Fetal Cardiovascular Magnetic Resonance Imaging – Technical Development and Clinical Utility

Background:
Congenital heart defects affect 1% of infants. Prenatal diagnosis of complex congenital heart defects reduces mortality and morbidity and there is a need for improved diagnostic methods. Recent development in cardiovascular magnetic resonance (CMR) imaging has enabled cine imaging of the fetal heart and blood flow measurements in fetal vessels. These methods may overcome current limitations of fetal echocardiography and provide additional insights in fetal cardiovascular pathophysiology, and improve diagnostics.

Research questions/methods:

Paper 1) How does fetal blood flow measurements using a Doppler ultrasound-based cardiac gating method compare to Metric Optimized Gating (MOG), the current CMR post-processing reference method?

Paper 2) Can neural networks be used for automatic measurement of total fetal volume from fetal MR images?

Paper 3) What is the clinical utility of fetal CMR for diagnosing complex congenital heart defects?

Paper 4) Can super-resolution image enhancement be used to reduce image acquisition time while maintaining image quality?

Results:

Paper 1) The Doppler-ultrasound gating method measures blood flow with a low bias compared to MOG. Variability was however larger but as direct cardiac gating is utilized the Doppler-ultrasound gating method may be more accurate.

Paper 2) Neural networks can automatically measure fetal volume from MR images. While automatic delineations may still require manual correction, they save approximately 30 – 60 minutes analysis time compared to fully manual delineations.

Paper 3) Fetal CMR improves prenatal diagnosis of congenital heart defects.

Paper 4) Super-resolution enhancement improves image quality in fetal CMR images with a short acquisition time. This may increase success rate of fetal CMR as fetal motion during acquisition is less likely.

Significance:
The current project shows that fetal CMR can improve prenatal diagnosis of congenital heart defects when echocardiography is insufficient. Furthermore, the Doppler-ultrasound gating method may improve accuracy of fetal blood flow measurements by CMR. Quantification of total fetal volume may further improve assessment of fetal growth and blood flow by indexing flow volumes to total fetal volume. Faster image acquisition by super-resolution enhancement increases the success rate of fetal CMR examination.
Published papers:
