Fetal Electrocardiography and Deep Learning for Prenatal Detection of Congenital Heart Disease

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Background Congenital heart disease (CHD) is the most common severe congenital anomaly worldwide with a reported incidence of eight per 1000 births. It has been demonstrated that the timely prenatal detection of CHD increases survival rates and decreases long-term morbidity. The prenatal detection of CHD is currently done via ultrasonic examination, typically performed at 20 weeks of gestation. Unfortunately more than half of CHD cases are still missed.

In adults and children, an important element in the diagnosis of heart disease is the assessment of the electrocardiogram. The objective of this study was to investigate the use of non-invasive fetal electrocardiography at 20 weeks of gestation for the early diagnosis of CHD.

Methods We performed multi-channel fetal ECG measurements in a cohort of 492 patients (347 healthy controls and 145 diagnosed with CHD) around 20 weeks of gestation. Using a combination of signal processing methods that aim to suppress interferences and correct for fetal movement, a high-quality, multi-channel fetal ECG was determined for each patient (Fig. 1). Subsequently, a convolutional neural network (CNN) was trained for classifying the ECGs as either originating from a control or CHD. Data was divided in a training set of 392 patients and a test set of 100 patients.

Results and Discussion The CNN was able to classify CHD in the test set with a sensitivity of 78% (specificity 74%). This detection rate is higher than that reported for current anomaly screening. It should be noted that our dataset was not fully representative for normal clinical practice, as the patients from the CHD cohort were selected based on prior diagnosis by a pediatric cardiologist. Yet, our results demonstrate that it is possible to detect CHD based on non-invasive fetal electrocardiography. Further research will focus on the combined used of ultrasound and electrocardiography towards improving CHD detection rates.
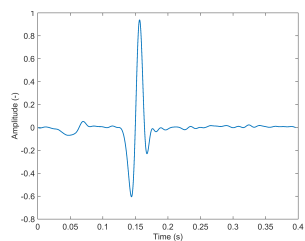

Figure 1: Example fetal ECG recorded at gestational age around 20 weeks. This example constitutes one of the channels of a multi-channel ECG recorded in a healthy fetus.