at induction (39.33 ± 1.50 vs. 39.01 ± 1.50 weeks) were recorded. Additionally, there was no statistically significant difference found in the indications for inducing labor between the women who delivered vaginally and those who did so by caesarean section. The most frequent reason for induction was rupture of membrane ROM (18 cases), accounting for 26.5% of the total. pregnant hypertension, pregnant diabetes mellitus, and oligohydraminos (4 patients), representing 5.9% of the total in each indication, were the least common causes. Forty patients (successful outcome) had NVD delivery; this constitutes 58.8% of patients; of them, 35.3% had a ruptured membrane and 23.5% had an unbroken membrane. The successful outcome was shown to be highly correlated with the membrane status. P-value (0.009). The current investigation discovered a strong correlation between the cervical volume (p value 0.022), posterior cervical angle (p value <0.001), and Bishop score (p value 0.002) after a successful induction of labor. Patients delivered vaginally had a mean cervical volume of 29.8±7.38mm, whereas patients delivered by C.S. had a mean cervical volume of 23.99±6.04mm (p value 0.022). Patients delivered vaginally had a mean posterior cervical angle of 119.07±12.76 degrees, whereas patients delivered by C.S. had a mean posterior cervical angle of 93.31±12.08 degrees. Cervical volume and PCA were shown to have a strong correlation (p value <0.001) with effective induction. However, compared to bishop and cervical volume, PCA was more sensitive and specific. Aladwy et al. (2018), who examined induction of labor in 70 women at Kasr El-Aini Hospital's obs&gyne department, concurred with our findings, observing that while PCA, bishop score, and cervical length did not differ statistically, PCA values greater than 99.5 had the highest accuracy in predicting successful IOL, with sensitivity of 91.84% and specificity of 90.4% **(7)**.

Furthermore, Mohamed Gibreil et al. (2018) investigated the induction of labor in seventy women at the AL-Azhar University Hospital's obs & gyne department. They discovered that a successful induction was significantly correlated with a bishop score of greater than five, a cervical length of 34.5 mm, and a PCA of 99.75 degrees (sensitivity 73.5%, specificity 81%), (sensitivity

91.8%, specificity 81), and (sensitivity 91.8%, specificity 90.5%), respectively. Furthermore, it was proposed that ultrasound readings are a more reliable indicator of a successful vaginal birth than the Bishop score **(8)**.

With a p-value of 0.016, there was a statistically significant higher frequency of cervical volume ≥27 in CS (71.4%) as compared to NVD (27.5%). Additionally, with a p-value of less than 0.001, the frequency of PCA ≥100 in NVD was statistically significantly greater at 51.5% than in C/S at 5.9%.

Athulathmudali SR et al. (2021) studied 100 pregnant women who underwent induction of labor; they discovered that the mean (SD) cervical volume was 27.5 (10.4) cm3, the mean (SD) cervical length was 3.6 (0.7) cm, and the median Bishop score was 5 (3–6). The likelihood of a vaginal birth within 24 hours was best predicted by cervical length [aOR = 12.12 (3.44, 42.71); < 0.001], while cervical volume also seemed to be a significant prospective predictor [aOR = 1.10 (1.01, 1.17); 0.01]. The results showed that cervical length (0.83) and cervical volume (0.74) had the highest AUCs. Less than 28.5 cm3 was the optimal cut-off value for cervical volume in predicting the chance of vaginal birth within 24 hours, with a 72% sensitivity and 74% specificity **(5)**.

With a p-value of 0.002, there was a statistically significant higher incidence of Bishop Score 7-8 in NVD, with 23 women (33.8%) having this score as opposed to C/S (5.9%). The posterior cervical angle's validity as an independent factor influencing the result of IOL was demonstrated using multivariate regression analysis. Comparing PCA greater than 100° to cervical volume measurement, the former showed higher sensitivity (89.8%), specificity (87.3%), positive predictive value (97.2%), and negative predictive value (90%) than the latter. and the corresponding Bishop scores were (36.9%) and (93.1%). The findings suggest that the PCA has a significantly higher predictive potential than the cervical volume and bishop score.

Keepanasseril et al. (2007) found that transvaginal sonography assessment of posterior cervical angle and cervical length is better than conventional Bishop Score in predicting successful labor induction in nulliparous women. The study involved 138 women who underwent cervical assessment with transvaginal sonography followed by digital cervical assessment using Bishop Score before induction of labor at the Postgraduate Institute of Medical Education and Research, India **(9)**.

Furthermore, our research supports the findings of a 2003 study conducted by Rane et al. at King's College Hospital in London, UK, on 604 women who were singleton pregnant at 35–42 weeks of gestation. Ultrasonography characteristics were found to be more predictive of the result of induction than the Bishop score, with an observed sensitivity of 89% for ultrasound findings and 65% for the

Bishop score in the prediction of vaginal birth within 24 hours **(10)**.

Cervical length did not indicate the manner of delivery, according to Paterson-Brown et al.'s (1991) comparison of ultrasonography data and the mode of delivery. While there was a strong correlation between Bishop Scores larger than five and successful vaginal delivery, their predictive accuracy for vaginal delivery was not particularly high overall. Nonetheless, it was discovered that the TVS measurement of a posterior cervical tilt greater than 70 degrees was a more reliable indicator of a successful vaginal birth than the Bishop Score **(11)**.

The wide range of methodology used in these investigations is probably what led to the finding of several PCA cutoffs.

Hatfield et al. (2007), in contrast to our study, discovered that cervical length did not indicate any specific result (e.g., mode of delivery). Instead, they assessed sonographic cervical characteristics to predict successful induction of labor. Cervical length was predictive of both failed and successful induction (likelihood ratio of negative test, 0.39–0.67) and positive test (likelihood ratio of 1.66, 95% CI, 1.20–2.31) **(12)**.

In their investigation of 166 women who had prostaglandin-induced labor, Rozenberg et al. (2005) discovered that the Bishop score was a more accurate predictor of the successful result of induced labor than cervical length **(13)**.

Additionally, Reis et al. (2003) conducted a prospective study on 134 women who were having many obstetric problems induce delivery at term. Every participant agreed to a transvaginal ultrasound and digital examination in order to determine their cervical length. The result of induced labor was not accurately predicted by ultrasound measurements of cervical length; only the obstetric history and digital examination correctly predicted vaginal birth within 24 hours **(14)**.

It was discovered that there is no significant association between PCA and bishop score and duration, but there is a strong correlation between the length of the first stage of labor and high measures of cervical volume. It was discovered that, contrary to what we had predicted (Hoesli IM et al., 1999), cervical length measurement was more accurate than cervical volume measurement determined by sonography in selecting women who were most likely to enter active labor **(15)**.

CONCLUSION

Transvaginal ultrasonography measurement of cervical length and volume is a potentially useful and safe method for tracking the development of labor during IOL and forecasting its outcome. Across a range of time points, our results show a reliable and constant relationship between cervical volume measurements and the outcome of labor induction as opposed to traditional vaginal exams. Furthermore, the fact that patients are more satisfied with US use indicates

that it can improve the delivery experience.

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