Uterine Electromyography in Humans – Contractions, Labor, and Delivery

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Abstract— **Today's maternal/fetal monitoring lacks the capability to diagnose labor and predict delivery. The objective of this work was to demonstrate that uterine electromyography (EMG) is proven to be a viable alternative to current monitoring techniques. Uterine EMG was monitored non-invasively and trans-abdominally from pregnant patients using surface electrodes. Several aspects of the uterine EMG were investigated: contraction plotting, diagnosing labor, and predicting delivery. Contractions were seen to correspond well with tocodynamometer- (TOCO-) plotted contractions. As well, increases in electrical activity were indicative of labor and imminent delivery. Uterine EMG could be a valuable tool for obstetricians if implemented on a routine basis in the clinic.**

Keywords— **Uterus, electromyography, EMG, labor, diagnosis, prediction.**

I. Introduction

Labor is the physiologic process by which a fetus is expelled from the uterus, and is defined loosely as regular uterine contractions accompanied by cervical effacement and dilation.[1] Preterm labor, defined as labor before 37 weeks' gestation, is the most common obstetric complication and occurs in about 20% of pregnant women. In the United States alone, 10% of the 4 million infants born each year are premature. [2 and 3] At $1500 a day for neonatal intensive care, this constitutes a national health care expenditure well over $5 billion. [4] In addition, preterm labor accounts for 85% of infant mortality and 50% of infant neurologic disorders. Current tocolytic therapy has not decreased the rate of preterm delivery. It is argued that the failure of the current strategies to decrease the rate of preterm labor might be because once preterm labor is finally diagnosed, any therapeutic benefit is lost or temporary. Therefore, one of the keys to treating preterm labor would be early detection or prediction. What is called for is a better method of monitoring patient uterine contraction activity.

Previous studies have established that the electrical activity of the myometrium is responsible for myometrial contractions [5, 6]. As well, extensive studies have been done in the last 60 years to monitor uterine contractility using the electrical activity measured from electrodes placed on the uterus [7-9]. However, more recent studies indicate that uterine EMG activity can actually be monitored accurately from the abdominal surface [10-12]. Although tocodynamometer (TOCO) has routinely been used in the clinic to measure contractions [13], it has been shown to have limited predictive capability [14]. Root-mean-square (RMS) signal processing has been established as a standard method for plotting signal amplitude changes [15]. Spectral-temporal mapping has been used successfully to identify spectral changes that occur in biological electrical signals [16, 17].

II. Objectives

- To determine if uterine contraction events plotted using uterine electromyography (EMG) data, correlate with TOCO-plotted contraction events.
- To compare uterine electromyography of labor patients to ante partum patients.
- To determine whether delivery can be predicted using transabdominal uterine electromyography.

III. Material and methods

- 323 contractions vs. no-contraction events were observed from ten term-pregnant women, all of whom ultimately delivered spontaneously. Uterine EMG was measured non-invasively from the abdominal surface of each patient for 30 minutes. TOCO was used simultaneously to measure uterine contractions. The STM and RMS methods were applied to the uterine EMG data to generate contraction curves similar to TOCO "bell-shaped" curves. Correspondence between the raw uterine EMG bursts and the uterine contractions plotted by the various methods was established by looking for temporal overlap of the events.
- Fifty patients (group 1: labor, n = 24; group 2: ante partum, n = 26) were monitored using transabdominal electrodes. Group 2 was recorded at several gestations. Uterine electrical ''bursts'' were analyzed by power-spectrum from 0.34 to 1.00 Hz. Average power density spectrum (PDS) peak frequency for each patient was plotted against gestational age, and compared between group 1 and group 2.

A total of 99 patients were grouped as either term (37 weeks or more) or preterm (less than 37 weeks). Uterine

electrical activity was recorded for 30 minutes in clinic. EMG "bursts" were evaluated to determine the PDS. Measurement-to-delivery time was compared with the average power density spectrum's peak frequency. Receiver operating characteristic (ROC) curve analysis was performed for 48, 24, 12, and 8 hours from term delivery, and 6, 4, 2, and 1 day(s) from preterm delivery.

IV. Results

Kappa inter-rater agreement was excellent (0.823) between EMG, TOCO, RMS and STM. Significant correlation was found between all plots. There was no significant difference in the percentage of burst/contraction events plotted by EMG, RMS, and STM compared to TOCO (Fig. 1 - EMG: 114.32 ± 18.86 %; OCO: 100.00 ± 0.00 %; MS: 109.18 ± 17.05 %; STM: 102.73 ± 8.31 %).

To Group 1 was significantly higher than group 2 for gestational age (39.87±1.08 vs. 32.96±4.26 weeks) and average PDS peak frequency (Fig. 2 - 0.51±0.10 vs. 0.40±0.03 Hz).

The power density spectrum peak frequency increased as the measurement-to-delivery interval decreased. ROC curve analysis gave high positive and negative predictive values for both term and preterm delivery (Table 1).

Table 1

Labor	PPV	NPV	SENS	SPEC	GS	P
Term	.854	.889	.918	.625	1 day	< 0.01
Preterm	.857	.886	.600	.969	4 days	< 0.01

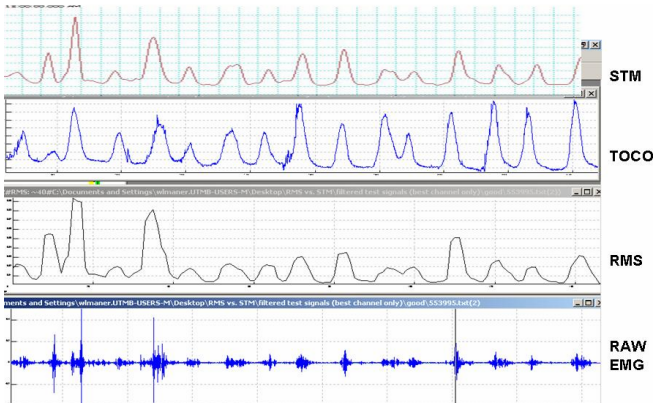

Fig. 1

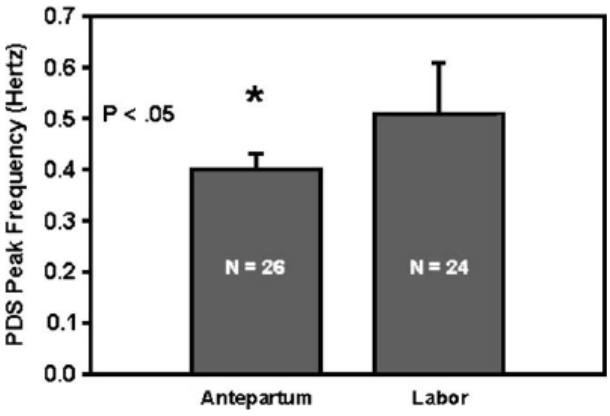

Fig. 2

At term, the average PDS peak frequency was significantly higher for the 24-or-fewer-hours-to-delivery group than for the more-than-24-hours-to-delivery group, whereas at preterm, the average PDS peak frequency was significantly higher in the 4-or-fewer-days-to-delivery group than in the more-than-4-days-to-delivery group (Fig. 3).

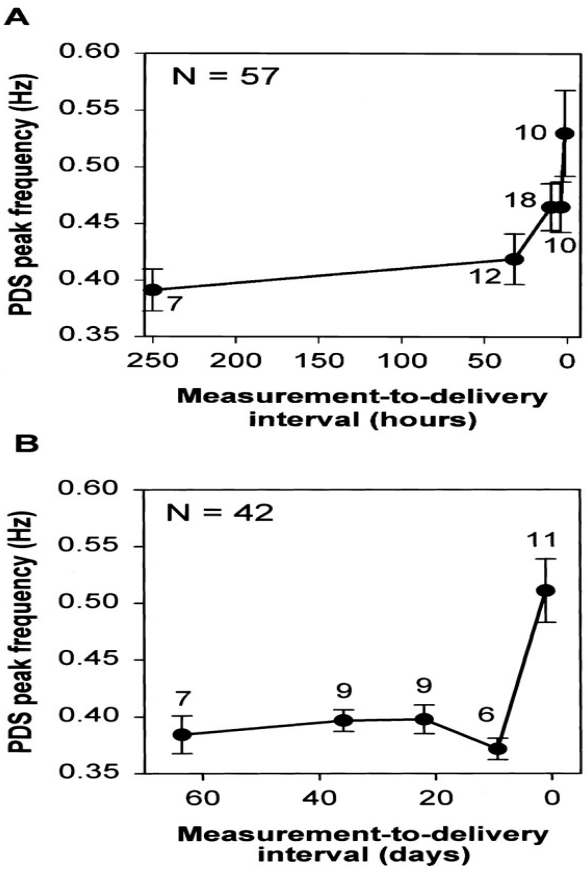

Fig. 3

V. Conclusions

Uterine EMG bursts correspond strongly to TOCO contraction plots. EMG-generated contraction plots (using RMS or STM) are statistically indistinguishable from TOCO contraction plots. So, for pregnant patients exhibiting myometrial activity, uterine EMG could be used in place of TOCO in the clinic for plotting contractions. Uterine EMG in antepartum patients is significantly lower than in laboring patients delivering <24 hours from measurement, giving uterine EMG the capability to diagnose labor in the clinic. Moreover, trans-abdominal uterine EMG predicts delivery within 24 hours at term and within 4 days preterm. This methodology offers many clinical advantages and benefits to obstetricians that are not currently available to them with presently used uterine monitoring systems. Supported by NIH R01-HD037480.

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