Fetal Growth in Diabetic Pregnancies

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Introduction: Pregnancy complicated by pre-existing or gestational diabetes often results in macrosomic infants (birth weight > 4000 g) with increased body fat, but not increased head or brain size[1]. They are at increased risk of shoulder dystocia[2], brachial plexus injury, prolonged labor and caesarean section. In the long term, the fetuses are at higher risk of becoming obese and developing Type 2 diabetes[3]. We previously demonstrated MRI measures of fetal fat increase in a small number of diabetic pregnancies at late gestation[4]. We now extend this to a larger group at different gestational ages, and include fetal length measurements.

Aim: To compare measurements of fetal weight, fetal length and fetal fat composition (made using a novel scanning/analysis protocol) in normal and diabetic pregnancies.

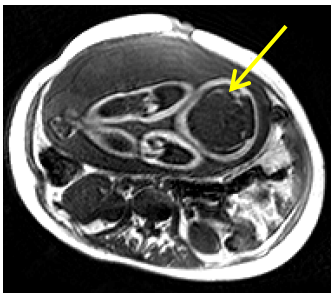

Figure 1: Image of a transverse plane through the fetal thorax showing fat only. Fetal fat surrounding thorax and legs can be seen.

Methods: Scanning: 14 diabetic and 12 control pregnant women were recruited with ethics approval; all gave informed consent. They 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 size. Women lay on their right side in the decubitus position to avoid vena caval compression. All scans were conducted with a specific absorption rate of <2.0 W kg^{-1}. Two sequences were acquired in 3 orthogonal blocks of images to allow motion effects to average out. To measure fetal weight and length a Half Fourier Single Shot Turbo Spin-Echo (HASTE: 123 slices in 147 s, 0.78×0.78×6.00 mm^3 voxels, TE = 120 ms) and Balanced Fast Field Echo (bFFE, 130 slices in 167 s, TR = 5.8 ms, TE = 2.3 ms, flip angle = 70°, 0.78×0.78×6.00 mm^3 voxels) sequences were acquired. To measure fetal adiposity a water suppressed fast field echo (FFE, 12 transverse slices encompassing the whole fetus in 12.4 s, slice gap = 20 mm, TR = 147 ms, TE = 4.6 ms, 1.88×1.86×6.00 mm^3 and FOV = 402 mm) sequence was acquired. Analysis: A semi-automated segmentation approach based upon pixel intensity was used to quantify the fat volume, taking account of noise and correcting somewhat for partial volume effects; this has previously proved to give reliable estimates[4,5]. The freehand mask drawn around the fetus on GIMP (2.2.13) and fat images were loaded into MATLAB (R2010a) to compute the intensity histogram ($h_{j=1\to N}$; where N is number of bins) within the masked region. Histograms were often bimodal with one peak corresponding to background noise and a second corresponding to fat voxels. The fetal fat volume (V_f) was calculated using:

$$V_f = XY(Z+G)\sum_{j}^{N} h_j S_j \quad \text{and} \quad S_j = (1-e^{\frac{-(j-2i_p)}{i_p/2}}) \text{ for } 2i_p < j < N \text{ or } S_j = 0 \text{ for } 2i_p < j < N$$

where X,Y,Z are the voxel dimensions, G is the slice gap and S_j is a scaling factor designed to take account of noise and partial volume effects. Total fetal volume was measured on bFFE or HASTE images by drawing a freehand mask around the fetus using Analyze 9.0. Percentage fetal fat was measured from total and fat volumes. The fetal length was found from the sums of the length of the fetal spine (measured in two curved sections), thigh, lower leg and skull height (crown to base of brain stem) on the bFFE and HASTE images using Analyze 9.0; in order to measure the length of the spine the images were resampled obliquely.

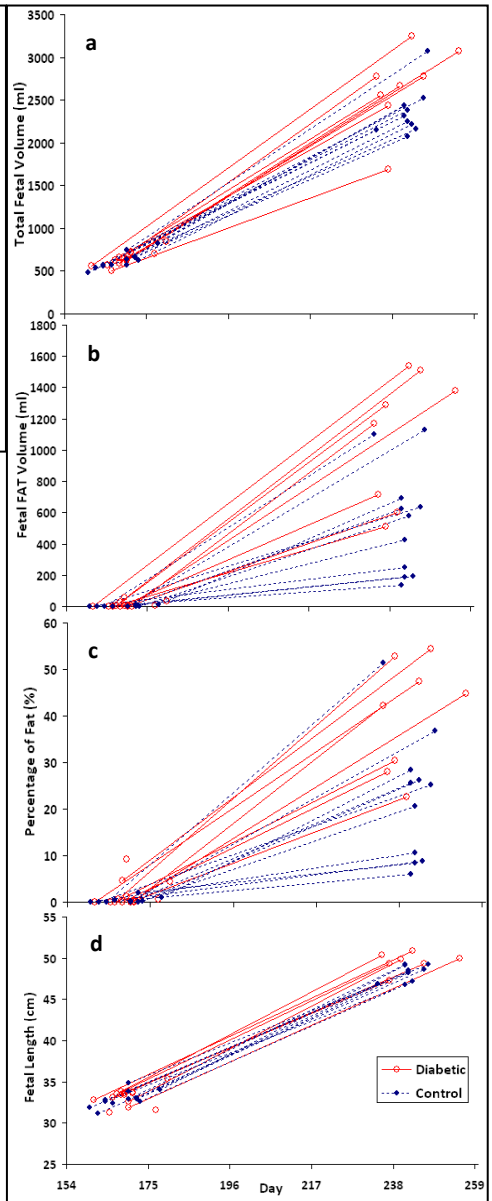

Figure 2: Growth of fetal (a) Total Volume; (b) FAT Volume; (c) Percentage Fat; and (d) Length

Results: Figure 1 shows a fat image from a diabetic pregnancy. At 22–26 weeks very little fetal fat was visible with no significant difference between diabetics and controls. At 33–37 weeks the data showed significant increase in fetal fat volume ($p = 0.006$), percentage fetal fat ($p = 0.009$) and fetal length ($p = 0.017$) in fetuses of diabetic mothers compared with controls (Figure 2). The total fetal volume of fetuses of diabetic mothers is greater than controls, but this difference was not statistically significant. The subjective intra-abdominal fat scores were 0.13 for diabetics and 0.3 for controls at 22–26 weeks, increasing to 1.46 for diabetics and 0.9 for controls at 33–37 weeks.

Discussion: MRI can measure the overall increase in fetal size and the increase in fetal fat fraction in diabetic pregnancies. In utero assessment of fetal size and fat distribution would allow clinicians to identify fetuses at risk of complicated delivery and study the effect of maternal diabetes on metabolic changes in the infant.

References: [1] P.M. Catalano, et al. (1998), Diabetes Care 21 Suppl 2 B85-90. [2] D.S. Acker, et al. (1985), Obstetrics & Gynecology 66 762-768. [3] S.P. Chauhan et al. (2005), Am J Obstet Gynecol **193** 332-346. [4] D. Anblagan, Proc ISMRM 20 (2011) 4183. [5] D. Anblagan, Proc ISMRM 19 (2010) 5910.

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