Electrohysterographic evaluation of preterm contractions in a patient with a unicornuate uterus

JANNEKE VAN 'T HOOFT1*, CHIARA RABOTTI2 & S.GUID OEI2,3

1Department of Obstetrics and Gynecology, Academic Medical Center, Amsterdam, 2Department of Electrical Engineering, Eindhoven University of Technology, Eindhoven, and 3Department of Obstetrics and Gynecology, Máxima Medical Center, Veldhoven, the Netherlands

Key words
Electrohysterogram, myometrial conduction, prediction, preterm delivery, unicornuate uterus

Correspondence
Janneke van’t Hooft, Department of Obstetrics and Gynecology, Academic Medical Center, Meibergdreef 9, 1105 AZ Amsterdam, the Netherlands. E-mail: j.vanthooft@amc.nl

Conflict of interest
The authors have stated explicitly that there are no conflicts of interest in connection with this article.


Abstract
Women with Müllerian anomalies are at increased risk of preterm labor. The analysis of parameters derived by the electrohysterogram such as its conduction velocity are promising for preterm delivery prediction. However, an electrohysterogram has never been measured in Müllerian anomalies. A multiparous woman with a unicornuate uterus presented at 28 weeks of gestation with preterm contractions. Three electrohysterogram recordings were performed between 28 and 30 weeks of gestation, 4 weeks before delivery. The conduction velocity values were in line with previous literature and differed significantly (p < 0.001) showing an increase between the first and last two recordings. The parameters derived from the electrohysterogram such as conduction velocity and power density spectrum peak frequency are promising ones to follow the evolution of pregnancy towards labor, and to distinguish between productive and unproductive uterine contractions, in the case of a unicornuate uterus as well as one that is normally developed.

Abbreviations: CV, conduction velocity; PDS, power density spectrum; pf, peak frequency.

Introduction
Preterm birth is one of the most important causes of neonatal morbidity and mortality. To date no methods in clinical use can properly predict preterm labor. There is evidence that the analysis of the electrohysterogram, an external uterine electromyogram, is a useful method for differentiation between productive and unproductive contractions and it is therefore a potential predictive tool in preterm labor (1). However, there are no data evaluating these techniques in cases of Müllerian anomalies, including unicornuate uterus. The incidence of preterm delivery is high in this group of patients (20.1% in unicornate uterus only) (2). Electrohysterogram measurements on this specific group of patients could contribute to the understanding of the mechanism behind preterm delivery, both in this situation and as regards the mechanisms behind preterm delivery for normal uterine development.

The different types of Müllerian embryological origin anomalies are classified by the American Fertility Society (3). One or both of the Müllerian ducts fail to finish an essential developmental step, namely elongation, canalization, fusion or septal resorption. In a unicornate uterus, failure in the elongation and canalization development can be either partial or complete. The unicornate uterus constitutes roughly 5% of the constellation of all uterine malformations and has a reported incidence of 1:4020 women in the general population (2).
We performed three electrohysterogram measurements on a patient with a unicornuate uterus admitted to our hospital due to preterm contractions. To the best of our knowledge this is the first article describing an electrohysterogram measurement on a patient with a Müllerian anomaly.

Material and methods

A 26-year-old woman, gravida 3 para 2, with a documented unicornuate uterus with a non-communicating rudimentary horn, presented at 28+0 weeks’ gestation with complaints of painful regular uterine contractions. The patient’s past obstetrical history included preterm contractions in her first and second pregnancy starting at 36+5 and 35+0 weeks, respectively. In her first pregnancy she delivered at 36+5 weeks after induction of labor due to fetal growth restriction. In her second pregnancy she received tocolytic medication but remained contractile for over 3 weeks, delivering spontaneously at 38+2 weeks.

The present pregnancy was uneventful until 28 weeks. On physical examination uterine contractions were visible externally and the tocodynamometer recording showed contractions with an interval of 2–5 min. The fetal fibronectin test was positive. No cervical changes were found on digital examination and no vaginal bleeding was observed. Transvaginal ultrasonography revealed a cervical length of 28 mm without funneling. No urinary tract infection was detected. Based on the clinical presentation and the positive fetal fibronectin test, the patient was defined as at risk for preterm delivery. She received a tocolytic agent rectally (100 mg indomethacin) followed by doses of oral tocolytics (nifedipin) spread over 48 h together with intramuscular betamethasone (12 mg) for fetal lung maturation. She was referred to our hospital due to insufficient neonatal backup at the previous hospital.

At our hospital, uterine contractions ceased rapidly but returned inconsistently after 2 days of admission. Fetal tracing and ultrasonography suggested a good fetal condition with normal growth, cephalic presentation and anterior placentation. No cervical changes were found on repeated digital examination and transvaginal ultrasonography. Due to a stable clinical condition and advanced gestational age, the patient was discharged at 30+0 weeks. However, she remained contractile until she spontaneously delivered at 34+2 weeks at the hospital of first admittance. The delivery was uncomplicated but, due to its premature age, the child had to be admitted to the neonatal ward.

After informed written consent, we performed three electrohysterogram measurements using a 64-electrode grid (1-mm electrodes with a 4-mm inter-electrode distance) placed 5 cm below the umbilicus on the midline of the abdomen, with a couple of bipolar electrodes and an accelerometer (to detect movements) on top of the grid. Ground and reference electrodes were placed on the hip (Figure 1). The first measurement was recorded at 28+6 weeks, 3 days after finishing tocolytic medication and approximately 5 weeks before delivery. The second and third recordings took place at 29+3 and 29+6 weeks (10 days after tocolytic medication and 4 weeks before delivery). All recordings lasted 30 min and were obtained in the afternoon around the same time of day.

After anti-aliasing low pass filtering, the electrohysterogram signal was recorded and digitized at a sampling frequency of 1024 Hz. Due to the low frequency content of these types of signals (4), most of the unwanted noise present in the electrohysterogram could be removed by band-pass filtering between 0.34 and 1 Hz (1,5). Finally, by down-sampling the signal up to 100 Hz, a reduction of the computation time could be achieved while keeping high the resolution of the derived power density spectrum (PDS) peak frequency (pf). All analyses were performed using MATLAB® (The Math Works®, Natick, MA, USA), exclusively during contractions. To this end, for each recording, contractions were estimated from the electrohysterogram signal using the method proposed by Rabotti et al. (6). Of all the segments which showed an increase of uterine activity in the estimated signal, the time intervals with the following requirements were selected for further analysis: a clearly visible contraction in the simultaneously recorded tocogram and a clear feeling of contraction by the woman. Selected contractions with a high movement artifact on the accelerometer were excluded.

Eventually, 21 contractions were selected independently by two of the authors. There was no disagreement on the selection. The PDSpf was calculated in each selected contraction segment individually for each channel. For the

Figure 1. Sensors used for recording: (a) tocodynamometer; (b) grid with accelerometer on top; (c) couple of bipolar electrodes; (d) ground and reference electrodes.
Electrohysterography in unicornuate uterus

J. van’t Hooft et al.

analysis of the conduction velocity (CV) in the individual spikes within the contraction burst, we used the algorithm proposed by Rabotti et al. (5) due to its accurate and high-resolution estimation of amplitude and direction for the CV vector. Only spikes propagating linearly through the grid were selected. A total of 1011 windows were analyzed with an average of 48 windows (minimum 23 and maximum 60) for each contraction segment.

The mean CV and PDSpf of each contraction segment were calculated. Moreover, to evaluate the combination of both electrohysterogram parameters, the PDSpf was multiplied by 100 and added to the corresponding CV, as described earlier by Lucovnik et al. (1). To define the differences in CV and PDSpf of the contractions on the three measurements performed, a one-way analysis of variance (ANOVA) test was used.

Results
By comparing the three measurements performed between 28 and 30 weeks of gestation (4 weeks before preterm spontaneous delivery), a significant increase of the CV and CV+PDSpf combination values was found between measurement 1 and measurements 2 and 3. None of the three measurements shows a significant difference for the PDSpf values alone. The results are presented in Table 1.

Discussion
Patients with a unicornuate uterus face many challenges. A review reported the following rates of obstetrical complications: 2.7% ectopic pregnancy, 24.3% first trimester abortion, 9.7% second trimester abortion, 20.1% preterm delivery, 10.5% intrauterine fetal demise, and 49.9% live births (2). A diminished muscle mass, abnormal uterine blood flow, and cervical incompetence are the three most reported explanations supporting the etiological differences in this group compared with normal uterine development (2).

In the case of preterm delivery, the congenital reduction in muscle mass of the unicornuate uterus is thought to play a major role in the onset of preterm contractions (2). Moreover, a tendency for reduction in myometrial thickness as gestation advances and additional wall thinning as a result of uterine contractions are reported (7). However, no physiological explanation for the relation between the reduced muscle mass and the concomitant increased risk for preterm delivery was given. Despite this increased risk, preterm contractions in patients with a unicornuate uterus are not necessarily productive contractions, i.e. contractions that lead to preterm delivery (the past obstetrical history in the presented case report is an example of this).

It has been previously suggested that the physiological process of the electrical activity of the uterus underlies the differentiation between productive and unproductive contractions (1,6,8). The formation of gap-junctions as labor approaches enhances the coordination among myometrial cells which is required for effective contractions (8). Being representative of the uterine electrical activity, the electrohysterogram can therefore support the characterization of uterine contractions. A previous clinical study recently reported on the accuracy of electrohysterogram-derived parameters such as CV and PDSpf in assessing the productiveness of the contractions (1).

In this study we evaluated the CV and PDSpf longitudinally. Although the results must be interpreted with care, as they representing one case only, they provide interesting insights as a clear example of unproductive preterm uterine contractions (1), since delivery occurred after more than 7 days. The CV and PDSpf values were within the range of values previously described for such contractions (1). Secondly, the significant duplication of the CV values in only 1 week’s time theoretically gives an indication of the gap-junction formation and therefore the preparation of the uterus towards delivery. While extensive evidence of the PDSpf increase as labor approaches can be found in the literature, the CV has not been studied longitudinally during pregnancy. This finding could be of clinical use, giving valuable information on the preparation phase of the uterus towards delivery beyond 7 days after performance of the measurement. This suggests that

<table>
<thead>
<tr>
<th>Electrohysterogram-parameter</th>
<th>Measurement 1 (n = 7)</th>
<th>Measurement 2 (n = 7)</th>
<th>Measurement 3 (n = 7)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean CV (cm/s)</td>
<td>11.96 ± 3.39*†</td>
<td>22.19 ± 2.44</td>
<td>27.80 ± 7.13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean PDSpf (Hz)</td>
<td>0.37 ± 0.02</td>
<td>0.43 ± 0.07</td>
<td>0.40 ± 0.03</td>
<td>0.054</td>
</tr>
<tr>
<td>Mean CV + Mean PDSpf</td>
<td>48.81 ± 4.07*†</td>
<td>65.47 ± 0.02</td>
<td>67.80 ± 0.02</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

n: number of contractions analyzed.
*Measurement 1 significantly different from measurement 2 (p = 0.002).
†Measurement 1 significantly different from measurement 3 (p < 0.001).
‡Measurement 1 significantly different from measurements 2 and 3 (p < 0.001).
analyzing the electrical activity underlying contractions is more informative than looking at the mechanical contraction alone. In spite of the abnormal uterine development in this patient, the physiological process of preparing for labor seems to be similar to that in a normally developed uterus. The electrohysterogram parameters, such as CV and PDspf, are promising to follow the evolution of pregnancy towards labor, as they distinguish between productive and unproductive uterine contractions.

**Acknowledgements**

Marit Leermakers, MD, for support with the measurements.

**Funding**

No special funding.

**References**


