Identifying Fetal Heart Anomalies using Fetal ECG and Doppler Cardiogram Signals

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The principal aim of fetal welfare testing is to identify fetuses with heart anomalies so that these adverse outcomes can be prevented. This study presents an automated and non-invasive technology using an integrated fetal transabdominal electrocardiogram system and Doppler cardiogram (DCG) to identify fetal heart anomalies. Simultaneous recording of the abdominal ECG signals and DCG signals from 5 pregnant women at the gestational age of 2836 weeks with normal single pregnancies and 5 pregnant women who were diagnosed to have fetal heart anomalies collected from Tohoku University Hospital. A total of 10 recordings (each of 1 min length) were sampled at 1,000 Hz with 16-bit resolution. Multiresolution wavelet analysis and Jensen-Shannon divergence (JSD) methods were used to identify the frequency contents of the Doppler signals to be linked to the opening and closing of the heart's valves (Aortic and mitral) and two wall motions (ventricular and atrial contraction). The JSD is a measure of distance between probability distributions which were defined from the wavelet decompositions of the DCG signals. For the normal fetuses, PEP (Pre-ejection period), VET (Ventricular ejection time), ICT(Isovolumic contraction time) and IVRT (Isovolumic relaxation time) were found to be 75.0$\pm$11.9 (msec), 153.2$\pm$18.9 (msec), 50.0$\pm$15.9 (msec) and 69.6$\pm$9.7 (msec) respectively. On the other hand, for fetuses with heart anomalies, these timing intervals were found to be 89.0$\pm$10.3 (msec), 168.6$\pm$25.0 (msec), 52.2$\pm$17.2 (msec) and 51.6$\pm$13.7 (msec) respectively. PEP, VET and IVRT values are significantly ($p<0.01$) different between the two groups. The ability of the newly developed system to accurately detect opening and closing timing in fetal cardiac valves has be confirmed using B-Mode and M-mode pulsed Doppler images of aortic and mitral valves. Figure 1 (see pdf). Example of simultaneously recorded fetal ECG and Doppler ultrasound data.