Purpose: The central nervous system (CNS) is the first organ to develop during mammalian embryogenesis and the CNS dynamically evolves well into the postnatal stages. Abnormal CNS phenotypes are normally visualized in vivo or with fixed samples using magnetic resonance imaging (MRI). Current MRI coil technology does not permit early-stage in vivo imaging of the mouse embryo CNS. Here, a custom-made, high-frequency-ultrasound annular-array system operating at 38 MHz was utilized to perform in vivo imaging of early-stage mouse embryo CNS.

Methods: A custom-made ultrasound scanning system using a piezopolymer-based annular array was utilized for the imaging studies. The array had five equal-area elements, a 6 mm total aperture, and a 12 mm geometric focus. The scanning system was designed to perform five scans across an object in order to acquire all transmit-to-receive data (25 data sets). This data was then synthetically focused to achieve enhanced depth of field and lateral resolution. In addition, the system utilized a coded-excitation scheme to enhance SNR and penetration depth, and a respiratory gate to reduce motion artifacts. A full 3D volumetric data set could be acquired in approximately 2 minutes.

Results:In vivo, in utero volumetric data were acquired from 78 mouse embryos spanning embryonic days 10 to 13. The data sets were processed with a semi-automated image segmentation algorithm and brain volumes were calculated. The results indicated that during these mid-gestational stages, there was an increase in CNS volume of 38% while volumetric renderings revealed the complex remodeling of the neuroarchitecture showing more cell proliferation than increase in brain mass.

Conclusions:High-frequency annular arrays with coded excitation offer an effective means of acquiring in vivo, in utero ultrasound data of the embryonic mouse and can be used to rapidly analyze the normal or abnormal development of the CNS during longitudinal studies.

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