OBJECTIVE: Intrauterine pressure catheter (IUPC) is the primary device used to evaluate uterine activity. In contrast to the IUPC, electrical uterine electromyography (EUM) enables noninvasive measurement of frequency, intensity, and tone of contractions. The aim of this study was to determine the accuracy of EUM compared to IUPC.

RESULTS: The correlation of the frequency, intensity, and tone of contractions between uterine electromyography and IUPC was strong with significant r values of 0.808-1 ($P < .0001$).

CONCLUSION: Electrical uterine electromyography yields information about uterine contractility comparable to that obtained with IUPC.

Key words: contractions, intrauterine pressure catheter, myometrial electrical activity

MATERIALS AND METHODS
This prospective observational study was carried out in a single institution, Meir Medical Center, Kfar Saba, Israel.

The inclusion criteria were singleton pregnancy without evidence of significant fetal malformations, patients ≥24 gestational weeks, in any stage of labor. All participants required IUPC for accepted obstetrical indications such as protracted labor or augmentation of labor for a multipara, or had an amniotic fusion catheter inserted for repeated variable decelerations. The catheter enabled evaluation of the contractions by IUPC without further intervention.

Power analysis calculation for correlation between the 2 methods indicated that 41 participants were required to achieve an α error of 0.05 and a β error of 0.9. Equivalence of the measurements was defined as a difference of up to 5 seconds between the 2 methods (EUM and IUPC) regarding the onset and the duration of the contraction, and <5% difference in the intensity of the contraction. These values are based on the assumptions that the differences in the measures have no clinical significance.

The use of an IUPC can present technical challenges; therefore, for the sake of better comparison between IUPC and EUM, only patients without technical difficulties with recording contractions by the IUPC or after resolving the technical difficulties were included in the study.

The study was approved by the national Israel Ministry of Health Ethical Committee (approval no. 116-09) and registered in the National Institutes of Health Clinical Trials Registry (NCT1165879). All participants signed an informed consent form.

Equipment
The EUM monitor is a novel technology software and device developed by OBT Tools (Migdal Ha’emek, Israel). The device measures the electrical activity of the uterus by using 9 surface EMG electrodes and a multichannel amplifier. The electrodes are placed in a square surrounding the umbilicus, forming 3 rows and columns. The location of the electrodes is determined using a noninvasive position sensor. The energy of the contractions is presented in units of microwatts (μW). The 9 electrodes enable precise measurements of the EMG from different areas of the uterus and the software enables incorporation of the data and analyzing them into a contraction wave.

In the current study, each participant was monitored for 30 minutes simultaneously by EUM and by IUPC and the measurements of the contractions were compared. The data evaluator was blinded to the stage of labor that was recorded, as well as to the outcome of the labor.

IUPC was measured using millimeters of mercury (mm Hg) and EUM, in μW.

Evaluated parameters were the onset of the contraction, its peak, time to nadir, the duration, and intensity of each contraction. As accepted while using IUPC, we also calculated the total elevation of mm Hg above baseline in all contractions during 10 minutes (known as Montevideo units) and the total μW during the 10 minutes measured by the EUM. The novel software of the tested device created the waveform of the contractions and enabled us to calculate the area under the curve of the contractions that were detected by the new method in a similar way to the accepted evaluation of Montevideo while using IUPC. We compared the ratios of these measurements in each participant. Since the units used to evaluate the contractions are different, we also calculated the area under the curve of the contractions and compared the correlation between the methods for that term, as well.

Statistical analysis
The statistical analysis was performed using software (SAS, version 9.2; SAS Institute, Cary, NC). Student t test was used to evaluate the differences between the contraction parameters: the onset of the contraction, its peak, the time to nadir, the duration, and the intensity as measured by the IUPC and EUM methods. Pearson analysis of coefficient was used for correlations.

RESULTS
The study population included 47 parturients in various stages of labor. The demographic and clinical characteristics of the participants are presented in the Table. Uterine contractions were evaluated simultaneously by EUM and IUPC.

We faced technical difficulties in monitoring contractions with IUPC in 7 patients, all of which were resolved after some maneuvers such as washing or replacing the catheter. No technical difficulties were encountered with EUM.

### Table: Demographic and clinical characteristics of participants

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Average ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal BMI</td>
<td>20.2–41.6</td>
<td>30.31 ± 4.626</td>
</tr>
<tr>
<td>Gravity</td>
<td>1–11</td>
<td>3 ± 2.77</td>
</tr>
<tr>
<td>Parity</td>
<td>0–8</td>
<td>2 ± 2.26</td>
</tr>
<tr>
<td>Gestation</td>
<td>32 wk ± 4 d–42 wk ± 6 d</td>
<td>39 wk ± 4 d ± 2 wk ± 2 d</td>
</tr>
<tr>
<td>Initial cervical dilatation, cm</td>
<td>1–9.5</td>
<td>4.7 ± 1.9</td>
</tr>
<tr>
<td>Fetal weight, g</td>
<td>1490–4300</td>
<td>3261 ± 584</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode of delivery</th>
<th>No. of parturients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal vaginal delivery</td>
<td>22</td>
<td>46.8</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>18</td>
<td>38.3</td>
</tr>
<tr>
<td>Vacuum-assisted vaginal delivery</td>
<td>7</td>
<td>14.9</td>
</tr>
<tr>
<td>Augmentation of labor with oxytocin</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

BMI, body mass index.

Final comparisons were done after resolution of the technical difficulties.

Paired t-test as well as Pearson analysis showed very high correlations between the EUM and the IUPC. There was a very strong correlation of the times the contractions began, reached their peak, and ended \((P < .0001)\) (Figure, A). Correlation of contraction length was \(0.904 (P < .0001)\) (Figure, B) and intensity was \(0.80 (P < .0001)\) (Figure, C). The average ratios of the 10-minute calculation of mm Hg (Montevideo) measured by the IUPC and the total \(\mu W\) measured by the EUM for all the contractions evaluated in the study were \(6.48 \pm 2.71\), respectively, with no significant differences between the study participants. This reflects a consistent correlation between the different units used using the 2 systems for evaluating uterine contractions. The calculations of area under the curve in both methods showed an average correlation coefficient of \(0.809 \pm 0.003 (P < .0001)\).

**COMMENT**

In the current study, we found a very strong correlation between measurement of uterine contractions by EUM and IUPC. Our results demonstrate the accuracy of EUM in measuring the onset, time to peak, duration, and intensity of uterine contractions compared to IUPC measurements. The accepted method for measuring the intensity of uterine contractions is by IUPC using mm Hg units and calculating Montevideo evaluation.\(^{23}\) The excellent correlation between Montevideo and the total \(\mu W\) during the 10-minute intervals and the area under the curves in both methods that was observed in the current study supports the reliability of EUM of uterine contractions.

Accurate monitoring of uterine contractions curve is an essential part of the cardiotocogram and should be obtained by the best method available. It might help to prevent fetal acidemia by detecting excessive uterine activity during labor.\(^{1,3,24}\) This is particularly important during a protracted active phase of labor or induction of labor when knowledge of the intensity of the contractions is essential for clinical decision making.\(^{5,7}\) Accurate assessment of frequency, duration, and intensity of contractions is even more critical when evaluating premature uterine contractions. It is well established that prematurity is a leading cause of fetal mortality and morbidity,\(^{25}\) yet over half of preterm labor episodes do not result in preterm births, meaning that there is overtreatment and many unnecessary hospitalizations for premature uterine contractions and suspected preterm labor.\(^{26}\) Therefore, better tools for diagnosing true preterm labor are essential. Previous preliminary studies have shown that measuring myometrial electrical activity may help identify patients in true preterm labor, but additional studies in that area are required.\(^{19,27}\)

Intrauterine pressure measurement is considered the most objective way of measuring uterine activity in labor, and in this respect it is superior to clinical assessment or external tocography.\(^{28}\) However, there are technical difficulties while using the IUPC.\(^{29,30}\) In 14.85% of the cases in our study, we had poor quality during part of the recordings, problems with balancing the baseline before measuring contractions, or difficulties with an occult or displaced catheter that had to be resolved prior to assessing uterine activity. We en-
countered no difficulties with the EUM, which emphasizes another benefit of this method. Published data supports that electrohysterographic contraction detection correlates with IUPC better than tocometry in patients with high body mass index.\textsuperscript{15} Given the high correlation between EUM and IUPC that was shown in the current study, EUM may have an advantage over the tocometry in overweight patients, as well.

Transabdominal uterine EMG with technology that is similar to that of the EUM has been shown to correlate with external tocometry and with IUPC. However, the number of patients analyzed was small and lacked statistical power to determine the accuracy of the method.\textsuperscript{15,30-32} Moreover, the wave curve was not described.\textsuperscript{15,27} The device and software used in the current study enable an integration of EMG signals detected from 9 points of the uterus in a way that enables not only an accurate evaluation of the beginning, peak, duration, and intensity of the contractions but also an evaluation of the progression of the contraction wave and calculating the area under curve similar to the current evaluation of the Montevideo but in a noninvasive technology.

The qualities of the EUM make it suitable for accurate evaluation of uterine contractions. It is a potential diagnostic tool for preterm labor, although further investigation is needed to support this hypothesis. Based on the results of the current study, we believe that EUM yields information about uterine contractility comparable to that obtained with IUPC.

REFERENCES


