IVIM Assessment of the Placenta, Basal Plate and Chorionic Plate in Diabetic Pregnancies

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Introduction: High volume, low resistance placental blood flow is essential for optimal materno-fetal nutrient exchange; aberrant placental blood flow is associated with growth restriction and pre-eclampsia. Fetal growth is increased in diabetic pregnancy with placental structure changes often resulting in abnormal vascular development and increased villous volume on histology[1]. In this study, we developed a scanning protocol to identify the difference in placental structure and function in diabetic mothers by using intravoxel incoherent motion (IVIM), a sensitive method of measuring blood movement, particularly in the placental intervillous spaces.

Aim: To study placental structure and blood flow in normal and diabetic pregnancies.

Methods: Scanning: Following ethics committee approval, we recruited 26 pregnant women from Queen's Medical Centre Nottingham: 14 diabetics and 12 controls matched for age, parity and BMI; all gave informed consent to participate in the study. Women were scanned twice at 22–26 weeks and 33–37 weeks gestational age (GA), using 1.5 T Philips Achieva MRI scanner with 5-element SENSE cardiac coil or 4-element SENSE torso coil, depending on the woman's size. Women lay on their right side in the decubitus position to avoid vena caval compression, and all these scans were conducted with a specific absorption rate of <2.0 W kg^{-1}. The IVIM sequence used was respiratory gated, standard diffusion pulsed spin echo sequence acquired with 5 transverse slices encompassing the placenta in 108 seconds (TR = 3000 ms, TE = 95 ms, FOV = 350×350×107 mm^3, 1.46×1.46×7 mm^3, 12 b values = 0, 1, 3, 15, 47, 80, 115, 206, 246, 346, 468 and 800 s mm^{-2}, repeated 5 times). Analysis: A region of interest comprising placenta, basal plate and chorionic plate was drawn around the whole placenta in a central slice for an intermediate b value. Each pixel in the ROI was fitted to: $S = S_0(1-f)e^{-bD} + fe^{-bD^*}$, where S_0 is the equilibrium signal, f is the moving blood volume of the placenta, D is the water self-diffusion coefficient and D^* is the pseudo diffusion coefficient, using MATLAB (R2010a). Data points corrupted by excessive motion, identified as lying > 2 standard deviations from the fitted line, were excluded and the data was refitted. ROIs were drawn on the placenta, basal plate and chorionic plate. The histogram of f and D in each ROI was found, and given the skewed distribution of values in these histograms, the mean, mode and fraction of pixels with $f > 0.8$ (f_{hi}) and $D > 0.0025$ (D_{hi}) in the histogram were noted. The total placental volume was measured by drawing an approximate freehand mask around the placenta using Analyze 9.0.

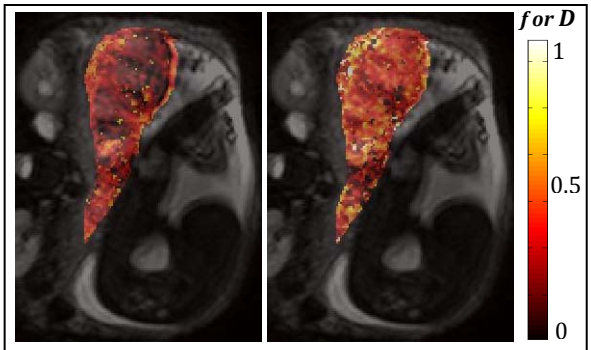

Figure 1: Map of f and D for a diabetic subject at 34 weeks

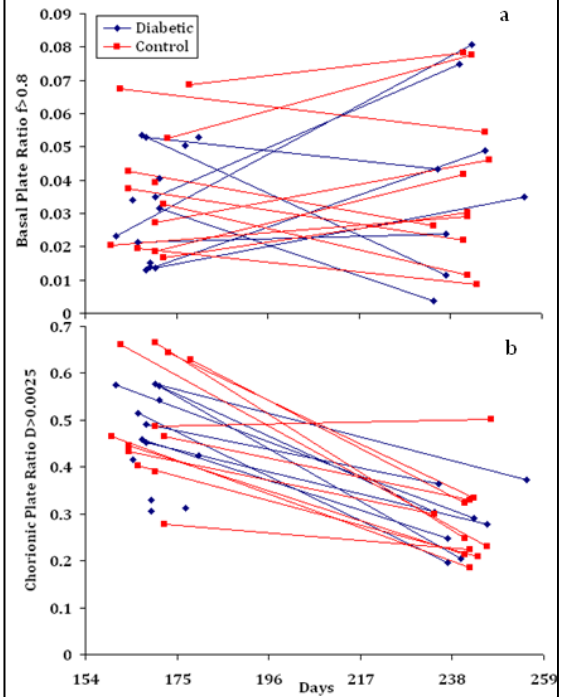

Figure 2: (a) Basal Plate Ratio f_{hi} and (b) Chorionic Plate Ratio D_{hi}

Results: In this abstract we are quoting results for f_{hi} and D_{hi} only, although consistent trends were found for the mode and mean of the histograms as well. For D_{hi}, there was a significant decrease between the two gestational ages for the placenta, basal plate and chorionic plate in the diabetic group ($p < 0.001$) and for the placenta ($p < 0.039$) and chorionic plate ($p < 0.001$) in the control group. This change in D was always most pronounced in the chorionic plate and least pronounced in the basal plate. There was a trend for D_{hi} to be lower in the diabetics than controls in the basal plate at late gestation but this was not significant. There was no particular trend in f_{hi} across gestational ages and no significant difference between the controls and diabetics group: however, the trend for f was to be non-significantly suppressed in the diabetic group at the earlier gestation (and this was actually significant for mean f). Placental volume increased from 437.15 ± 0.12 ml to 780.31 ± 0.20 ml between the two gestational ages but there was no change between diabetics and controls.

Discussion: This is the first reported measurement of IVIM in the chorionic plate which probably predominantly reflects fetal blood circulation to the placenta. Our results demonstrating no change in f with gestational age in control subjects are consistent with previous results for both the basal plate and placenta[2]. Since f measures blood movement per voxel in the placenta, and the placental volume is increasing with advancing gestation, a net increase in blood delivery to the placenta is postulated. This is consistent with ultrasound data that show an overall increase in uterine artery blood flow but a decrease in uterine artery blood flow per unit fetal weight with advancing gestation[3]. The lack of change in f in diabetic pregnancies cannot explain the rapid growth of fetuses in these pregnancies. The pronounced change in D during pregnancy could be consistent with increased villous branching during gestation but at present its interpretation in the chorionic plate and basal plate is less clear. These findings are consistent with Power Doppler ultrasound data in the third trimester[4]. Future work will correlate MR measures with maternal levels of hypoglycemia and will further investigate the use of the IVIM model in these three ROIs to understand how changes in flow may affect the modeled parameters.

References: [1] T. Mayhew. (2002), Diabetologia, **45** 1434-1439. [2] D. Anblagan, Proc ISMRM 20 (2011) 151. [3] J.C. Konje et al. (2001), Am J Obstet Gynecol, **185(3)** 608-13. [4] N. Jones (2011) Ultrasound Obstet Gynecol, 38 (Suppl 1) 41. **FUNDED BY DIABETES UK.**