Detection of Fetal Cardiac Repolarization Abnormalities using Magnetocardiography

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Repolarization abnormalities such as long QT syndrome (LQTS) and T-wave alternans (TWA) are strongly associated with channelopathies, cardiomyopathies, and sudden death at all ages; however, repolarization abnormalities cannot be assessed by current diagnostic methods in the fetus. Fetal magnetocardiography (fMCG) directly measures the electro- physiology of the fetal heart, and provides an effective method of analyzing repolarization abnormalities *in utero*. Characterization and detection of repolarization abnormalities, however, are much more difficult in fetuses than in adults due to the low amplitude of fetal signals and the presence of strong interference from various environmental and bio- logical sources. We developed signal processing techniques to increase the signal resolution of repolarization waves, allowing characterization of the electrophysiology of repolarization waves in greater detail. We also designed robust statistical detectors, incorporating the generalized likelihood ratio test and maximum likelihood estimation, to objectively detect repolarization abnormalities including TWA and QTc prolongation. The TWA detector was capable of detecting brief episodes of TWA and was remarkably immune to interference. The detection of TWA could be automated to scan the entire recording and identify time periods during which TWA was present. The accuracy of QTc measurement was greatly improved by the T-wave end detector, which showed clear transitions from signal-containing to signal-free regions. It improved the veracity of QT measurement by providing an objec- tive means of delineating the end of T-wave. These technical improvements were applied to study a group of 30 fetuses with suspicion of LQTS. fMCG showed its high diagnostic and prognostic value. Based on QTc measurements, fMCG was able to identify the fetuses that tested positive for LQTS with high accuracy. The longer the QTc, the higher the likelihood of fetal or neonatal serous abnormalities, including Torsades de Pointes (TdP). In addition, fMCG was invaluable for the detection and definitive diagnosis of TdP and other complex LQTS rhythms. Due to the ability to effectively treat TdP in utero, these capabilities can be lifesaving. Therefore, fMCG can play a critical role in the diagnosis and management of fetuses at risk of LQTS.