Quantitative MRI of the human fetal ganglionic eminence – neuroradiological insights into a transient brain structure

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Objective

Failure of fetal interneuron migration arising from the ganglionic eminence may lead to neuropsychiatric and neurodevelopmental disorders.[1,2] Early detection of alterations of this transient brain structure at prenatal stages, may improve the MRI phenotyping of neurodevelopmental diseases. This atlas-based fetal MRI study aimed to quantitatively assess longitudinal development of the ganglionic eminence.

Methods and Materials

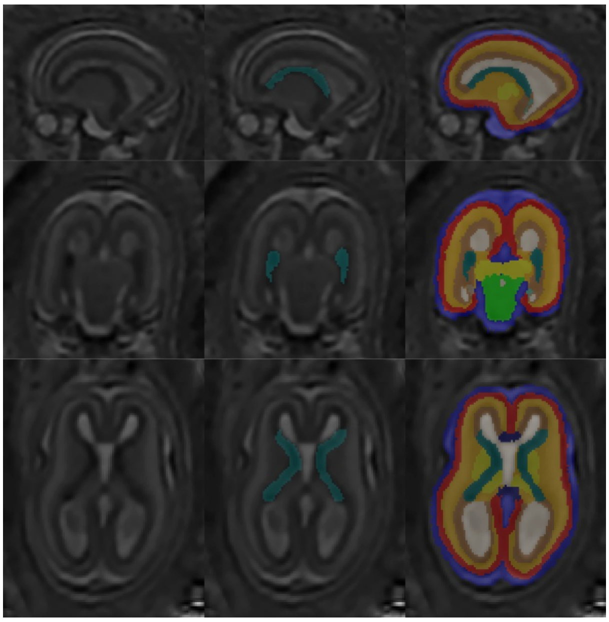
In this IRB-approved single-center study, reports of pregnant women undergoing fetal MRI were retrospectively assessed. After exclusion of cases with significant fetal, maternal and/or paternal comorbidities such as cardiac defects, fetal growth restriction or severe structural CNS anomalies, MRI data was subjected to advanced postprocessing modalities. Super-resolution reconstructions were generated using 1.5T and 3T MRI scans of the fetal brain and semi-automated tissue-segmentations of various fetal brain compartments were performed. The ganglionic eminence was defined as a hypointense region adjacent to the ventricular system, lying laterocaudally to the lateral ventricles. Tissue segmentation was done in accordance with the histological fetal atlantes by Bayer and Altman, which were used as a reference guide.[3,4] After quality control and manual correction of a quantitative analysis of the ganglionic eminence was performed by several raters.

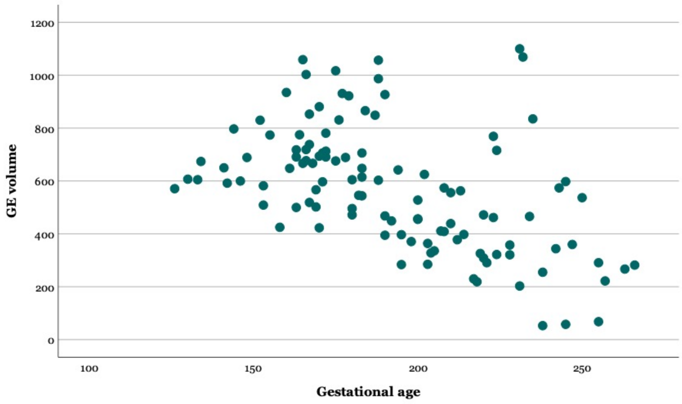
Results

A total of 112 patients were retrospectively included. Selection was based on the absence of structural brain anomalies, cardiac defects, fetal growth restriction, and/or poor super-resolution image quality. The gestational age ranged from 19-39 weeks (mean 27.5 GW). Mean maternal age was 33.1 years.
In the observed time interval, the volume of the ganglionic eminence ranged from 1,100.25mm^3 to 53.25mm^3 (mean 572.31mm^3, SD 232.01). Throughout the entirety of the investigated gestational period, the average volumes continuously decreased. For each gestational day, a volumetric reduction of 3.59mm^3 (95% CI 2.45 – 4.73) within the ganglionic eminence was detected. These results are in line with the current knowledge from histological studies, indicating a decrease of this transient structure in the human brain even during pregnancy.[5] Contrary to previous literature, MRI-based detection of the ganglionic eminence was possible in some cases even after gestational week 30 and onwards.

Conclusion

Super-resolution based quantitative MR volumetry allowed to analyze the continuous decline in size of the ganglionic eminence from 19GW onwards - initially documenting a physiological degenerative process in the developing human brain. The first set of reference values of this structure was provided, enabling radiologists to objectively quantify GE development using fetal MRI.





References

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Figures

Left: Super-resolution imaging of a fetal brain at 19+1 gestational weeks with tissue-based segmentation of brain compartments. Color coding: petrol – ganglionic eminence, blue - external cerebrospinal fluid (CSF) spaces, red – cortex, orange – subcortical parenchyma, brown – periventricular zone (combination of sub- & ventricular zone), white – ventricular system, yellow – deep gray nuclei, green – brainstem, gray/turquoise – right/left hippocampus
Right - Top: Ganglionic eminence volumes throughout gestation given in mm^3 and gestational days.
Right - Bottom: Longitudinal volumetric development of the ganglionic eminence visualized using segmentation data and 3D-reconstruction of fetuses at 19+1, 24+3, and 29+5 gestational weeks.