Impact of Motion and Maternal BMI on Segmentation in Fetal MRI

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Introduction: Fetal size and fetal adipose tissue volume are important indicators of fetal growth and metabolic development and may be measured by segmenting the relevant anatomy from images acquired using ultrasound (US) or Magnetic Resonance Imaging (MRI). US is routinely used in fetal imaging, but attenuation of the US beam by maternal subcutaneous adipose tissue results in reduced image quality in patients with a high body mass index (BMI)\(^1\). MRI has the advantage of being relatively unaffected by subcutaneous fat but MRI image quality can be degraded by fetal and maternal motion\(^2\). The severity of these motion artefacts may be affected by maternal BMI and gestational age (GA). Our objective was to assess how maternal BMI and GA interacts with motion artefacts to affect the ability to segment images in fetal MRI.

Materials & Methods: Two readers viewed images in 3D Slicer 4.7.0 (www.slicer.org) and rated FIESTA and LAVA-Flex 3D MRI 3D volumes (from 14 patients) for the impact of motion and other artefacts on the ability to segment structures. A 5-point Likert scale was used to rate the severity of image quality degradation and the ability to segment images. No motion or artefacts in the image was denoted by 1 and 5 indicates a total loss of the ability to segment images. Scores above 2 represent impaired segmentation of the fetus and placenta. Spearman correlations were determined for combinations of pre-pregnancy maternal BMI, or Gestational Age (GA) vs Fetal Motion (FM), Maternal Motion (MM), or Non-Motion Artefacts (NMA). Prism 7.02 (GraphPad Inc, USA) was used to calculate the Spearman correlations and inter-reader reliability was calculated using the Intra-Class Correlation (ICC) coefficient available in SPSS (IBM, USA).

Results: Readers rated that image quality in 10 of 14 FIESTA 3D volumes had a negative impact on their ability to segment the fetus or placenta; in 8 3D volumes this was attributed to motion. No statistically significant (P>0.05) correlations were produced via the mean data from both readers. However, NMA scores increased with increasing BMI and MM increased with GA. The former and latter trends had Spearman correlation coefficients of 0.51 and 0.43, respectively. In contrast to the FIESTA study, the LAVA-Flex study yielded a statistically significant (P<0.05) correlation between pre-pregnancy maternal BMI and the combined impact of FM, MM, and NMA on image segmentation. The Spearman correlation coefficient was 0.57. Inter-reader reliability had an ICC of 0.82 denoting a strong inter-reader reliability.

Discussion & Conclusion: 3D fetal MRI image quality was degraded by motion and NMA artefacts. MM was affected by increased GA due to incomplete breath-holds and discomfort due to increased fetal size. Retrospective motion correction could be used to reduce the motion artefacts. We postulate that the incidence of NMA in fetal MRI was affected by maternal BMI, as the consequence of chemical shift and B0 inhomogeneity artefacts increase with BMI. Further investigation will help determine the prevalence and magnitude of artefacts as a function of maternal BMI in fetal MRI.