

Preinduction sonographic measurement of cervical length in the prediction of successful induction of labor

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ABSTRACT

Background Induction of labor is carried out in approximately 20% of pregnancies. However, approximately 20% of women having induction of labor end up having a Cesarean delivery. The traditional method of predicting whether an induced labor will result in successful vaginal delivery is based on the preinduction 'favorability' of the cervix as assessed by the Bishop score. However, this assessment is subjective and several studies have shown a poor predictive value for the outcome of induction.

Objectives To examine the relationship between preinduction sonographically measured cervical length and the Bishop score and to compare the two measurements in the prediction of successful vaginal delivery within 24 h of induction.

Methods In this multicenter study, preinduction cervical assessment was undertaken in 240 women with singleton pregnancies at 37–42 weeks of gestation. The Bishop score was assessed by digital examination and the cervical length was measured by transvaginal sonography.

Results Multiple regression analysis demonstrated that cervical length, Bishop score and parity provided independent contribution in the prediction of the likelihood of delivering vaginally within 24 h. Further examination of the different components of the Bishop score showed that only cervical length provided a significant contribution in the prediction of the likelihood of vaginal delivery within 24 h. In the receiver operating characteristic curves, the best cut-off point for the prediction of successful induction was 28 mm for cervical length and 3 for the Bishop score. However, cervical length appears to be a better predictor than the Bishop score, with a sensitivity of 0.87 and a specificity of 0.71 compared to 0.58 and 0.77, respectively. Similarly, the Kaplan–Meier survival curves indicate that better discriminatory results in the prediction of vaginal delivery within 24 h are achieved using cervical length rather than the Bishop score.

Conclusion Transvaginal sonographic measurement of cervical length provides a useful prediction of the likelihood of vaginal delivery within 24 h of induction.

INTRODUCTION

Induction of labor is carried out in approximately 20% of pregnancies¹. The commonest indication for induction is prolonged pregnancy and several studies have shown that induction, compared to expectant management, is associated with a substantial reduction in perinatal mortality^{2–4}. However, approximately 20% of women having induction of labor end up having a Cesarean delivery^{5,6}. The traditional method of predicting whether an induced labor will result in successful vaginal delivery is based on the preinduction 'favorability' of the cervix as assessed by the Bishop score. However, this assessment is subjective and several studies have shown a poor predictive value for the outcome of induction^{7–9}.

Some recent studies have reported that transvaginal sonographic assessment of the cervix may provide a more sensitive prediction of successful induction, compared to the Bishop score^{10–14}. However, the number of patients examined in these studies ($n = 50–109$) was too small for definite conclusions to be drawn. The aims of this more extensive study were to examine the relationship between preinduction sonographically measured cervical length and the Bishop score and to compare the two measurements in the prediction of successful vaginal delivery within 24 h of induction.

METHODS

Preinduction cervical assessment was undertaken in 240 women who attended for delivery at King George and Harold Wood Hospitals, Essex, UK, Queen Elizabeth Hospital, Greenwich, London, UK and Lewisham General Hospital, Lewisham, London, UK. The entry criteria for the study were singleton pregnancy at 37–42 weeks of gestation, live fetus

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in cephalic presentation, intact membranes, no vaginal bleeding and no uterine scar. All women gave their written informed consent and the study was approved by the South Thames Multi-Centre Ethics Committee and subsequently by the local ethics committees.

Transvaginal sonography was carried by sonographers who had received The Fetal Medicine Foundation Certificate of Competence in Cervical Assessment. The probe was placed in the vagina approximately 3 cm proximal to the cervix to avoid any cervical distortion of its position or shape and a sagittal view of the cervix, with the echogenic endocervical mucosa along the length of the canal, was obtained. The calipers were used to measure the distance between the internal os and external os, the furthest points at which the cervical walls were juxtaposed¹⁵⁻¹⁷. Three measurements were obtained and the shortest, technically best measurement in the absence of uterine contractions was recorded.

Induction of labor was performed according to the guidelines of the Royal College of Obstetricians and Gynaecologists issued in July 1998. The Bishop score was assessed by an experienced obstetrician or midwife who was not aware of the sonographic findings. Nulliparae with an unfavorable cervix (Bishop score less than 5) received 2 mg Dinoprostone Gel (Pharmacia & Upjohn, Milton Keynes, UK) vaginally. Those with a Bishop score of 5 or 6 and all multiparae received 1 mg Dinoprostone Gel and those with a score of 7 or more had artificial rupture of the membranes. The women had further vaginal examinations at 6-hourly intervals and, depending on the Bishop score, further doses of Dinoprostone Gel were considered. The maximum dose over 24 h was 3 mg, or 4 mg in nulliparae with an unfavorable cervix. The procedure was repeated the following day if labor did not ensue. Oxytocin augmentation was started in cases with unsatisfactory progress of labor or following amniotomy.

Statistical analysis

The group of women was divided into approximate quartiles of cervical length and Bishop score, respectively, and these subgroups were compared using log-rank tests and Kaplan-Meier curves. Multivariable Cox regression analysis was used to investigate the usefulness of cervical measurement by ultrasound, Bishop score and parity in independently predicting successful induction of labor (vaginal delivery within 24 h). Receiver operating characteristic curves for the two methods were compared. Chi-square was used to analyze categorical variables (Yates corrected chi-square is reported throughout), and unpaired *t*-test, Mann-Whitney *U*-test and linear regression were used for continuous variables' analysis. Two-sided *P*-values are reported throughout.

RESULTS

The mean gestation at induction was 41 weeks (range 37-42 weeks). Of the 240 women, 128 (53.3%) were nulliparae and 112 (46.7%) were multiparae. The indications for induction were prolonged pregnancy beyond 41 weeks of gestation (*n* = 158), pregnancy induced hypertension (*n* = 24), maternal diabetes mellitus (*n* = 7), maternal cholestasis (*n* = 3), pruritus

(*n* = 4), hypothyroidism (*n* = 1), maternal renal disease (*n* = 1), previous pregnancy complicated by shoulder dystocia, fetal macrosomia or precipitated labor (*n* = 8), suspected fetal growth restriction (*n* = 7), oligohydramnios (*n* = 3), polyhydramnios (*n* = 2), reduced fetal movements (*n* = 5), fetal abnormality (cystic adenomatoid malformation of the lung, hydrops at 23 weeks, *n* = 2), large for gestational age (*n* = 6) and maternal request for social reasons or discomfort (*n* = 9). Demographic characteristics of the study population are shown in Table 1.

Vaginal delivery occurred in 194 (80.8%) women and, in 142 (73.2%) of these, delivery was within 24 h of induction. There were 46 (19.2%) deliveries by Cesarean section, 23 (50%) for failure to progress and 23 (50%) for suspected fetal distress. In the 162 women who delivered within 24 h of induction, there were 20 (12.3%) Cesarean sections, all but one for fetal distress whereas, in the 78 delivering after 24 h, there were 26 (33.3%) Cesarean sections. In the further analysis of data, the 19 women who delivered by Cesarean section for fetal distress within 24 h were excluded because, as the primary outcome measure was vaginal delivery within 24 h, such deliveries were considered to be censored at the time of the Cesarean section and therefore the hypothesis that cervical length or the Bishop score would predict the outcome of induction of labor could not be tested.

Vaginal delivery within 24 h of induction occurred in 74.3% (81 of 109) of the multiparous women, compared to 54% (61 of 112) in the nulliparous women (*P* = 0.0003). Similarly, the median induction to delivery interval in the multiparous

Table 1 Demographic characteristics of the study population (*n* = 240)

Characteristic	
Nulliparous (<i>n</i> (%))	128 (53.3)
Multiparous (<i>n</i> (%))	112 (46.7)
Race (<i>n</i> (%))	
White	188 (78.3)
Black	28 (11.7)
Asian	24 (10.0)
Age (years, mean (range))	29.7 (16.8-44.8)
Body mass index (mean (range))	28.1 (17-50.2)
Gestational age at induction (weeks, mean (range))	41 (37-42)

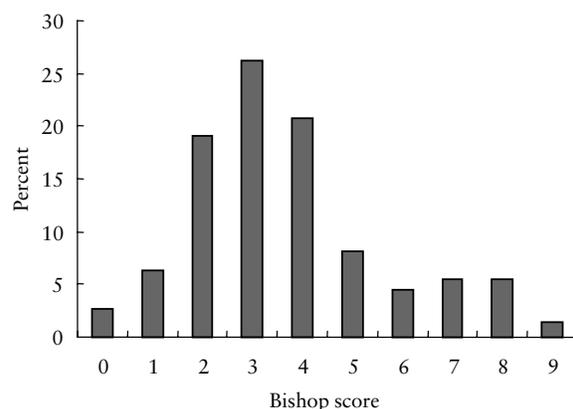


Figure 1 Frequency distribution of Bishop score.

group (13.9 h, range 2–107 h) was significantly shorter than in the nulliparous group (22.7 h, range 4–114 h) ($P = 0.025$). In the multiparous group, the median Bishop score (4, range 0–9) was significantly different from the median value in the nulliparous group (3, range 0–9) ($P = 0.002$). On the other hand, the median cervical length measured sonographically was not statistically different in the two groups (24 mm, range 0–50 mm and 25.5 mm, range 0–50, respectively) ($P = 0.463$).

The median Bishop score in all participants was 3 (0–9), and the distribution is shown in Figure 1. There was a significant association between the Bishop score and the induction to delivery interval (Figure 2, $r = 0.5156$, $P < 0.0001$). Further-

more, the likelihood of vaginal delivery within 24 h increased with the Bishop score (Table 2, Figure 3).

The median sonographically measured cervical length was 25 mm (range 0–50 mm), and the distribution is shown in Figure 4. There was a significant association between cervical length and the induction to delivery interval (Figure 5, $r = 0.7061$, $P < 0.0001$). Furthermore, the likelihood of vaginal delivery within 24 h decreased with cervical length (Table 2, Figure 6).

There was a significant association between cervical length and the Bishop score (Figure 7, $r = 0.6434$, $P < 0.0001$). Multiple regression analysis demonstrated that cervical length and parity provided significant independent contribution

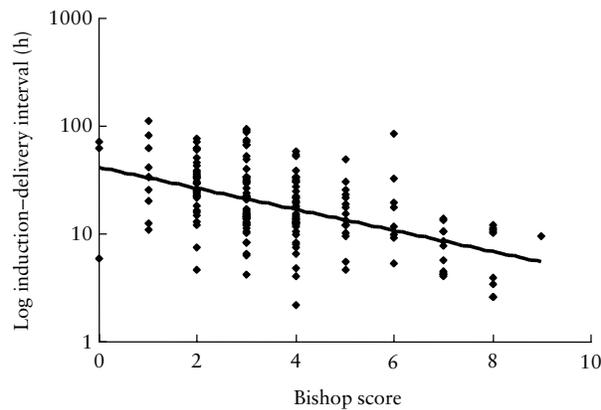


Figure 2 Association between induction-to-delivery interval (logarithmic scale) and Bishop Score.

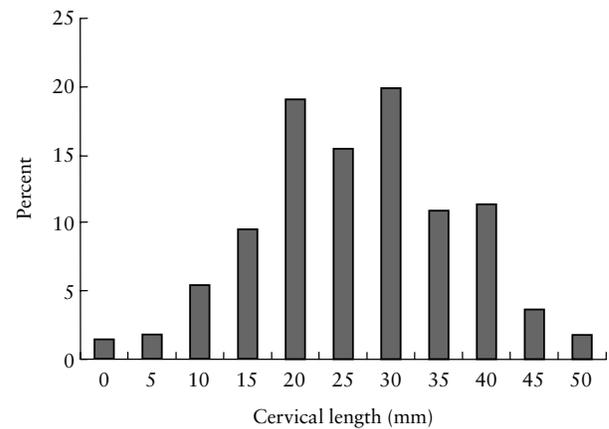


Figure 4 Frequency distribution of sonographically measured cervical length.

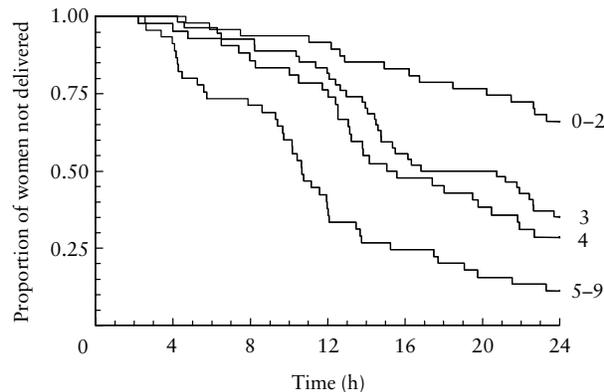


Figure 3 Kaplan-Meier survival curve estimates of proportions not delivering within 24 h, by quartiles of Bishop score.

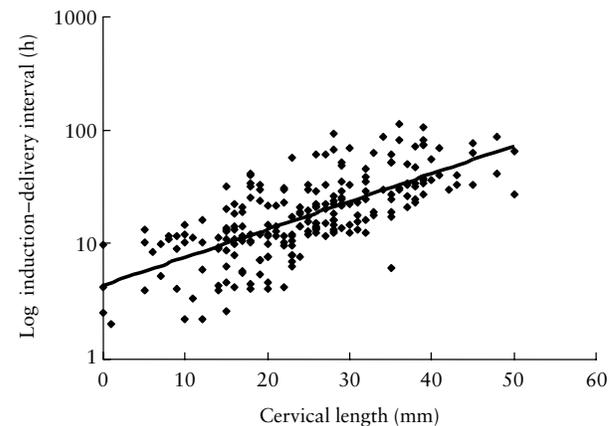


Figure 5 Association between interval to delivery time (logarithmic scale) and sonographically measured cervical length.

Table 2 Proportions of women not delivering within 24 h, according to quartiles of Bishop score and cervical length

Bishop score*	Undelivered within 24 h (% (n))	Cervical length (mm)†	Undelivered within 24 h (% (n))
0–2	65 (40/62)	32–50	84 (48/57)
3	34 (20/58)	25–31	33 (18/55)
4	28 (13/46)	19–24	21 (11/53)
5–9	9 (5/55)	0–18	2 (1/56)

*Chi-square = 40.7, d.f. = 3, $P < 0.0001$; †chi-square = 92.3, d.f. = 3, $P < 0.0001$.

with some evidence of an independent effect from the Bishop score in the prediction of the likelihood of delivering vaginally within 24 h (Table 3). Further examination of the different components of the Bishop score showed that only digital cervical length provided a significant contribution in the prediction of the likelihood of vaginal delivery within 24 h (Table 4).

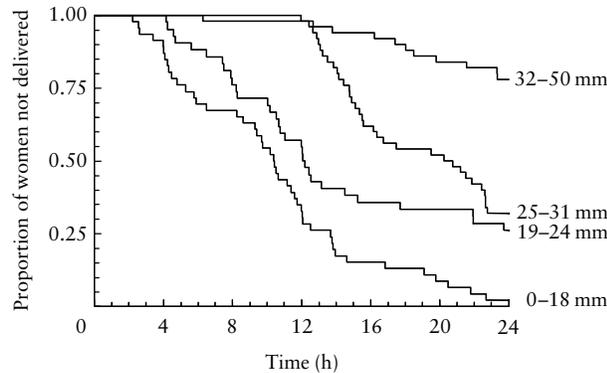


Figure 6 Kaplan-Meier survival curve estimates of proportions not delivering within 24 h, by quartiles of cervical length.

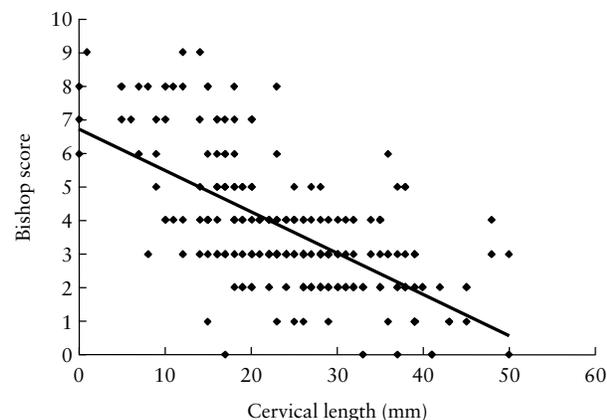


Figure 7 Association between Bishop score and sonographically measured cervical length.

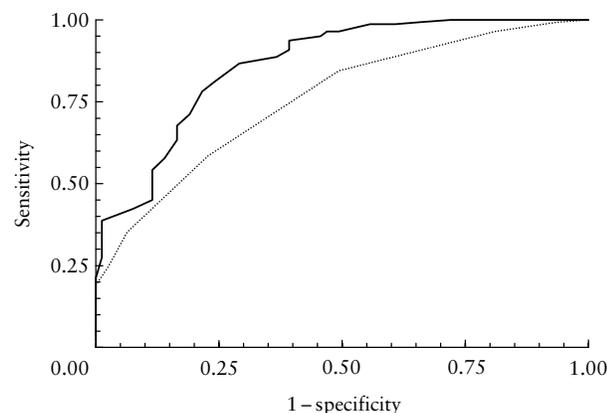


Figure 8 Receiver-operating characteristic curves for the two methods of assessment: sonographically measured cervical length (solid line) and Bishop score (dotted line).

Table 3 Results of multivariable Cox regression analysis of time to delivery within 24 h, looking at Bishop score, cervical length and parity

Variable	Hazard ratio	95% confidence interval	P
Bishop score	1.14	0.99–1.31	0.066
Cervical length	0.91	0.89–0.94	< 0.001
Parity			< 0.001
Primiparae	1.00	—	
Multiparae	2.05	1.37–3.07	

Table 4 Results of multivariable Cox regression analysis of time to delivery within 24 h, looking at components of Bishop score, cervical length and parity

Variable	Hazard ratio	95% confidence interval	P
Dilatation			0.90
0	1.00	—	
1	0.87	0.49–1.56	
2	0.90	0.44–1.84	
Station			0.41
0	1.00	—	
1	0.84	0.51–1.39	
2	0.60	0.28–1.27	
Length			< 0.001
0	1.00	—	
1	0.94	0.55–1.60	
2	3.86	1.68–8.83	
Consistency			0.70
0	1.00	—	
1	1.21	0.78–1.86	
2	1.16	0.42–3.17	
Position			0.77
0	1.00	—	
1	1.08	0.66–1.76	
Cervical length	0.90	0.87–0.92	< 0.001
Parity			< 0.001
Nulliparae	1.00	—	
Multiparae	2.22	1.50–3.28	

In the receiver operating characteristic curves, the best cut-off point for the prediction of successful induction was 28 mm for cervical length and 3 for the Bishop score. However, cervical length appears to be a better predictor than the Bishop score with a sensitivity of 0.87 and a specificity of 0.71 compared to 0.58 and 0.77, respectively (Figure 8). Similarly, the Kaplan-Meier survival curves indicate that better discriminatory results in the prediction of vaginal delivery within 24 h are achieved using the cervical length rather than the Bishop score (Figures 3 and 6).

DISCUSSION

This study has demonstrated that, in singleton pregnancies undergoing induction of labor with Dinoprostone Gel at 37–42 weeks, mainly for prolonged pregnancy, the Cesarean section rate is about 20% and successful vaginal delivery within 24 h of induction occurs in approximately 60%. These findings are compatible with those of previous reports⁶. The study has

also demonstrated that induction to delivery interval is significantly associated with both the preinduction Bishop score and the sonographically measured cervical length. However, sonographically measured cervical length was better than the Bishop score in predicting the likelihood of vaginal delivery within 24 h of induction.

Measurement of cervical length was successfully achieved in all cases. However, those undertaking this measurement should receive appropriate training because, compared to mid-trimester cervical assessment, the technique at term is more difficult, especially when the head is engaged and the alignment of the cervix is distorted.

Previous studies on the value of preinduction sonographic measurements of cervical length have reported conflicting results. Paterson-Brown *et al.*¹⁰ examined 50 pregnancies before induction and reported that, although the Bishop score correlated significantly with successful vaginal delivery, the score fell well short of being a satisfactory predictor of successful induction. In addition, they found that sonographically measured cervical length was not significantly associated with either the Bishop score or the induction-to-delivery interval. Boozarjomehri *et al.*¹¹ examined 53 women before induction and reported that, although sonographically measured cervical length was correlated with the duration of the latent phase of labor, there was no significant association with the induction-to-delivery interval or to cervical effacement measured by digital examination. Watson *et al.*¹² examined 109 women before induction and reported a significant association between sonographically measured cervical length and clinical assessment of cervical effacement; however, neither of the two provided a useful prediction of the length of the latent phase of labor. Gonen *et al.*¹³ examined 86 women before induction and reported significant associations between both the Bishop score and sonographically measured cervical length with successful induction and the induction-to-delivery interval. However, in a logistic regression model that included these parameters as independent variables, only the Bishop score and parity were significantly correlated with successful induction and the duration of labor. Ware and Raynor¹⁴ examined 77 women before induction and found that both sonographically measured cervical length and Bishop score predicted induction-to-delivery interval and likelihood of vaginal delivery. In a logistic regression model, only cervical length and parity were independent predictors of vaginal delivery.

In this study, we defined successful induction of labor as vaginal delivery occurring within 24 h. This endpoint has been traditionally used in several studies to examine the efficacy of an inducing method^{11,18}. Prolonged labor is associated with higher rate of medical intervention, results in maternal exhaustion, increased morbidity and longer hospitalization with subsequent adverse financial implications^{19–22}. Indeed, in our study, the Cesarean section rate in those delivering after 24 h from induction was three-fold higher than in those delivering within 24 h. Similarly, there was a four-fold increase in the instrumental delivery rate in the group delivering after 24 h from induction.

Both sonographic cervical assessment and the Bishop score successfully predicted vaginal delivery within 24 h. As the cervical length increases, the likelihood of delivering within

24 h decreases whilst, as Bishop score increases, the likelihood of delivering within 24 h increases. However, the receiver-operating characteristic curves for the two variables showed that, for any given false-positive rate, the sensitivity of sonographically measured cervical length in predicting successful induction of labor was approximately 20% higher than that for the Bishop score. Furthermore, the survival analysis demonstrated better discriminatory results in favor of cervical length with only 2% of women in the short cervix group (0–18 mm) remaining undelivered after 24 h compared to 9% of women in the high Bishop score group (BS = 5–9). Similarly, 84% of women in the long cervix group (32–50 mm) remained undelivered after 24 h compared to 65% of women in the low Bishop score group (BS = 0–2). These findings suggest that sonographic cervical length is a better test than the Bishop score for predicting successful induction of labor.

Multiple regression analysis demonstrated that in the prediction of vaginal delivery within 24 h of induction, there are independent contributions from cervical length, parity and the Bishop score. In terms of the components of the Bishop score, the only significant contributor was effacement, which is also an index of cervical length. Furthermore, the significant contribution of effacement was the consequence of the high likelihood of successful delivery in those with a very short cervix. This is consistent with the original observation of Bishop, who introduced the scoring system, that a score of 9 or more in multiparous women is associated with a high chance of successful induction²³. However, the majority of patients undergoing induction do not present with a fully effaced cervix and, in such patients, digital examination, unlike sonographic measurement of cervical length, does not provide a useful prediction of outcome of induction^{7–9}.

Transvaginal sonographic measurement of cervical length, which can be achieved easily and with minimal discomfort to the patient, provides a useful prediction of the likelihood of vaginal delivery within 24 h of induction and of the induction-to-delivery interval. Women with a cervical length of less than 19 mm can be counseled that delivery will invariably occur within 24 h of induction, whereas those with cervical length of more than 31 mm can be advised that they have an approximately 85% chance of remaining undelivered after this interval.

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