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Original Research Article

Transvaginal sonographic assessment of cervical length and posterior cervical angle in predicting the success of labor induction

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Abstract

Background: Induction of labor (IOL) is a critical intervention aimed at facilitating childbirth for various reasons. When it fails, there is an increased likelihood of delivery by cesarean section. Any tool that can accurately predict the success of IOL can improve maternal and fetal outcomes. This can be achieved by incorporating transvaginal sonographic parameters namely posterior cervical angle (PCA) and cervical length to predict the mode of delivery along with Bishop score.

Materials and Methods: This prospective observational study included 115 participants at term with singleton gestation. The subjects underwent pre-induction cervical assessment using Bishop score and measurement of posterior cervical angle and cervical length using transvaginal sonography. The study compared the sonographic parameters with Bishop's score among the participants to accurately predict the mode of delivery.

Results: IOL was successful in 74% of cases (N=85) and unsuccessful in 26% of cases (N=30). PCA >99 degrees, cervical length of less than or equal to 2.6cm, and Bishop score of >3 could successfully predict vaginal delivery. However, a PCA of >99 degrees had the best sensitivity, positive predictive value, negative predictive value, diagnostic accuracy and was superior to cervical length and Bishop score in predicting the success of labor induction.

Conclusion: Both PCA and cervical length are complementary tools for accurate cervical assessment prior to IOL. However, PCA is the most important determinant in predicting the chances of success of labor induction thereby helping the obstetrician and patient in prompt decision making.

Keywords: Posterior cervical angle, Cervical length, Labor induction, Bishop score, Transvaginal sonography.

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1. Introduction

Induction of labor (IOL) refers to iatrogenic stimulation of uterine contractions before the onset of spontaneous labor as a therapeutic option when the benefits of expeditious delivery outweigh the risks of continuing the pregnancy.[1] IOL is termed successful when it results in an uncomplicated vaginal delivery. However, IOL may fail, and labor may not start or progress as expected even in appropriately selected cases, and this can lead to a greater number of emergency primary cesarean sections which are associated with increased maternal and fetal morbidity and a poor childbirth experience for the mother. Approximately 20% of pregnancies undergo labor induction[2] and among these cases, about 20% of women ultimately require a cesarean section.[3]

Although successful induction depends on many factors, the most important is the patient's cervical characteristics. Bishop scoring is the most common way to assess the ripeness of the cervix before labor.[4] Assessment of readiness of the cervix by the traditional digital examination using Bishop scoring and its various modifications has time and again proven to be a flawed method. Any tool that aims at achieving patient satisfaction and helps avoid unnecessary primary cesarean sections and their long-term complications by predicting the success of IOL is the need of the hour in modern-day obstetrics.

Transvaginal assessment of the cervix is an objective and non-invasive method, and it is superior to the Bishop score as

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it is more precise and reproducible and offers additional details about the structure and dynamics of the cervix that influence the success of labor.[5,6] Our work aimed to study the usefulness of cervical length and posterior cervical angle along with Bishop score using transvaginal ultrasound to predict the success of IOL.

2. Material and Methods

This was a prospective observational study conducted at the Department of Obstetrics and Gynecology, Kasturba Medical College, Manipal from January 2023 to June 2024 after obtaining approval from the institutional ethics committee (IEC number: 414/2022). CTRI trial registration was done with registration number- CTRI/2023/03/050490. The sample size was calculated as explained in the next paragraph. Written and informed consent was taken from all patients included in the study. Patients with singleton pregnancy between 37-41 weeks period of gestation with a live fetus having longitudinal lie and vertex presentation were included. The exclusion criteria were mothers with BMI > 40kg/m 2, fetal macrosomia (> 4 kg), CPD, and a history of previous uterine scar. All women in this study were subjected to thorough obstetric history taking and a complete physical and obstetric, ultrasound examination before induction of labor. Then a digital vaginal examination was done to assess pelvic adequacy and cervical characteristics, and the cervical favorability was scored based on Burnett modified Bishop score. (**Table 1**) This was followed by a transvaginal ultrasound examination of the cervix to assess its readiness by measuring cervical length and posterior cervical angle. For this, a Philips Clear Vue 350 ultrasound system equipped with a C5-2 broadband curved array transducer of frequency range 2-5 MHz was used. The patient was asked to empty her bladder and placed in dorsal position. The transvaginal ultrasound probe was gently inserted into the vagina till it reaches the posterior fornix and the sagittal view of the cervix is obtained. Efforts were made to optimize the image so that it occupies 2/3rd of the screen showing the complete view of the anterior and posterior lips of the cervix and the full length of the cervical canal with internal and external os. Calipers were placed between the internal and external os and the distance between the two was measured as cervical length. (**Figure 1**) The posterior cervical angle (PCA) is measured in the midsagittal plane at the level of internal os. From the internal os along the posterior uterine wall, a line was drawn. The angle between the line used for cervical length and a line drawn along the posterior uterine wall was measured as the posterior cervical angle. (**Figure 2**). The frozen transvaginal ultrasound images were printed and cervical length and PCA were measured. These patients were induced with different cervical ripening agents and followed up to delivery. The labor was monitored and managed according to standard care by the labor room obstetricians who were blinded to the antenatal ultrasound parameters. IOL was considered successful when it resulted in uncomplicated vaginal delivery. Delivery by cesarean section was done in cases of fetal distress, non-reassuring fetal heart rate, non-progress of labor, and failed induction. Among the unsuccessful IOL group, only the cases related to labor dystocia were considered for data analysis. Nonprogress of labor in the active phase was defined according to the modified WHO partograph (all our patients had partographic management of labor and fetal heart was monitored by cardiotocography in all patients) and included any of the following conditions: protracted active phase of labor (cervical dilatation crossing alert line), secondary arrest of cervical dilatation (< 1 cm/hour), absence of descent of fetal head despite good uterine contractions and prolonged second stage of labor by more than 2 hours. When the patient failed to enter the active phase of labor after IOL, it was considered as failed induction.

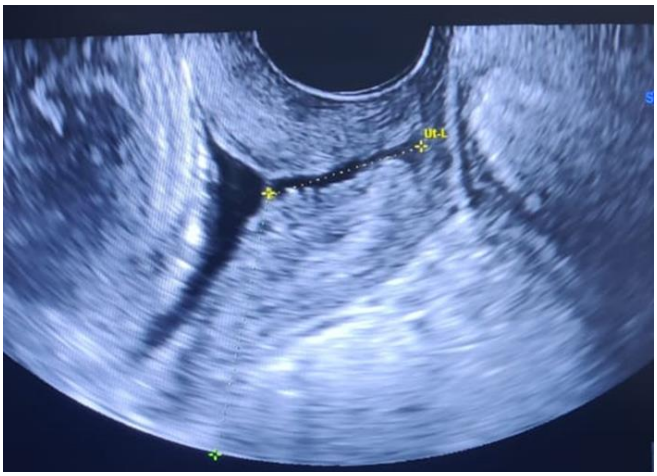

Figure 1: Transvaginal ultrasound scan of cervix showing length of 20 mm

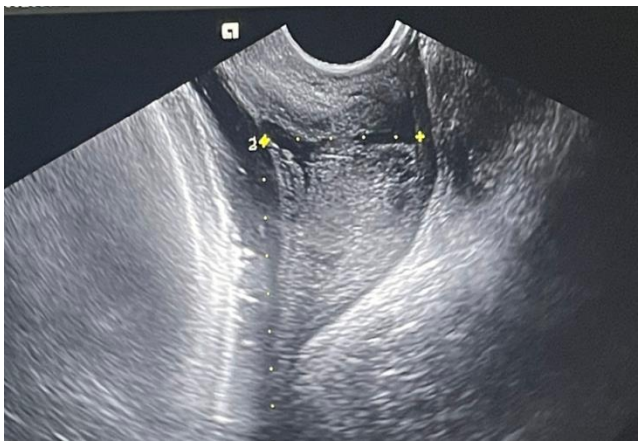

Figure 2: Transvaginal ultrasound scan of cervix showing PCA of 100 degrees

2.1. Sample size estimation

Al-Adwy conducted a blind prospective observational study that evaluated the predictive value of the Bishop score and the posterior cervical angle (PCA) against cervical length and IOL success.[7] PCA larger than 99.5° demonstrated higher sensitivity (91.84%), specificity (90.48%), positive predictive value (95.7%), negative predictive value (82.6%),

positive likelihood ratio (9.64), and negative likelihood ratio (0.09). Therefore, comparing both cervical length and the Bishop score, PCA greater than 99.5° was the most accurate predictor of successful IOL. Based on this information, we calculated the minimum required sample size.

Formula:

$$\frac{n = Z^2 1 - \frac{\alpha}{2}\, p(1-p)}{d^2}$$

p: sensitivity of the new test
d: precision
$Z_{1-\alpha/2}$: desired confidence level
(for 95% confidence level, α=0.05 and Z 1-α /2 ≈1.96)

By dividing the adjusted variance by the square of the precision, the formula provides the minimum sample size necessary to estimate the sensitivity with the specified precision and confidence level. The estimated sample size is 115.

2.2. Statistical analysis

MS Excel spreadsheet program was used to code and record the data. The analysis is done using SPSS (Statistical Product and Service Solutions) software v23 (IBM Corp). Means, standard deviations, and medians, IQR were used to comprehend continuous variables for descriptive analysis. Frequencies and percentages were used for categorical variables.

Independent sample 't' test was used for comparing two groups in which the data was continuously distributed data. Non-parametric tests such as the Wilcoxon Test were used to compare groups where the data was not normally distributed. Categorical data was compared using the Chi-square test. Fisher's Exact test was used in cases where the expected frequency in the contingency tables was found to be less than five or more than twenty-five percent of the cells. Spearman's correlation was used to find a linear correlation between two non-normally distributed continuous variables. P value was considered statistically significant if its value was less than 0.05.

Paired analysis for continuous variables was calculated using a Paired t-test when comparing two continuous variables. Non-parametric test, the Wilcoxon Signed Rank test was used for comparing non-continuous variables.

ROC analysis was performed to predict an optimal cut-off for a continuous predictor predicting a binary outcome. Sensitivity, Specificity, positive predictive value, negative predictive value, and Diagnostic accuracy were calculated for assessing the diagnostic performance of predictors, by making a 2x2 cross-table with the outcome.

3. Results

Figure 3 shows the study consort. Induction of labor was successful in 74% of cases (N=85) and it was unsuccessful in 26% of cases (N=30). We noted an appreciable rate of vaginal delivery even among the primigravida (70%). Unsuccessful IOL cases were delivered by the cesarean section. Failed induction (50%, N=15) is the most common indication. Non-progress of labor (37%) and second-stage arrest (13%) were the other causes of cesarean delivery.

Among the different demographic characteristics studied, BMI shows statistical significance between the two groups and thereby lower BMI is one of the important factors in predicting the success of IOL. Other factors like age, parity, pregnancy duration, and neonatal weight did not show any statistical significance. (**Table 2**)

The most common indication in this study for induction of labor was postdated pregnancy (74.8%). The remaining causes for IOL were premature rupture of membranes (12%), gestational hypertension (6%), early labor (2.5%), gestational diabetes (2.5%), and early and late-onset FGR (1%).

The three cervical parameters differed significantly between our two study groups. Overall, a higher Bishop score, wider posterior cervical angle, and shorter cervical length were noted to be the important determinants in predicting successful labor induction (**Table 3**). We also compared the transvaginal ultrasound variables namely posterior cervical angle and cervical length with the traditional Bishop score and tried to establish their correlation using the Spearman Correlation test. There was a strong positive correlation between Bishop Score and posterior Cervical angle, and this correlation was statistically significant (rho = 0.88, p = <0.001). For every 1 unit increase in Bishop Score, the posterior cervical Angle (Degrees) increases by 12.67 units. (**Figure 4**). However, a moderate negative correlation was noted between cervical Length (cm) and Bishop score with statistical significance (rho = -0.52, p = <0.001). For every 1 unit increase in Cervical Length (cm), the Bishop Score decreases by 0.76 units. (**Figure 5**)

The optimal cut-off values for predicting successful IOL were PCA of more than 99 degrees, cervical length of less than or equal to 2.6cm, and Bishop score of more than 3 derived from the ROC curve in this study. There was a significant difference between the two study groups regarding the overall accuracy of PCA, cervical length, and Bishop test as evidenced by a comparison of the AUC values (0.928 vs 0.891 vs 0.9). However, a PCA of more than 99 degrees had the best sensitivity, positive predictive value, negative predictive value, and diagnostic accuracy in comparison with the cervical length and the bishop score (**Table 4**).

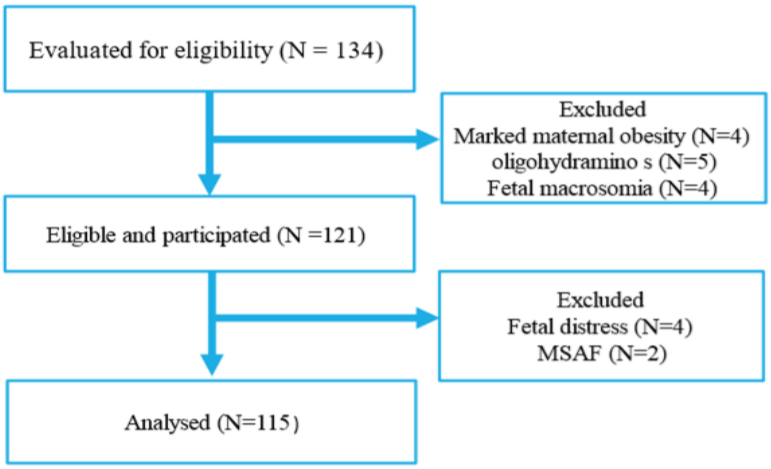

Figure 3: The study consort shows the recruitment of participants

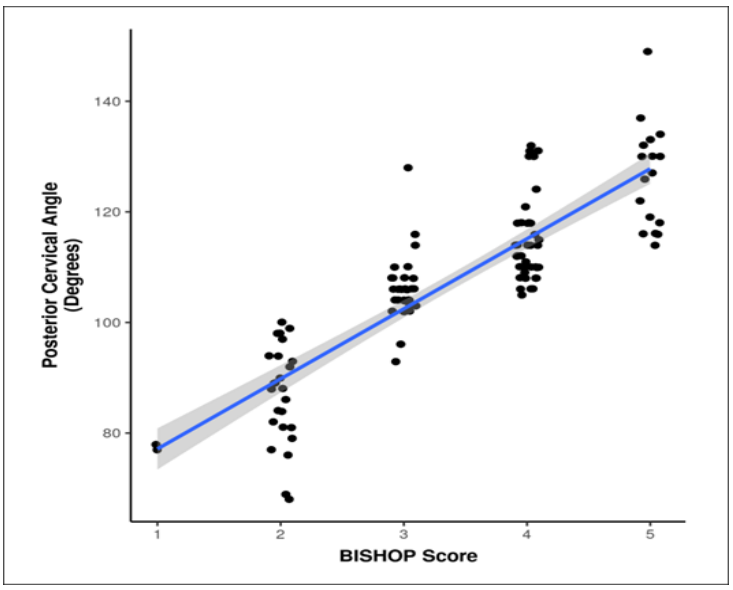

Figure 4: Scatterplot of posterior cervical angle and Bishop score

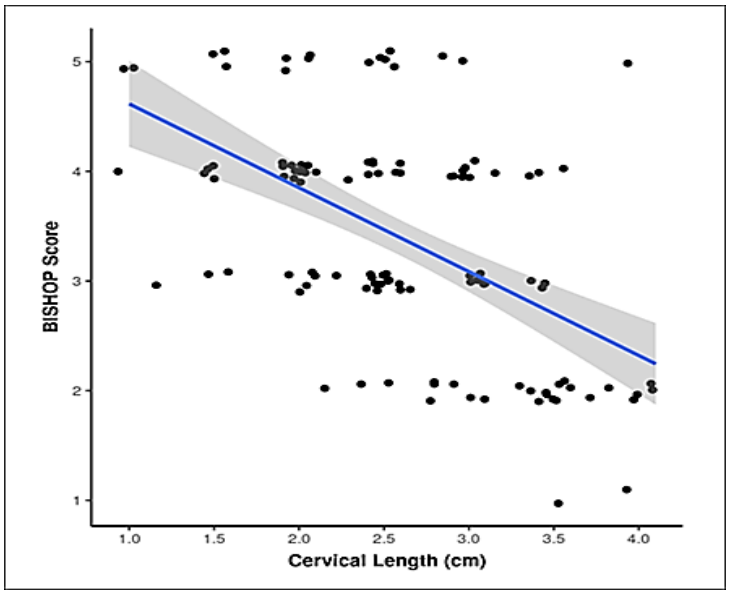

Figure 5: Scatterplot of bishop score and cervical length

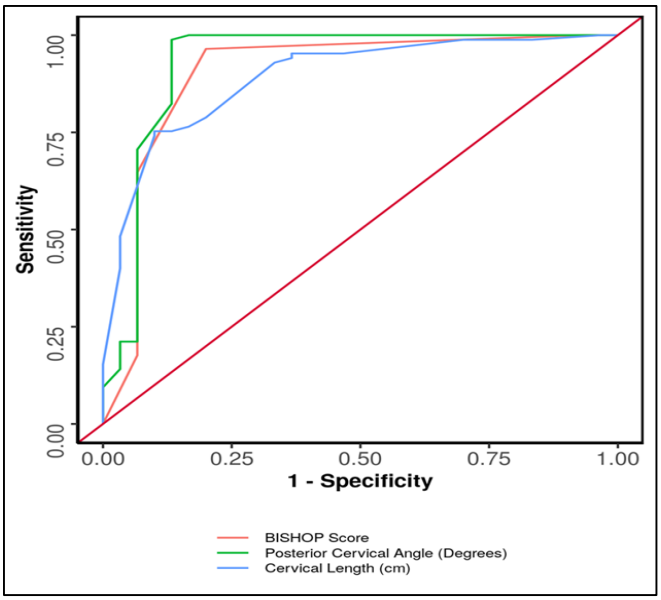

Figure 6: ROC analysis for various variables to predict vaginal delivery

Table 1: Burnett modified bishop score

Score	**0**	**1**	**2**
Position of cervix	Posterior	Mid position	Anterior
Length of cervix(cm)	2	1	≤0.5
Dilatation (cm)	0	1	≥2
Consistency	Firm	Soft	Soft and stretchable
Station	-2	-1	0

Table 2: Demographic and clinical characteristics with respect to mode of delivery

Characteristic	**Successful IOL**	**Unsuccessful IOL**	**Difference between groups (95% CI)**	**p-value**
Age (years)	29.59 ± 3.43	30.13 ± 3.14	0.55 (-1.91 to 0.82)	p = 0.407
BMI (kg/m²)	26.01 ± 3.46	29.29 ± 3.70	3.28 (-4.83 to -1.72)	p=<0.001
Primi	65 (76.47%)	28 (93.33%)	16.86% (-100.00% to -4.17%)	p = 0.058
Multi	20 (23.53%)	2 (6.67%)	16.86% (-100.00% to 29.55%)	p = 0.058
Pregnancy duration (POG)	39.47 ± 0.87	39.80 ± 0.55	0.33 (-0.60 to -0.06)	p = 0.067
Neonatal weight	2995.47 ± 390.20	3130.83 ± 388.64	-135.36 (-301.22 to 30.50)	p = 0.107

Table 3: Cervical characteristics of the study groups

Characteristic	**Successful IOL**	**Unsuccessful IOL**	**Difference between groups (95% CI)**	**p-value**
BISHOP Score (Median)	4.00 (3.00 - 4.00)	2.00 (2.00 - 2.00)	1.52 (1.16 to 1.88)	<0.001
Posterior Cervical Angle (Degrees)	113.8 (10.2)	89.5 (13.4)	24.30 18.88 to 29.71)	<0.001
Cervical Length (cm) by TVS	2.3 (0.6)	3.34 (0.52)	-1.01 (-1.24 to -0.78)	<0.001

Table 4: ROC analysis for various variables to predict vaginal delivery

Predictor	Cut off	AUROC	95% CI	p-value
BISHOP Score	≥ 3	0.900	0.816-0.985	<0.001
Posterior Cervical Angle (Degrees)	≥ 99	0.928	0.851-1	<0.001
Cervical Length (cm)	≤ 2.6	0.891	0.825-0.958	<0.001

Table 5: ROC analysis of the accuracy of three cervical tests in predicting successful induction of labor

Predictor	Sn	Sp	PPV	NPV	DA
BISHOP Score	96%	80%	93%	89%	92%
Posterior Cervical Angle (Degrees)	99%	87%	96%	96%	96%
Cervical Length (cm)	75%	90%	96%	56%	79%

4. Discussion

We have noted an appreciable rate of successful IOL as high as 70% even among the primigravida in this study. The unindicated cesarean section is one of the biggest drawbacks of induction of labor especially in primigravida. This was overcome in our study by incorporating transvaginal cervical parameters namely PCA and cervical length which helped us to predict the success of IOL more confidently and accurately as it provided objectivity and made us avoid resorting to unnecessary cesarean section in haste. The posterior cervical angle acted as an excellent tool in achieving our goal as it had better sensitivity, specificity, and predictive value than the conventional Bishop score.

A Bishop score of >3 could predict vaginal delivery accurately in the present study. However, the sole reliability of Bishop score to predict the success of IOL has been questioned by many authors previously. In a review of 40 studies reporting on 13757 women, Kolkman et al concluded that there is no solid evidence validating the current use of the bishop score in obstetric practice even though it has been used for more than 40 years to assess cervical ripeness and predict the outcome of IOL.[8] By contrast, a meta-analysis that included 59 studies confirmed a positive correlation between IOL outcome and Bishop score.[9]

There have been several studies in the recent past that have investigated the role of ultrasound measurement of cervical length to predict the success of IOL. Transvaginal cervical length of<2.6cm had fair chances of successful IOL in this study. Our results complemented by Abdullah et al who reported the best cut-off measurement of 27 mm for cervical length and 4 for Bishop score to predict the outcome of IOL.[10] The study by El Mekkawi et al also compared the predictive accuracy of transvaginal cervical length (TVCL) and the modified Bishop's score for successful induction of labor among nulliparous women and found that a transvaginal cervical length of <28mm was more specific and had a higher positive predictive value than modified Bishop score.[11] Another study by Alanwar et al concluded that both transvaginal sonography for cervical length and Bishop score are useful predictors of the need for cesarean delivery following labor induction.[12]

The micro environmental factors such as collagen fiber remodeling, its orientation, and dispersion which contribute to cervical stiffness are reflected by PCA.[13] Our study showed that a wider PCA of >99 degrees had a favorable IOL outcome. In a retrospective cohort study conducted by Eun-Ju Kim et al.[14] PCA of >96.5 degrees was the only predictor with a successful vaginal birth irrespective of induction of labor. Sabry et al conducted a study evaluating different parameters and found that PCA of 99 degrees is superior to Bishop score and transvaginal cervical length for predicting successful labor prediction. Another study found that the success of labor induction can be highly predicted by transvaginal sonography of cervical length and PCA, as it is more objective and accurate than the Bishop score.[15]

5. Strengths and Limitations

Ours was a prospective study which are very few in literature with a good sample size. Prediction of IOL outcome is a difficult task, especially among the primigravida. However, we have achieved a good rate of vaginal delivery even among the primigravida by incorporating the transvaginal sonographic metrics.

The present study also has limitations. The fetal position which affects the outcome of IOL was not assessed in the present study. Different cervical ripening agents were used in the present study. So, further studies can be undertaken by addressing these limitations to assess their effect on IOL outcomes.

6. Conclusion

In conclusion, transvaginal sonographic examination of the cervix with PCA and cervical length is an important and promising advancement in obstetric care, providing an in-depth understanding of cervical dynamics that has a major impact on labor induction management and effectiveness. Their routine incorporation before IOL can help us predict the IOL success and help in rapid and prompt decision-making both by the patient and obstetrician.

7. Author Contribution

Dr. Rama Majji contributed to the data collection and analysis. Dr. Jyothi Shetty came up with the idea and conceptualization and methodology development. She also did the cervical assessment by Bishop scoring and transvaginal sonographic assessments. Dr. Prathiksha Keshava Murthy has contributed to the transvaginal assessment of the cervix and in the preparation of the manuscript.

8. Source of Funding

None.

9. Conflict of Interest

Nil.

10. Ethical Approval

Ethical No.: 414/2022.

11. Acknowledgement

None.

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