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ORIGINAL ARTICLE

Cervical length measured before delivery and the success rate of vaginal birth after cesarean (VBAC)

Ron Beloosesky, Nizar Khatib, Nadir Ganem, Emad Matanes, Yuval Ginsberg, Mike Divon and Zeev Weiner

Department of Obstetrics and Gynecology, Rambam Medical Center, Haifa, Israel

ABSTRACT

Objective: To test the hypothesis that measuring cervical length (CL) close to the time of delivery is a predictor of successful vaginal birth following a cesarean.

Methods: A prospective longitudinal study included women with singleton pregnancies at 38–41 weeks, who previously underwent a cesarean, and who were interested in trial of labor. Patients who did not have a spontaneous onset of labor were induced at 41 weeks' gestation. CL measurements were performed prior to labor by transvaginal ultrasound, recorded, and blinded from the caring physicians.

Results: Vaginal birth was achieved in 63/105 (60%) of patients participating in the study. The mode of delivery significantly correlated with CL, Bishop score, and previous obstetrical history. When multivariate analysis was performed, only CL and previous obstetrical history correlated significantly with mode of delivery. In the subgroup of patients with no previous vaginal delivery, only CL had a significant correlation with mode of delivery. The ROC curve demonstrated a high prediction of vaginal delivery by CL for the entire study group and for the subgroup of patients with no previous vaginal delivery (AUC = 0.8, $p < .0001$).

Conclusions: CL measurement after 36 weeks has a high predictive accuracy for a successful vaginal birth after cesarean.

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KEYWORDS
Cervical length; vaginal birth after cesarean; TOLAC; cesarean delivery

Introduction

In the past decade, the rate of cesarean section reached a new record of 31% in the USA [1]. One of the main contributors to this sharp increase was the decline in the rate of vaginal births after cesarean (VBAC), reaching 6.5% in 2006. However, according to the literature, the success rate of VBAC should range between 60% and 80% [2]. In addition, several studies report that women with a successful VBAC have less morbidity than women undergoing elective repeat cesarean deliveries, while women with failed VBAC have a higher morbidity rate than those undergoing elective repeat cesarean deliveries [2,3]. Therefore, it is important to predict the probability of a successful VBAC in order to counsel patients appropriately. Several investigators have attempted to develop models based on multiple clinical factors to predict the probability of a successful VBAC [4–7]. The main limitations of those models is their use of previous vaginal birth as the best and only reliable parameter for predicting a successful VBAC, while most patients choosing VBAC have an obstetrical history of only one previous delivery by cesarean section.

In recent years, the sonographic measurement of cervical length (CL) has been widely used to predict preterm and term labor under various circumstances [8–11]. Based on previous studies that used CL measurements in different obstetrical situations, we hypothesized that CL when performed close to the time of delivery may also predict a successful VBAC. We therefore designed the following study to test this hypothesis.

Methods

We performed a prospective longitudinal study of all pregnant patients who presented at our outpatient clinic for consultation during April 2013–March 2014, with singleton pregnancies at 38–41 weeks' gestation, and who were interested in trial of labor after cesarean (TOLAC). Patients who attempted TOLAC and who were not presented at our outpatient clinic for consultation did not participate in the study. All patients had only one previous cesarean section with a low transverse uterine incision. Exclusion criteria included any contraindication for vaginal delivery or maternal

CONTACT Zeev Weiner z_weiner@rambam.health.gov.il Department of Obstetrics and Gynecology, Rambam Medical Center, Haifa 31096, Israel

or fetal condition that could affect the mode of delivery, such as fetal demise or medical conditions such as diabetes, hypertension, intrauterine growth restriction, or oligohydramnios. Patients in labor or with regular uterine contractions (suspected to initiate labor) were also excluded. Patients who reached 41 weeks' gestation were induced using an intracervical balloon catheter or amniotomy with Oxytocin augmentation, according to their Bishop score. Intrauterine pressure catheters were used when Oxytocin was administered. The study was approved by the Institutional Review Board, and all patients signed an informed consent.

CL was measured in all patients between 38 and 41 weeks' gestation within a week prior to delivery. A pelvic exam was performed on all patients prior to their ultrasound examination; then the Bishop score was calculated and recorded. CL measurements were obtained by transvaginal ultrasound with the patients in the lithotomy position, based on the method described by Iams et al. [12]. Transvaginal ultrasound examinations were performed by one operator (I. M.), using a Voluson 730 expert (GE Healthcare, Solingen, Germany) with a 5–9 MHz transvaginal probe. The CL measurements were recorded and blinded from the caring physician. We correlated between the mode of delivery and different parameters, including: CL, Bishop score, previous obstetrical history (previous or no history of vaginal delivery), indication of previous cesarean section (for labor dystocia or other reason), BMI, maternal age, gestational age at delivery, birth weight, and spontaneous labor versus induction.

Statistical analysis

Clinical and demographic data were collected and statistical analysis performed using SPSS version 21 (IBM Corp., Armonk, NY). A *t*-test or Mann–Whitney *U* test was performed to test for differences between the two groups of patients. The Fisher's exact test was employed for categorical parameters. Spearman's rho correlation was performed to test for potential associations between different parameters, in order to control for multicollinearity. Where multicollinearity existed, the multivariate model was adjusted appropriately. Multivariate logistic regression analysis was used to find associations between modes of delivery and independent parameters. A receiver operating characteristic (ROC) analysis with Youden index was performed to determine the most efficient cutoff values for CL, in order to discriminate between vaginal and cesarean delivery. The highest value of the area under the curve (AUC) was determined. A p value of less than .05 was consider significant

Results

All 105 patients who met the inclusion criteria agreed to participate in the study. The total number of deliveries during this period of time was 5105 and the total number of patients attempting TOLAC was 143 (39 patients were not presented for consultation). VBAC was achieved in 63 out of 105 patients (60%). Characteristics of the study group are presented in Table 1. There were no adverse maternal or fetal outcomes in the study group. Spontaneous onset of labor occurred in 87 patients, and induction of labor was performed in 18 (17%) patients because of premature rupture of membrane or post-term pregnancy. Cesarean section was performed during labor for two indications: labor dystocia and non-reassuring fetal heart rate monitoring. Epidural anesthesia was provided to all patients at the beginning of the active phase of labor, or prior to cesarean section for patients who did not reach the active phase of labor. All patients had continuous electronic fetal heart rate monitoring.

Table 2 presents correlations between mode of delivery and different parameters, for all patients. Mode of delivery correlated significantly with CL, Bishop score, and previous obstetrical history. However, when multivariate analysis was performed, only CL and previous obstetrical history had a significant correlation with mode of delivery. CL had a normal distribution based on Kolmogorov–Smirnov test. The mean CL for women who had experienced a successful VBAC was 2.7 ± 0.9 cm compared to 3.6 ± 1.1 cm for women who failed to achieve a VBAC and continued to require cesarean sections ($p < .0001$). Ten of 63 patients with VBAC had CL greater than 3.6 cm (16%) and 7 of 42 patients who had a cesarean section had CL less than 2.7 cm (17%). For each reduction of 10 mm in CL, the odds ratio for vaginal delivery was 4.19 ($p < .0001$). The odds ratio for a successful VBAC in women who had experienced a previous vaginal

Table 1. Characteristic of the study group.

Number of patients (*N*)	105
Maternal age (years, mean ± SD)	32 ± 4.9
Number of patients with previous vaginal delivery (%)	33 (31)
Gestational age when exam was performed (weeks, mean ± SD)	39.3 ± 1.4
Time between exam and delivery (days, mean ± SD)	3.1 ± 2.1
Patients body mass index (mean ± SD)	30.6 ± 4.5
Gestational age at delivery (weeks, mean ± SD)	40.1 ± 1.1
Number of VBAC performed (%)	63 (60%)
Birth weight (grams, mean ± SD)	3459.2 ± 454
Number of inductions of labor/total births (%)	18/105 (17%)
Number of previous cesarean section because of dystocia (%)	22 (21%)

delivery was 9, compared with women with no previous vaginal delivery.

In the selected subgroup of patients with no previous vaginal delivery (Table 3), mode of delivery correlated significantly with CL, Bishop score, and birth weight. However, in the multivariate analysis only CL significantly correlated with mode of delivery.

Prediction of vaginal delivery by CL is presented in ROC curves for the entire study group (Figure 1) (area under the curve = 0.76, CI between 0.663–0.856, $p < .0001$) and for the subgroup of patients with no previous vaginal delivery (Figure 2) (area under the curve = 0.8, CI between 0.7 and 0.9, $p < .0001$). According to ROC analysis, the CL was found to be discriminative for achieving or not achieving a vaginal delivery. For example, according to Figure 2, 78% of patients with a CL of more than 41 mm and 100% of patients with a CL of more than 45 mm had a cesarean section. However, 84% of the patients with a CL less than 28 mm experienced a vaginal delivery.

Discussion

In this study, we report that CL measured after 36 weeks' gestation, close to the time of delivery, is highly accurate in predicting the success rate of VBAC. We chose patient exclusion criteria very carefully in order to eliminate confounding variables that could potentially affect the results. In addition, the major advantage of our study is that we were able to focus on the group of patients that did not have a prior vaginal birth.

Several methods have been proposed in the literature to estimate the probability of a successful VBAC on a population-level, based on multiple clinical factors [4]. However, the prospects for a given individual may also depend on demographic characteristics and obstetrical history. Grobman et al. [4] proposed a

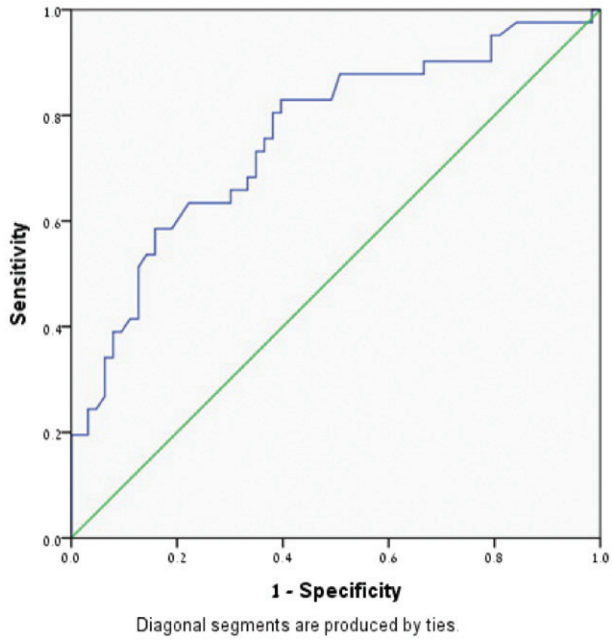

Figure 1. Receiver operating characteristics (ROC) curve of cervical length in the prediction of a successful vaginal delivery in the group of women with previous cesarean delivery.

Table 2. Correlation between different parameters and mode of delivery for all patients in the study group.

	Cesarean section, $N = 42$	Vaginal delivery, $N = 63$	p
Cervical length (cm, mean ± SD)	3.6 ± 1.1	2.7 ± 0.9	<.0001
Number patients with Bishop score <5 (%)	37 (88)	38 (61)	.003
Number of patients with previous vaginal delivery (%)	6 (15)	27 (43)	.003
Number of patients with BMI <30 (%)	13 (34)	30 (50)	.14
Maternal age (years, mean ± SD)	32 ± 4.8	32 ± 5.1	1.00
Gestational age when exam was performed (weeks, mean ± SD)	39.2 ± 1.5	39.5 ± 1.4	.30
Gestational age at delivery (weeks, mean ± SD)	40.0 ± 1.06	40.1 ± 1.1	.74
Birth weight (grams, mean ± SD)	3522 ± 428	3417 ± 470	.25
Number of patients with induction of labor (%)	8 (20)	10 (16)	.60
Number of previous cesarean sections because of dystocia (%)	10 (23.8)	12 (19)	.63

Table 3. Correlation between different parameters and mode of delivery only in patients who did not have a previous vaginal delivery.

	Cesarean section, $N = 36$	Vaginal delivery, $N = 36$	p
Cervical length (cm, mean ± SD)	3.5 ± 1.2	2.4 ± 0.8	<.0001
Number patients with Bishop score <5 (%)	31 (86)	18 (50)	.002
Number of patients with BMI <30 (%)	11 (33)	15 (44)	.46
Maternal age (years, mean ± SD)	31.9 ± 4.5	31.6 ± 5.4	.77
Gestational age when exam was performed (weeks, mean ± SD)	39.1 ± 1.5	39.5 ± 1.4	.36
Gestational age when exam was performed (weeks, mean ± SD)	40.1 ± 1.03	40.0 ± 1.1	.91
Birth weight (grams, mean ± SD)	3520 ± 384	3300 ± 424	.024
Number of patients with induction of labor (%)	6 (17.6)	2 (5.6)	.15
Number of previous cesarean sections because of dystocia (%)	9 (25)	6 (16.7)	.56

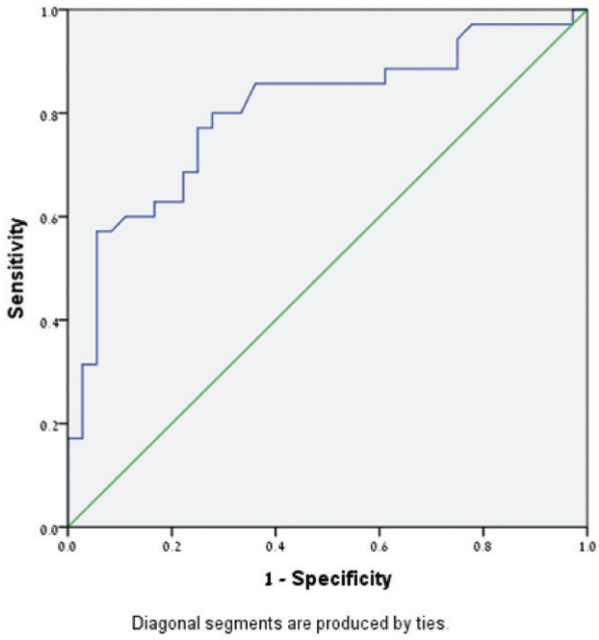

Figure 2. Receiver operating characteristics (ROC) curve of cervical length in the prediction of a successful vaginal delivery in the group of women with previous cesarean delivery who did not have a previous vaginal delivery.

model based only on information available during the first prenatal visit, in order to determine probability of a successful VBAC. These variables included: maternal age, body mass index, ethnicity, prior vaginal delivery, prior VBAC, and potential recurrent indications for a cesarean delivery. The predictive model based on those variables found previous vaginal delivery was the strongest predictor of a successful TOLAC. Additional studies analyzing possible factors affecting the success rate of a VBAC determined the most reliable predictors were prior vaginal birth and preferably a prior VBAC [5–7]. However, most of the patients undergoing TOLAC have not experienced a previous vaginal birth and require consultation to estimate the probability for a successful VBAC. Patients and their attending physician are intimidated by the possible complications of TOLAC, such as a long unsuccessful labor with risk of uterine rupture and other maternal and fetal complications. Therefore, patients identified as having a high chance of a successful VBAC may be more confident in choosing the TOLAC option. On the other hand, being able to recognize patients with a very low chance for a successful VBAC may help avoid an unnecessary long and risky TOLAC.

In recent years, measurement of CL has been successfully used to predict the mode of delivery, preterm delivery, and successful induction of labor at term [8–11]. Miller et al. [8] reported on the association between a second trimester CL measured in nulliparous women, and frequency of primary cesarean section at term. Pandis et al. [9] examined the CL prior to induction of labor with misoprostol and dinoprostone gel. The authors reported that measuring CL was useful in predicting the likelihood of vaginal delivery within 24 h, and the induction to delivery interval. Similar results were reported by Ben-Harush et al. [10]. We therefore hypothesized that ultrasound measurement of CL could predict the mode of delivery in women undergoing TOLAC. As hypothesized, CL measured prior to labor was, by itself, a very strong predictor of a successful VBAC.

Very recently, Comas et al. published their results regarding the correlation between ultrasound examination and success rate of VBAC [13]. The authors measured not only the CL, but also the posterior cervical angle and the fetal head-perineum distance. They found that CL and fetal head-perineum distance as well as other variables were associated with the success rate of VBAC. Their results for the likelihood of a vaginal delivery based on several variables were similar to our findings. However, they did not focus on the major subgroup of patients with no previous vaginal birth. We demonstrated that by using only a simple measurement of CL without additional variables for this subgroup, we were able to achieve a very high accuracy in predicting a successful VBAC, which reached 84% when the CL was less than 28 mm. It is interesting that in both studies, the CL was more accurate than the Bishop score in predicting the success of VBAC. Should we obstetricians abandon the Bishop score and use CL for estimating cervical condition?

In conclusion, we have demonstrated that CL measured during the last month of pregnancy, close to the time of delivery, predicts the success rate of VBAC. This is the best most reliable parameter for predicting the success rate of VBAC in patients with previous cesarean section and without a history of vaginal delivery. Although larger studies are needed to support our data we already recommend adopting this method when counseling patients prior to VBAC.

Disclosure statement

The authors report no conflict of interest.

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