Published in final edited form as:

Am J Obstet Gynecol. 2011 March ; 204(3): 228.e1–228.10. doi:10.1016/j.ajog.2010.09.024.

Noninvasive Uterine Electromyography For Prediction of Preterm Delivery*

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Abstract

Objective—Power spectrum (PS) of uterine electromyography (EMG) can identify true labor. EMG propagation velocity (PV) to diagnose labor has not been reported. The objective was to compare uterine EMG against current methods to predict preterm delivery.

Study design—EMG was recorded in 116 patients (preterm labor, n=20; preterm non-labor, n=68; term labor, n=22; term non-labor, n=6). Student's t-test was used to compare EMG values for labor vs. non-labor (P<0.05 significant). Predictive values of EMG, Bishop-score, contractions on tocogram, and transvaginal cervical length were calculated using receiver-operator-characteristics analysis.

Results—PV was higher in preterm and term labor compared with non-labor (P<0.001). Combined PV and PS peak frequency predicted preterm delivery within 7 days with area-under-the-curve (AUC) = 0.96. Bishop score, contractions, and cervical length had AUC of 0.72, 0.67, and 0.54.

Conclusions—Uterine EMG PV and PS peak frequency more accurately identify true preterm labor than clinical methods.

Keywords

prediction; preterm labor; propagation velocity; uterine electromyography

INTRODUCTION

Other than childbirth, “threatened preterm labor” is the most common diagnosis that leads to hospitalization during pregnancy.¹ Up to 50% of patients admitted for threatened preterm

*Presented orally at the 57th Annual Scientific Meeting of the Society for Gynecologic Investigation; March 27th, 2010, Orlando, Florida.

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labor are, however, not in true labor, and will eventually deliver at term.² 20% of symptomatic patients that are diagnosed as not being in preterm labor, on the other hand, will deliver prematurely.³ This leads to unnecessary treatments, missed opportunities to improve neonatal outcome, and largely biased research of treatments.

Myometrial activation, required for effective contractions and true labor, is characterized by molecular changes leading to an increase in coupling and excitability of cells.⁴⁻⁷ Electrical activity of the myometrium, which can be monitored non-invasively by measuring the uterine electromyography (EMG), changes at delivery as a result of these events.⁸⁻¹⁴ 'Bursts' of electrical signals responsible for contractions have been reported to be more frequent and their duration more constant in labor.¹⁵⁻¹⁶ An increase in peak amplitude and frequency of EMG signals, assessed by power-spectrum (PS) analysis, has also been observed prior to labor.¹⁵⁻¹⁷⁻¹⁸ Propagation velocity (PV) of electrical signals in the myometrium has been shown in-vitro to increase before delivery when gap junctions are increased.¹⁹⁻²⁰ As a result, it has been suggested that EMG could be used to assess the PV in vivo. Previous studies mainly focused on methods for assessing EMG signal propagation.²¹⁻²⁸ However, the prognostic capability of PV for predicting labor (term or preterm) has not been evaluated yet.

This study investigates whether uterine EMG can be used to evaluate PV of uterine electrical signals in labor and non-labor patients at term and preterm and compares diagnostic accuracy of various EMG parameters, including PV, to methods currently used in the clinic to predict preterm delivery.

MATERIALS AND METHODS

Patients

116 pregnant women were included in the study at a single institution (St. Joseph's Hospital and Medical Center, Phoenix, Arizona). From previous EMG studies, there has been reported difference in means of EMG PS peak frequency in labor vs. non-labor patients of $(0.4708 - 0.3982 = 0.0726 \text{ Hz})$, and an average standard deviation of $[(0.0459 + 0.0231)/2 = 0.0345 \text{ Hz}]$.¹⁶ Using power of 0.80, and $\alpha = 0.05$, with t-test, gives a desired sample size of 5 per group minimum.

88 consecutive preterm patients were included. They were admitted with the diagnosis of preterm labor at less than 34 weeks of gestational age. The cut-off of 34 weeks was chosen because the risk of death and handicap is mainly increased if delivery occurs prior to this time point, and attempts to stop preterm labor are very rarely done at later gestations.²⁹ Preterm labor was diagnosed clinically as at least 6 contractions in 60 minutes assessed by TOCO and/or maternal perception and a cervical dilatation of at least 2 cm or effacement of at least 80% assessed by digital cervical examination. Calculation of gestational age was based on the last menstrual period or, when it differed by ≥ 7 days from the ultrasonographic estimation (calculated by crown-rump length measured within the first trimester), on ultrasound. Women delivering within 7 days from the EMG measurement were classified in the preterm labor group and those delivering outside of 7 days from the measurement in the preterm non-labor group.

28 consecutive patients presenting with regular uterine contractions with intact membranes at term (>37 weeks of gestation) were also included. Women delivering within 24 hours from the EMG measurement were defined as being in labor (term labor group) and those delivering outside of 24 hours from the measurement as not being in labor (term non-labor group).

Different cut-off measurement-to-delivery intervals for term and preterm labor vs. non-labor groups were chosen based on previous studies, which showed, that an increase in uterine EMG activity occurs within approximately 24 hours from delivery at term, and within several days from delivery preterm.¹⁷

All women included provided written informed consent for study participation. Data from patients who ultimately underwent cesarean-section were not used for analysis (Figure 1). We chose to exclude the cesarean-section patients because the decision on when exactly the surgery will be performed is based on several considerations, including those on fetal well-being and the subjective assessment of labor progress. This decision is therefore too subjective and arbitrary to include in a proper receiver-operating-characteristics (ROC) analysis in which one wants to also accurately determine the mean measurement-to-delivery-interval.

We chose to include PPROM patients because our objective was to evaluate whether uterine EMG measurements can differentiate between true preterm labor, i.e. patients who are going to deliver spontaneously within a short period of time, and those who are not in true preterm labor, when the clinical evaluation does not allow us to make this differentiation.

The St. Joseph's Hospital and Medical Center Institutional Review Board approved the study.

Uterine EMG Signal Recordings

Uterine EMG measurements were performed by 5 different researchers within 24 hours from patient's admission to the hospital. We standardized the electrode arrangement to the following: 2.5 cm electrode-electrode vertical and horizontal separation distances (measured from center-to-center) in a square-shaped pattern about the navel, and with each electrode positioned in the vertex of each of the 4 corners of the square. Uterine EMG was measured for 30 minutes from each patient using a custom-built uterine EMG patient-monitoring system. Patients were asked to remain still while supine without disturbing any of the probes and wires for the recordings.

Signal Analysis

Analog EMG signals were digitally filtered to yield a final band-pass of 0.34 to 1.00 Hz, in order to exclude most components of motion, respiration, and cardiac signals from the analysis. Data were sampled at 100 Hz (this high sampling rate was chosen so as to increase the resolution of PS analysis later).

Previously Described EMG Parameters—EMG parameters were chosen from previous publications.^{17,30} The definition of these parameters, as well as the rationale for their use, can also be found in those publications.

Propagation Velocity Analysis—PV can be calculated by dividing the distance (D) that the propagating wave travels by the amount of time (T) required for the propagating wave to traverse this distance. All the time differences in corresponding action potential peaks for each burst of action potentials were calculated, and the average of absolute values of all time differences for bursts in a patient's uterine EMG recording was used to calculate the PV.

Only those pairs of peaks on different channels (electrode pairs) with congruent shapes and within 2 seconds temporal separation of one another were included in the analysis, insuring that any peak observed on one channel during any 2-second window "matched" the associated peak on the other channel (Figure 2).

For our EMG instrument, we use differential, bipolar electrode pairs. The advantage of a differential bipolar setup over a mono-polar setup is signal quality, allowing us to more accurately identify individual uterine voltage peaks. Only those bursts for which the mean voltage peak value was > 2 times the mean baseline voltage peak value were used in these calculations, in order to clearly see and compare uterine voltage peaks at adjacent electrodes. Within each of these electrical contractile bursts, there were found anywhere from about 30 to 60 voltage peaks (associated with propagating voltage waves) which were analyzed (Figure 2). More than 25 000 voltage peaks pairs were analyzed, with an average of approximately 215 peaks per patient.

Common Obstetric Measures

Presence or absence of contractions on TOCO at the time of EMG measurement was documented by the researcher recording the EMG. Transvaginal cervical length and Bishop score were also documented, but only when they were assessed no more than 24 hours before or after the EMG measurement. Bishop score has not been developed as a predictor of preterm birth. Nevertheless, it gives a metric evaluation of digital cervical examination, which is commonly used to diagnose preterm labor and predict delivery. That is why we chose to compare predictive values of Bishop score to those of uterine EMG. Transvaginal cervical length was measured by one of 5 board certified perinatologists or one of 4 certified ultrasound technicians. Digital examination was performed by one of 26 resident physicians involved in the care of the patients included in the study.

Statistics

Student's t-test and Mann Whitney U-test (when appropriate, due to non-normal distribution of variables) were used to compare delivery within, vs. outside of, 24 hours from the measurement in term patients, and 7 days from the measurement in preterm patients. Statistical comparison between preterm and term patients was performed to determine whether gestational age impacts EMG PV. Data were analyzed by ANOVA and Dunn's test was used for pair-wise comparisons among groups. Pearson's correlation analysis was used to determine whether demographic and/or clinical parameters influence the PV. A P value of < 0.05 was considered significant.

Receiver-operating-characteristics (ROC) curves were used to estimate the predictive values of EMG parameters that were significantly higher in preterm patients delivering within 7 days, and to assess the diagnostic accuracy of Bishop score, contractions on TOCO, and trans-vaginal cervical length for predicting preterm delivery within 7 days. Diagnostic accuracy of EMG, Bishop score, TOCO and trans-vaginal cervical length were then compared.

The ROC analysis was also performed on the cohort of patients for whom the results of all the examined methods were available. ROC curves constructed on this cohort were compared by Student's t-test.

Repeatability and reproducibility measures—The PV analysis was re-performed on a subset of the data to determine intra-observer and inter-observer agreement. Approximately 175 voltage spikes from patients in term labor, term non-labor, preterm labor and preterm non-labor groups were re-analyzed. The intra-observer and inter-observer agreements were calculated according to the statistical methods proposed previously.³¹

RESULTS

116 patients were evaluated in the study. The data regarding the preterm and term groups will be presented in separate sections.

Preterm patients

General—The study population consisted of 88 pregnant women admitted at our institution between September, 2009 and February, 2010 with the diagnosis of preterm labor at less than 34 weeks gestation. Uterine EMG was initially recorded in 98 preterm patients, but 10 patients who underwent cesarean section were subsequently excluded from the analysis. Patients were included in the study at a median of 28 5/7 weeks of gestational age (range 21 5/7 to 33 6/7 weeks). 9 (10%) patients were <24 weeks', 31 (35%) 24-28 weeks', 33 (38%) 28-32 weeks' and 15 (17%) > 32 weeks'. Delivery within 7 days from the EMG measurement occurred in 23% (20/88) of the cases. Out of 68 patients who did not deliver within 7 days from admission, 23 delivered at term (after 37 weeks), and 45 delivered before 37 weeks of gestation. Clinical background variables are summarized in Table 1. Note that at the time of EMG measurement (no more than 24 hours after admission to the hospital) the contractions were detected by TOCO in only 30% (26/88) of patients, although they were all initially admitted for preterm labor. In spite of this, uterine EMG signals were being produced and easily detected in these patients. This confirms that EMG is a much more sensitive technology for assessing contractile activity than is the TOCO.

Transvaginal cervical length was measured in 67% (59/88) of patients. Cervical length was not significantly shorter in women who delivered within 7 days (median 2.0 cm) compared with that in women who did not (median 2.8 cm) ($P = 0.16$).

EMG Parameters—EMG PV was significantly higher in patients delivering within 7 days from the measurement (52.56 ± 33.94 cm/s) compared to those who delivered after 7 days (11.11 ± 5.13 cm/s) ($P < 0.001$; Figure 3). No statistically significant correlation was found between PV and the following demographic/clinical variables: maternal age, body mass index, number of previous gestations, number of previous preterm births, gestational age, twin gestations, PPRM, smoking, drug abuse, tocolytic treatment, and antenatal corticosteroids.

PS peak frequencies were also significantly higher in women who delivered within 7 days (0.56 ± 0.15 Hz) compared to those who did not (0.44 ± 0.07 Hz) ($P = 0.002$; Figure 4). All other EMG parameters analyzed did not differ significantly among groups. (Table 2).

Predictive values of EMG PV, PS peak frequency, and the combination (rescaled sum) of these parameters for predicting preterm delivery at various time points were calculated (Table 3). PV and PS peak frequency were then combined, by looking at the sum of their rescaled values. Specifically, PS peak frequency was multiplied by 100 and added to the corresponding PV value. The combination of these two parameters yielded the best predictive values at 7 days to delivery. These values were higher than for any parameter alone at any time point. A similar combination (product) using PV and PS peak frequency yielded no better results.

The sum of PV and PS peak frequency increased as the measurement-to-delivery interval decreased, as shown in Figure 5. Based on this figure it is possible to speculate that the EMG activity increases even before 7 days from delivery and it may be useful to identify patients in preterm labor even prior to this cut-off.

Figure 6 and Table 4 present ROC analysis results. The ROC curve for uterine EMG differed significantly from the ROC curve for Bishop score ($P=0.02$), transvaginal cervical length ($P=0.03$), and TOCO ($P<0.001$), even when the ROC analysis was performed on the same group of patients for which the results of all the methods were available.

Term Patients

Uterine EMG was recorded in 36 term patients and 8 patients who underwent caesarean-section were subsequently excluded from the analysis. Gestational age at inclusion did not differ significantly between the two groups ($P=0.216$). The median gestational age for labor patients was 39 2/7 (range 38 0/7 to 40 6/7 weeks) and for non-labor patients 38 5/7 (range 37 1/7 to 41 1/7 weeks). The median measurement to delivery interval for non-labor patients was 8 days (range 3 to 14 days) and in labor group 4 hours (range 2 to 14 hours). PV was significantly higher ($P<0.001$) in labor (31.25 ± 14.91 cm/s) compared with non-labor patients (11.31 ± 2.89 cm/s). (Figure 7). In an ROC analysis to distinguish between term patients in true vs. false labor, PV had an area under the curve (AUC) of 0.98. For predicting delivery within 24 hours, a PV > 13.19 cm/s had 100% sensitivity, 83% specificity, 96% positive predictive value (PPV) and 100% negative predictive value (NPV).

Comparison between preterm and term patients

PV was significantly higher in labor at term and preterm compared with non-labor patients at term and preterm. The differences between term and preterm labor and term and preterm non-labor groups were not significant ($P > 0.05$). (Figure 7)

Repeatability and reproducibility measures

Intra-observer and inter-observer agreements were 99.92 ± 0.04 % and 99.67 ± 0.20 %, respectively. The technique to assess the PV of uterine EMG signals, described in the methods, is therefore highly repeatable and reproducible.

COMMENT

Noninvasive measurement of uterine EMG propagation and frequency can identify true preterm labor more accurately than the currently used methods. It can therefore identify those patients who will really benefit from early institution of tocolytic therapy, transport to a hospital with facilities for neonatal intensive care, and administration of steroids. At the same time, uterine EMG also identifies patients in false preterm labor who are not going to deliver within the next 7 days. This can help to avoid substantial economic costs associated with unnecessary hospitalization, the maternal risks associated with tocolytics, and the potential fetal risks associated with steroids. In the case of low PV and peak frequency values, it therefore stands to reason that it would be safe not to admit, treat, or transfer the patient, regardless of the presence of contractions on TOCO, and regardless of digital cervical exam and transvaginal cervical length results, since all of the changes in the myometrium required for labor are not yet fully established.

Methods currently available to clinicians to diagnose preterm labor have several major drawbacks. Digital cervical examination is subjective, and does not provide accurate diagnosis of true preterm labor.^{32,33} In the present study, the predictive measures of Bishop score were high only at scores of > 10 , which is not useful clinically, because at that point imminent delivery is already obvious. An interesting finding of this study was that the uterine EMG is better than transvaginal cervical length in predicting preterm birth within 7 days of evaluation. This raises an important aspect related to the clinical utility of the cervical length in predicting preterm delivery within a short time interval. There is compelling data to suggest that cervical length is a good predictive marker for preterm birth

between 24 to 32 weeks of gestation, but on the long and not on the short time interval.³⁴ It can be argued that the cervical length was only measured in 67% of the patients included, and only in 7 patients who delivered within 7 days. In many of the patients who presented with advanced cervical dilatation, cervical length was not obtained, and those patients were more likely to deliver within 7 days. The predictive values would, therefore, most likely be better if the transvaginal cervical length of all patients were known. However, several patients with short cervixes in this study did not deliver within one week, and some did not deliver preterm at all. Further studies are needed to determine if addition of the fetal fibronectin test can improve the predictive value of transvaginal cervical length alone. However, given that the cervical length has much lower predictive values compared to uterine EMG, we doubt that the fetal fibronectin test will significantly change the results.

Our results also confirm that monitoring uterine activity with TOCO is not helpful in identifying patients in preterm labor.^{35,36} Only 23% of patients with contractions on TOCO during the 30 minutes of EMG recording delivered within 7 days, and the absence of contractions apparently does not rule out preterm labor reliably, as the NPV was only 79%. Approximately 1 in 5 patients who exhibited no contractions registering on TOCO did, nevertheless, deliver preterm within one week.

We are highly encouraged that measuring uterine electrical activity is superior to TOCO. It does not only detect uterine contractions as does TOCO, but can also identify myometrial properties that distinguish physiological preterm contractions from true preterm labor.

PS peak frequency has been the most predictive of true labor in both human and animal studies.^{16,17} Our results confirm that shifts to higher uterine electrical signal frequencies occur during transition from a non-labor state to both term and preterm labor states, and can be reliably assessed by non-invasive trans-abdominal uterine EMG. In addition, we demonstrate that PV of EMG signals in the myometrium can not only be determined by EMG measurement, but also that PV predicts preterm delivery more accurately than any other EMG parameter investigated so far. Similar data was obtained with patients at term. Possible reasons for the increased PV during preterm and term labor are the presence of gap junctions, number of muscle cells recruited, ion channels (size and number), cellular resting potential, and cellular threshold potential, conduction pathways – all of these play a part in what types of EMG signals are ultimately received at the electrodes.

We evaluated many EMG parameters and their predictive values for preterm delivery among patients admitted for “threatened preterm labor”. EMG PV, PS peak frequency, and their combination (rescaled sum) identified which patients will deliver soon and which will not with highest PPV and NPV. It would be useful to do a prospective clinical trial to confirm our results. They may be extremely important clinically, but could also lead to more reliable analyses of treatments and eventually to more effective interventions to prevent preterm birth.

Condensation: Uterine Electromyography distinguishes between true and false preterm labor more accurately than methods used clinically today.

Acknowledgments

Sources of Funding: 1) NIH R01HD037480 2) St. Joseph's Foundation, Phoenix, AZ

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Figure 1.
Flow sheet diagram for better visualization of study groups.

Figure 2.

Propagation velocity of electromyographic (EMG) signals was calculated from the time difference of the signal arrival at adjacent electrodes (t). Top trace shows a sample recording from two electrode pairs (channels 1&2). Note the excellent temporal correspondence between EMG and mechanical contractile events (measured by TOCO). Bottom trace shows the expanded EMG burst, with the individual voltage peaks clearly distinguishable.

Figure 3. Comparison of uterine electromyography propagation velocity values for preterm patients delivering within 7 days of measurement vs. those delivering more than 7 days from measurement. Means and standard deviations shown; * represents statistical significance ($P < 0.05$).

Figure 4.

Comparison of uterine electromyography power spectrum (PS) peak frequency values for preterm patients delivering within 7 days of measurement vs. those delivering more than 7 days from measurement. Means and standard deviations shown; * represents statistical significance ($P<0.05$).

Figure 5. Uterine electromyography propagation velocity (PV) + power spectrum peak frequency (PS) increases as the measurement-to-delivery interval decreases. □ Preterm labor – delivery ≤ 7 days from the measurement; ● delivery > 7 days from the measurement.

Figure 6.

Comparison of receiver-operating-characteristics (ROC) curves for uterine electromyography (EMG) parameters (rescaled sum of propagation velocity [PV] and power spectrum [PS] peak frequency) and currently used clinical methods to predict preterm delivery within 7 days.

Figure 7.

Propagation velocity was significantly higher ($P < 0.001$) in labor groups compared to non-labor groups. The differences between term vs. preterm labor and term vs. preterm non-labor groups were not significant ($P > 0.05$). Data are presented as box plots and not vertical bar charts due to non-normal distribution in term labor group. Term Labor – delivery within 24 hours; Term Non-labor – delivery after 24 hours; Preterm Labor – delivery within 7 days; Preterm Non-labor – delivery after 7 days.* represents statistical significance.

Table 1

Clinical Background Variables in Women Delivering Preterm Within, as Compared to After, 7 Days from the Uterine Electromyography Measurement

Variable	Women Delivering Within 7 days (n=20)	Women Delivering After 7 days (n=68)	P-Value
Maternal age (years)	24 (18-40)	27 (18-43)	0.59
Nulliparous	5	16	0.99
Number of previous gestations	1 (0-8)	1 (0-11)	0.64
Previous preterm delivery or late abortion	2	13	0.54
Twin gestations	1	8	0.65
Gestational age at measurement	27 5/7 (22 6/7 to 33 4/7)	28 6/7 (21 5/7 to 33 6/7)	0.51
Preterm premature rupture of membranes	3	2	0.42
Smoking	1	9	0.58
BMI (kg/m ²)	28 (24 to 47)	27 (20 to 45)	0.15
Illicit drug abuse	1	7	0.72
Tocolytic treatment	16	53	0.89
Antenatal corticosteroids	11	54	0.09
Contractions on TOCO	7	19	0.64
Bishop score	7 (2-13)	5 (1-10)	0.01*
Transvaginal cervical length (cm) (n=59)	2.0 (0.5 – 3.5) (n=7)	2.8 (0.3 – 4.8) (n=52)	0.16

Data are median (range) and n. P value calculated by Mann-Whitney U-test and Student's T-test.* represents statistical significance (P<0.05); BMI body mass index

Table 2

Comparison of Diagnostic EMG Parameters for Preterm Delivery Within, as Compared to After, 7 Days from the Uterine Electromyography Measurement

EMG Parameter	Women Delivering Within 7 days	Women Delivering After 7 days	P-value
PS Peak Frequency *	0.56 ± 0.15 Hz	0.44 ± 0.07 Hz	0.002
Propagation Velocity *	52.56 ± 33.94 cm/s	11.11 ± 5.13 cm/s	<0.001
PS Median Frequency	0.64 ± 0.12 Hz	0.68 ± 0.05 Hz	0.11
PS Peak Amplitude	50.98 ± 84.70 μV^2	70.56 ± 134.64 μV^2	0.63
PS Median Amplitude	16.27 ± 44.14 μV^2	10.16 ± 16.29 μV^2	0.58
Mean Burst Duration	35.53 ± 9.00 s	39.32 ± 12.26 s	0.21
SD of Burst Duration	7.44 ± 5.85 s	10.16 ± 7.0 s	0.07
Mean Inter-burst Interval	307.5 ± 178.38 s	348.96 ± 227.27 s	0.65
SD of Inter-burst Interval	184.14 ± 136.68 s	149.76 ± 157.92 s	0.26

PS power spectrum; SD standard deviation; P value calculated by Mann-Whitney U-test and Student's T-test.* represents statistical significance (P<0.05).

Table 3

Predictive Measures of Uterine Electromyography Propagation Velocity, Power Spectrum Peak Frequency and Their Rescaled Sum, at 1, 2, 4, 7, and 14 Days to Delivery

	1 day to delivery			2 days to delivery			4 days to delivery			7 days to delivery			14 days to delivery		
	PV	PFR	PV + PFR	PV	PFR	PV + PFR	PV	PFR	PV + PFR	PV	PFR	PV + PFR	PV	PFR	PV + PFR
AUC	0.91	0.61	0.90	0.92	0.66	0.90	0.96	0.74	0.95	0.95	0.78	0.96	0.89	0.71	0.89
Best cut-off	22.13 cm/s	0.87 Hz	191.96	28.00 cm/s	0.87 Hz	191.96	24.88 cm/s	0.64 Hz	95.33	22.88 cm/s	0.64 Hz	84.48	26.6 cm/s	0.64 Hz	84.48
Sensitivity (%)	100	14	14	77	8	8	82	18	53	85	15	70	70	13	61
Specificity (%)	80	100	100	92	100	100	93	100	100	94	100	100	99	100	100
PPV (%)	30	100	100	63	100	100	74	100	100	81	100	100	94	100	100
NPV (%)	100	92	92	96	83	84	69	80	88	96	78	90	90	71	85

PPV - propagation velocity; PFr - power spectrum peak frequency; AUC - area under the curve; PPV - positive predictive value; NPV - negative predictive value; Best cut-off values are presented as cm/s and Hz. Their rescaled sum has no units.

Table 4

Predictive Measures of Uterine Electromyography Parameters (Combination of Propagation Velocity and Power Spectrum Peak Frequency) Compared to Currently Used Methods to Predict Preterm Delivery Within 7 Days.

Method	AUC	Best cut-off	Sensitivity	Specificity	PPV	NPV
EMG (PV + PS Peak Frequency) (N=88)	0.96	84.48	70%	100%	100%	90%
Bishop Score (N=88)	0.72	10	18%	100%	100%	81%
Transvaginal Cervical Length (N=59)	0.67	0.7 cm	14%	98%	50%	90%
Contractions on TOCO (N=88)	0.54	N/A	35%	72%	27%	79%

EMG uterine electromyography; PV propagation velocity; PS power spectrum; TOCO tocodynamometer; AUC area under the curve; PPV positive predictive value; NPV negative predictive value; N number of patients included in the analysis.