Assessment of fetal lung maturation from diffusion weighted MRI at 3T

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Purpose: Accurate prenatal assessment of lung maturation is extremely important as fetuses with inadequate lung development require intensive monitoring and care immediately after birth. Fetal lung development is currently investigated non-invasively by volumetry of lungs in MR images acquired using SSFSE or SSFP sequences. Diffusion measurements can provide additional, functional information in these studies as a marker of lung maturity. The aim of the study is to establish the normal range of fetal lung diffusion values measured at 3T in fetuses with normal lung development. This study will help to determine whether the diffusion coefficient can be used to assess fetal lung development.

Methods & Materials: A multi-slice single shot Echo Planar Imaging (EPI) sequence was used to acquire diffusion weighted scans in 24 fetal MRI exams. All scanning was performed on a Siemens 3T Skyra scanner. In-plane resolution was 2.5mm x 2.5mm for each study and slice thickness was set at 3mm. Echo time (TE) was 60ms whereas repetition time (TR) ranged from 2s to 4.4s depending on the number of slices required to cover the lungs. Each patient was scanned with 6 different b-values (0, 50, 100, 200, 400, 600 sec/mm^2) in multiple planes (axial, coronal, oblique). For each b-value, 3 orthogonal diffusion directions were acquired. Cases with large fetal movements (9 cases) were identified and removed from the study leaving results from 15 patients. Regions of interest were manually selected in each lung (Figure 1) and the mean signal value was calculated for each b-value. A single exponential was used to fit the data (excluding B=0 image), yielding an apparent diffusion coefficient (ADC) for each subject.

Results: The ADC averaged over all 15 subjects with an average ± SD gestational age of 28 ± 6 weeks, was found to have a mean of 2um^2/ms with a standard deviation of 0.4um^/ms. ADC values ranged from 1.2um^2/ms (21 weeks) to 2.8um^2/ms (36weeks). In figure 2, the ADC value from each subject is plotted against gestational age. ADC was found to be positively associated with gestational age, with a regression value of 0.061 and correlation coefficient of 0.8021.

Conclusions: This work presents the first in vivo measurements of diffusion in the fetal lungs at a 3T scanner. Some previous work (Balassy et al [2], Lee et al [3]) found no correlation between ADC and gestational age, but in these studies only two B values were acquired and therefore the results are highly sensitive to confounding perfusion effects and fitting errors. We have found a high correlation (R=0.8021) between ADC and gestational age in fetuses with normal lung development. These age-related changes in ADC are thought to reflect an increase in pulmonary vasculature related to formation of capillary bed at the air-blood barrier, as reported in a 0.5T study by Moore et. al [1]. The capability to assess morphology and physiology of lung maturation non-invasively with fetal MRI may support improved diagnosis, may lead to an improved understanding of the risk factors for adverse outcome, and ultimately facilitate a better predictive model for fetuses with higher risk and may require postnatal intervention. Faster acquisition might reduce the effect of motion and allow for a higher success rate (15/24 in this work), which will be explored in future work.

References: 1. Moore, R.J. et. al (2001), *MRM*, *45*, 247-253. **2.** Balassy C. et al. (2008) Eur Radiol. **3.**. Lee. W. et. al, Ultrasound Obstet Gynecol (2009)
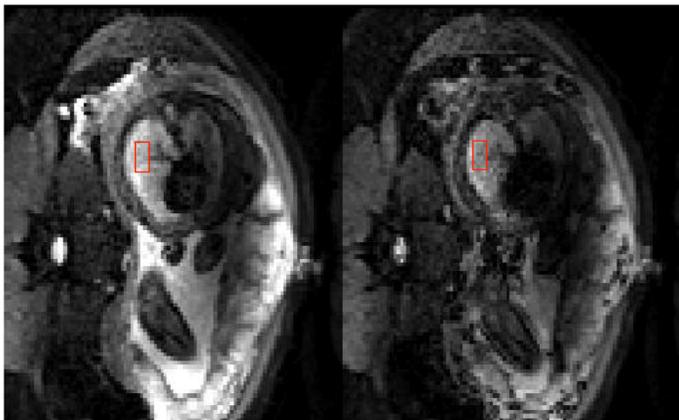

Figure 1- Axial diffusion weighted images (b=0 left, b=200sec/mm^2 right) in a fetus at 35 weeks gestation with normal lungs.
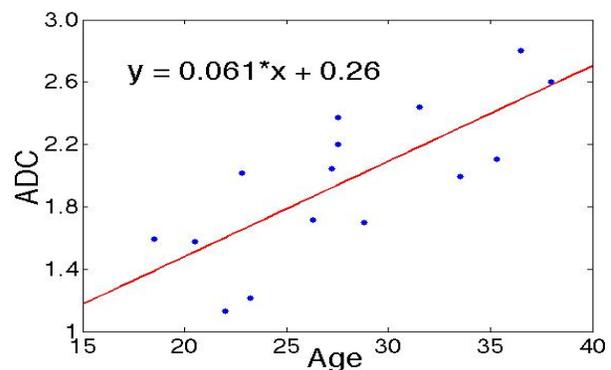

$$y = 0.061*x + 0.26$$

Figure 2- Apparent Diffusion Coefficient (ADC) plotted against gestational age. ADC was found to increase with gestational age with a correlation coefficient of 0.8021.