

MR Compatible Fetal Electrocardiogram Gating

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Introduction Gating of sequences to the fetal ECG would be a major advance for fetal imaging using MRI. Real time imaging such as echo planar or single shot fast spin echo imaging can be used to effectively freeze fetal motion but is not synchronized to the cardiac cycle as required for phase contrast measurements. Self-gating, navigator based methods avoid having to detect the fetal ECG by acquiring a signal from the centre of k-space with each k-space line acquisition but these have varying degrees of success dependent on patient motion. Retrospective gating uses continuous acquisition of data together with labeling of each acquisition of the cardiac phase at the time of acquisition but is only possible with a measured ECG signal. Metric optimized gated imaging is a variant on retrospective gating where the ECG signal cannot be measured directly which uses data self-consistency. The aim of this study was to develop methods to directly detect and gate to the fetal ECG.

Methods Pregnant women (n=3) with known CNS pathology coming for a follow up examination were assessed using the fetal ECG system. A compact monitoring device with advanced software capable of reliably detecting both the mECG and fECG traces simultaneously was modified by the manufacturer (AN24, Monica Healthcare, Nottingham, UK) to provide an external TTL trigger signal from the detected fECG signal (1). The attenuated fECG gating pulse from the device was fed back into the standard MR ECG system to allow fetal triggering. Six metre long high resistance carbon ECG leads were fed through waveguides into the MR scan room from the device. The leads were attached to five MR compatible electrodes and placed on the lower abdomen of the pregnant woman close to the anticipated location of the fetal heart. Images were acquired using a 1.5T HDx MR System (GE Healthcare, Milwaukee, USA) using a range of sequences including single shot fast spin echo (SLT=3 and 5mm), MR Fiesta (FA=60°) 2D and 3D, T1 FRGE, FLAIR, Axial DWI ($b=700s/mm^2$), a real time movie sequence and a fetal ECG gated RVLA cine sequence (n=1). Typical FOV was 350mm and scan time was approximately 30 minutes.

Results No safety issues or radiofrequency generated burns were encountered using the device to record the FECG during fetal imaging. Fig 1 shows raw and FIR filtered (4Hz-45Hz bandpass) ECG data acquired in the magnet without imaging gradients present showing mECG and fECG components. The mECG was approximately 80bpm and the fECG was 140 bpm

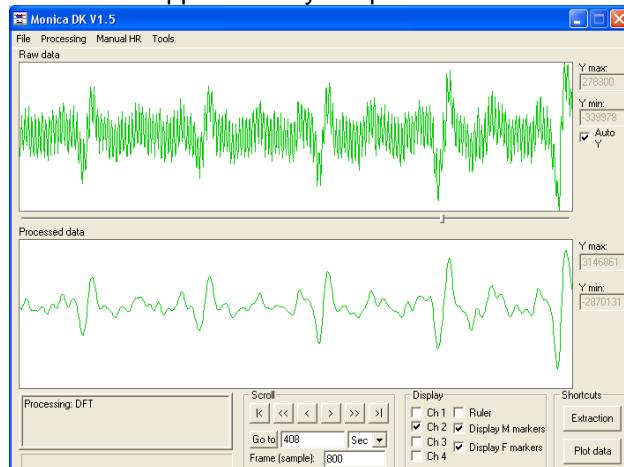


Fig 1. Combined fECG and mECG signal

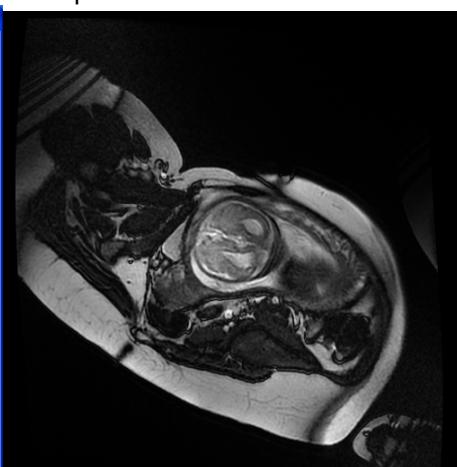


Fig. 2, fECG RVLA cine gated fetal image

Discussion Artifact from the imaging gradients was picked up on the ECG during sequences which increased the minimum time required to reliably detect the fECG between each single shot imaging sequence. It was possible to gate to the fECG signal using rapid sequences but further work is required to automatically threshold the fECG signal after gradient induced artifacts to provide a reliable trigger in the MR.

Reference 1. Paley et al., Proc. ISMRM, Montreal, 2011, 1155.