Noninvasive Fetal ECG and Heart Rhythm Monitor

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Up to 30% of women have fetal complications during pregnancy. The most frequent is fetal hypoxia or distress - a physical stress, experienced by a fetus due to the lack of oxygen. Another serious problem is preterm birth. It is the leading cause of death in a newborn. In the United States about 12% of all babies, are born prior to 37 weeks gestation. Unfortunately the trend is expected to get worse.
The way for detecting symptoms of hypoxia and risk of preterm delivery is monitoring of the fetus heart rate and mother uterine activity.

At present, the basic methods for monitoring the heart condition of unborn baby is the ultrasound Doppler and cardiotocography.

However, the ultrasound methods have a number of disadvantages, and it exposes the fetus to prolonged ultrasound “lightening”, thus not absolutely safe.
Considerably more information for early detection of the fetal heart and rhythm disorders can be obtained by analyzing primary bioelectric signals. But monitoring the fetal ECG through abdominal surface is difficult due to the noises, co-existence of maternal and fetal ECG’s acquired from a patient, as well as the very low fetal signal level relative to the maternal ECG. Thus, the implementation of this technology requires to create high-quality hardware for recording an abdominal signals and advanced algorithms to process them.
The New monitor’s operation principle totally differs from the ultrasonic devices’ ones. The monitoring procedure looks as follows: several ECG electrodes are placed on the maternal abdomen, the electrodes are connected to the portable monitoring device. The electrical signal from the maternal abdomen surface is transmitted to a PC. The PC software extracts a fetal ECG tracing from signal and calculates the heart function of the fetus. The operational process if fully safe, non-invasive and passive, e.g. it does not require the fetal insonification.
The system is intended for monitoring and measurement the following heart activity parameters of the fetus and mother:

- Fetal Heart Rate (fHR), basal HR;
- Mother Heart Rate (mHR);
- Mother movement activity (MMov);
- FHR Accelerations and Decelerations;
- High and low variation episodes;
- The level of antenatal fetal distress;
- Fetus and mother heart rate variability (HRV);
- Fetal ECG morphology (PQ, QRS, QT intervals R, S, and T peaks amplitudes, ST level, etc.).
Fetal ECG monitor advantages:

- Non-invasive and passive fetal heart rate measurement;
- The quantity and time of inspection is not limited;
- The possibility to perform continuous fHR monitoring during 24 hours (fetal ECG holter);
- The wireless, small, light (sized as cell phone) recorder;
- No belt to fix CTG transducers;
- The high mHR and fHR measurement accuracy (“beat to beat”);
- The automatic fHR analysis (baseline, accelerations, decelerations, etc) in real time;
- The remote CTG data transferring (by Internet);
- User-friendly software interface.
The developed prototype consists of two parts:

- the set of 3/5/8 channel very low-noise recorders with wireless data transmission and internal memory for acquisition and recording of fetal ECG and electrical uterus activity signals;
- PC with analyzing software based on advanced original algorithms.
XAI-MEDICA fetal ECG monitor software

Fetal ECG extraction window
Fetal heart rhythm ("beat-to-beat")
XAI-MEDICA fetal ECG monitor software

CTG window (FHR and its parameters)
Character of Rhythmogram and type of regulation:
HRV Rhythmogram characterized by poorly expressed fast waves and expressed slow waves with their relative constancy. This character of rhythmogram and heart rhythm regulation reflects increasing of sympathetic influences and can be an evidence of possible pathological changes in heart regulation. Changes of vascular tone are possible.

Assessment of the Autonomic Nervous System:
Total power of HRV spectrum moderate (TP: 1384 ms2).
Level and ratio of vegetative influences in heart rhythm modulation (VLF: 228 ms2 (17%), LF: 695 ms2 (53%), HF: 391 ms2 (30%)) evidences in favor of relative prevalence of parasympathetic prevalence.

Mother HRV window (cardiac autonomic regulation)
Fetal HRV window (extremely low HRV, high risk of fetal death)
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Fetal ECG morphology window
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