

# Transvaginal ultrasound cervical length for prediction of spontaneous labour at term: a systematic review and meta-analysis

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Accepted 30 August 2015. Published Online 28 October 2015.



This article includes Author Insights, a video abstract from the article's author available at <https://vimeo.com/148893294>

**Background** The possibility to predict the delivery date is a question frequently raised by pregnant women. However, a clinician has currently little to predict when a woman at term will deliver.

**Objective** To evaluate the predictive accuracy of transvaginal ultrasound (TVU) cervical length (CL) for spontaneous onset of labour in singleton gestation enrolled at term by a meta-analysis.

**Search strategy** We performed a literature search in electronic databases.

**Selection criteria** We included only studies assessing the accuracy of TVU CL in prediction of spontaneous onset of labour in singleton gestations with vertex presentation who were enrolled at term.

**Data collection and analysis** The primary outcome was the accuracy of CL for prediction of spontaneous labour within 7 days. Pooled sensitivities and specificities were calculated.

**Main results** Five studies including 735 singleton gestations were included. For the prediction of spontaneous labour within 7 days

for CL <30 mm the pooled sensitivity was 64% and pooled specificity was 60%. The higher the CL, the better the sensitivity; the lower the CL, the better the specificity. A woman with a singleton gestation at term and a TVU CL of 30 mm has a <50% chance of delivering within 7 days, while one with a TVU CL of 10 mm has an over 85% chance of delivery within 7 days.

**Conclusions** TVU CL at term has moderate value in predicting the onset of spontaneous labour. A woman with a TVU CL of 10 mm or less has a high chance of delivering within a week.

**Tweetable abstract** Cervical length at term has moderate value in predicting the onset of spontaneous labour.

**Keywords** Cervical length, labour, ultrasound.

**Linked article** This article is commented on by ES Miller and WA Grobman, p. 23 in this issue. To view this mini commentary visit <http://dx.doi.org/10.1111/1471-0528.13749>.

Please cite this paper as: Saccone G, Simonetti B, Berghella V. Transvaginal ultrasound cervical length for prediction of spontaneous labour at term: a systematic review and meta-analysis. BJOG 2016;123:16–22.

## Introduction

The possibility to predict the delivery date is a question frequently raised by pregnant women. So far, data from the last menstrual period and the first accurate ultrasound examination are the two important methods for estimating gestational age and due date.<sup>1–3</sup> Nonetheless, only 5% of women deliver on their due date.<sup>4</sup> A clinician has currently little to predict when a woman at term, e.g. 38 or 39 weeks, will deliver.<sup>1</sup>

Over the last few years, cervical assessment has moved from digital examination to ultrasound evaluation, and ultrasound of the cervix has been the focus of much research.<sup>5–8</sup>

Transvaginal ultrasound (TVU) cervical length (CL) has been assessed in several populations (e.g. asymptomatic women as well as women with symptoms of preterm labour)<sup>5,9</sup> to evaluate the risk of preterm birth,<sup>10</sup> and in women before induction of labour to predict induction outcome.<sup>11,12</sup>

Many observational studies have evaluated the association between TVU CL at term and the interval to delivery.

Although TVU CL is reproducible and easy to learn,<sup>13,14</sup> studies demonstrate conflicting results regarding its predictive accuracy in this clinical scenario.<sup>15–19</sup>

The aim of this meta-analysis is to evaluate the accuracy of TVU CL in the prediction of spontaneous onset of labour within 7 days in singleton gestations at term.

## Methods

### Eligibility criteria

This review was performed according to a protocol designed *a priori* and recommended for systematic review.<sup>20</sup> We performed a computerised literature search in MEDLINE, OVID, Scopus, the PROSPERO International Prospective Register of Systematic Reviews and EMBASE with the use of keywords related to ‘cervical length,’ ‘delivery’ and ‘transvaginal ultrasound’ from inception of each database to October 2014. No restrictions for language or geographic location were applied. One reviewer (G.S.) performed the search and two reviewers (B.S., V.B.) independently inspected the search results and reviewed citations for potentially eligible studies. Disagreements were resolved by discussion.

### Study selection

We considered randomised controlled trials (RCTs), case-control and cohort studies. Studies were included if they reported data allowing construction of a  $2 \times 2$  table. We included only studies assessing the accuracy of TVU CL in prediction of spontaneous onset of labour as defined by the authors, including spontaneous rupture of membranes, in singleton gestations with vertex presentation who were enrolled at term.<sup>21</sup> Exclusion criteria included studies on women enrolled before 37 weeks or after 41 weeks, studies on women with premature rupture of membranes, studies on women with multiple gestations and case-report studies. The primary outcome was the accuracy of TVU CL in the prediction of spontaneous onset of labour within 7 days in term singletons. We planned subgroup analyses according to parity and according to gestational age.

### Data abstraction

Data abstraction was completed by two independent investigators (G.S., B.S.). Each investigator independently abstracted data from each study separately. Discrepancies were resolved by discussion with a third reviewer (V.B.). All authors of each included study were contacted for missing data.

The quality assessment of each included study was reviewed using Quality Assessment of Diagnostic Accuracy Studies (QUADAS) criteria.<sup>22</sup> The meta-analysis was reported following the Preferred Reporting Item for Systematic Reviews and Meta-analyses (PRISMA) guidelines.<sup>23</sup> Before data extraction, the protocol of this review was regis-

tered with the PROSPERO International Prospective Register of Systematic Reviews (CRD42014015657) following the PRISMA guidelines for protocols (PRISMA-P).<sup>24</sup>

### Data analysis

For all the included studies we constructed a  $2 \times 2$  table cross-classifying CL and the outcome of spontaneous onset of labour within 7 days using each CL measurement mentioned in the included studies. We generated the Forest plot for the pooled sensitivity and specificity with 95% confidence interval (CI). A linear regression was performed to analyse the relation between CL (predictor variable; X) and the most important test characteristics (criterion variable; Y), i.e. sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). Additionally, summary receiver-operating characteristics (sROC) curves were plotted. The area under the curve (AUC) and the  $Q^*$  index were also computed to evaluate the overall performance of the diagnostic test accuracy. The AUC of an sROC curve is a measure of the overall performance of a diagnostic test in accurately differentiating those cases with and those without the condition of interest. The  $Q^*$  index is defined by the point at which sensitivity and specificity are equal, which is closest to the ideal top-left corner of the sROC space. Both values range between 0 and 1, with higher values indicating better test performance.<sup>25</sup> The following guidelines have been suggested for interpretation of AUC values: low ( $0.5 \geq \text{AUC} < 0.7$ ), moderate ( $0.7 \geq \text{AUC} < 0.9$ ) or high ( $0.9 \geq \text{AUC} \leq 1$ ) accuracy.<sup>25</sup>

The degree of between-study heterogeneity was evaluated using the  $I^2$  statistic, which represents the percentage of between-study variation that is due to heterogeneity rather than chance. A value of  $>30\%$  indicate a substantial level of heterogeneity.<sup>26</sup> The principal component analysis (PCA) was performed to find the relation between the variables. The PCA is a statistical procedure that shows the relation between the variables in a graphic model.<sup>27</sup> Potential publication biases were assessed statistically using Begg’s and Egger’s tests.<sup>28</sup>

The data analysis was completed independently by authors G.S. and B.S. using Meta-DiSc 1.4 ([http://www.hrc.es/investigacion/metadisc\\_en.htm](http://www.hrc.es/investigacion/metadisc_en.htm); Hospital Universitario Ram  on y Cajal, Madrid, Spain). The completed analyses were then compared, and any difference was resolved by review of all the data.

## Results

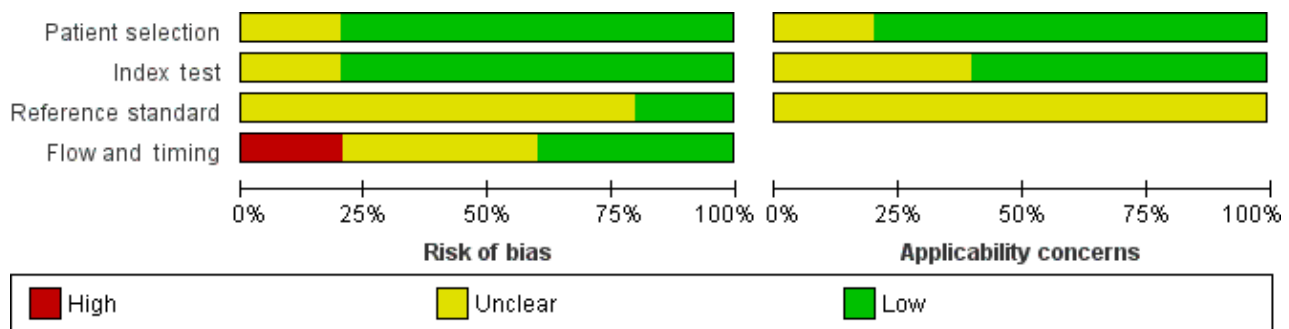
### Study selection and study characteristics

Five prospective cohort studies, which met inclusion criteria, were included in the meta-analysis (Figure S1).<sup>16–19,29</sup> Table 1 shows the characteristics of the included studies. In all, 735 women were analysed. All studies included only

**Table 1.** Characteristics of the included studies

	Rozenberg 2000 <sup>17</sup>	Bayramoglu 2005 <sup>19</sup>	Tolaymat 2007 <sup>16</sup>	Meijer Hoogveen 2008 <sup>18</sup>	Miura 2010 <sup>29</sup>
Location	France	Turkey	USA	Holland	Japan
Study design	Prospective cohort	Prospective cohort	Prospective cohort	Prospective cohort	Prospective cohort
Inclusion criteria	Singletons with vertex presentation	Singletons with vertex presentation	Singletons with vertex presentation	Singletons with vertex presentation	Singletons with vertex presentation
Sample size	126	93	120	162	234
Range GA (weeks <sup>days</sup> )	39 <sup>4</sup> –40 <sup>3</sup>	37 <sup>6</sup> –40 <sup>6</sup>	37 <sup>0</sup> –40 <sup>6</sup>	37 <sup>0</sup> –40 <sup>6</sup>	37 <sup>0</sup> –40 <sup>6</sup>
Nulliparous	62/126 (49.2%)	44/93 (47.3%)	66/120 (55.0%)	162/162 (100%)	138/234 (58.9%)
Optimum cut-off point of CL	26 mm	25 mm	25.3 mm	N/R	25 mm
Primary outcome	Spontaneous labour within 7 days	Spontaneous labour within 7 days	Spontaneous delivery within 7 days	Delivery prior to 41 weeks	Spontaneous labour within 7 days

CL, cervical length; GA, gestational age; N/R, not reported.



**Figure 1.** Review authors' judgement of risk of bias and applicability concerns based on Quality Assessment of Diagnostic Accuracy Studies tool presented as percentages across included studies.

uncomplicated singleton gestations with vertex presentation and included both nulliparous and multiparous women without stratifying data by parity. Figure 1 shows the results of the quality assessment presented as percentages across the studies. None of the included studies had high risk of bias in patient selection and index test. Publication bias, assessed using Begg's and Egger's tests, showed no significant bias ( $P = 0.51$  and  $P = 0.44$ , respectively). The method of CL ascertainment was clearly described in all the individual studies. In three studies,<sup>17–19</sup> endocervical canal length was measured as the distance between the internal and external os using a vaginal probe at 5 MHz. In the other two studies, a 6-MHz probe was placed in the anterior fornix of the vagina.<sup>16,29</sup> Three anatomic landmarks defined the appropriate sagittal view: the internal os, the external os and the endocervical canal. The image was enlarged while visualising the three landmarks simultaneously. Gentle pressure exerted on the cervix by the transducer was reduced followed by minimal pressure to allow visualisation of the three landmarks; this procedure was

repeated three times and the shortest measurement was recorded.<sup>16</sup> In all the included studies the women had empty bladders during the ultrasound scan.

### Synthesis of results

From all the included studies we were able to construct a  $2 \times 2$  table for the primary outcome (i.e. spontaneous labour within 7 days) considering  $CL < 30$  mm. Figure S2 shows the sensitivity and specificity of  $CL < 30$  mm in prediction of spontaneous labour in each study and the pooled analysis (five studies, 735 women). For the prediction of spontaneous labour within 7 days, sensitivity of  $CL < 30$  mm ranged from 46 to 80% and specificity from 40 to 84%. The pooled sensitivity was 64% (95% CI 58–69%) and pooled specificity was 60% (95% CI 55–65%). The positive predictive value (PPV) and the negative predictive value (NPV) were 71 and 64%, respectively. Corresponding positive likelihood ratio (LR+) and negative likelihood ratio (LR–) were 2.30 (95% CI 1.42–3.72) and 0.50 (95% CI 0.38–0.65), respectively. The AUC for diagnostic accuracy

of CL < 30 mm for prediction of spontaneous labour within 7 days was 0.8 and suggested moderate diagnostic accuracy (Figure S3).

Table 2 shows the pooled sensitivity and specificity stratified by each CL measurement. A woman with a TVU CL of 30 mm has a < 50% chance of delivering within 7 days

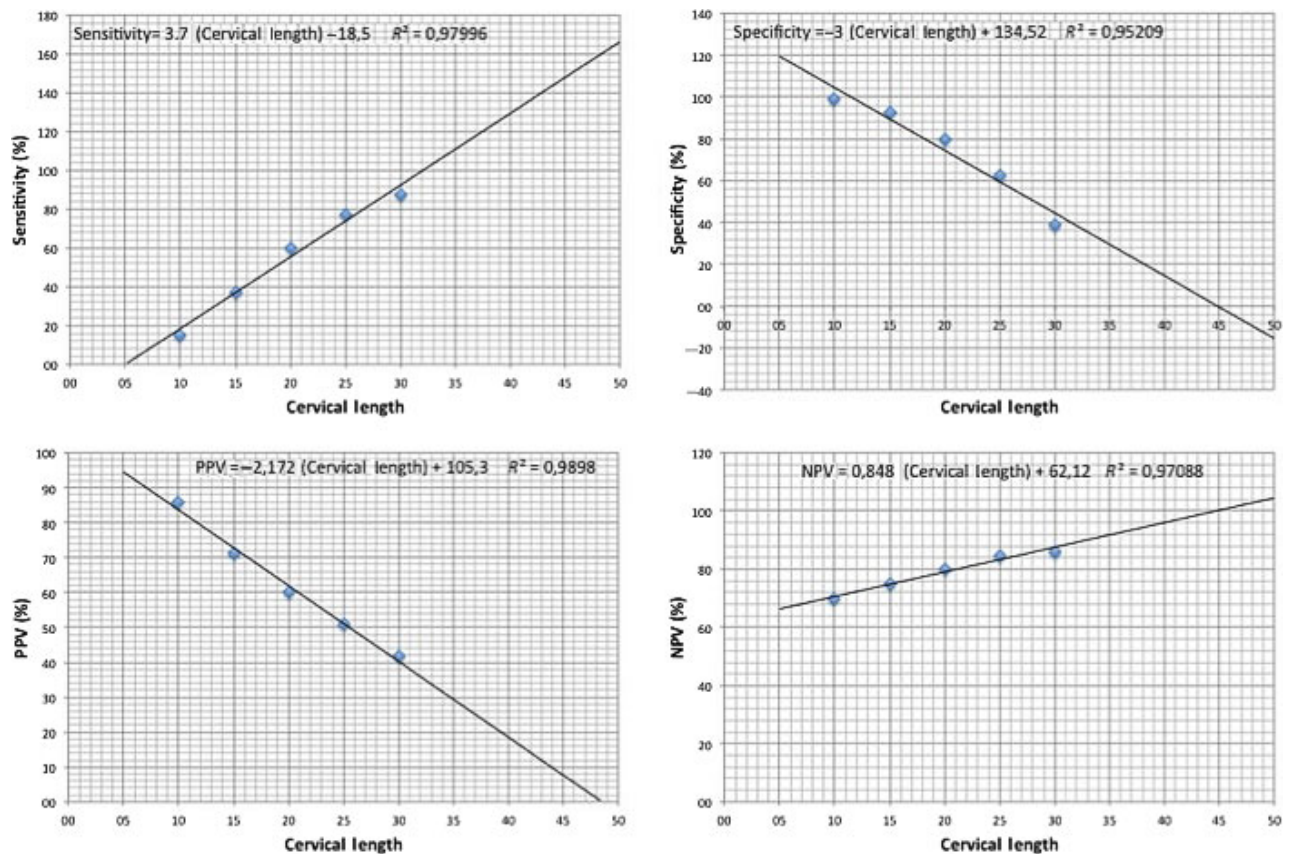
(PPV = 41.7%), whereas one with a TVU CL of 10 mm has an over 85% chance of delivery within 7 days (PPV = 85.7%). The higher the CL, the better the sensitivity; the lower the CL, the better the sensitivity (Table 2). Through the PCA we observed that by increasing the mm, the sensitivity was higher, whereas by decreasing the mm,

**Table 2.** Pooled sensitivity and specificity for each measurement with 95% confidence interval

CL	Sensitivity (95% CI)	Specificity (95% CI)	PPV (%)	NPV (%)	LR+	LR-
30 mm (four studies, 609 women)	88% (73–92)	38% (33–45)	41% (33–51)	86% (80–91)	1.4 (1.2–3.5)	0.3 (0.2–0.5)
25 mm (four studies, 573 women)	76% (64–85)	63% (54–69)	51% (41–59)	85% (79–88)	2.0 (1.1–4.7)	0.4 (0.2–0.6)
20 mm (four studies, 573 women)	60% (54–71)	79% (71–89)	61% (51–70)	79% (70–88)	3.0 (1.8–5.7)	0.5 (0.3–0.7)
15 mm (three studies, 480 women)	36% (28–43)	92% (85–95)	71% (60–79)	74% (61–80)	5.0 (3.2–7.5)	0.6 (0.5–0.8)
10 mm (one study, 120 women)	15% (10–29)	98% (89–99)	85% (73–91)	69% (60–76)	12.0 (10.5–19.5)	0.9 (0.6–0.9)

CI, confidence interval; CL, cervical length; LR+, positive likelihood ratio; LR-, negative likelihood ratio; NPV, negative predictive value; PPV, positive predictive value.

Data are presented as percentage with 95% confidence interval.



**Figure 2.** Linear regression between cervical length (predictor variable; X) and sensitivity, specificity, positive predictive value and negative predictive value (criterion variable; Y). NPV, negative predictive value; PPV, positive predictive value.

the other three variables (i.e. LR, PPV and specificity), statistically strongly correlated, were higher (Figure S4). By a linear regression, we found the best-fitting straight line through the points;  $R^2$  was very high ( $>0.9$ ) (Figure 2). None of the included studies stratified data by parity or by gestational age, so these subgroup analyses were not feasible.

## Discussion

### Main findings

This systematic review assessed whether TVU assessment of CL can be used as predictor for spontaneous labour within 7 days in singleton gestations at term. A woman with a TVU CL of 30 mm has a  $<50\%$  chance of delivering within 7 days, whereas one with a TVU CL of 10 mm has an over 85% chance of delivery within 7 days.

### Comparison with existing literature

A prior systematic review has shown that TVU CL measured at or near term has a moderate capacity to predict the outcome of delivery after induction of labour.<sup>11</sup> This meta-analysis included 31 studies reporting both CL and outcome of delivery. Sensitivity of CL in prediction of caesarean delivery ranged from 0.14 to 0.92 and specificity from 0.35 to 1.00.<sup>11</sup>

Other studies have shown that TVU CL could be an alternative method to Bishop score in the prediction of caesarean delivery and of successful labour induction.<sup>30–32</sup> Cubal et al. in particular found that TVU CL was a better predictor of successful induction of labour in nulliparous women compared with Bishop score,<sup>31</sup> whereas Uzun et al.<sup>32</sup> reported the opposite.

### Strengths and limitations

One of the strengths of our study is the inclusion of study data on CL in prediction of spontaneous onset of labour in a specific population, i.e. singleton at term. This is the first meta-analysis evaluating the capacity of TVU CL in the prediction of spontaneous labour or delivery. No similar meta-analyses were found during the systematic review. The overall risk of bias of the included studies was low. Most of the included studies had the same primary outcome (i.e. spontaneous labour within 7 days).

Limitations of our study are inherent to the limitations of the included studies. The number of the included women is limited. None of the included studies stratified data by parity, and none of them compared CL with digital exam or with Bishop's score. The predictive values of a given CL may significantly vary across the gestational age range from 37 to 40 weeks. Unfortunately, as no study stratified for or reported data by gestational age, a subgroup analysis according to gestational age was not feasible. The predictive values

are dependent on the prior probability of an event happening, and therefore they cannot be generalised for the whole pregnancy interval covered by this meta-analysis.

### Interpretation

Obstetricians and midwives have always been puzzled by the patient's question: 'When will I deliver?' Being able to predict the date of onset of spontaneous labour has several potential benefits. In women with risk factors for stillbirth, a long TVU CL might sway the caregiver to induction, as the chance of timely spontaneous labour is low. Women with short TVU CL would be pushed to make last-minute plans for welcoming the newborn. Providers and birth locals may be able to better plan staff and coverage. These data on TVU CL prediction of spontaneous labour may also be helpful for women choosing between planned repeat caesarean delivery in the 39th week and awaiting spontaneous labour to attempt vaginal birth after a previous caesarean. This information can also allow caution to be taken regarding earlier, perhaps unnecessary, inductions if the TVU CL is long, i.e. unfavourable. It can enable better plans to be made regarding maternal transport; for example, a woman with a TVU CL of 10 mm at 37 weeks carrying a fetus with a congenital diaphragmatic hernia may want to move closer to the hospital if she is currently living far away. For pregnant women, this information may help them to arrange their social activities and deal with their anxiety. TVU CL as a screening test at term for prediction of spontaneous labour may be best considered in women who will benefit most from this test. Figure 2 and equations reported in Figure 2 could be used by obstetricians to predict the probability of spontaneous delivery within 7 days calculating sensitivity, specificity, PPV and NPV for any TVU CL measurement at term.

## Conclusion

CL by transvaginal ultrasound at term in singletons gestations, which is easily performed, could be used for prediction of spontaneous labour. Figure 2 can be used to estimate the chance (positive predictive value) that a woman has of spontaneous delivery within 1 week. Some women and their providers may benefit from knowing term TVU CL to make more accurate plans for birth. Given the limitations of this meta-analysis, future clinical research with stratification of women according to gestational age and parity is needed to confirm our findings.

### Disclosure of interests

Full disclosure of interests available to view online as supporting information.

### Contribution to authorship

All authors contributed equally to this work.

## Details of ethics approval

None required.

## Funding

None.

## Acknowledgements

None.

## Supporting Information

Additional Supporting Information may be found in the online version of this article:

**Figure S1.** Flow diagram of studies identified in the systematic review.

**Figure S2.** Pooled sensitivity (A) and pooled specificity (B) for cervical length <30 mm for prediction of spontaneous labour within 7 days.

**Figure S3.** Summary receiver operating characteristics curve with 95% confidence interval for cervical length <30 mm for prediction of spontaneous labour within 7 days

**Figure S4.** Principal component analysis to correlate the variables. ■

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