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Control of Electrical Activity of the Human Uterus during Pregnancy and Labor/Delivery

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I. INTRODUCTION

The uterus of pregnant women is known to produce biopotentials wave forms which produce contractions. Similarly, contractile activity can itself initiate electrical activity through mechanotransduction pathways. Aims: In these studies of pregnant patients, we used electromyographic (EMG) recording methods and new approaches to study uterine vector analysis, commonly used for the heart: vectorcardiography analysis and methods to evaluate mechanotransduction.

II. METHODS

Patients were: 1) Patients at term not in labor (n=3); 2) Patients during 1st stage of labor at cervical dilations from 2 to 10 cm (n=30); and 3) patients in the 2nd stage of labor and during delivery (n=3). We used dc-coupled electrodes and PowerLab hardware (model # PL2604, ADInstruments, Castle Hill, Australia), with software (LabChart, ADInstruments) for storage and analysis of biopotentials. Uterine and abdominal EMG recordings were made from the surface of each patient using 3 electrode pairs with 1 pair (+ and –, with 31 cm spacing distance) placed in the right/ left position (X position) and with 1 pair placed in an up/down position (Y position, also 31 cm apart) and the third pair at the front/back (Z position).

III. RESULTS

Using signals from the three X, Y and Z electrodes, slow (0.03 to 0.1 Hz, high amplitude) and fast wave (0.3 to 1 Hz, low amplitude) biopotentials were recorded. The amplitudes of the slow waves and fast waves were significantly higher during the 2nd stage of labor compared to the 1st stage (respectively, $p = 9.54 \times e^{-3}$ and $p = 3.94 \times e^{-7)}$. When 2 channels were used, for example the X vs. Y, for 2-D vector analysis or 3 channels, X vs. Y vs. Z for 3-D analysis, are plotted against each other on their axes, this produces a vector electromyometriogram (EMMG) that shows no directionality for fast waves and downward direction for slow waves. Similarly, during the 2nd stage of labor during abdominal contractions ("pushing") the slow and fast waves were enlarged. Manual applied pressure was used to evoke bioelectrical activity to examine the mechanosensitivity of the uterus.

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IV. DISCUSSION & CONCLUSION

1) Phasic contractility of the uterus is a product of slow waves and groups of fast waves (bursts of spikes) to produce myometrial contractile responses;
2) 2-D and 3-D uterine vector analysis (uterine vector electromyometriogram) demonstrate no directionality of small fast waves while the larger slow waves represent downward direction of biopotentials towards the cervical opening;
3) Myometrial cell action event excitability and subsequent contractility likely amplifies slow wave activity input and uterine muscle contractility via mechanotransduction systems;
4) Models illustrate the possible relationships of slow to fast waves and the association of a mechanotransduction system and pacemaker activity as observed for slow waves and pacemakers in gastrointestinal muscle.
5) The interaction of these systems is thought to regulate uterine contractility.
6) This study suggests a potential indicator of delivery time. Such vector approaches might help us predict the progress of gestation and better estimate the timing of delivery, gestational pathologies reflected in bioelectric events, and perhaps the potential for premature delivery.

Instant Amplitude and Frequency of Uterine Action Potentials during labor

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Abstract— **The noninvasive uterine electromyogram signal acquisition method or electrohysterography, EHG, has been used to study the electrical dynamics of the miometrium during pregnancy, labor and delivery. The EHG shows intermittent action potentials when the uterus is at rest and burst of action potentials are presents during labor myometrial contractions. This work explores changes in the instant frequency and amplitude associated of uterine contractions and activity between them. Additionally, the sample entropy was calculated for both types activity**

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Classification and functional relationships of EMG signals occurring between and during uterine contractions of labor

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Abstract—**Electromyography (EMG) is an established technique that is used to non-invasively assess muscle function. EMG has been used to assess function of the pregnant uterus for decades, however, methods of obtaining data, processing signals, or interpreting results have not been standardized. Indeed, even the important signals produced by the pregnant uterus during labor are unclear. We have developed an EMG sensor specifically to assess the status of the pregnant uterus. The sensor was designed to provide spatial filtering parameters that correspond to uterine regions, which are intermediate contractile units of the laboring uterus. The size of the regions is determined by the mean distance an action potential can propagate within the uterine wall. While the design of the regional sensors was intended to facilitate reporting the activities of individual regions, in clinical testing we identified two reproducible classes of bioelectrical signals that were expressed between contractions.**

These classes can be characterized as
1. Mixed amplitude, uniform frequency signal with a form similar to skeletal muscle fasciculations (which we call the "fasciculation-like signal", FLS);
2. Uniform amplitude, uniform frequency signal associated with oxytocin exposure (which we call the "Oxytocin-Associated Signal", OAS).

Signals occurring between contractions are distinct from the mixed frequency, mixed amplitude signal produced during a regional contraction (which we call the "Contraction-Associated Signal", CAS). Here we characterize each of these three signal types by frequency distribution and amplitude distribution. Further, we standardize nomenclature of regional bioelectrical signals relative to the expression of the associated physiological role.

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