T_2* measurements of the fetal liver in response to maternal oxygen breathing

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Introduction

Babies that are born below the normal birth weight distribution are considered as being small for gestational age (SGA). Intra uterine growth retardation (IUGR) is a condition affecting a significant number of SGA babies. These babies are at a greater risk of complications during pregnancy and there is also a significant increase in compromised neurodevelopment and health problems in later life. Clinical management of these 'at risk' fetuses is made more difficult by the current inability to differentiate between small fetuses that are growing normally and 'high risk' fetuses with falling growth. Placental delivery of oxygen to the fetus is believed to be compromised in IUGR. This has been monitored by cordocentesis, which is invasive and a risk to the fetus. MRI is a possible safe and non-invasive method of investigating differences in fetal oxygen saturation using the BOLD effect. Here the transverse relaxation T_2* is dependant on haemoglobin saturation. This change in T_2* on maternal oxygen breathing has been suggested as a method for identifying babies suffering from IUGR [1]. Therefore T_2* changes were measured in the fetal liver which, unlike the brain, is not preferentially protected from the effects of IUGR.

Method

Following ethical approval and informed consent, 52 pregnant volunteers were recruited onto the study. The volunteers ranged from normal pregnancy to suspected IUGR. Gestation at the time of scanning was 28-39 weeks. Scanning of volunteers was carried out using a GE (General Electric, Milwaukee, WI) 1.5 tesla CVi/NVi scanner using a phased array body coil. The examination was carried out with the mothers breathing normally (air) and while breathing 100% oxygen delivered at thirty litres per minute (O_2). This was started 15 minutes before scanning to achieve equilibrium between the maternal and fetal circulations. Following conventional three plane localisers of the mother, single shot fast spin echo (SSFSE) images were obtained of the fetus. Using these images an axial slice (Fig 1: white line) was selected in the middle of the fetal liver. Double echo gradient echo images of these slices were then acquired during a maternal breath hold (13 s). Echo times of 4.5ms and 18ms were used to ensure that the images had sufficient SNR and that fat and water were in phase. Where necessary this was repeated to obtain images without significant fetal motion.

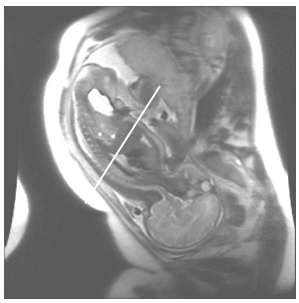

Fig 1: Sagittal localiser

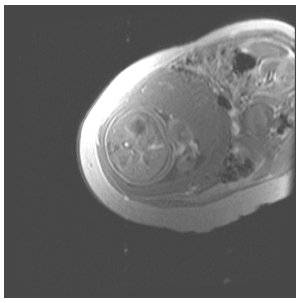

Fig 2: 1st echo TE = 4.5 ms

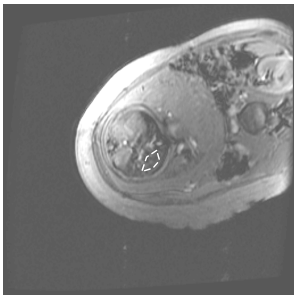

Fig 3: 2nd echo TE = 18 ms

Analysis, including the determination of a region of interest (Fig 3 dashed line) and the calculation of the mean T_2*, was conducted using in-house software written using IDL (Research Systems, Inc., Boulder, CO). The T_2* for the air (T_2*air) and oxygen (T_2*O_2) was calculated and the change ΔT_2* (T_2*O_2 - T_2*air).

Results

For each individual fetus the relative change on oxygen breathing (ΔT_2* / T_2*air) of the liver was assessed. The percentage change was plotted against gestational age (completed weeks) at time of scanning for all patients. Non-parametric analysis (Spearman's rho) demonstrated a significant correlation ($p = 0.040$, 2-tailed).

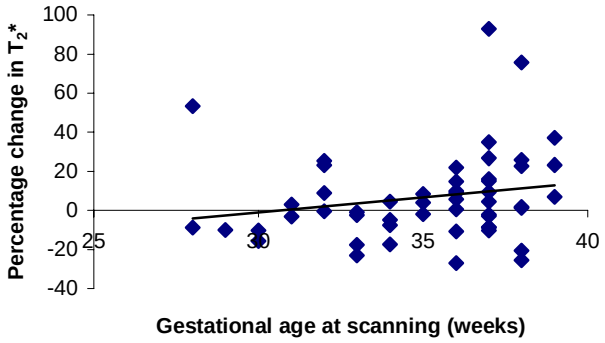

Fig 4: Percent ΔT_2* vs. gestational age

Discussion

This work has built upon the original work [1] and has demonstrated a correlation between gestational age and the percentage change in T_2*. An understanding of oxygenation is important in the management of SGA fetuses [2] and this result contributes to that goal. There also appears to be a trend linking the measured parameter and clinical outcome.

References

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