Is measurement of cervical length an accurate predictive tool in women with a history of preterm delivery who present with threatened preterm labor?

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KEYWORDS: cervical length; preterm delivery; preterm labor; risk

ABSTRACT

Objective To determine whether sonographically measured cervical length is an effective predictive tool in women with threatened preterm labor and a history of past spontaneous preterm delivery.

Methods This was a retrospective cohort study of all women with singleton pregnancies who presented with preterm labor at less than 34+0 weeks' gestation and underwent sonographic measurement of cervical length in a tertiary medical center between 2007 and 2012. The accuracy of cervical length in predicting preterm delivery was compared between women with and those without a history of spontaneous preterm delivery. Women with risk factors for preterm delivery other than a history of preterm delivery were excluded from both groups.

Results Overall, 1023 women who presented with preterm labor met the study criteria, of whom 136 (13.3%) had a history of preterm delivery (past-PTD group) and 887 (86.7%) had no risk factors for preterm delivery (low-risk group). The rate of preterm delivery was significantly higher for women with a history of preterm delivery (36.8% vs 22.5%; P < 0.001). Cervical length was significantly correlated with the examination-to-delivery interval in low-risk women (r = 0.32, P < 0.001) but not in women who had had a previous preterm delivery (r = 0.07, P = 0.4). On multivariable analysis, cervical length was independently associated with the risk of preterm delivery for women in the low-risk group but not for women with a history of previous preterm delivery. For women with previous preterm delivery who presented with threatened preterm labor, cervical length failed to distinguish between those who did and those who did not deliver prematurely (area under the receiver–operating characteristics curve range, 0.475–0.506). When using standardized thresholds, the sensitivity and specificity of cervical length for the prediction of preterm delivery were significantly lower in women with previous preterm delivery than in women with no risk factors for preterm delivery.

Conclusion Cervical length appears to be of limited value in the prediction of preterm delivery among women with threatened preterm labor who are at high risk for preterm delivery owing to a history of spontaneous preterm delivery in a previous pregnancy. Copyright © 2014 ISUOG. Published by John Wiley & Sons Ltd.

INTRODUCTION

Prematurity remains the main reason for neonatal mortality and morbidity. One of the challenges in the management of preterm labor is to distinguish between true and false preterm labor, since fewer than 15% of those presenting with threatened preterm labor will actually deliver within 7 days of presentation or before 35 weeks' gestation.

One of the most widely investigated tools for the prediction of preterm delivery in women with threatened preterm labor is sonographic measurement of cervical length. Although previous studies have found an association between the risk of preterm delivery and sonographically measured short cervical length in women presenting with threatened preterm labor, most of these studies did not stratify the predictive value of cervical length by the a priori risk for preterm delivery. This question is of interest since the predictive value of a given test is dependent on this baseline risk. This is especially true in cases in which the negative likelihood ratio associated with that test is only moderate. Furthermore, it is clear that women who present with...
preterm labor represent a heterogeneous group in terms of the underlying mechanisms for preterm labor, and it might be that the performance of cervical length as a predictor would be different in each of these subgroups.

One specific subgroup of women at high risk for preterm delivery comprises women with a history of preterm delivery, which has been shown to be one of the most important risk factors for future preterm delivery. While there is much evidence showing the role of cervical length in predicting future preterm delivery in asymptomatic women with a history of preterm delivery, there is limited information regarding the predictive performance of cervical length in women with a history of preterm delivery who present with threatened preterm labor.

Our aim in this study was to determine whether sonographically measured cervical length is an effective predictive tool in women with threatened preterm labor who are at high risk for preterm delivery owing to a history of past spontaneous preterm delivery.

**METHODS**

This was a retrospective cohort study of all women who presented with threatened preterm labor in the presence of intact membranes and underwent sonographic measurement of cervical length in the ultrasound unit in a tertiary referral medical center between January 2007 and December 2012. The study group included women with threatened preterm labor who had a history of spontaneous preterm delivery at less than 37 + 0 weeks' gestation (past-PTD group), and the predictive accuracy of cervical length in that group was compared with that observed in a control group of women with threatened preterm labor and no known risk factors for preterm delivery (low-risk group).

Only women with singleton pregnancies who presented at a gestational age of 24 + 0 to 33 + 6 weeks were included in the study. Women with multiple gestations, cervical cerclage, other risk factors for preterm delivery (a history of cone biopsy, congenital uterine anomaly or past dilatation and evacuation beyond 13 weeks' gestation), cervical dilatation > 3 cm at presentation, pregnancies complicated by placental abruption, chorioamnionitis, stillbirth or major fetal anomalies, women with a history of indicated preterm delivery and women who underwent indicated delivery before 37 + 0 weeks for any maternal or fetal indication or did not deliver in our medical center were excluded from both the study and control groups. The study was approved by the local institutional review board.

Women were identified using the comprehensive database of sonographic examinations in our ultrasound unit. This database contains data on all sonographic examinations performed in the ultrasound unit, which are entered in real-time by the performer of the examination immediately after completion. Initially, all women who underwent sonographic measurement of cervical length using transvaginal ultrasound were identified and information regarding cervical length, presence of funneling and change in cervical length during the examination (either spontaneous or in response to Valsalva maneuver) was extracted. The medical charts of these women were then thoroughly reviewed in order to identify only those women for whom the indication for sonographic measurement of cervical length was threatened preterm labor. For these women, the following information was extracted: demographic, medical and obstetric history, complications during current pregnancy, validation of gestational age by first-trimester ultrasound, gestational age at presentation, frequency and regularity of uterine contractions, results of vaginal examination, interventions for threatened preterm labor, gestational age at delivery and onset of delivery (i.e. spontaneous vs indicated). For women with repeated measurements of cervical length at different times through gestation only the first measurement was included in the analysis.

Threatened preterm labor was defined as the presence of at least three regular and painful uterine contractions within a 30-min period. Tocolysis with nifedipine, indomethacin or atosiban, and betamethasone for fetal lung maturation, were administrated based on the decision of the attending physician.

All sonographic examinations were performed by senior physicians specialized in ultrasonography or by experienced sonographers, with the following ultrasound systems: Voluson E8 and Voluson 730 Expert (GE Medical Systems, Zipf, Austria) and ATL 5000 (Philips Medical Systems, Solingen, Germany). Measurement of cervical length was performed transvaginally after the patient had emptied her bladder, according to a standard technique. Briefly, measurement of cervical length was performed in the sagittal plane, visualizing the full length of the endocervical canal from the internal to the external cervical os, while exerting as little pressure with the transducer as possible. At least three measurements were obtained and the shortest measurement recorded. The presence of cervical funneling or change in cervical length, either spontaneously or in response to Valsalva maneuver, was also routinely documented.

In our institution treatment with vaginal progesterone was recommended for asymptomatic women with a short cervix at mid-gestation.

Data analysis was performed with the SPSS v 21.0 software (SPSS Inc., Chicago, IL, USA). We compared the accuracy of cervical length in predicting preterm delivery in women with a history of preterm delivery (before 37 + 0 weeks’ gestation) and those without known risk factors for preterm delivery.

Spearman's correlation coefficient was used to assess the correlation between cervical length at presentation and examination-to-delivery interval, and the correlation coefficients for the two groups were compared using Fisher's Z-transformation. Kaplan–Meier survival analysis was used to compare the proportion of women undelivered by time from presentation between the two study groups, and between women with a short or long cervix within each of the groups. The log-rank test was used to compare
Cervical length in women with a history of PTD

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Women with sonographic measurement of cervical length during study period (n = 1950) (2680 measurements)

Indication for measurement, threatened PTL (n = 1350) (1766 measurements)

Previous PTD (n = 311)

No previous PTD (n = 1455)

Excluded (n = 743):

Repeated measurement

Multiple pregnancy

Use of cerclage

Indicated PTD

Other risk factors for PTD*

Other†

113

303

13

131

25

32

5

34

12

42

7

26

Past-PTD group (n = 136)

Low-risk group (n = 887)

Figure 1 Flow-chart showing make-up of study groups. *Other risk factors for preterm delivery included a history of cone biopsy, congenital uterine anomaly or past dilatation and evacuation beyond 13 weeks’ gestation. †Cases complicated by major anomalies, delivery before 24 weeks, stillbirth or incomplete data. PTD, preterm delivery; PTL, preterm labor.

the survival distributions. Multivariable logistic regression analysis was used to assess the association of cervical length as a continuous measure and the risk of preterm delivery for each of the two study groups while controlling for potential confounders including maternal age, parity, fetal sex and gestational age at presentation.

Receiver–operating characteristics (ROC) analysis was used to determine the area under the ROC curve (AUC) as an overall measure of the discriminative ability of cervical length. The AUCs for each of the groups were compared using the method of Hanley and McNeil. ROC analysis was also used to calculate several standardized outcome-specific thresholds for each of the individual outcome variables, including: (1) the threshold associated with a detection rate (sensitivity) of 80%; (2) the threshold associated with a false-positive rate (1 – specificity) of 20%; and (3) the threshold associated with the inflexion point in the ROC curve, which is usually associated with the optimal balance between sensitivity and specificity. We used these standardized outcome-specific thresholds in order to facilitate comparison of the sensitivity and specificity of cervical length as predictor between the two study groups; P < 0.05 was considered to be statistically significant.

RESULTS

Characteristics of the study group

A total of 2680 sonographic examinations of cervical length were performed in 1950 women during the study period, of whom 1350 underwent measurement of cervical length after presenting with threatened preterm labor (Figure 1). Of these, 1023 women were eligible for the study, 136 (13.3%) with a history of preterm delivery (past-PTD group) and 887 (86.7%) with no risk factors for preterm delivery (low-risk group) (Figure 1).

The demographic and obstetric characteristics and delivery outcomes of the women in the two groups are presented in Table 1. Women in the past-PTD group were older, and the median gestational age at their previous preterm delivery was 34 weeks. There were no differences between the two groups with respect to cervical length at presentation (29.9 ± 31.0 mm) and gestational age at the time of sonographic examination (29.4 ± 29.9 weeks).

With respect to delivery outcome, women in the past-PTD group had a significantly higher rate of spontaneous preterm delivery before 37 + 0 and before 35 + 0 weeks’ gestation, confirming that women in this group were at higher risk of preterm delivery (Table 1). There were no differences between the two groups with respect to the rate of spontaneous preterm delivery before 32 + 0 weeks (3.7% vs 3.2%), time interval from examination at presentation to delivery (53.1 ± 23.9 vs 57.2 ± 25.5 days) and rate of spontaneous delivery within 7 days and 14 days from the time of sonographic examination (3.7% vs 2.5% and 5.9% vs 5.5%, respectively). The mean birth weight in the past-PTD group was significantly lower than in the low-risk group, while the mean birth-weight percentile was similar in both groups.

As a first step, the association between cervical length at the time of presentation with threatened preterm labor and the risk of preterm delivery was assessed for each of the
two groups. Cervical length was significantly correlated with the examination-to-delivery interval only for women in the low-risk group ($r = 0.32$, $P < 0.001$), while such an association was not observed in the past-PTD group ($r = 0.07$, $P = 0.4$) (Figure 2).

The rate of preterm delivery before 37, 35, and 32 weeks as well as the rate of delivery within 7 and 14 days from presentation, as a function of cervical length at presentation, is presented in Figure 3. For women in the low-risk group, the rate of spontaneous preterm delivery consistently increased as the cervical length at presentation decreased. This pattern was observed for all outcome variables of preterm delivery studied. In contrast, for women in the past-PTD group, such a relationship between cervical length and rate of preterm delivery was not observed.

The association of cervical length with the risk of preterm delivery in the two groups was also assessed by means of survival analysis (Figure 4). Overall, the proportion of women undelivered at any given time from the time of examination was significantly lower in the past-PTD group, confirming that women in this group were at a higher risk of preterm delivery ($P = 0.03$; Figure 4a). For women in the low-risk group, stratification of the analysis by cervical length at presentation resulted in clearly distinct survival curves such that the proportion of women undelivered at any given time from the time of examination was significantly lower in women with a cervical length of < 25 mm at presentation ($P < 0.001$; Figure 4b). In contrast, similar stratification of the analysis in the past-PTD group resulted in two overlapping curves ($P = 0.5$; Figure 4c), further reflecting the limited association between cervical length and risk of preterm delivery in this group.

Because the two groups differed in some of the background characteristics such as maternal age, parity and fetal sex, we used multivariable logistic regression analysis in order to assess the association between cervical length as a continuous variable and risk of preterm delivery in each of the two groups while controlling for these potential confounders (Table 2). For women in the low-risk group, cervical length was significantly associated with the risk of preterm delivery, so that the risk of all the preterm delivery outcome variables (i.e. delivery before 37, 35 and 32 weeks and delivery within 14 and 7 days from presentation) consistently decreased by a similar magnitude of 6–8% for each additional mm of cervical length ($P < 0.001$; Table 2). In contrast, among women in the past-PTD group, there was no significant association between cervical length and risk of preterm delivery, even when limiting the analysis to specific subgroups based on gestational age at previous preterm delivery ($< 34 + 0$ or $\geq 34 + 0$ weeks) (Table 2).

We next analyzed the association between cervical length and preterm delivery from a more clinically

Table 1 Demographic and obstetric characteristics of women who presented with threatened preterm labor with a history of past preterm delivery (past-PTD group) and those who presented without such a history (low-risk group)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Past-PTD group (n = 136)</th>
<th>Low-risk group (n = 887)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>34.9 ± 5.5</td>
<td>32.7 ± 5.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Maternal age &gt; 35 years</td>
<td>64 (47.1)</td>
<td>260 (29.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nulliparous</td>
<td>—</td>
<td>476 (53.7)</td>
<td>N/A</td>
</tr>
<tr>
<td>GA at previous PTD (weeks)</td>
<td>34 (31–36)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>GA at previous PTD &lt; 34 weeks</td>
<td>59 (43.4)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>GA at previous PTD &lt; 32 weeks</td>
<td>37 (27.2)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cervical length measurement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA at examination (weeks)</td>
<td>29.4 ± 2.8</td>
<td>29.9 ± 2.8</td>
<td>0.07</td>
</tr>
<tr>
<td>Cervical length (mm)</td>
<td>29.9 ± 9.9</td>
<td>31.0 ± 10.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Cervical length &lt; 15 mm</td>
<td>9 (6.6)</td>
<td>66 (7.4)</td>
<td>0.7</td>
</tr>
<tr>
<td>Cervical length &lt; 20 mm</td>
<td>20 (14.7)</td>
<td>128 (14.4)</td>
<td>0.9</td>
</tr>
<tr>
<td>Cervical length &lt; 25 mm</td>
<td>42 (30.9)</td>
<td>215 (24.2)</td>
<td>0.1</td>
</tr>
<tr>
<td>Cervical length &lt; 30 mm</td>
<td>65 (47.8)</td>
<td>338 (38.1)</td>
<td>0.03</td>
</tr>
<tr>
<td>Funneling</td>
<td>12 (8.8)</td>
<td>32 (3.6)</td>
<td>0.005</td>
</tr>
<tr>
<td>Tocolysis</td>
<td>98 (72.1)</td>
<td>588 (66.3)</td>
<td>0.2</td>
</tr>
<tr>
<td>Progesterone administered</td>
<td>30 (22.1)</td>
<td>53 (6.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Delivery outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GA at delivery (weeks)</td>
<td>36.6 ± 2.6</td>
<td>37.6 ± 2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GA at delivery &lt; 37 + 0 weeks</td>
<td>50 (36.8)</td>
<td>200 (22.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GA at delivery &lt; 35 + 0 weeks</td>
<td>25 (18.4)</td>
<td>91 (10.3)</td>
<td>0.005</td>
</tr>
<tr>
<td>GA at delivery &lt; 32 + 0 weeks</td>
<td>5 (3.7)</td>
<td>28 (3.2)</td>
<td>0.7</td>
</tr>
<tr>
<td>Interval from examination to delivery (days)</td>
<td>53.1 ± 23.9</td>
<td>57.2 ± 25.5</td>
<td>0.08</td>
</tr>
<tr>
<td>Delivery within 2 days of examination</td>
<td>3 (2.2)</td>
<td>6 (0.7)</td>
<td>0.08</td>
</tr>
<tr>
<td>Delivery within 7 days of examination</td>
<td>5 (3.7)</td>
<td>22 (2.5)</td>
<td>0.4</td>
</tr>
<tr>
<td>Delivery within 14 days of examination</td>
<td>8 (5.9)</td>
<td>49 (5.5)</td>
<td>0.9</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>30 (22.1)</td>
<td>179 (20.2)</td>
<td>0.6</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2798 ± 610</td>
<td>2941 ± 621</td>
<td>0.01</td>
</tr>
<tr>
<td>Birth-weight percentile (%)</td>
<td>51.9 ± 25.0</td>
<td>50.5 ± 27.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Birth weight &lt; 10th percentile</td>
<td>6 (4.4)</td>
<td>67 (7.6)</td>
<td>0.2</td>
</tr>
<tr>
<td>Male fetus</td>
<td>84 (61.8)</td>
<td>467 (52.6)</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD, n (%), or median (interquartile range). GA, gestational age; N/A, not applicable; PTD, preterm delivery.
Cervical length in women with a history of PTD

Figure 2 Correlation between cervical length at presentation with preterm labor and time interval to delivery for: (a) women without a history of preterm delivery (PTD) (low-risk group \( r = 0.32, P < 0.001 \)) and (b) those with such a history (past-PTD group \( r = 0.07, P = 0.4 \)). The relationship was best described using a linear equation.

Figure 3 Rate of preterm delivery (PTD) according to cervical length at presentation for: (a) women without a history of PTD (low-risk group) and (b) those with such a history (past-PTD group), showing rate of PTD before \( 37 + 0 \) weeks' gestation (-----), before \( 35 + 0 \) weeks (- - - -) and before \( 32 + 0 \) weeks (----), and within 14 days (-- -- --) and 7 days (-----) from presentation.

practical perspective by comparing the accuracy of cervical length in predicting preterm delivery in each of the two groups. The predictive accuracy of cervical length was calculated for each of the outcome variables using a fixed threshold of 25 mm (Table 3). In addition, in order to facilitate comparison of the predictive accuracy of cervical length between the two groups, ROC analysis was used to calculate three additional standardized outcome-specific thresholds for each of the individual outcome variables: (1) the threshold associated with a detection rate (sensitivity) of 80%; (2) the threshold associated with a false-positive rate (1 – specificity) of 20%; and (3) the threshold associated with the inflexion point in the ROC curve (Figure 5 and Table 3). In addition the AUC for each of the outcome variables was compared between the two groups.

Overall, the ability of cervical length to discriminate between women who did and those who did not deliver prematurely as reflected by the AUC was significantly higher for women in the low-risk group than for women in the past-PTD group for each of the four outcome variables (Table 3). In fact, for women in the past-PTD group, cervical length failed to discriminate between women who
The aim of the present study was to determine whether sonographically measured cervical length is an effective predictive tool in women with threatened preterm labor who are at high risk for preterm delivery owing to a history of previous preterm delivery. The main finding of this study is that in women with a history of preterm delivery who present with threatened preterm labor, cervical length is not associated with a risk of preterm delivery and is not useful for distinguishing between women who are at low risk and those who are at high risk for preterm delivery in the current pregnancy. This conclusion is supported by different analytic approaches demonstrating a lack of correlation between cervical length and examination-to-delivery interval, the lack of an association between cervical length and the risk of preterm delivery even after adjustment for potential confounders. Survival analysis and the failure of cervical length to distinguish between women at high or low risk for preterm delivery in the current pregnancy. This observation is in contrast to findings in women with no risk factors for preterm delivery, for whom cervical length is independently associated with the risk of preterm delivery even after adjustment for potential confounders. Survival analysis and the failure of cervical length to distinguish between women at high or low risk for preterm delivery, as reflected by the low AUC, also support this conclusion. This observation is in contrast to findings in women with no risk factors for preterm delivery, for whom cervical length is independently associated with the risk of preterm delivery and can be used for stratification of the risk of this eventuality.

Previous studies of women presenting with threatened preterm labor have reported an inverse association between cervical length and the risk of preterm delivery, as was observed in the group of women who were at low risk for preterm delivery in our cohort (women without previous spontaneous preterm delivery). However, none of these studies assessed the predictive performance of cervical length in the subgroup of women who did and women who did not deliver prematurely (AUC ranging from 0.475 to 0.506) (Table 3).

The use of either a fixed threshold of cervical length of 25 mm or a threshold that is associated with a detection rate (sensitivity) of 80% was significantly higher in the low-risk group than in the past-PTD group (Table 3). Similarly, when the false-positive rate (1-specificity) was set at 20%, the sensitivity of cervical length for the prediction of preterm delivery before 35 + 0 weeks was significantly higher for women in the low-risk group than for those in the past-PTD group (Table 3).

**DISCUSSION**

The aim of the present study was to determine whether sonographically measured cervical length is an effective predictive tool in women with threatened preterm labor who are at high risk for preterm delivery owing to a history of previous preterm delivery. The main finding of this study is that in women with a history of preterm delivery who present with threatened preterm labor, cervical length is not associated with a risk of preterm delivery and is not useful for distinguishing between women who are at low risk and those who are at high risk for preterm delivery in the current pregnancy. This conclusion is supported by different analytic approaches demonstrating a lack of correlation between cervical length and examination-to-delivery interval, the lack of an association between cervical length and the risk of preterm delivery even after adjustment for potential confounders. Survival analysis and the failure of cervical length to distinguish between women at high or low risk for preterm delivery, as reflected by the low AUC, also support this conclusion. This observation is in contrast to findings in women with no risk factors for preterm delivery, for whom cervical length is independently associated with the risk of preterm delivery and can be used for stratification of the risk of this eventuality.

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The use of either a fixed threshold of cervical length of 25 mm or a threshold that is associated with a detection rate (sensitivity) of 80% was significantly higher in the low-risk group than in the past-PTD group (Table 3). Similarly, when the false-positive rate (1-specificity) was set at 20%, the sensitivity of cervical length for the prediction of preterm delivery before 35 + 0 weeks was significantly higher for women in the low-risk group than for those in the past-PTD group (Table 3).
The reason for the low predictive accuracy of cervical length in the group of women with previous preterm delivery is unclear, though one possible explanation could be the higher a priori risk for preterm delivery in this subgroup. Recently, Schaaf et al. studied more than 1,000,000 deliveries in order to validate a prognostic model for spontaneous preterm delivery before 37 weeks’ gestation, and found that previous preterm delivery was the strongest risk factor (odds ratio, 9.5). A history of previous preterm delivery has also been reported by others as being one of the strongest predictors of recurrent preterm delivery. Thus, it is possible that the negative predictive value of cervical length in this specific subgroup is more limited, considering the relatively low negative likelihood ratio of cervical length in women with preterm labor.

However, the lower predictive accuracy of cervical length in women with previous preterm delivery cannot be attributed solely to the high a priori risk for preterm delivery, but is also the result of the inferior discriminative ability of cervical length in that subgroup of women, as reflected by the lower AUC. It has been shown that women who present with preterm labor represent a heterogeneous group in terms of the underlying pathogenic mechanisms for preterm labor, and it could be that in this subgroup of women with a history of preterm labor the underlying mechanism for preterm labor is different and is less often accompanied by concomitant gradual cervical shortening or ripening, resulting in cervical length being an ineffective marker for the prediction of preterm delivery in this subgroup. Unfortunately, owing to the retrospective nature of the current study, other markers such as fetal fibronectin, vaginal and cervical cultures or other information that may provide clues to the underlying etiology of threatened preterm labor were not available. Finally, another possible explanation could be differences in the rates of interventions between the

### Table 3
Predictive accuracy of cervical length at different gestational ages for preterm labor (PTL) in women presenting with threatened PTL with a history of previous preterm delivery (PTD) (past-PTD group) and those without such a history (low-risk group)

<table>
<thead>
<tr>
<th>Threshold type</th>
<th>Past-PTD group</th>
<th>Low-risk group</th>
<th>P for:*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sens. Spec. PPV NPV</td>
<td>Sens. Spec. PPV NPV</td>
<td></td>
</tr>
<tr>
<td>Delivery at 35 weeks</td>
<td>AUC = 0.506 (95% CI, 0.372–0.641)</td>
<td>AUC = 0.708 (95% CI, 0.645–0.771)</td>
<td>0.005</td>
</tr>
<tr>
<td>Fixed</td>
<td>25 32.0 69.4 19.0 81.9</td>
<td>25 56.0 79.4 23.7 94.0</td>
<td>0.03 0.02</td>
</tr>
<tr>
<td>Inflexion point</td>
<td>26.5 40.0 63.1 19.6 82.4</td>
<td>27.5 62.6 70.6 19.6 94.3</td>
<td>0.04 0.1</td>
</tr>
<tr>
<td>Detection rate of 80%</td>
<td>40 80.0 16.2 17.7 78.3</td>
<td>36 80.2 36.8 12.7 94.2</td>
<td>0.9 &lt;0.001</td>
</tr>
<tr>
<td>False-positive rate of 20%</td>
<td>22 28.0 82.9 26.9 83.6</td>
<td>25 56.0 79.4 23.7 94.0</td>
<td>0.01 0.4</td>
</tr>
<tr>
<td>Delivery within 14 days</td>
<td>AUC = 0.475 (95% CI, 0.248–0.701)</td>
<td>AUC = 0.729 (95% CI, 0.646–0.811)</td>
<td>0.02</td>
</tr>
<tr>
<td>Fixed</td>
<td>25 37.5 69.5 7.1 94.7</td>
<td>25 59.2 77.8 13.5 97.0</td>
<td>0.3 0.04</td>
</tr>
<tr>
<td>Inflexion point</td>
<td>27.5 50.0 58.6 7.0 94.9</td>
<td>22.5 59.2 82.2 16.3 97.2</td>
<td>0.6 &lt;0.001</td>
</tr>
<tr>
<td>Detection rate of 80%</td>
<td>41 75.0 13.3 5.1 89.5</td>
<td>34 79.6 45.8 7.9 97.5</td>
<td>0.8 &lt;0.001</td>
</tr>
<tr>
<td>False-positive rate of 20%</td>
<td>22 25.0 81.3 7.7 94.5</td>
<td>24 59.2 80.1 14.8 97.1</td>
<td>0.07 0.8</td>
</tr>
</tbody>
</table>

*Comparison of the two groups for: (1) area under receiver–operating characteristics (ROC) curve (AUC) (in first row of each outcome variable, using the method of Hanley and McNeil) or (2) sensitivity and specificity (using the chi-square test). Predictive accuracy calculated for both a fixed threshold (25 mm) and standardized outcome-specific thresholds (those associated with the inflexion point in the ROC curve, a detection rate of 80% and a false-positive rate of 20%). NPV, negative predictive value; PPV, positive predictive value; Sens., sensitivity; Spec., specificity.

### Figure 5
Receiver–operating characteristics (ROC) curve for accuracy of cervical length in the prediction of preterm delivery before 37 + 0 weeks’ gestation; area under curve = 0.672. Similar analysis was performed for the other outcome variables of preterm delivery including delivery before 35 + 0 and before 32 + 0 weeks, and delivery within 14 and 7 days from presentation (data not shown). ROC-curve analysis was used to identify several standardized outcome-specific thresholds for each of the different outcome variables: (1) threshold associated with a detection rate of 80%; (2) threshold associated with a false-positive rate of 20%; and (3) threshold associated with the inflexion point of the ROC curve.

With a history of preterm delivery, which constituted 7–30% of the women included in those studies. In other studies that did address this specific group of women with a history of previous preterm delivery, analysis of the predictive accuracy of cervical length was limited to asymptomatic women and did not include women with threatened preterm labor. Thus, extremely limited information is available regarding the accuracy of cervical length in the prediction of preterm delivery in women with threatened preterm labor who have a history of previous spontaneous preterm delivery.
two groups. Women in the past-PTD group were more likely to be treated with progesterone, which may affect the relationship between cervical length at presentation and the risk of preterm delivery. However, progesterone was taken by only a relatively small proportion of the women in that group (22%). Furthermore, there was no difference in the relationship between cervical length and the risk of preterm delivery between the subgroups of women who took, and those who did not take, progesterone.

In addition to its retrospective nature, the current study is also limited by the relatively small number of women in the past-PTD group. Nevertheless, this study represents one of the largest cohorts published so far addressing this specific group of women with both a history of spontaneous preterm delivery and threatened preterm labor in the index pregnancy. Moreover, we performed a thorough analysis using a standardized threshold that permitted a more reliable comparison of the predictive accuracy of cervical length between the two groups.

In summary, cervical length appears to be of limited value in the prediction of preterm delivery among women with threatened preterm labor who are at high risk for preterm delivery owing to a history of preterm delivery in a previous pregnancy. Additional studies are necessary to validate this observation and to compare the predictive accuracy of cervical length in this specific subgroup of women with other predictive tests as well as to investigate the underlying reasons for this observation.

REFERENCES


