

Pre-induction sonographic measurement of cervical length in prolonged pregnancy: the effect of parity in the prediction of induction-to-delivery interval

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KEYWORDS: cervical length; induction of labor; parity; prolonged pregnancy; transvaginal sonography

ABSTRACT

Objective To examine the effect of parity on the relationship between pre-induction cervical length and the induction-to-delivery interval and rate of vaginal delivery within 24 h in women undergoing induction of labor for prolonged pregnancy.

Methods In 382 singleton pregnancies, induction of labor was carried out at 41 + 3 to 42 + 1 weeks of gestation. The cervical length was measured by transvaginal sonography before induction. Univariate analyses were performed by constructing Kaplan–Meier survival curves for the induction-to-delivery interval for various subgroups, and comparing these using log rank tests. Multivariate analyses were performed using the Cox proportional hazards model and multiple linear regression.

Results Successful vaginal delivery within 24 h of induction occurred in 67% of the women and the pre-induction cervical length was significantly associated with the induction-to-delivery interval and the rate of vaginal delivery within 24 h. Sonographically measured cervical length was better than the Bishop score or cervical length by vaginal examination in predicting the outcome of induction. Parity provided a significant independent contribution, in addition to pre-induction cervical length, in the prediction of the outcome of labor. Thus, in multiparae the incidence of successful vaginal delivery within 24 h of induction was about 30% higher than in nulliparae. For the same cervical length, the induction-to-delivery interval in multiparae was 37% lower than in nulliparae.

Conclusion In women undergoing induction of labor for prolonged pregnancy, cervical length and parity provide

independent prediction of induction-to-delivery interval and the likelihood of vaginal delivery within 24 h of induction. Copyright © 2003 ISUOG. Published by John Wiley & Sons, Ltd.

INTRODUCTION

In prolonged pregnancy, induction of labor, compared to expectant management, is associated with a substantial reduction in perinatal mortality^{1–5}. However, approximately 20% of women having induction of labor need a Cesarean delivery^{5,6}. The pre-induction Bishop score, which is the traditional method of predicting whether an induced labor will result in successful vaginal delivery, is subjective and has a poor predictive value for the outcome of induction^{7–9}. In contrast, measurement of cervical length by transvaginal sonography (TVS) is objective and provides useful prediction of the likelihood of vaginal delivery within 24 h of induction^{10–13}.

The aim of this study was to examine the effect of parity on the relationship between pre-induction sonographically measured cervical length and the induction-to-delivery interval and the rate of vaginal delivery within 24 h, in women undergoing induction of labor for prolonged pregnancy.

METHODS

Pre-induction cervical assessment was undertaken in 382 women who attended for delivery at St Mary's Hospital, Portsmouth; King George Hospital, Romford; Harold Wood Hospital, Harold Wood or Lewisham General Hospital, London, UK. Included in this study are 150

women who were also included in a previous paper by our group¹³. The entry criteria for the study were singleton pregnancy, live fetus, cephalic presentation, and minimum gestation of 41 + 3 weeks. All women gave their written informed consent and the study was approved by the ethics committee of each hospital.

TVS was carried out 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 of the cervical canal between the furthest points at which the cervical walls were juxtaposed^{14–16}. 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 Gynaecologists⁴ and National Institute of Clinical Excellence (NICE)¹⁷. An experienced obstetrician or midwife, who was not aware of the sonographic findings, assessed the Bishop score. The 150 women from our previous publication¹³ had induction of labor before publication of the NICE guidelines where the agent used was dinoprostone gel. Nulliparae with an unfavorable cervix (Bishop score < 5) received 3 mg dinoprostone pessary or 2 mg dinoprostone gel (Pharmacia & Upjohn, Milton Keynes, UK) vaginally. Those with a Bishop score of 5–7 and all multiparae received 3 mg dinoprostone pessary or 1 mg dinoprostone gel and those with a score ≤ 8 had an artificial rupture of the membranes. The women had further vaginal examinations at 6-hourly (dinoprostone gel) or 8-hourly intervals (dinoprostone pessary) and depending on the Bishop score and indication for induction, a further 3 mg dinoprostone pessary or dinoprostone gel was considered. As it is not practical to ensure repeat agent insertion at exactly 6 h (gel) or 8 h (pessary) due to busy labor wards, a maximum time gap of 10 h between subsequent pessary insertions and 8 h for subsequent gel insertions was allowed for including the women in the analysis. The maximum dose of dinoprostone pessary over 24 h was 6 mg and dinoprostone gel over 24 h was 3 mg in multiparae or 4 mg in nulliparae with an unfavorable cervix. Oxytocin augmentation was started in cases with unsatisfactory progress of labor or following amniotomy.

Statistical analysis

The women were divided by parity into nulliparae and multiparae. They were further subdivided into four groups according to cervical length (1–10, 11–20, 21–30 and 31–40 mm). They were also divided into four groups according to Bishop score (0–3, 4, 5–8 and 9) and four groups according to cervical length by vaginal examination (< 1, 1–2, 2–4 and > 4 cm). Univariate analyses were performed by constructing Kaplan–Meier

survival curves for the induction-to-delivery interval, and subgroups compared using log rank tests. Times that exceeded 24 h or which resulted from Cesarean sections were treated as censored. A multivariate analysis was performed using the Cox proportional hazards model. Within the subgroup of 311 mothers who did not require a Cesarean section we used multiple regression to study the effect of both parity and cervical length on induction-to-delivery interval. Times were transformed to a logarithmic scale to achieve linearity and homogeneity of variance. Receiver–operating characteristics (ROC) curves were used to assess the ability of sonographic cervical length, Bishop score and cervical length by vaginal examination to predict delivery within 24 h. Two-sided *P*-values are reported throughout.

RESULTS

Sonographic measurement of cervical length was successfully carried out in all 382 pregnancies. The demographic characteristics are shown in Table 1. There were 192 nulliparous and 190 multiparous women and the median cervical length was 18 (range, 5–39) mm and 16 (range, 1–40) mm, respectively ($P < 0.05$). In 71 cases a Cesarean section for fetal distress ($n = 37$) or failure to progress ($n = 34$) was performed, including 34 cases in which Cesarean section was within 24 h of induction for fetal distress ($n = 26$) or failure to progress ($n = 8$).

The median induction-to-vaginal delivery interval was 15.5 h (95% CI 14.1–16.9) and this was significantly shorter in multiparae than in nulliparae (median 12.3 h, 95% CI 10.8–13.8 vs. 21.8 h, 95% CI 20.0–23.6; $\chi^2 = 56.4$, $P < 0.0001$). Vaginal delivery within 24 h of induction occurred in 255/382 cases (67%, 95% CI 62%–71%) and this was significantly higher in multiparae than in nulliparae (81% or 153/190, 95% CI 74%–86% vs. 53% or 102/192, 95% CI 46%–60%; $\chi^2 = 32.3$, $P < 0.0001$).

The proportions of women undelivered at various times during the first 24 h, estimated using Kaplan–Meier methodology, according to sonographically measured cervical length, Bishop score and cervical length by vaginal examination are shown in Figures 1–3. Log rank tests demonstrated that the best discriminator of induction-to-delivery interval was sonographic cervical length. ROC curves were constructed for each predictor (Figure 4) and

Table 1 Demographic characteristics of the study population ($n = 382$)

Characteristic	n (%)
Nulliparae	192 (50.3)
Multiparae	190 (49.7)
Caucasian	344 (90.1)
Asian	20 (5.2)
Afro-Caribbean	18 (4.7)
Age in years (median (range))	29 (16–45)
Body mass index (median (range))	27 (16–52)

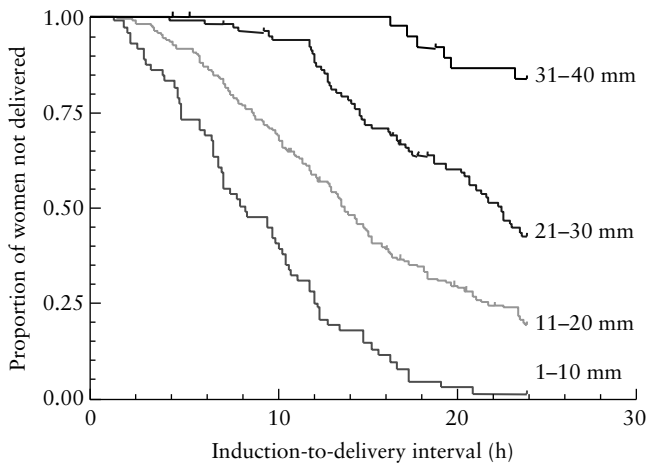


Figure 1 Kaplan-Meier survival curve estimates of proportions not delivering within 24 h according to sonographically measured cervical length (log rank (Peto): $\chi^2 = 159.5, P < 0.0001, \chi^2$ for trend = 135.8, $P < 0.0001$).

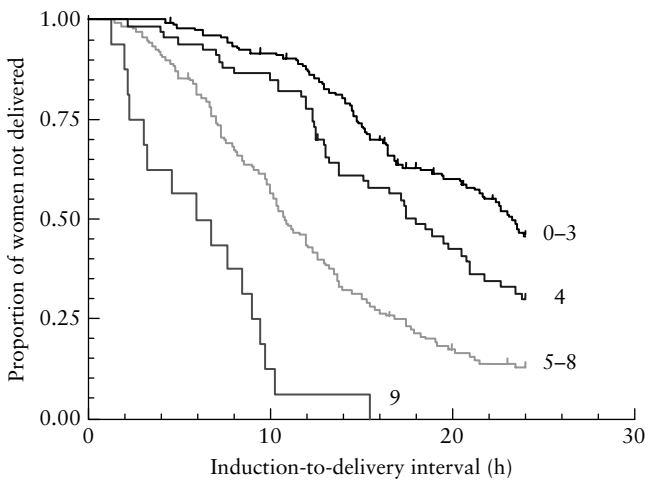


Figure 2 Kaplan-Meier survival curve estimates of proportions not delivering within 24 h according to Bishop score (log rank (Peto): $\chi^2 = 137.49, P < 0.0001, \chi^2$ for trend = 99.3, $P < 0.0001$).

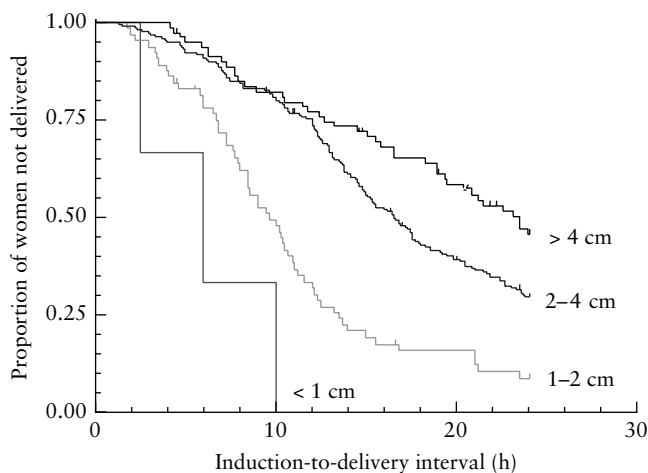


Figure 3 Kaplan-Meier survival curve estimates of proportions not delivering within 24 h according to cervical length by vaginal examination (log rank (Peto): $\chi^2 = 68.0, P < 0.0001, \chi^2$ for trend = 46.5, $P < 0.0001$).

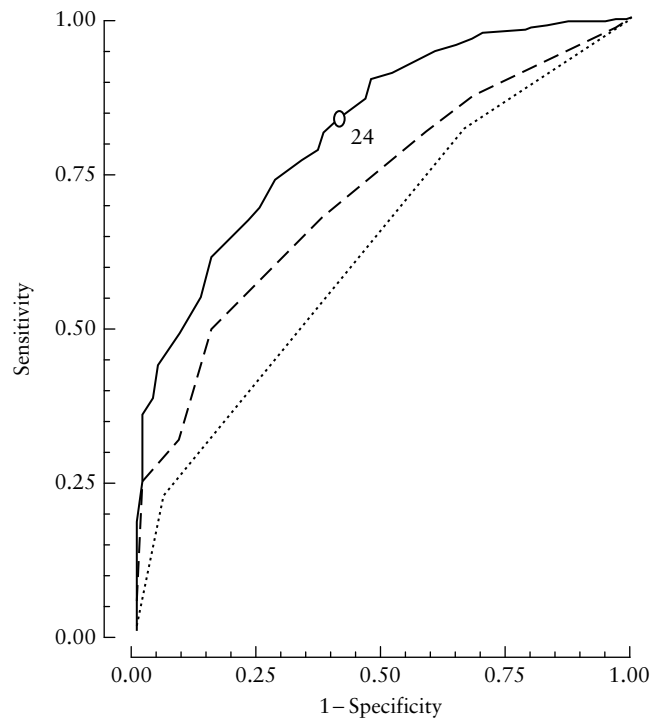


Figure 4 Receiver-operating characteristics curves for the three methods of assessment: sonographically measured cervical length (solid line), Bishop score (dashed line) and cervical length measured by vaginal examination (dotted line) for delivery within 24 h.

sonographic cervical length was found to be the best discriminator on the basis of area under the curve (areas 82%, 72% and 63%, respectively). Using the optimum cut-off of 24 mm a sensitivity of 84% and a specificity of 59% were obtained.

The percentage of those delivering within 24 h according to parity and sonographic cervical length is shown in Figure 5. The percentage for nulliparous women with a cervical length of < 20 mm was about 80% and

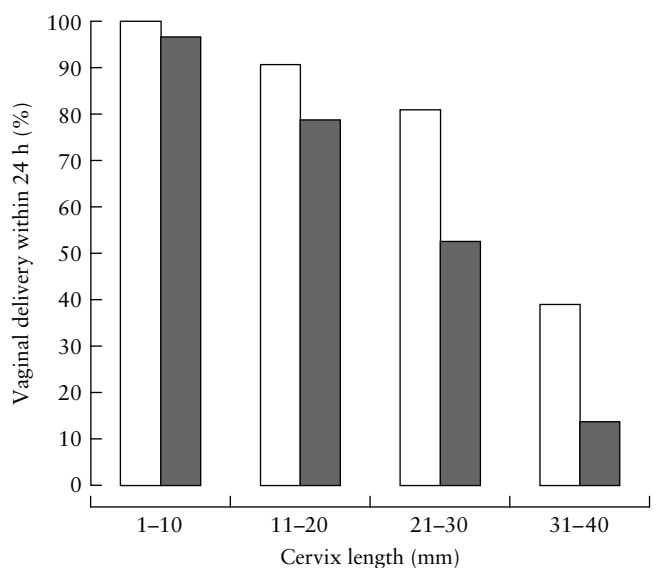


Figure 5 Percentage of women delivering within 24 h according to pre-induction sonographically measured cervical length in nulliparae (■) and multiparae (□).

for those with a cervix > 30 mm it was about 10%. The respective percentages for multiparous women were about 90% and 40%.

A proportional hazards regression analysis demonstrated that sonographically measured cervical length, parity and Bishop score provided significant independent contributions in the prediction of induction-to-delivery interval (Table 2). Further examination of the different components of the Bishop score showed that cervical dilatation, station and consistency provided a significant contribution in the prediction of delivery within 24 h (Table 3). The hazard ratios for parity in Tables 2 and 3 are slightly different because in the one the total and in the other the components of Bishop score are used for comparison.

Within the subgroup of 311 mothers who did not require Cesarean section, parity, Bishop score and cervical

Table 2 Results of multivariate Cox proportional hazard model of induction-to-delivery interval within 24 h, looking at Bishop score, cervical length and parity

Variable	Hazard ratio	95% CI	P
Bishop score	1.289	1.197–1.389	< 0.0001
Cervical length by scan	0.913	0.896–0.931	< 0.0001
Parity			< 0.0001
Nulliparae	1.00		
Multiparae	2.401	1.861–3.099	

Table 3 Results of multivariate Cox proportional hazard model of time to delivery within 24 h, looking at components of Bishop score, sonographic cervical length and parity

Variable	Hazard ratio	95% CI	P
Parity			< 0.0001
Nulliparae	1.00		
Multiparae	2.49	1.89–3.29	
Sonographic cervical length	0.91	0.89–0.93	< 0.0001
Dilatation			< 0.009
0	1.00		
1	1.12	0.74–1.70	
2	1.85	1.11–3.07	
3	8.37	0.70–100.29	
Station			< 0.037
0	1.00		
1	0.85	0.58–1.25	
2	1.31	0.84–2.07	
Length			0.863
0	1.00		
1	0.84	0.61–1.32	
2	1.01	0.62–1.65	
3	1.10	0.14–8.72	
Consistency			< 0.015
0	1.00		
1	1.30	0.954–1.78	
2	2.25	1.30–3.89	
Position			0.081
0	1.00		
1	1.14	0.84–1.55	
2	2.24	1.11–4.53	

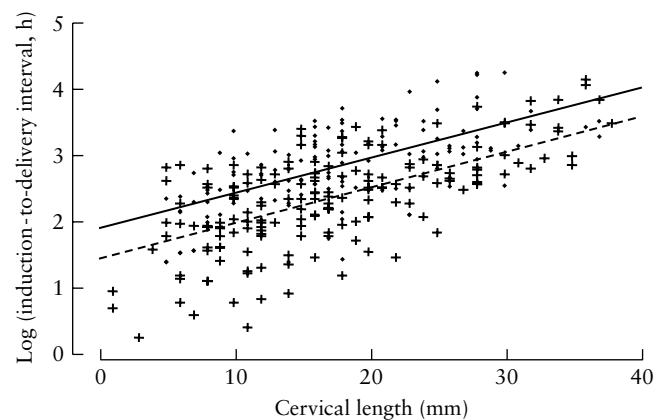


Figure 6 Association between sonographically measured cervical length and logarithm of induction-to-delivery interval (hours) in nulliparae (solid line and dots) and multiparae (dashed line and plus signs) (nulliparae: $\log \text{ time} = 1.90 + 0.0533 \text{ cervix length (mm)}$, multiparae: $\log \text{ time} = 1.44 + 0.0533 \text{ cervix length (mm)}$).

length were found to be significant predictors of the induction-to-delivery interval. Sonographically measured cervical length was found to explain a greater proportion of the total variation (15.6%) compared to Bishop score (3.8%). Parallel regression equations were fitted using cervical length as a predictor for both nulliparous and multiparous women (Figure 6). These models showed that the geometric mean time to delivery for multiparae was 37% lower than the corresponding figure for nulliparae.

DISCUSSION

The findings of the study, that in singleton pregnancies undergoing induction of labor for prolonged pregnancy successful vaginal delivery within 24 h of induction occurs in approximately 70% of the women and that pre-induction cervical length is significantly associated with the induction-to-delivery interval and the rate of vaginal delivery within 24 h, are compatible with previous reports^{5,10–13}. We have also demonstrated that sonographically measured cervical length is better than the Bishop score or cervical length by vaginal examination in predicting the outcome of induction. The findings of previous studies on pre-induction sonographically measured cervical length and outcome are summarized in Table 4^{10–13,18,19}. 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 method⁴.

Parity provided significant independent contribution, in addition to pre-induction cervical length, in the prediction of the outcome of labor. Thus, in multiparae the incidence of successful vaginal delivery within 24 h of induction was about 30% higher than in nulliparae. For the same cervical length the induction-to-delivery interval in multiparae was 37% lower than in nulliparae.

TVS measurement of cervical length can be achieved easily and with less discomfort to the patient than a vaginal examination. Measurement of cervical length

Table 4 Previous studies on the value of pre-induction sonographically assessed cervical length

Reference	n	Findings
Paterson-Brown et al. ¹⁸	50	No significant association between cervical length and Bishop score or the induction-to-delivery interval
Boozarjomehri et al. ¹⁰	53	Significant association between cervical length and length of latent phase of labor
Watson et al. ¹⁹	109	No significant contribution of cervical length and parity in the prediction of length of latent phase of labor
Gonen et al. ¹¹	86	Only the Bishop score and parity are significantly correlated with successful induction and the duration of labor
Ware and Raynor ¹²	77	Both sonographically measured cervical length and Bishop score predict the induction-to-delivery interval and likelihood of vaginal delivery
Pandis et al. ¹³	240	Significant association between cervical length and likelihood of delivery within 24 h and induction-to-delivery interval

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.

Pre-induction cervical length provides a useful prediction of the likelihood of vaginal delivery within 24 h of induction and of the induction-to-delivery interval. Nulliparous women with a cervical length < 20 mm can be counseled that they have an 80% chance of delivering within 24 h of induction and those with a cervix measuring > 30 mm have about a 90% chance of remaining undelivered. Multiparous women with cervical length < 20 mm can be counseled that they have a 90% chance of delivering within 24 h and those with a cervix measuring > 30 mm can be advised that they have an approximately 60% chance of remaining undelivered at this interval.

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REFERENCES

- Cole RA, Howie PW, Magnaughton MC. Elective induction of labor. A randomised prospective trial. *Lancet* 1975; 1: 767–770.
- Hannah ME, Hannah WJ, Hellmann J, Hewson S, Milner R, Willan A. and the Canadian Multicenter Post-term Pregnancy Trial Group. Induction of labor as compared with serial antenatal monitoring in post-term pregnancy. A randomised controlled trial. *N Engl J Med* 1992; 326: 1587–1592.
- Sue-A-Quan AK, Hannah ME, Cohen MM, Foster GA, Liston RM. Effect of labor induction on rates of stillbirth and Cesarean section in post-term pregnancies. *CMAJ* 1999; 160: 1145–1149.
- Royal College of Obstetricians and Gynaecologists (RCOG). Induction of labor. In *Evidence-based Clinical Guideline Number 9*. London: RCOG Clinical Support Unit, 2001.
- Crowley P Interventions for preventing or improving the outcome of delivery at or beyond term. The Cochrane Library, Issue 2, 2003. <http://www.update-software.com> [Accessed 3 January 2003].
- Arulkumaran S, Gibb DM, Tambyraja RL, Heng SH, Ratnam SS. Failed induction of labor. *Aust N Z J Obstet Gynaecol* 1985; 25: 190–193.
- Friedman EA, Niswander KR, Bayonet-Rivera NP, Sachtleben MR. Relation of prelabor evaluation to inducibility and the course of labor. *Obstet Gynecol* 1966; 28: 495–501.
- Hughey MJ, McElin TW, Bird CC. An evaluation of preinduction scoring systems. *Obstet Gynecol* 1976; 48: 635–641.
- Dhall K, Mittal SC, Kumar A. Evaluation of pre-induction scoring systems. *Aust N Z J Obstet Gynaecol* 1987; 27: 309–311.
- Boozarjomehri F, Timor-Tritsch I, Chao CR, Fox HE. Transvaginal ultrasonographic evaluation of the cervix before labor: presence of cervical wedging is associated with shorter duration of induced labor. *Am J Obstet Gynecol* 1994; 171: 1081–1087.
- Gonen R, Degani S, Ron A. Prediction of successful induction of labor: comparison of transvaginal ultrasonography and the Bishop score. *Eur J Ultrasound* 1998; 7: 183–187.
- Ware V, Raynor D. Transvaginal ultrasonographic cervical measurement as a predictor of successful labor induction. *Am J Obstet Gynecol* 2000; 182: 1030–1032.
- Pandis GK, Papageorghiou AT, Ramanathan VG, Thompson MO, Nicolaides KH. Preinduction sonographic measurement of cervical length in the prediction of successful induction of labor. *Ultrasound Obstet Gynecol* 2001; 18: 623–628.
- Sonek JD, Iams JD, Blumenfeld M, Johnson F, Landon M, Gabbe S. Measurement of cervical length in pregnancy: comparison between vaginal ultrasonography and digital examination. *Obstet Gynecol* 1990; 76: 172–175.
- Anderson HF, Nugent CE, Wanty SD, Hayashi RH. Prediction of risk for preterm delivery by ultrasonographic measurement of cervical length. *Am J Obstet Gynecol* 1990; 163: 859–867.
- Sonek J, Shellhaas C. Cervical sonography: a review. *Ultrasound Obstet Gynecol* 1998; 11: 71–78.
- Inherited Clinical Guideline D – Induction of labor. National Institute for Clinical Excellence, June 2001. <http://www.nice.org.uk>.
- Paterson-Brown S, Fisk NM, Edmonds DK, Rodeck CH. Pre-induction cervical assessment by Bishop's score and transvaginal ultrasound. *Eur J Obstet Gynecol Reprod Biol* 1991; 40: 17–23.
- Watson WJ, Stevens D, Welter S, Day D. Factors predicting successful labor induction. *Obstet Gynecol* 1996; 88: 990–992.