Postnatally, a comprehensive assessment of heart rhythm and function is obtained by recording electrocardiography and echocardiography simultaneously; however, prenatally this has not been possible due to the low quality signals produced by fetal ECG. Previous work by our group has simultaneously recorded fetal magnetocardiography (fMCG) and fetal echocardiography (fEcho) using a superconducting quantum interference device (SQUID) housed inside a magnetically-shielded room (MSR) and battery-operated ultrasound scanner, respectively; however, the scanner inside the MSR introduced significant interference in the fMCG data. In this study we used a fMCG system based on an array of optically-pumped magnetometers housed within a person-sized magnetic shield. The new system improved the fMCG signal quality by shielding the OPMs from scanner interference.

Simultaneous fMCG-fEcho were performed on a handful of healthy fetuses and those with arrhythmia. The P-wave, an important diagnostic feature, was clearly resolved in the fMCG signal. We were able to implement this technique to record real-time fMCG-fEcho. We also demonstrated that the valve clicks from fEcho images could be used to resolve QRS complexes in stretches of low-quality fMCG data, potentially allowing us to perform fMCG in fetuses in the first trimester.

The magneto-mechanical parameters of fetuses with LQTS, those with a family history of LQTS but tested negative for LQTS (mutation-negative), and normal fetuses were also explored via fMCG and fEcho. The isovolumetric relaxation time (IVRT) was found to be a reliable predictor of the QT interval in the LQTS fetuses. The IVRT was prolonged in the LQTS and mutation-negative fetuses compared to the controls. QRS-T discordance was proposed as a contributing factor to IVRT prolongation due to a high rate of discordance in the LQTS and mutation-negative fetuses.

The same parameters were assessed in fetuses with congenital heart defects (CHD). The IVRT was prolonged in the CHD fetuses but could not predict the QT interval. These fetuses also displayed a high rate of QRS-T discordance.

Neither the magnetic nor mechanical parameters could independently characterize the fetal cardiac conditions examined in this project; however, new insights into the diseased conditions were provided by combining the magneto-mechanical parameters.