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Predicting labor induction success by cervical funneling in uncomplicated pregnancies

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Abstract

Aim: Predictive accuracy of cervical funneling for successful vaginal delivery prior to labor induction was compared to that of conventional methods such as Bishop score and cervical length.

Methods: Prospective observational study was conducted on nulliparous women at 38 gestational weeks or more with intact membranes who delivered vaginally following labor induction. Transvaginal ultrasound was performed prior to labor induction to evaluate the cervix, to determine the cervical length and to check for the presence of funneling. Following pelvic examinations, the Bishop score was calculated. Predictive accuracy of the three different methods, namely cervical funneling, cervical length and Bishop, were compared.

Results: A total of 235 nulliparous women with intact membranes were recruited. Of these, 194 women (82.6%) had successful vaginal deliveries following induction. Cervical funneling was observed in 105 women (44.7%). The rate of successful vaginal delivery was significantly higher in women with cervical funneling than in those without funneling (90.5% vs 76.2%, $P < 0.004$). Multivariable analysis showed that cervical funneling, similar to traditional measures such as the Bishop score and cervical length, was an independent predictor of successful vaginal delivery following labor induction (odds ratio = 2.95; 95% confidence interval: 1.38–6.47; $P = 0.007$).

Conclusions: Similar to the conventional methods of cervical evaluation, such as the Bishop score and cervical length, cervical funneling may serve as a useful and valid predictor of successful vaginal deliveries prior to labor induction.

Key words: cervix uteri, cesarean section, delivery, induced labor, obstetric, ultrasonography.

Introduction

Induction of labor refers to the artificial initiation of labor prior to the commencement of spontaneous labor to attain vaginal delivery. Labor induction is indicated in situations where the benefit of timely delivery outweighs the potential risks of prolonged pregnancy for the mother or the neonate.[1–3] According to previous reports, labor is induced in 20–25% of all pregnancies.[4,5]

There are potential medical advantages to elective labor induction at full term, such as the reduction of stillbirths and prevention of excessive fetal growth, which may lead to macrosomia and other negative results.[6–8] Despite the advantages, labor induction can lead to increased rates of cesarean delivery, which is one of the important drawbacks.[9–12] The Bishop score and cervix length have been used to determine readiness of the cervix; thus, have been applied in the clinical setting as predictive parameters of successful labor induction.[13–16] Recently, cervical length measured by transvaginal ultrasonography has been used as a predictor of successful vaginal delivery.[15,16] Currently, cervical length is routinely measured to assess the maturity of the cervix at term.[17–19]

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Cervical funneling is the painless dilation of the internal cervical os due to the bulging of the amnion from inside the uterus, while the ectocervix remains closed[20,21] (Fig. 1). Although cervical funneling is known to be correlated with preterm labor and delivery,[22,23] little is known about its association with successful labor induction in the context of term pregnancies. In light of this, this study aimed to evaluate whether the presence of cervical funneling may serve as a predictor of successful vaginal delivery prior to labor induction and to compare its predictive ability with that of conventional methods of cervix evaluation, such as the Bishop score and cervical length.

Methods

Study design and population

This study was conducted between January 1, 2011 and November 30, 2018, at the National Health Insurance Service Ilsan Hospital in the Republic of Korea. All patients provided informed consent prior to study enrollment. The study was approved by the Institutional Review Board of the National Health Insurance Service Ilsan Hospital (NHIMC #2014-04-031 and #2016-03-030).

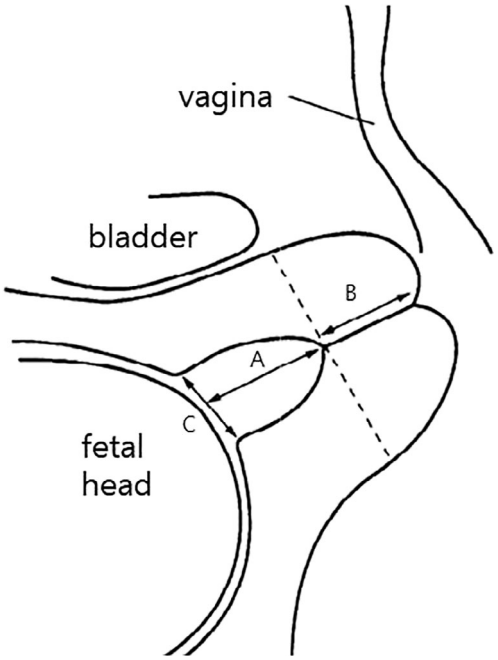

Figure 1 Transvaginal ultrasound of the cervix with funneling, showing funnel length (a), functional length (b) and funnel width (c). Cervical funneling was defined as bulging of the membranes into the endocervical canal with the bulge protrusion at least 15% of the entire cervical length [$A/(A + B) > 0.15$]. Adapted from cervical funneling: sonographic criteria predictive of preterm delivery.

All women who were being induced were eligible for the study. The indications for labor induction, in accordance with the standard medical and obstetric practice, included post-term pregnancy, oligohydramnios, hypertensive disorders complicating pregnancy, diabetes mellitus including gestational diabetes mellitus, fetal anomaly, maternal medical condition, nonreassuring fetal status on cardiotocograph and elective induction due to maternal psychosocial status.[24] The inclusion criteria were: (i) nulliparous women, (ii) live singleton pregnancy, (iii) gestational age between 38 and 42 weeks, (iv) cephalic presentation and (v) intact membranes. Patients were excluded from the study if they were undergoing labor induction due to premature rupture of membranes which likely alters the course of labor and if there were indications for cesarean section, such as placenta previa, previous cesarean section and previous myomectomy. Women with myomas of 8 cm or larger, severely uncontrolled diabetes, or hypertensive condition were also excluded.

Most women were admitted to the delivery room directly from the outpatient department. After admission to the delivery room for induction of labor, all patients were clinically evaluated by pelvic examination to determine fetal head engagement and the Bishop scores were calculated based on cervical dilatation (0–3), effacement (0–3), consistency (0–2), position (0–2) and station of the fetus (0–3). The maximum possible Bishop score for each patient was 13. These five components of the Bishop score were measured by one expert (EHK).

Thereafter, ultrasonography was performed by one expert (EHK) using the Philips Ultrasound IU22 (Bothell, Washington, DC, USA) and the EPIQ 7 (Bothell, Washington, DC, USA) with a vaginal probe. The probe was inserted into the vagina, 3 cm from the cervix and the length between the internal and external os of the cervix was measured in the longitudinal section in accordance with the previously validated technical criteria.[25] The cervical longitudinal section was defined by the view of the cervical canal and the cervical length was defined as the shortest value based on four or more measurements. Cervical funneling was defined by sonographic findings of ballooning of the membranes into a dilated internal os with a closed external os, with protrusion of at least 15% of the entire cervical length. We observed the

uterine cervix for at least 30 s and funneling was diagnosed only when the sonographic shape persisted during the time period.

Induction of labor was performed using a continuous administration of oxytocin (Pitocin, intravenous injection, 10 IU/mL, Jeil Pharmaceutical Co. Ltd., Daegu, Korea) when the Bishop score was 5 or more or for those with Bishop score 4 and below, vaginal administration of prostaglandin E2 (Propess, intravaginal, 10 mg, Bukwang Pharm Co. Ltd., Seoul, Korea) and women who were prescribe with E2 only received it once. Fetal heart rate was continuously monitored by cardiotocography 30 min to 1 h after prostaglandin E2 or oxytocin administration in all patients. The prostaglandin E2 vaginal insertion was removed after 24 h or earlier in cases where the active labor had commenced, membranes had ruptured, or abnormal cardiotocography traces such as uterine hyperstimulation or other alteration in fetal heart rate were found.

Using the institution's electronic medical records, we obtained data on the patients' mode of delivery (vaginal or cesarean), the time between the first therapy and vaginal delivery, duration of the second stage of labor, maternal age, gestational age, decrease in hemoglobin level after delivery as a surrogate for the blood loss during the delivery and length of hospital stay.

Statistical analysis

Demographic and clinical characteristics were compared between patients with and without funneling using Student's *t*-test for continuous values and using χ^2 test or Fisher's exact test for categorical values. Independent predictors of successful vaginal delivery were determined by multivariate analysis using a logistic regression model. Independent variables for multivariate analysis included maternal age, gestational age, neonatal birthweight and prepregnancy maternal body mass index (BMI), which were thought to influence success of the vaginal delivery. All *P*-values were two-tailed and $P < 0.05$ was considered statistically significant. All analyses were performed using the Statistical Package for Social Sciences version 23.0 (SPSS Inc., Chicago, IL, USA).

Table 1 Patient characteristics ($n = 235$)

Characteristic	Value†
Age (years)	31.02 ± 4.48
Gestational age (weeks)	39.16 ± 0.77
Bishop score‡	3.74 ± 1.71
Cervical length (mm)	18.47 ± 7.82
Cervical funneling	105 (44.7%)
Engagement of fetal head	200 (85.1%)
Cesarean section rate	41 (17.4%)
Neonatal birthweight (g)	3163 ± 468
Neonatal birthweight >3500 g	56 (23.8%)

†Values are presented as the mean ± standard deviation or *n* (%). ‡Total possible score = 13.

Results

A total of 502 women at 38 gestational weeks or more who underwent labor induction were recruited into this study. After excluding 25 women who refused to participate, 195 multiparous women, 34 women with premature rupture of membranes, 7 women with myoma larger than 8 cm, 2 women with intrauterine fetal death and 2 women with severely anomalous babies, the remaining 235 women were included in the final analysis. Demographic data and clinical outcomes are summarized in Table 1. The average age was 31.02 ± 4.48 years and the mean gestational age at delivery was 39.16 ± 0.77 weeks. Evaluation of cervical status prior to labor induction showed a mean Bishop score of 3.74 ± 1.71 and a mean cervical length of 18.47 ± 7.82 mm. Cervical funneling was found in 105 patients (44.7%). Upon admission for labor induction, engagement of the fetal head was found in 84.4% of patients and eventually, 41 patients (17.4%) underwent cesarean section. Indications for labor induction in all patients are listed in Table 2. The most common indications were electively induced labor (51.9%), intrauterine growth restriction (12.8%) and oligohydramnios (11.5%).

Analysis of patient demographics showed that women with cervical funneling and those without funneling were not significantly different in terms of maternal age, gestational age, pre-pregnancy maternal BMI, neonatal birthweight and rate of neonates with birthweight greater than 3500 g (Table 3). In contrast, engagement of the fetal head was more frequently observed in patients with cervical funneling than in those without (90.5% vs 80.8%, $P = 0.038$). Patients with cervical funneling were also more likely to present with shorter cervical lengths (13.72 ± 6.25 mm vs 22.31 ± 6.80 mm, $P < 0.001$) and higher Bishop scores (4.31 ± 1.50 vs 3.28 ± 1.73, $P < 0.001$) (Table 4). Moreover, the rate of successful vaginal delivery was higher in those with cervical funneling than in those without funneling (90.5% vs 76.28%, $P = 0.004$).

Table 2 Indications for labor induction† (n = 235)

Indication	n (%)
Elective	122 (51.9)
Intrauterine growth restriction	30 (12.8)
Oligohydramnios	27 (11.5)
Hypertensive disorder complicating	21 (8.9)
Post-term	13 (5.5)
Maternal medical condition	10 (4.3)
Diabetes mellitus/gestational diabetes mellitus	8 (3.4)
Fetal anomaly	1 (0.4)
Nonreassuring fetal status	2 (0.9)

†Per clinical assessment, there may be more than one indication per patient.

Although a higher proportion of patients with cervical funneling delivered vaginally within 12 h of labor induction than did those without (66.3% vs 45.5%, P = 0.009), the duration of the second stage labor was not found to be different between the groups.

Results from univariate logistic regression analyses are presented in Table 5. All three metrics of cervical status, namely cervical funneling (odds ratio [OR] 2.98, 95% confidence interval (CI): 1.38–6.40, P = 0.005), Bishop score (OR 1.40, 95% CI: 1.15–1.72, P = 0.001), Bishop score of less than 6 (OR 0.11, 95% CI: 0.02–0.83, P = 0.032) and cervical and cervical length (OR 0.94, 95% CI: 0.89–0.98, P = 0.005), were found to be independent predictors of successful vaginal delivery following labor induction. Using the multivariate analysis to adjust for other possible factors affecting delivery outcome, such as maternal age, gestational age, neonatal birthweight and maternal prepregnancy BMI, cervical funneling was still found to be an independent predictor of successful vaginal delivery following labor induction (OR: 2.95, 95% CI: 1.38–6.47, P = 0.007). The more classical means of evaluating cervical status, the Bishop score and cervical length, were also shown to be independent predictors of successful vaginal delivery.

Discussion

Principal findings of the study

Similar to the conventional methods, the presence of cervical funneling on transvaginal ultrasonography may predict the success of labor induction and is associated with a reduction of delivery time.

Table 3 Comparison of patient characteristics according to cervical funneling

	Cervical funneling		P-value
	Present (n = 105)	Absent(n = 130)	
Age (years)	30.74 ± 4.42	31.25 ± 4.53	0.393
Gestational age (weeks)	39.20 ± 0.78	39.12 ± 0.76	0.452
BMI before pregnancy (kg/m^2)	22.33 ± 3.71	21.84 ± 3.94	0.339
BMI at term (kg/m^2)	27.39 ± 4.06	27.00 ± 3.99	0.472
Engagement of fetal head	95 (90.5%)	105 (80.8%)	0.038*
Neonatal birthweight (g)	3113 ± 520	3206 ± 450	0.163
Neonatal birthweight ≥3500 g	23 (21.9%)	33 (25.4%)	0.343

*Statistical significance. BMI, body mass index.

Table 4 Comparison of outcomes according to cervical funneling

	Cervical funneling		P-value
	Present (n = 105)	Absent (n = 130)	
Cervical length (mm)	13.72 ± 6.25	22.31 ± 6.80	<0.001*
Bishop score	4.31 ± 1.50	3.28 ± 1.73	<0.001*
Bishop score < 6†	81 (77.1%)	117 (90.0%)	0.007*
Vaginal delivery	95 (90.5%)	99(76.2%)	0.004*
Duration of second stage (min)‡	63 ± 40	62 ± 47	0.805
Delivery within 12 h§	63/95 (66.3%)	45/99 (45.5%)	0.003*
Delivery time (min)‡	805 ± 579	946 ± 512	0.073

Values are presented as the mean ± standard deviation or n (%); *Statistical significance; †Bishop score of less than 6 as a cut-off was based on the previous study[34]; ‡Duration among patients with successful vaginal delivery; §Percentage among patients with successful vaginal delivery.

Table 5 Logistic regression analysis for successful vaginal delivery

	Unadjusted			Adjusted†		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Funneling	2.98	1.38–6.40	0.005	2.95	1.38–6.47	0.007
Bishop score	1.40	1.15–1.72	0.001	1.43	1.16–1.77	0.001
Bishop score < 6	0.11	0.02–0.83	0.032	0.11	0.01–0.82	0.031
Cervix length	0.94	0.89–0.98	0.005	0.93	0.89–0.97	0.002

†Adjusted for maternal age, gestational age, neonatal birthweight and prepregnancy body mass index. CI, confidence interval; OR, odd ratio.

In this study, we evaluated whether the presence of cervical funneling could be a predictive marker for successful labor induction in women at 38 gestational weeks or more with intact membranes. Contrary to the present study, our previous study showed that only cervical funneling was a predictive marker for successful vaginal delivery.[26] It is possible that the results differ because we included those with premature rupture of membranes in our previous study. We decided to exclude those with ruptured membranes in the present study, because we hypothesized that those with ruptured membranes may have a significantly altered course of labor compared to those without.

Until now, the Bishop score and cervical length have been considered the preferred indices for determining cervical favorability and, subsequently, the likelihood of successful vaginal delivery. However, as previously noted, many studies have questioned these methods as accurate tools to predict successful labor induction. The major disadvantage of cervical assessment using the Bishop score is the intra- and inter-observer variations and the potential pain and discomfort to the patients. Several studies have suggested that the Bishop score is actually a poor predictor of induction outcomes.[27–30] With respect to cervical length, contrary to the findings of early reports, studies have shown a wide variation regarding its accuracy for the prediction of successful labor induction. Moreover, the accuracy of cervical length was not necessarily superior to that of the Bishop score.[31,32]

Brieger *et al*. first suggested that cervical funneling can be explored as a predictive marker for early onset of labor in parturient women within preterm labor setting.[33] Within our study population, the prevalence of cervical funneling was 45.5%, which is higher than the 25% reported by Brieger *et al*. and lower than the 52.7% reported in our previous study.[26] One explanation for the high variance may be the lack of established definition of cervical funneling. Our criterion, which is the protrusion of the amnion to a minimum of 15% of the cervical length, may represent a useful measure for future clinical and research investigations regarding cervical funneling. According to our definition, those with cervical funneling frequently also present with shortened cervical lengths. Thus, it is not surprising that both cervical funneling and cervical length could serve as valid predictors of vaginal delivery. Moreover, the difference in the inclusion criteria, specifically the exclusion of those with premature rupture of membranes in our present study, may account for the lower prevalence of cervical funneling compared to our previous study.

In addition, we found that, while the overall duration of labor was shorter among patients with cervical funneling, the duration of the second stage of labor did not differ from those without funneling, suggesting that cervical funneling may be related to the ease in cervical dilation and not the descent of the fetus.

Clinical implications

Cervical funneling could very likely be a category of cervical effacement or be the same clinical manifestation at the preterm stage; however, we could not describe in detail the difference in the mechanism of the two terms.

We hypothesized that an improved method for evaluating cervical status prior to labor induction and for predicting the likelihood of successful vaginal delivery may facilitate the discussion between patients and physicians. Informed decisions will ease the anxiety of patients and decrease the rates of unnecessary cesarean section. Our results showed that patients with cervical funneling are more likely to successfully deliver vaginally and this finding was further supported by the multivariable logistic regression analysis results when other potential factors were taken into consideration. While the total delivery time

and the duration of the second stage of labor did not differ, those with cervical funneling were more likely to deliver within 12 h of induction. Furthermore, sonographic evaluation of the presence of cervical funneling may be easier for clinicians and is more comfortable for patients compared to the conventional methods.

Strengths and limitations

Our study has several strengths. First, by collecting the data from a single institution with a uniform protocol, we were able to obtain complete medical records. Second, in order to reduce inter-observer variations, pelvic examination and ultrasonography were performed by only one expert. Third, unlike the previous study, we excluded women with premature rupture of membranes, which, unlike other indications for labor induction, may alter the course of labor.

There are several limitations to our study such as its small sample size. Other potential limitations include the heterogeneity in the indications for labor induction and the differences in the methods used for induction. Furthermore, had we chosen a different definition of cervical funneling, we may have obtained different results.

Conclusions

Our study demonstrates that the presence of cervical funneling may serve as a valid predictor of successful vaginal delivery prior to induction of labor, similar to the Bishop score and cervix length. Furthermore, the presence of cervical funneling may be associated with a reduction in the total duration of labor during labor induction.

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Disclosure

No author has any potential conflict of interest.

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