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Fetal diffusion tensor imaging to assess normal white and grey matter development

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Objective

Fetal brain Diffusion Tensor Imaging (DTI) can generate unique quantitative metrics that reflect the integrity of the developing brain. However, this technique is highly sensitive to motion corruption and MRI acquisition artifacts. The objective of this study was to quantify DTI metrics in White and Grey Matter across gestation in a cohort of fetuses without abnormalities using the most up-to-date methods to correct artifacts related to MRI acquisition and materno-fetal movement.

Methods

This study was part of the LUMIERE on the FETUS trial (NCT04142606). MRI scans were performed on a 1.5T General Electric Sigma system (GE Healthcare, USA). No maternal or fetal sedation were used. The pipeline for calculating the diffusion tensor included: denoising, correction of Gibb's ringing artifact, eddy current correction, bias removal, registration to a reference template, slice to volume reconstruction and constrained spherical convolution to obtain Fractional Anisotropy (FA), Apparent Diffusion Coefficient (ADC), Axial Diffusivity (AD) and Radial Diffusivity (RD) maps. Structural template from the Boston's group were used to obtain Region-of-interest in 16 White and 34 Grey matter regions in both hemispheres. We excluded cases in which the reconstruction failed or when too many fetal movements were present.

Results

Fetal DTI were successful in 94/111(85%) fetuses at a median gestational age 30[21-36] weeks of gestation. We found tracts-specific, non-linear and age-related changes in FA, ADC, AD and RD in each White and Grey matter regions. No difference were found between the two hemispheres and between male or female fetuses (all $p>0.05$).

Conclusion

To our knowledge, this is the first study including such a large number of fetuses aiming to explore the connectivity in the entire fetal brain including white and grey Matter regions after applying the most recent technique of artifacts correction, which represent the main limit of the fetal DTI. These changes in DTI metrics may help to characterize the development of the fetal brain connectivity in utero and be a useful resource for detection of abnormal fetal brain development in utero.