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Prediction of Preterm Delivery via Assessment of Cervical Length Changes

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ABSTRACT

Background and Objective: Preterm labor is one of the most significant challenges to maternal and neonatal health. In rare instances, cervical insufficiency may culminate in preterm delivery. The clinical distinction between high-risk and low-risk patients for preterm labor remains challenging. The objective of the present study is to predict preterm delivery and the timing of labor through the evaluation of cervical length changes.

Methods: This cross-sectional study was conducted on 80 pregnant women hospitalized due to preterm labor. Upon admission, all patients underwent transvaginal ultrasonography. Based on the cervical length measured at admission, they were divided into two groups: high-risk (cervical length<15 mm) and low-risk (cervical length>15 mm). The following variables were assessed and compared between the groups: maternal age, gestational age, cervical length, delivery time, body mass index (BMI), and progesterone use.

Findings: The mean level of change in cervical length between admission and 48 hours after arrest of labor was 2.09±6.47 mm (p=0.021). The mean maternal age was 26.9±6.6 years, and the mean gestational age at admission was 31.16±1.35 weeks. The mean cervical length at admission was 29.24±3.66 mm, whereas 48 hours after arrest of labor, it measured 31.33±2.14 mm. Preterm labor within 7 days of admission occurred in 7.5% of patients, and 83.8% delivered before 34 weeks of gestation. A cervical length change (Δ_{CL}) of less than -5.5 mm demonstrated a sensitivity of 66.7%, while a Δ_{CL} of less than -6.5 mm demonstrated a sensitivity of 85% for predicting preterm labor.

Conclusion: The present study demonstrated that significant changes in cervical length can serve as an important predictive marker for preterm labor in high-risk pregnant women. Specific thresholds of cervical length changes, particularly significant reductions, exhibit a strong correlation with the likelihood of preterm labor.

Keywords: *Pregnant Women, Prediction, Preterm Labor, Cervical Length Changes.*

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Introduction

Preterm labor is defined as delivery occurring between 20+0 and 36+6 weeks of gestation and is considered one of the most significant challenges to maternal and neonatal health. According to the World Health Organization, the global incidence of preterm labor is rising, and it remains the leading cause of mortality among children under five years of age (1, 2). Preterm labor is categorized into spontaneous and indicated subtypes. Approximately 70-80% of preterm labors occur spontaneously, of which 40-50% result from spontaneous onset of preterm labor and 20-30% from preterm premature rupture of membranes (PPROM). In rare instances, cervical insufficiency may also lead to preterm labor (3, 4). Conversely, 20-30% of preterm labors are medically indicated to safeguard maternal or fetal well-being. The most common indications include preeclampsia, placenta previa, placental abruption, intrauterine growth restriction (IUGR), and multiple gestations (5, 6).

Epidemiological evidence indicates that approximately 9% of pregnant women present with threatened preterm labor and require active clinical management (7). Risk stratification in this cohort typically relies on two primary biomarkers: transvaginal ultrasound assessment of cervical length and fetal fibronectin test. An inverse correlation exists between cervical length and preterm labor risk among symptomatic patients, and cervical shortening has likewise been associated with adverse outcomes (6). Similarly, elevated levels of fetal fibronectin are correlated with an increased risk of preterm labor at a clinically alarming threshold (7, 8). Ultrasonographic measurement of cervical length remains a standard tool for estimating the likelihood of preterm labor in women presenting with threatened labor. Recent studies have likewise reported a significant association between the risk of preterm labor and short cervical length measured by ultrasound (9, 10).

The clinical distinction between patients who are truly at high risk for imminent preterm delivery and those who are at relatively low risk remains a persistent and significant challenge in the management of women presenting with threatened preterm labor. This difficulty is underscored by the observation that nearly half of all pregnancies complicated by threatened preterm labor ultimately progress to term delivery without intervention (11-15). The problem is especially pronounced in cases where a pregnant patient is initially categorized as high-risk on the basis of admission findings—namely, a shortened cervical length on transvaginal ultrasound and an elevated fetal fibronectin level—yet the preterm labor episode resolves spontaneously or in response to tocolytic therapy within 48 hours, thereby calling into question the predictive accuracy of these baseline markers (8, 16-19). In light of these clinical uncertainties, the primary objective of the present study was to systematically evaluate changes in cervical length among women diagnosed with threatened preterm labor and to explore whether such dynamic changes bear a meaningful relationship to the eventual timing of delivery and overall pregnancy outcome. To this end, cervical length was measured both at the time of hospital admission and again at least 48 hours after the arrest of preterm labor; these measurements were then analyzed in relation to the actual delivery interval. The insights derived from this study are expected to assist clinicians in refining their management approaches, particularly with respect to crucial decisions such as hospital discharge versus continued inpatient monitoring and intensified obstetric surveillance.

Methods

In this cross-sectional study, which was conducted under ethics code IR.UMSU.REC.1401.175, 80 pregnant women hospitalized due to preterm labor (threatened preterm delivery) were selected using convenience sampling and subsequently evaluated. Upon admission, all patients underwent transvaginal

ultrasonography using an Echovist-200 device (SHU 454, Schering AG, Berlin, Germany) for cervical length measurement, performed by a single radiologist for all patients. Between 48 and 120 hours following admission, provided that all contraindications had been resolved and tocolytic therapy had been discontinued, a second transvaginal ultrasound was performed to reassess cervical length after the arrest of preterm labor, and patients were followed up thereafter. Patients were stratified into high-risk and low-risk groups based on cervical length measured at admission; those with a cervical length of less than 15 mm were considered high-risk (29). Additionally, based on changes in cervical length, patients were categorized into three groups: decreased (Δ_{CL}<-2 mm), unchanged (-2 mm ≤ Δ_{CL} ≤ 2 mm), and increased (Δ_{CL}>2 mm). Ultimately, patients were divided into three groups according to the timing of subsequent delivery: Group 1 comprised patients who delivered within 7 days of admission; Group 2 comprised those who delivered after 7 days but prior to 34 weeks of gestation; and Group 3 comprised those who delivered at or after 34 weeks of gestation. Cervical length changes were then compared between the designated groups. The variables examined in this study included maternal age, gestational age, cervical length, delivery time, BMI, smoking status, use of assisted reproductive technologies, and progesterone administration. Data were collected using a researcher-developed checklist whose validity and reliability had been confirmed by faculty members. All patient information was reviewed and reported with strict confidentiality. No additional costs were incurred by patients as a result of this study protocol.

Inclusion criteria comprised pregnant women between 24+0 and 34+6 weeks of gestation, singleton pregnancies, provision of informed consent for study participation, and hospitalization with preterm labor defined by a Bishop score of <6, in the absence of vaginal bleeding. Exclusion criteria included preeclampsia, refusal to participate, preterm premature rupture of membranes, antepartum hemorrhage, history of tocolytic therapy, fetal congenital anomalies, fetal distress, pregnancies complicated by intrauterine growth restriction (IUGR), cervical dilation ≥3 cm, and presence of cervical cerclage.

Based on the study by Rennert et al. in 2021 (9), which reported adjusted odds ratios (aOR) of 0.90 for cervical length changes in relation to delivery before 34 weeks and 0.88 for delivery within 7 days of admission, sample size calculation was performed using G*Power software. With a type I error (alpha) of 5% and a statistical power of 80%, the initial calculated sample size was 79 patients. To enhance the precision of the study and account for an anticipated 10% attrition rate, the final sample size was determined to be 87 patients.

Data were analyzed using SPSS statistical software version 22. Initially, the distribution of data was determined using the Kolmogorov–Smirnov test. For comparisons of quantitative data between the two groups, Student's t-test was employed for normally distributed data, whereas the Mann–Whitney U test was used for non-normally distributed data. Qualitative data were compared using the Chi-square test (for normally distributed data) or Fisher's exact test (for non-normally distributed data), with a p-value of < 0.05 considered statistically significant. To evaluate the performance of diagnostic tests, receiver operating characteristic (ROC) curve analysis was performed. Sensitivity and specificity data were collected at various cutoff points. The ROC curve was constructed, and the area under the curve (AUC) was calculated to assess the test's ability to correctly identify true positives and true negatives.

Results

The present study evaluated a total of 80 pregnant women who had been hospitalized with a clinical diagnosis of preterm labor, defined as threatened preterm delivery. Baseline cervical length measurements obtained at the time of hospital admission yielded a mean value of 31.16±1.35 mm, while repeat measurements performed 48 hours after the documented arrest of preterm labor demonstrated a mean value

of 31.33±2.14 mm, indicating a slight increase over the observation period. Among the study population, 9 patients were identified as having high-risk pregnancies on the basis of their admission cervical length (Table 1). Patients were categorized into three groups based on cervical length changes: decreased (Δ_{CL}<-2 mm), unchanged (-2 mm ≤ Δ_{CL} ≤ 2 mm), and increased (Δ_{CL}>2 mm). According to the results, 7.5% (n=6) of cases delivered within the first 7 days following admission, and 8.8% (n=7) delivered before 34 weeks of gestation (Table 2).

The mean cervical length changes observed after the arrest of preterm labor were 2.76±1.12 mm among patients who delivered beyond 7 days following admission, and 0.87±6.25 mm among those who delivered after 34 weeks of gestation, indicating a diminished risk of premature delivery. In contrast, patients who ultimately delivered at or before 34 weeks demonstrated a mean cervical length change of 1.38±0.91 mm. Collectively, these data suggest that a reduction in cervical length following the arrest of preterm labor is associated with an increased risk of subsequent preterm labor, whereas an increase in cervical length appears to reflect therapeutic success in delaying delivery. Cervical length measurements at admission, at 48 hours following arrest of preterm labor, and the corresponding changes, categorized according to final delivery timing, are summarized in Table 3.

Table 1. Demographic and Baseline Characteristics of Pregnant Women

Variable	Mean±SD or Number(%)
Age (years)	26.9±6.6
Gestational age (weeks)	31.16±1.35
Cervical length at admission (mm)	29.24±3.66
High-risk women	9(11.3)
Cervical length 48 hours after arrest of preterm labor (mm)	31.33±2.14
Cervical length changes (mm)	1.89±0.42
Smoking	0(0)
Progesterone use	30(37.5)
Delivery time	
<7 days	6(7.5)
<34 weeks	7(8.8)
≥34 weeks	67(83.8)

Table 2. Frequency of Preterm Labor According to Cervical Length Change (Δ_{CL}) Classification

Time of Preterm Labor	Δ_{CL} Classification		
	Increased (n=31) Number(%)	Unchanged (n=34) Number(%)	Decreased (n=15) Number(%)
Within 7 days after admission	3(9.7)	1(2.9)	2(13.3)
Before 34 weeks	5(16.1)	1(2.9)	1(6.7)

Table 3. Cervical Length Measurements at Admission and 48 Hours After Arrest of Preterm Labor, and Corresponding Changes, Stratified by Ultimate Delivery Timing

Delivery Time	Cervical Length, Mean±SD		
	At Admission	48 Hours After Arrest of Labor	Changes
<7 days	28.51±3.19	30.12±1.27	2.76±1.12
<34 weeks	27.57±2.34	34.16±1.84	6.25±0.87
≥34 weeks	29.48±2.59	31.25±1.63	1.38±0.91

The mean cervical length change observed between admission and 48 hours following the Arrest of labor was 2.09±6.47 mm. A one-sample t-test comparing this value against the null hypothesis of zero change revealed statistical significance (p=0.021), confirming that the observed change was non-zero. Furthermore, as illustrated in Figure 1, a cervical length reduction exceeding 5.5 mm (Δ_{CL}<-5.5 mm) was found to predict preterm labor within 7 days of admission, with a sensitivity of 66.7% (AUC=0.73; 95% CI: 0.60-0.86; p=0.021). The findings of the present study further revealed that a decrease in cervical length of more than 6.5 mm (i.e., Δ_{CL}<-6.5 mm) served as a sensitive predictor of preterm labor occurring before 34 weeks of gestation, achieving a sensitivity of 85.7% (Figure 2).

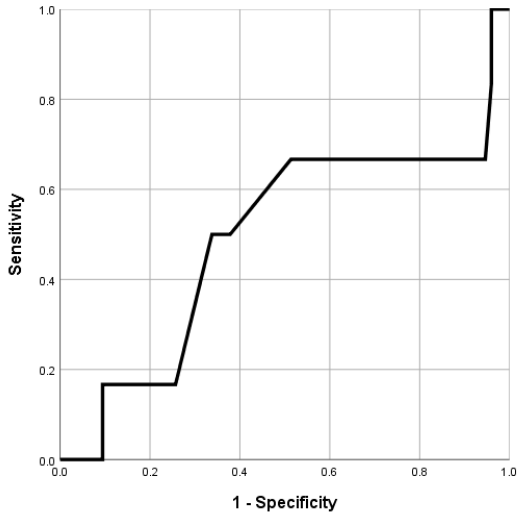


Figure 1. Estimation of Preterm Labor Occurrence (Within 7 Days of Admission) Based on Cervical Length Changes. Sensitivity: 66.7% (50%-81%), Specificity: 75.0% (60%-87%), Positive Predictive Value (PPV): 70.0% (54%-83%), Negative Predictive Value (NPV): 72.0% (58%-84%), Positive Likelihood Ratio (LR+): 2.67 (1.5-4.6), Negative Likelihood Ratio (LR-): 0.44 (0.26-0.73).

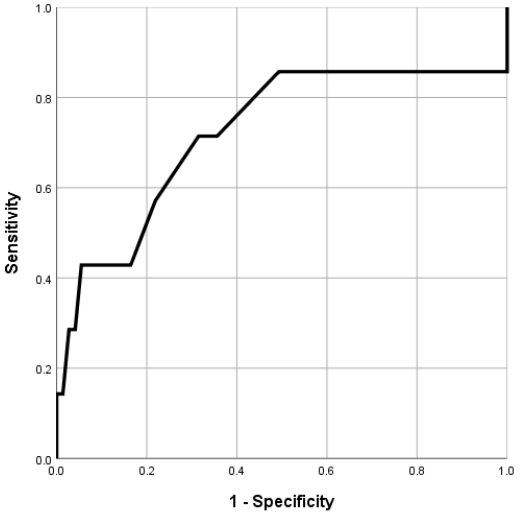


Figure 2. Estimation of Preterm Labor Occurrence (Before 34 Weeks) Based on Cervical Length Changes. Sensitivity: 85.7% (70%-95%), Specificity: 80.0% (65%-90%), Positive Predictive Value (PPV): 75.0% (60%-87%), Negative Predictive Value (NPV): 88.0% (74%-96%), Positive Likelihood Ratio (LR+): 4.29 (2.3-7.8), Negative Likelihood Ratio (LR-): 0.18 (0.08-0.38).

Moreover, when considering preterm labor as a general outcome regardless of gestational age subgroup, the same cutoff value of Δ_{CL}<-6.5 mm was associated with a sensitivity of 84.6% for the prediction of premature delivery (Figure 3).

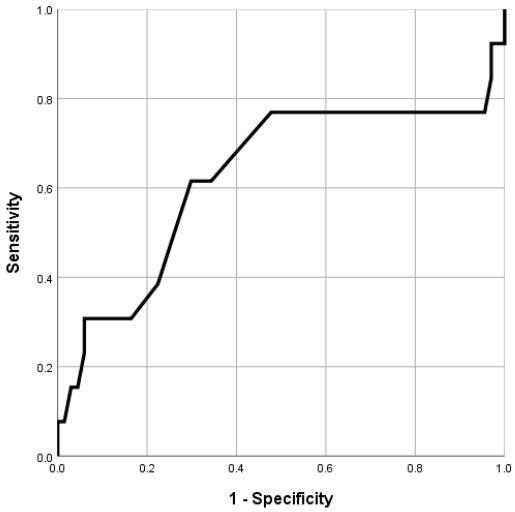


Figure 3. Estimation of Preterm Labor Occurrence (Overall) Based on Cervical Length Changes.
Sensitivity: 84.6% (69%-94%), Specificity: 78.0% (63%-89%), Positive Predictive Value (PPV): 73.0% (58%-86%), Negative Predictive Value (NPV): 87.0% (73%-95%), Positive Likelihood Ratio (LR+): 3.84 (2.0-7.1), Negative Likelihood Ratio (LR-): 0.20 (0.09-0.40).

Discussion

In the present study, cervical length changes following the arrest of preterm labor were 2.76±1.12 mm in patients with a delivery interval of >7 days, indicating successful prolongation of pregnancy. Furthermore, in mothers who delivered after 34 weeks, the change was 6.25±0.87 mm, while in those who delivered at ≤ 34 weeks, the cervical length change was 1.38±0.91 mm, which continued to indicate a trend toward preterm labor. According to the evidence, nearly 10% of women presenting with threatened preterm labor require hospital admission, and the primary markers available for evaluating these patients and assessing the risk of preterm labor during hospitalization include cervical length measurement and fetal fibronectin testing (2, 3, 17-22). Cervical length exhibits an inverse relationship with the risk of preterm labor in symptomatic women, and cervical shortening during hospitalization is directly associated with preterm delivery (6, 17). The main challenge in this context concerns the extent to which changes in cervical length during hospitalization can predict preterm labor in these women—an issue that the current pilot study has sought to address. The principal finding of the current study was that a cervical length reduction of more than 5 mm within 48 hours of admission in women with threatened preterm labor can predict preterm labor within 7 days of initial admission or the occurrence of preterm labor before 34 weeks of gestation.

The results of the current investigation have clearly demonstrated that evaluating dynamic changes of cervical length—specifically, the change observed between the time of hospital admission and the 48-hour reassessment following successful arrest of preterm labor activity—provides clinically valuable information for predicting subsequent preterm delivery risk in women presenting with threatened preterm labor. This finding is further supported by a consistent body of evidence from earlier studies, which have generally reached a consensus that there exists a robust inverse relationship between cervical length and the risk of

preterm labor in women with threatened preterm labor (10, 12, 17). In the present study, the overall preterm labor rate was 16.3%. By comparison, DeFranco et al. (20) reported a rate of 12% in a general obstetric population, suggesting that the higher rate observed in our cohort is likely attributable to our exclusive focus on women presenting with threatened preterm labor. In contrast, Griggs et al. reported a preterm labor rate of 28.3%, although this figure corresponded to deliveries prior to 37 weeks of gestation (10). Regarding the clinical utility of cervical length measurements, prior studies have proposed a post-arrest cervical length threshold of 15 mm as a meaningful prognostic indicator (21). The increase in cervical length observed at 48 hours in our study may be partially explained by the therapeutic effect of tocolytic agents. Supporting this notion, Gürsoy Erzincan et al. demonstrated that, following 48 hours of successful tocolysis, combined assessment of myometrial thickness and cervical length represents a valuable management tool in women with preterm labor (13). Given that all participants in our study received tocolytic therapy, it is reasonable to postulate that the observed cervical length elongation within 48 hours of labor arrest reflects successful tocolytic response, which may in turn have contributed to the reduced preterm labor rate in this population.

The results obtained in the current study demonstrated that in women experiencing preterm labor before 34 weeks, a decrease in cervical length was associated with an increased risk of preterm labor; however, the results were not statistically significant. In alignment with our findings, Rennert et al. reported that an increase in cervical length during the 48 hours following arrest of preterm labor was associated with a reduced risk of preterm labor before 34 weeks (OR=0.90) and preterm labor within 7 days of admission (OR=0.91) (9). In the study by Moroz et al., the mean cervical length change was reported as -0.21 cm/week in women delivering before 35 weeks and -0.10 cm/week in those delivering at or after 35 weeks (23). Additionally, that study reported that a rapid cervical length change exceeding -0.2 cm/week was associated with 3.45-fold increased odds of preterm labor. In the study by Dude et al., among 1,552 women, 114 (7.4%) experienced preterm labor in their subsequent pregnancy. Compared with women whose cervical length remained stable or increased, those whose cervical length shortened were more likely to experience preterm labor. Cervical shortening was associated with preterm labor, and the authors ultimately concluded that mid-trimester cervical shortening during pregnancy was independently associated with an increased risk of preterm labor (22).

In the present study, only 8.8% of cases experienced preterm labor before 34 weeks, and 7.5% of deliveries occurred within 7 days of admission—figures that are consistent with previous studies (17). Furthermore, among women who demonstrated an increase in cervical length, 3 patients (9.6%) experienced preterm labor within 7 days of admission. Previous studies have reported that a cervical length of less than 15 mm can predict preterm labor within 7 days of admission, and have recommended that further research is needed to better understand whether the predictive characteristics of cervical length screening via transvaginal ultrasound can contribute to improved clinical management and, consequently, better outcomes (24). In the current study, this threshold was found to be 10 mm; however, the difference was not statistically significant, which may be attributable to the small sample size (n=6) in this subgroup. To gain a better understanding of whether the predictive characteristics of cervical length screening using transvaginal ultrasound can enhance clinical management and thereby improve outcomes, further studies are required, along with the integration of knowledge and clinical experience. This will be of great importance for generalizing the results of evidence-based clinical studies in the context of treatment and patient survival (25-27).

A limitation of this study is its single-center design; therefore, future studies are recommended to be conducted as cohort investigations in pregnant women with threatened preterm labor, so that cervical length changes can be quantitatively utilized as a tool for risk stratification in this population. The present study demonstrated that significant changes in cervical length can serve as an important predictive marker for preterm delivery in high-risk pregnant women. Specific thresholds of cervical length alteration, particularly significant reductions, exhibit a strong correlation with the likelihood of preterm labor. These findings confirm the importance of accurate cervical length assessment in the clinical management of high-risk pregnancies and may assist clinicians in therapeutic decision-making and the prevention of preterm labor.

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