Uterine electric activity during the third stage of labor; a look into the physiology of a deserted stage

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Abstract

Objective: To evaluate uterine activity during the third stage of labor and compare it to that observed in the second stage of labor.

Study design: Uterine electric activity was prospectively measured using electrical uterine myography (EUM) in 44 women with singleton pregnancy at term during the final 30 min of the second stage and throughout the third stage of labor. Results are reported using a scoring index of 1–5 mWS (micro-Watt-Second). Patients were stratified into two groups based on the duration of the third stage (<15 min and >=15 min).

Results: The mean durations of the second and third stages were 51.9 ± 62.5 and 15.4 ± 7.5 minutes, respectively. During the third stage, uterine activity (contractions peaks) was similar to that observed during the second stage of labor (3.43 ± 0.64 mWS versus 3.42 ± 0.57 mWS, p = 0.8). No correlation was found between the duration of the third stage and EUM measurements during the third (p = 0.9) or the second (p = 0.2) stages of labor. No association was found between EUM measurements during the third stage and parity, maternal age, fetal weight, duration of labor, gestational age, gravity or BMI. The rate of oxytocin use during the second stage and EUM measurements during the second or third stage did not differ among women with short versus long duration of the third stage.

Conclusion: Uterine activity during the third stage is comparable and as intense as that occurring during the second stage. Third stage length cannot be predicted by contraction intensity during the second or third stage of labor.

Keywords

Delivery, electrical uterine activity, myography, third stage

Introduction

The third stage of labor is defined as the time interval from delivery of the fetus to the expulsion of the placenta and membranes. It is a relatively short albeit important interval due to its possible complications, most importantly (PPH). Better understanding of the physiologic events occurring during this stage may aid in reducing maternal morbidity and mortality. Several studies conducted over half a century ago have described uterine activity during the third stage of labor [1–3]. However, those studies used different techniques to evaluate uterine contractions in the second and third stage [1], and their techniques measuring uterine activity were not easily clinically applicable [1–3]. Since these classic publications, limited data exists concerning the physiology of uterine contraction throughout the third stage [4]. The scarcity of data regarding uterine activity during the third stage of labor may partly be attributed to technical limitations of measuring uterine contraction along this phase utilizing conventional measures [5,6]. In contrast to tocodynamometry which is limited by its inability to assess uterine contraction following the emptying of the uterus, intrauterine pressure catheter (IUPC) could be used to measure uterine activity in the third stage of labor [3,7,8]. However, it is an invasive method often accompanied by patient discomfort as well as an increased risk for uterine infection and perforation [9,10].

In an attempt to overcome these disadvantages and yet provide a measuring tool for uterine activity, an option which is not invasive on the one hand and precise on the other is needed. Accordingly, uterine muscle electromyography (EMG) is an alternative measure for assessing uterine activity. While most EMG devices utilized only two electrodes, a novel EMG device has been developed which includes nine electrodes and a positional sensor (EUM-100, OB-Tools Ltd, Migdal Haemek, Israel). It provides valuable data about contraction intensity, duration and interval, and was validated in comparison with other measures of uterine activity [11–14].

Therefore, we aim to characterize uterine electrical activity following the delivery of the fetus and throughout the third stage of delivery.
Materials and methods

Study population
We conducted a prospective study of women undergoing vaginal labor and delivery of a singleton pregnancy at term between December 2011 and May 2012. The study was approved by the local institutional review board, and all women provided written informed consent.

All women delivered a spontaneous vaginal delivery. The third stage of labor was defined as the time interval from the delivery of the fetus to the expulsion of the placenta. The uterine electrical activity was measured using the EUM-100 device (OB-Tools Ltd, Migdal Haemek, Israel) during the final 30 min of the second stage and throughout the third stage of labor. Our local protocol for active third stage management does not include administration of oxytocin until the placenta has been delivered, thus EUM measurements along the third stage was not affected by uterotonic drugs.

The EUM device
A novel EMG device, EUM-100, was used to measure the electrical uterine activity. The system is comprised of a multichannel surface electromyogram, a three-dimensional position sensor and a personal computer providing data analysis and a graphical user interface.

The surface EUM activity is acquired by nine electrodes evenly placed on the patient’s abdomen and a tenth common ground electrode on the patient’s left thigh. After placement of the electrodes, their exact locations are determined using a three-dimensional position sensor (miniBird; Ascension Technology, Burlington, VT). If the patient changed position during the EUM monitoring, the relative position of electrodes does not change significantly because the spacing of the electrodes compensates for such movements. The measurement of EUM signals together with their physical location provides an accurate estimation of the uterine activity in the three-dimensional space.

Uterine muscle activity is quantified using the EUM index which is defined as the mean electrical activity of the uterine muscle over a period of 10 min and is measured in units of micro-Joule (micro-Watt-Second, mWS) with an automatic data analyzer blinded to clinical outcome.

Measurement of EUM activity
EUM activity was recorded along the active phase of delivery including the final 30 min of the second stage of labor and throughout the third stage of labor.

As the fetus is expelled, the uterus is reduced by size. The receiving electrodes which are attached to the abdominal surface simultaneously change their position accordingly so they remain placed over the reduced sized uterus. This was ascertained by the researcher, and in place of need the researcher adjusted the electrode placement correctly over the uterus for the duration of the third stage. To validate the signals measured during the third stage of labor are those of the contracting, reduced size uterus, we also studied four non-gravid women who were similarly connected to the device for 30 min. No EUM activity was recorded in these non-gravid women whose uterus is at a reduced size position. Indeed, in those non-laboring women, no such activity was expected. This confirms the electrical activity recorded during the third stage was in fact that of the contracting uterus.

EUM data was not available to the treating physician or to the research team. All clinical decisions were based on the routinely used external tocodynamometer during the second stage.

Statistical analysis
We analyzed EUM activity measured during the third stage of labor and compared it to that measured in the second stage of labor. Patients were stratified into two groups based on the duration of the third stage. We defined short third stage duration as less than 15 min and long third stage as equal or more than 15 min. Demographic and obstetrical variables were compared between the groups. Data analysis was done with the SPSS v17.0 software (SPSS, Chicago, IL, USA). Student’s t-test was used to compare continuous variables, and the chi-squared test was used for categorical variables. Differences were considered significant when the p value was less than 0.05.

Results
The study population included 49 pregnant women recruited in the first stage of labor. Of these, one patient underwent cesarean section due to suspected fetal non-reassuring fetal heart rate; one patient underwent manual removal of the placenta due to suspected retained placenta; and another three women withdrew consent. Thus, data from 44 parturient were available for analysis. The demographic and clinical characteristics of the participants are presented in Table 1.

Third stage contraction intensity measured by electrical uterine myography
The average EUM value measured during the third stage was 3.42 ± 0.57 mWS. No significant correlation was found between contraction intensity as measured by EUM during the third stage and demographic characteristics as parity (p = 0.536), maternal age (p = 0.345), gestational age (p = 0.561), fetal birth weight (p = 0.546) and duration of the second stage of labor (p = 0.26) or duration of the third stage of labor (p = 0.968)

Table 1. Demographic and obstetrical characteristics.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Average ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>21–40</td>
<td>31.6 ± 4.7</td>
</tr>
<tr>
<td>Gestation</td>
<td>1–11</td>
<td>2.95 ± 1.9</td>
</tr>
<tr>
<td>Parity</td>
<td>0–4</td>
<td>1.52 ± 1.15</td>
</tr>
<tr>
<td>Week of gestation</td>
<td>36–41</td>
<td>39.25 ± 1.16</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2606–4022</td>
<td>3335.73 ± 355.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode of delivery</th>
<th>No. of parturients</th>
<th>Percentage n = 45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal vaginal delivery</td>
<td>41</td>
<td>91.1</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>Vacuum-assisted vaginal delivery</td>
<td>3</td>
<td>6.6</td>
</tr>
<tr>
<td>Augmentation of labor with oxytocin</td>
<td>16</td>
<td>36.4</td>
</tr>
</tbody>
</table>
Comparison between second and third stage electrical uterine myography

Duration and intensity

The mean durations of the second and third stages of labor were 51.9 ± 63.5 (range 3–213 minutes) and 15.4 ± 7.5 (range 2–44 min) min, respectively.

EUM activity during the third stage was as intense as that measured during the second stage and no difference was found among the overall power of contraction peaks during the third stage to those measured during the second stage of labor (3.43 ± 0.64 mWS versus 3.42 ± 0.57 mWS, respectively, \( p = 0.8 \)) (Table 2). No correlation was found between the duration of the third stage and EUM contraction intensity measurements during the third (\( p = 0.9 \)) or the second (\( p = 0.2 \)) stages of labor.

Paired student \( t \)-test shows that for a given parturient, a high correlation exists between contraction intensity measurements during the second and the third stage of labor (\( p < 0.001 \)) (Figure 1).

Table 2. Mean EUM index and duration of second and third stage of delivery.

<table>
<thead>
<tr>
<th>Second stage</th>
<th>Third stage</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length range (min)</td>
<td>3–213</td>
<td>2–44</td>
</tr>
<tr>
<td>Length avg. (min)</td>
<td>51.9 ± 63.5</td>
<td>15.4 ± 7.5</td>
</tr>
<tr>
<td>EUM (mWS)</td>
<td>3.42 ± 0.574</td>
<td>3.43 ± 0.643</td>
</tr>
</tbody>
</table>

EUM – electrical uterine myography. Data is presented as Mean ± Standard Deviation, N/A, not applicable.

Table 3. Comparison between women with short versus long third stage of delivery.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n = 24)</th>
<th>Group 2 (n = 20)</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>31.3 ± 5.0</td>
<td>31.95 ± 4.65</td>
<td>0.66</td>
</tr>
<tr>
<td>Gestational age (wks)</td>
<td>39.5 ± 1.1</td>
<td>38.95 ± 1.19</td>
<td>0.12</td>
</tr>
<tr>
<td>Gravity</td>
<td>2.63 ± 1.4</td>
<td>3.35 ± 2.39</td>
<td>0.21</td>
</tr>
<tr>
<td>Purity</td>
<td>1.5 ± 1.25</td>
<td>1.55 ± 1.05</td>
<td>0.88</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>26.9 ± 4.06</td>
<td>28.68 ± 3.51</td>
<td>0.22</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>3368.21 ± 371.86</td>
<td>3296.75 ± 340.8</td>
<td>0.51</td>
</tr>
<tr>
<td>EUM second stage</td>
<td>3.52 ± 0.57</td>
<td>3.3 ± 0.561</td>
<td>0.21</td>
</tr>
<tr>
<td>(mWS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EUM third stage</td>
<td>3.46 ± 0.71</td>
<td>3.38 ± 0.56</td>
<td>0.67</td>
</tr>
</tbody>
</table>

EUM – electrical uterine myography. Data are presented as Mean ± Standard Deviation.

Figure 1. Correlation between the second and third stage of delivery by EUM activity. EUM – electrical uterine myography; mWS – micro-Watt second.
Discussion

We aimed to characterize electrical myometrial activity during the third stage of delivery using a novel EMG device. Our main findings were: (1) overall, the third stage of delivery is characterized by similar uterine activity and intensity of contractions to that observed during the second stage. (2) For a given woman in labor, a high correlation exists between intensity of uterine contraction in the second and third stages of labor. (3) No correlation was found between the duration of the third stage and EUM measurements during the second or third stage. (4) Contractions intensity during the third stage is unrelated to clinical as well as demographic characteristics as parity, maternal age, fetal weight and duration of labor.

Third stage pathologies are accountable for a substantial amount of morbidity and mortality associated with labor and delivery [15]. Outlining of the physiologic events taking place during a normal third stage of labor and at the same time providing a good clinical tool that obviates the risks accompanying this assessment remains a prerequisite for improving its management as well as preventing its major impact complications.

While extensive research has been devoted to uterine contractions during the first and second stages of labor, relatively little attention has been drawn for characterizing uterine contractions during the third stage of labor.

Placental separation has long been recognized as the hallmark of the third stage. Current understanding of this process is incomplete. A century ago Duncan and Shultze proposed the role of retro-placental hematoma as the major event causing this separation [16]. This theory was later challenged and denied by various authors [17–19]. A possible mechanism proposed by Reinolds [20] was that forceful uterine contractions induce shear forces between the uterine wall and the stiffer tissue of the placenta, and cause the separation of the placenta. This assumption was supported by sonographic observations [21]. However, this observation is limited to sonographic view of uterine contractions and not by standardized measurements of electrical uterine activity, of which documentation is lacking.

Classic reports have described uterine activity during the third stage of labor. Alvarez and Caldeyro assessed the uterine activity during the third stage by connecting a mercury manometer to the umbilical vein by thus recording the pressure exerted on the placenta by the contractions [1]. They showed that the uterus continues to perform rhythmical painless contractions with intensity similar to those of the first and second stage. In their work, different methods were used to assess uterine activity before and following birth. Later on Caldeyro-Barcia and Poseiro reported early third stage contraction intensity of approximately 80 mmHg by measuring internal pressure [2]. Confirmation of this work was provided by Hendrix in 1968 reporting uterine contractions after birth were nearly identical to those resulting in delivery of the infant [3].

These previous attempts to evaluate third stage uterine activity had few limitations: (1) different modalities were used before and after birth, making the comparison between the two stages problematic. (2) Invasive techniques such as IUPC were used which pose risks of infection, placental and fetal harm or uterine perforation [6–7]. (3) Some of the techniques used are not adequate for routine clinical evaluation.

In our study, the use of a novel EMG device, allowed us to overcome these limitations. We evaluated uterine activity during the third stage in a noninvasive manner, and in continuity with the second stage for comparison.

Several earlier studies have validated the use of EUM for assessing uterine contractions during labor. The device provides valuable data concerning contraction intensity, duration and interval, and strongly correlates with other measures of uterine activity [11,12,22,23]. In one study, women in labor were monitored simultaneously with an IUPC and EUM. It has been shown that EUM accuracy in assessing contractions intensity is comparable to that of intrauterine pressure catheter which is considered as gold standard for evaluating uterine contractions [12].

Electrical uterine activity during the third stage of labor has not been reported before. There is a substantial reduction in uterine size following the delivery of the fetus, yet with replacement of electrodes over the reduced size uterus similar electrical activity is measured during the third stage as well. This activity does not present when studying EUM activity in non-gravid patients as no electrical activity is expected, affirming the activity measured was indeed that of the contracting uterus.

Importantly, EUM carries the advantage of allowing comparison of contraction power prior to and following delivery of the fetus using the same modality. This comparison reveals that overall myometrial activity along the third stage is as intense as that measured during the second stage and implying that the contractions required for completion of the delivery of the placenta are of the same fortitude as those generated for the expulsion of the fetus. While a wide range of contraction intensity is measured (in mWS) for different women during labor and delivery, for a defined woman in labor we found a strong correlation between the intensity of uterine contraction in the second and third stages. This finding might suggest that a certain myometrium is capable of generating typical contraction intensity.

Another finding is that uterine contractions intensity during the third stage was found to be independent of various clinical and demographic variables such as parity, maternal age, fetal weight and duration of labor. We speculate that placental separation and expulsion may be an autonomous process of labor that does not depend upon specific parturients characteristics or the birth process rather than intensity and power of myometrial contractions, yet this should be verified by larger-scale investigations.

Our study has a few limitations. The study was observational and not interventional, thus delivery was managed by physician’s preference. Therefore, some of the women were treated with oxytocin during active labor, yet not during the third stage as administration was halted until completion of placental delivery. Some of the women were under epidural analgesia. Both these interventions are known to affect uterine contractions and may affect EUM recordings reported.
Furthermore, a larger sample size may enable us to better define differences among the groups. Nevertheless, our study provides novel information regarding the physiology of contractions along the third stage of labor, and is the first to noninvasively quantify contraction intensity during this period, as well as compare it to second stage contractions using the same modality.

Our work suggests EUM may provide a clinically applicable, noninvasive tool allowing real-time quantification of third stage uterine contractions.

Additional studies are needed to study EUM activity over the course of complicated third stage of delivery such as uterine atony, PPH and retained placenta to allow better understanding and furthermore treating these pathologies.

**Declaration of interest**

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

**References**