Assessment of Fetal Fat Distribution with Water-Fat MRI

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Target Audience: Researchers and clinicians interested in the applications of fetal MRI, particularly with high BMI expectant mothers.

Introduction: Intrauterine growth restriction (IUGR) represents a significant obstetric pathology, requiring careful management. IUGR fetuses have elevated perinatal morbidity and mortality, and are at increased risk of chronic diseases later in life, including heart disease, diabetes and obesity, collectively known as Metabolic Syndrome.[1,2] Current detection of IUGR involves ultrasound (US) evaluation of fetal size and Doppler US to assess placental function. However, this assessment fails to address risk for long term metabolic disturbances associated with IUGR. Moreover, obstetric ultrasound is less reliable in high-BMI patients.[3] Fetal fat distribution may serve as an identifying characteristic of IUGR, as IUGR infants have reduced subcutaneous fat.[4] Fetal fat distribution has particular relevance in a high-BMI population, as such fetuses are suspected to have increased intra-abdominal fat, particularly in the liver.[5] MRI may provide an early measurement of fetal fat distribution, which would add assessment of metabolic risk to US's capacity to address neonatal morbidity. This study attempts to develop a tool for in utero fetal fat distribution, by translation of validated fat imaging techniques for adults to fetal MRI.

Methods: Women in their 2nd or 3rd trimester with singleton pregnancies were recruited during obstetric clinics at our institution. Consenting patients had fetal MRI performed in a wide-bore (70 cm diameter) 1.5 T MRI (GE Optima 450w) with a 32 coil abdominal phased array. Scout images were acquired to locate the fetus and determine its orientation. Water-only and fat-only images were produced during a maternal breath hold with a 3D LAVA Flex acquisition in a plane axial to the fetal abdomen (TR 6.2 ms, flip angle 5°, Field of View 48 cm, 160×160 pixels, slice thickness 4 mm, 32-48 slices, 2× parallel MRI acceleration, acquisition time 109-24 s). A fat fraction image was calculated from the fat and water images using Matlab (Fat Fraction = Fat/(Water+Fat)). Images were evaluated for their ability to be segmented: images were deemed "segmentable" when the subcutaneous tissue and intra-abdominal cavity could be delineated or "non-segmentable" when they could not. An ROI within the fetal liver was also drawn to assess liver fat content. This study was approved by our institution's Office of Research Ethics.

Results: 7 patients consented to the study (gestational age 20-32 weeks). Motion free fetal water and fat images were successfully obtained using the LAVA Flex sequence in all 7 patients. In 1 of the 7 patients, the scan was repeated once for technical reasons. In all patients, segmentable fat fraction images were obtained. Liver ROIs demonstrated an average fetal liver fat percentage ranging from a minimum observed value of 0.35% to a maximum of 0.97%, with no voxels within these ROIs registering a fat fraction above 2.0%.

Conclusion: Fetal MRI using water-fat separation techniques allow for the segmentation and quantification of fetal adipose tissue volume and liver fat in normal-BMI and high-BMI pregnancy. This has the potential to provide additional diagnostic information in the evaluation of IUGR *in utero*.

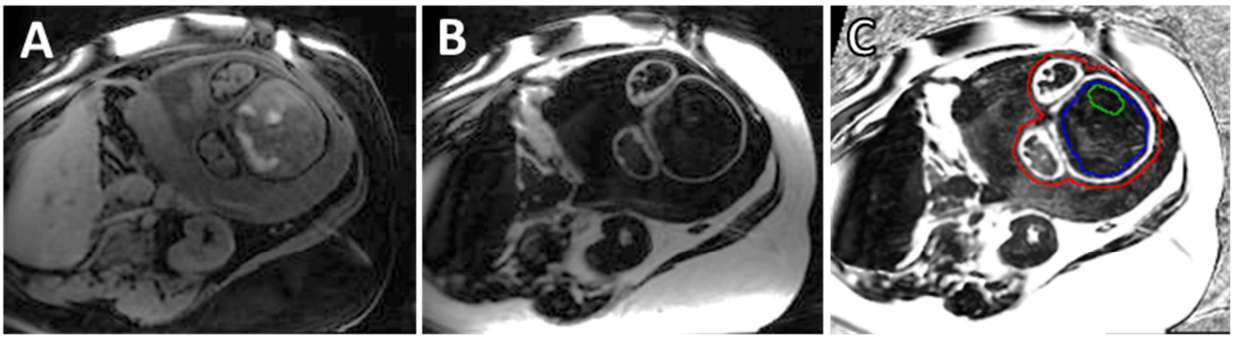

Fig 1. Typical LAVA Flex acquisition through fetal abdomen. Water-only (A) and fat-only (B) images were free of motion artefact. The fat fraction image (C) was segmented into subcutaneous adipose tissue (between red and blue) and intra-abdominal adipose tissue (interior of blue). Fetal liver fat fraction was measured in the lower right lobe of the liver (green region of interest).

References: [1] Resnick. Obstet Gynecol. 2002;99(3):490-496. [2] Suhag and Berghella. Curr Obstet Gynecol Rep. 2013;2:102-111. [3] Fuchs et al. Ultrasound Obstet Gynecol. 2013;41:40-46. [4] Rodriguez et al. J Perinat Med. 2011;39:355-357. [5] J Clin Invest 2009;119(2):323-335.