Directional uterine EMG sensors identify bioelectrical activity in obese patients

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BACKGROUND

- Monitoring labor contractions in obese parturients with legacy tocodynamometry can be challenging, but uterine electromyography (uEMG) offers a promising alternative.
- To accurately report contractions of true labor, and minimize false positives, uEMG measures local signals produced by 8-10cm uterine "regions" using directional Area Sensors (Figure 1).
- Area Sensors have already been validated in BMI <35kg/m^2 patients.
- Abdominal adiposity increases the distance from skin to uterus which also distorts the parallel alignment between the Area Sensors and uterus, which may impair the independence of the sensors.

OBJECTIVE

To determine if Area Sensors provide the signal independence needed to measure individual regional activity in obese patients with BMI ≥ 35kg/m^2

METHODS

- Secondary analysis of a prospective cohort study of singletons ≥ 30 wks GA presenting with regular contractions.
- Groups of 4 subjects each were created according to body mass index (BMI): 20-29.9, 30-34.9, and > 35kg/m^2.
- Six abdominal sensors were placed and distances between sensor pairs were recorded (Figure 1).
- Primary outcome: Presence of signal independence for sensors > 14 cm apart.
- Contraction monitoring is impeded when multiple sensors report the same signal (i.e. exhibit dependence). Appropriate sensor independence is achieved if 2 sensors separated by more than 14 cm produce uEMG signals without crosstalk. The measurement of channel crosstalk is detailed in Figure 2 legend.
- Crosstalk analysis was performed in 9 channel pairs in each of 4 contractions per subject.

Figure 1: Placement of directional Area Sensors

a) Schematic diagram of sensor placement.

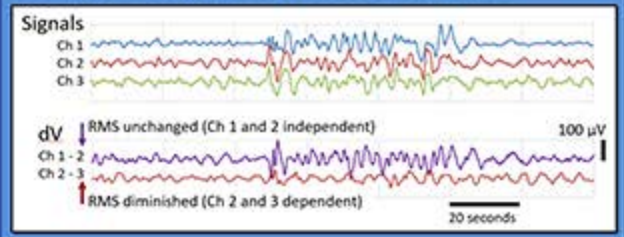
Each open-area hexagonal sensor corresponds to a specific uEMG channel. ECG pads were used for grounding, reference, and fetal heart rate. Contractions on uEMG were identified by computer algorithm. Distances between sensors were measured center-to-center (red line).

b) Patient surface view of open Area Sensor.

This view of the bottom of the directional sensor shows the electroconductive adhesive gel and silver chloride tape which allows for recording of uterine bioelectrical activity through the skin.

Figure 2: Channel crosstalk calculation

The upper panel shows raw voltage signals from ch1, 2 and 3 obtained from a subject with a BMI of 38kg/m^2. The lower panel shows the delta voltages (*dV*) of ch 1-2 and 2-3. The root mean squared (RMS) of ch1, ch2 and *dV* 1-2 were all similar, indicating minimal crosstalk between ch1 and ch2. Thus, these channels were labeled "independent". The RMS of *dV* ch 2-3 was <50% of the RMS of ch1. Diminished RMS indicates that 2 channels observed the same signal. Ch2 and Ch3 were labeled dependent.



RESULTS

- A total of 144 crosstalk analyses were performed for each BMI group.
  - 90.5% (n=391/432) of signals were independent.
- The frequency of independent signals was similar in the 20-29.9 (n=132), 30-34.9 (n=134), and >35 (n=125) BMI groups (p=.164).
- Mean sensor separation increased as a function of BMI group (Table).
- When sensors were ≤ 14 cm apart, signal dependence was the same for the 20-29.9 and 30-34.9 BMI groups but ~1.9 fold greater in the ≥ 35 BMI group.
- When sensors were > 14 cm apart, signal dependence was rare.

Table: Sensor separation and characteristics of dependent signals

BMI group (kg/m^2)	Mean Separation			% dependent signals	
	Sensors	Dependent signals	Independent signals	Separation ≤14 cm	Separation >14 cm
20-29.9	15.8 cm	11.0 cm	16.1 cm	14% (9/64)	2.5% (2/80)
30-34.9	17.7 cm	12.5 cm	18.4 cm	13% (7/52)	2.2% (2/92)
≥35	18.2 cm	13.4 cm	18.1 cm	25% (14/56)	2.3% (2/88)

Within each group, mean separation was greater for independent signals than dependent signals

CONCLUSION

The ability of Area Sensors to detect signal independence is not affected by obesity.

- In obese patients sensor distance from the uterus increases as a function of abdominal adiposity—*Our data proves that sensor independence is maintained when placed >14cm apart in patients with BMI >35kg/m^2.*
- Emerging technologies need to be effective in patients of all sizes to improve quality and safety of patient care.