



MD-PhD Cross Talks

SY16-1

Developmental Brain Imaging: An M.D.'s Perspective

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Developmental brain imaging is essential for elucidating the structural and functional maturation of the infant brain. Magnetic resonance imaging (MRI) offers a unique, non-invasive tool to visualize these processes, but conventional techniques are often limited to descriptive findings. The introduction of quantitative image processing has significantly enhanced the ability to characterize brain development and relate imaging findings to clinical outcomes. The implementation of quantitative image processing was made possible through collaborative work between M.D. and Ph.D. researchers.

One major area of quantitative image processing has been the investigation of the neonatal glymphatic system, which facilitates cerebrospinal fluid transport and metabolic waste clearance. MRI-based assessment of perivascular spaces (PVS) has revealed neonatal maturation patterns reflected in PVS volume changes. This was made possible through quantitative image processing of segmenting PVS in early brain MRI. With neonatal PVS volumetric extraction, the study "Association of Hypoxic-Ischemic Injury of the Brain With MRI-Derived Glymphatic Function Parameters in Neonates" demonstrated that hypoxic-ischemic injury disrupts glymphatic function. In addition, a pilot study showed that neonatal PVS volume correlates with neurodevelopmental outcomes at 24 months.

Radiomics has also expanded opportunities in developmental brain imaging by extracting high-dimensional features from routine MRI scans. In the study of neonatal brain MRI radiomics analysis, radiomic features identified developmental vulnerabilities invisible to conventional interpretation. This approach is relevant in preterm infants, where brain maturation is highly asynchronous and susceptible to disruption, highlighting the value of computational techniques for risk stratification.

In conclusion, these investigations demonstrate that combining clinical radiology with quantitative image processing can provide further insights into the developing brain. Developmental brain imaging represents a multidisciplinary frontier where medical expertise and biomedical engineering converge to generate innovative knowledge.