Altered Global and Regional Subplate Growth in Fetuses with Congenital Heart Disease

Yao Wu, Kushal Kapse, Yuan-Chiao Lu, Li Zhao, Mary Donofrio, Gilbert Vezina, Adré J. du Plessis, Catherine Limperopoulos

BACKGROUND: The subplate evolution plays a key role in the maturation of the cerebral cortex in the fetal brain. Human fetal subplate neurons generate around 5 to 6 gestational weeks (GW), and start to disappear in the 3rd trimester of pregnancy. Recent advances in fetal MRI techniques allow us to study the fetal subplate structure from 17 GW until the end of the 2nd trimester.

OBJECTIVE: To analyze subplate volume and 3D surface measures (i.e., thickness, gyrification index, sulcal depth, and curvature) in healthy fetuses and fetuses with congenital heart disease (CHD).

DESIGN/METHODS: We prospectively recruited women with normal pregnancies and those pregnancies complicated by a fetal CHD diagnosis. Participants underwent a fetal MRI on a GE 1.5T scanner using single shot fast spin echo acquisitions. Images of axial, sagittal, and coronal planes were reconstructed into a high resolution 3D volume using slice-to-volume reconstruction. The subplate zone was automatically segmented by combining the prior information from CRL fetal brain atlases and nonlinear registration, and manually corrected using ITK-SNAP software. Subplate volume, thickness, gyrification index, sulcal depth, mean curvature, Gaussian curvature, and curvedness were measured. Linear regression model was used to measure the subplate volume and surface measures in CHD vs controls, adjusting for gestational weeks at MRI.

RESULTS: We studied 50 healthy fetuses (24.7±2.8, 18.3-27.6 GW) and 32 fetuses with CHD (25.8±1.5, 22.3-28.6 GW). Fetuses with CHD had smaller subplate volumes ($p<0.001$) and mean thickness ($p<0.001$) compared to controls. Thickness differences between CHD and controls were more pronounced in the right hemisphere than the left. Subplate posterior regions had the most significant increases in subplate thickness as the age increased. Differences in local gyrification index, sulcal depth, and curvature measures were noticed on frontal, temporal, occipital and parietal lobes of subplate surfaces in CHD vs controls.

CONCLUSIONS: We firstly report 3D global and regional differences in subplate volume and surface measures in healthy and CHD fetuses by using advanced fetal MRI techniques. The extent to which these fetal subplate growth impairments predict later brain development is unclear and currently under investigation.

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