Placental T2 relaxation parameters at different gestational ages in mouse pregnancy

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Introduction: Healthy development of the fetus is governed by the transfer of oxygen and nutrients from the maternal blood to the fetal blood, and placenta is the facilitator of this exchange. Placental insufficiency and consequent hypoxemia are major causes for fetal growth restriction [1]. The diagnosis of fetal growth-restriction (FGR) is complex and usually involves the combination of fetal biometry, Doppler and biophysical profiling [2]. Doppler-based flow measurements from the umbilical vessels have been used to diagnose FGR, but this measure is the bulk outcome of alterations in the micro-capillary activity in the villous tree, and cannot provide a sensitive measure of the intrinsic alterations in the placenta itself. Mouse models have been extensively used to study placental insufficiency, and these provide valuable information relating to the complex process of pregnancy [3]. Growing body of evidence points out to altered placental function and structural morphology in cases of fetal growth restriction [4]. Tissue transverse relaxation parameter in MRI has been shown to correlate with micro-vascular perfusion status of the tissue in adults [5]. MRI provides a non-invasive quantitative measure of the relaxation times, and this may be used to assess the functional/structural changes in the placenta. In this work we present our preliminary results of T2 relaxation times of the placenta in normal mice pregnancy, measured at two different gestational ages (12 and 17 days; full term gestation is 18-20 days).

MRI Imaging: We scanned a total of 4 pregnant CD-1 mice on gestational day (GD) 12 (n=1) and GD17 (n=3). All the scans were performed on a 7.0T, 20 cm bore superconducting magnet (ClinScan, Bruker, Karlsruhe, Germany) interfaced with a Siemens console. The study was approved by the Wayne State University- Institutional Animal Care and Use Committee (IACUC). The animals were first subjected to a series of localization scans followed by the T2 relaxation time estimation sequences. A fat saturated, multi echo T2 weighted spin echo sequence was used for T2 measurement, which was acquired using the following sequence parameters: matrix size of 160x320; TR of 2540 ms; slice thickness of 0.7mm; an in-plane resolution of 0.13x0.13 mm^2 and pixel bandwidth - 130 Hz/pixel. A total of 6 echoes at the following TEs, 15,30,45,60,75, 90 milliseconds, were acquired and T2 maps were generated in-line by the Siemens console software.

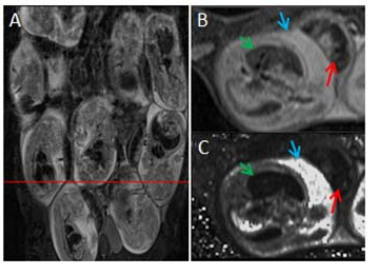

Figure 1:(A)The coronal images of mouse showing the different fetal units. (B)Axial T2WI showing a fetus and the corresponding placenta(red arrow) and lung (green arrow) and amniotic fluid(blue arrow). (C) Axial section of the T2 map. The red lines in A, indicate the localization lines of B and C.

Results: After manual observation only 13 fetuses (5 fetuses from GD12, and 8 fetuses from GD17) were clearly visible along with the corresponding placenta. A total of five fetuses and their five placentas were analyzed at GD12, for which the T2 value was 62.58 +/- 5.78 ms (mean +/- SD). The standard deviation quoted here represents across fetus variation. Similarly, the mean T2 relaxation time of the 8 placentas of fetuses at GD17 was 35.03 +/- 8.9 ms. Figure 1 (B and C) shows the T2 map of one fetus at GD17. Also shown is the T2 coronal image used for localization (the line represents location of the axial slice shown). Figure 2 shows the individual T2 values measured from the fetuses plotted across their gestational age. Standard error in each measurement is also shown. A decrease in the T2 value of the placenta with gestational age is seen, which is consistent with typical findings in human placenta [6].

Discussion: We have measured the T2 relaxation times of the placenta at two time-points during pregnancy in CD-1 mice. The study suggests a decreasing trend in T2 relaxation times with increasing gestational age, which is in good agreement with previous MRI studies on the human placenta [6]. The placenta is the only fetal tissue that is in direct contact with maternal blood. The placental volume increases as the fetus develops and in addition to this, there is an increase in the blood volume in the placenta at later gestational ages. An increase in blood volume is consistent with the decrease in T2 relaxation times seen in this study. Apart from blood volume, the hematocrit (in human: [7]) and the oxygen extraction fraction may also be changing with gestational age, which can affect the T2 relaxation parameter. Although blood oxygenation in the fetal vasculature in the placenta is expected to vary with respect to the gestational age, the oxygenation in the intervillous space containing maternal blood is expected to remain constant. Hence, changes in T2 value of the placenta may be used as surrogate measure for fetal oxygenation status.

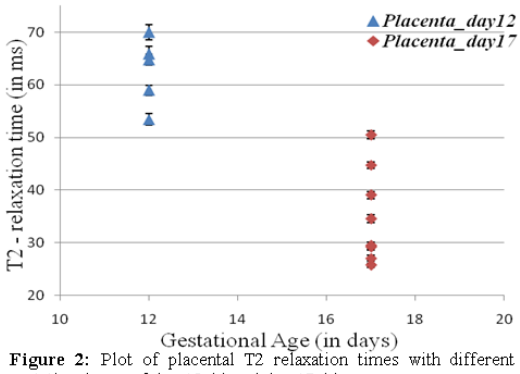

Figure 2: Plot of placental T2 relaxation times with different gestational ages of day 12 (▲) and day 17 (◆).

Conclusions: The placenta is a relatively large and immobile organ, whose T2 relaxation times are dependent on its functional status and the gestational age of the fetus. A change in the T2 relaxation values could reflect changes in the functional status of the placenta. In this work we have quantified the normal/baseline T2 relaxation times of the placenta in CD-1 mice at GD12 and GD17. Quantification of T2 along the entire gestational period, where the placenta is seen, may be beneficial for studies related to placental abnormalities in mouse model.

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