Placental Imaging and Relaxation Parameter Mapping at 1.5 Tesla

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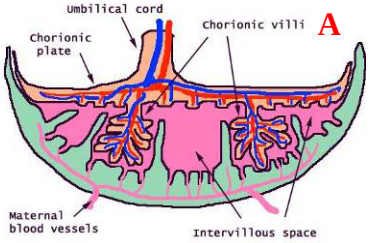


Introduction

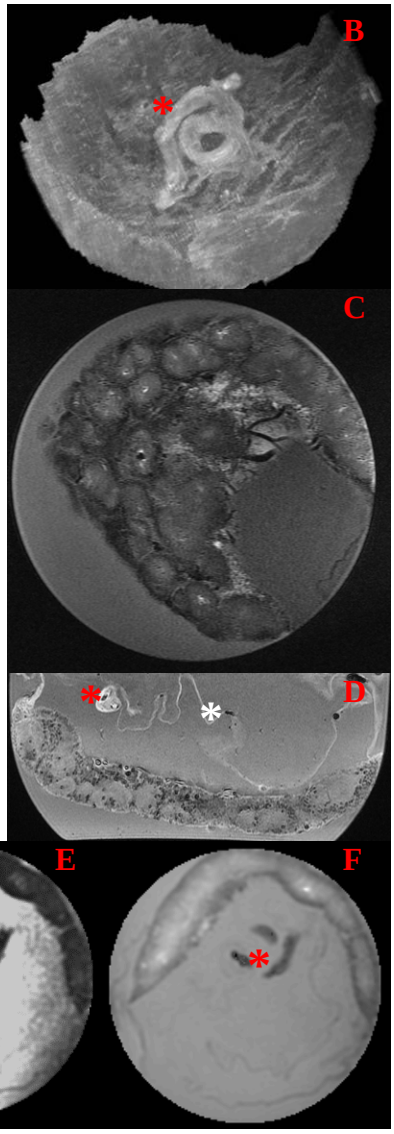
While it is known that the human placenta has abnormal pathology in pregnancies complicated by intra-uterine growth restriction (IUGR) and pre-eclampsia, our ability to diagnose and to treat or prevent these life-threatening complications early during pregnancy is quite limited. In the aforementioned complications, at term the placenta is smaller in volume, has shallower chorionic villi (defective throphoblast invasion), lower levels of diffusion, altered placental arterial patterning(1), and reportedly has lower T_1 and T_2 relaxation times than placentas from normal pregnancies.(2) This feasibility study on a term placenta from a normal pregnancy was undertaken at 1.5 Tesla in order to A) measure placental T_1 and T_2 relaxation times, B) map T_1 and T_2 relaxation times 3-dimensionally, C) determine placental volume, and D) visualize morphology such as placental and umbilical vasculature, and deposits of fat and calcium. Such imaging is applicable to non-destructive *ex vivo* characterization of human placentas, and eventually to *in vivo* clinical studies.

Methods

A placenta donated from an uncomplicated singleton pregnancy was secured in a tissue equivalent phantom(3) and scanned at room temperature on a 1.5T GE EXCITE clinical MR scanner (GE Medical Systems, Waukesha, WI) in combination with an 8 channel volume coil.(MRI Devices, Waukesha, WI) Structural imaging included **1)** axial and sagital T_2 weighted Fast Spin Echo imaging (at=4.5 min, TE= 85ms, TR=6.35s, FOV=20cm, NEX=2, slice=2mm, 0.1 mm spacing, 512x256, echo train=12), **2)** Gradient echo imaging (at=12.25 min, TE=8ms, flip angle=20, FOV=12cm, NEX=3, slice=1.6mm, 80locations/ slab, 384x284), and **3)** 3D T_1 weighted spoiled gradient echo imaging. Volumetric T_1/T_2 measurement was performed with a 3D IR prepped balanced SSFP sequence that measured the recovery of the magnetization into the steady state of the balanced SSFP sequence(4,5). From this time course both T_1 and T_2 relaxation times were calculated by nonlinear least squared fitting of the characteristic equation to the data implemented in IDL (Research Systems Inc., Boulder, CO). Magnetization values were sampled at twenty time points from each voxel in the 3D slab. Afterwards, a 3 second dead time was implemented to allow full longitudinal relaxation before repeating the inversion for the next phase encode. Total scan time to acquire a 128x128x32 3D volume (FOV=32cm, NEX=1, slice= 2mm) with in-plane resolution of 2mm was 8 min.

Images

Figure (A) Scheme of placenta, taken from http://www.siumed.edu/ Fetal veins and arteries are shown in blue and red, chorion in beige. Maternal blood vessels / inervillous space in pink **Figure (B)** 3D rendering of placenta (T_1 –FSPGR). Umbilical cord is the brighter twisted tissue marked by asterisk. **Figure (C)** Horizontal cross section (T2 -FSE) from maternal side (bottom) of placenta. Fetal cotyledon (circular sections) visualized as many small ovoids. Vessels are dark, fatty and calcium deposits are bright. **Figure (D)** Vertical cross section of placenta (T_1 –FSPGR). Vessels running through the placenta are seen as dark circles in the tissue. Fetal membranes are visible and marked by white asterisk. Umbilical cord marked by red asterisk. **Figures (E, F)** T_1/T_2 maps from horizontal slice near fetal side (top) of the placenta, cord is marked by an asterisk.



Discussion:

Non-destructive high resolution MRI of human placental morphology and function is possible in a clinically relevant time span. Placental volume determined by 3D reconstruction (**Figure B**) was 450+/- 10 mL, in agreement with previous studies(6). For the first time at 1.5T, placental T_1 and T_2 relaxation times were determined to be 1000ms and 39ms, respectively (data not shown). 3-D T_1 and T_2 relaxation maps (**Figures E, F**) were collected from the entire placenta. Average T_1 and T_2 relaxation times were calculated from this method to be 1000(+/-100)ms and 40(+/-3) ms, respectively. Placental and umbilical vasculature can be visualized (**Figure D**), suggesting that measurements of umbilical flow, in addition to placental flow(7) and diffusion(8), should be possible at 1.5 T. High resolution MRI of the placenta at 1.5 Tesla has many potential uses both *in vivo* and *ex vivo*. It can be used as a non destructive tool to image placental microstructures. Also, scans undertaken early in the 2nd trimester may aid in early diagnosis of IUGR and/or pre-eclampsia.

References (1) Bergam and Ullberg, in press (2) Duncan, et.al., Placenta 19:539 (1998) (3) Beck, et.al. 11th ISMRM, #2364 (2003) (4) Schmitt, et. al., MRM 51:661 (2004) (5) Scheffler, MRM 49:781 (2003) (6) Kublk-Huch, et.al., Radiology 219:567 (2001) (7) Moore, et.al. MRM 43:295 (2000) (8) Gowland, et.al. MRM 40:467 (1998)

Acknowledgements

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