The Effect of Magnetic Resonance Imaging on Fetal Heart Rate.

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Introduction
Safety is one of the main issues surrounding any imaging modality in obstetrics. The use of Doppler ultrasound to detect gross changes in fetal heart rate (FHR) is an accurate and objective method of assessing fetal distress or well-being. Magnetic Resonance Imaging (MRI) has previously been applied to the accurate estimation of fetal weight, organ size and in the measurement of placental perfusion. Although follow up studies have revealed no ill effects to children imaged in utero, signs of fetal distress have not previously been monitored during MRI.

Methods
All MRI was performed on the 0.5T purpose built echo-planar MR scanner at the University of Nottingham. The MBEST encoding sequence was used to acquire all images. A sinc modulated radio frequency (rf) pulse centred at 22 MHz with a band width of 17 kHz was applied for 3.5 ms with the switched gradient sinusoidally modulated at 0.5 kHz. The echo time to the centre of k-space was 65 ms. Images of the fetus were acquired at the rate of 4 Hz.

FHR was recorded using a modified Sonicaid Meridian 800™ Doppler ultrasound monitor (Oxford Instruments). This system used 1.5 MHz ultrasound pulses with a 1:4 duty cycle and 3.125 kHz repetition rate. The returning ultrasound signal has a Doppler component with a bandwidth of 600 Hz.

To modify the transducer, all ferric metal within the transducer was replaced with equivalent aluminium components. An 8 m lead connected the transducer to the monitor so that the monitor was not exposed to high magnetic fields close to the scanner. This lead has the potential to introduce rf interference into the scanner. Conversely MR imaging has the potential to introduce rf interference into the Ultrasound monitor. To provide rf shielding, the Ultrasound transducer was coated in a copper/silver spray and the wire was wrapped in three layers of plastic backed aluminium foil. The foil was sufficiently thin that eddy currents introduced by the switched gradients did not accumulate but robust enough to eradicate interference. The foil was continuous with both the earthed wall of the magnet and the copper/silver spray so that the transducer was effectively shielded. Finally, a non-conducting outer lacquer was applied to insulate the patient from any electrical connection.

The effectiveness of the RF shield was verified by measuring image signal to noise on a water phantom and on a human volunteer both with and without synchronous ultrasound measurements. Examination of the signal recorded from the ultrasound monitor showed no additional noise artefacts introduced by the modifications made to the US equipment or by MR imaging.

Cardiotocographic (CTG) recordings were obtained for ten pregnant volunteers. All patients were at term (37 to 41 weeks) with singleton fetuses in cephalic presentation. This study received local ethics committee approval and full informed consent was obtained from the subjects. CTGs were recorded for a period of 15 minutes outside the scanner and then for 15 minutes during MR imaging. The CTG analysis was based on the description of FHR patterns by Nijhuis with respect to baseline heart rate, accelerations, deceleration’s and heart rate patterns.

Results
MR scanning was successfully completed in all ten cases. One CTG suffered considerable loss of signal due to fetal movement after the patient entered the magnet. All other recordings were of good quality. The Wilcoxon Matched-Pairs Single-Ranks test was used to compare 15 standard CTG variables averaged over all subjects. There were no significant changes in any of the parameters during scanning compared to recordings obtained outside the scanner.

Discussion and Conclusion
Fetal CTG is a reliable method of assessing fetal well-being during MR scanning. Existing CTG equipment may be adapted to be MR compatible without technical difficulty or expense. As MRI becomes a more clinically applicable imaging modality for diagnosis of both fetal and maternal conditions, fetal CTG has the potential to become an important tool for assessing fetal safety during MRI.

This study, reporting the first recording of fetal cardiotocography during Magnetic Resonance Imaging, was not able to demonstrate any effect of imaging at 0.5 T on fetal heart rate or heart rate patterns.

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