Advanced Ultrasound Imaging of the Brain in Neonatal Hydrocephalus Using a Rat Hydrocephalus Model

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Background and Objective:

Preterm infants are at risk of developing post-hemorrhagic hydrocephalus. Earlier detection and intervention via placement of an intraventricular catheter improves neurologic and cognitive outcomes. However, intraventricular catheter placement is invasive with many risks, including hemorrhage and infection. Magnetic resonance imaging (MRI) can be used to detect ventriculomegaly and suggest hydrocephalus but cannot diagnose it. MRI is also difficult to obtain in preterm infants. Shear wave elastography (SWE) is an ultrasound technique measuring tissue stiffness and could serve as a rapid, bedside technique to detect hydrocephalus. We hypothesize that SWE stiffness measurements of the brain will positively correlate to MRI-derived ventricular volumes.

Methods:

Rats were bred to be wild-type, heterozygous, or homozygous for a Wpk mutation causing obstructive hydrocephalus. SWE and MRI of the rats were obtained at 7 and 14 days postnatally. Stiffness was measured using the Aixplorer SWE analysis tool. Lateral ventricular volumes were measured from the T2-weighted MRI images by planimetric analysis.

Results:

Stiffness and ventricular volumes were compared between genotypes via Kruskal-Wallis test at 7 and 14 days. SWE comparisons were 12.75 ($p < 0.05$) and 16.54 ($p < 0.001$), respectively. MRI volume comparisons were 18.78 ($p < 0.001$) and 19.01 ($p < 0.001$), respectively. MRI volume measurements were correlated to the SWE measurements via Spearman's Rank correlation at 7 days ($r = 0.539$, $p < 0.05$), 14 days ($r = 0.488$, $p <.05$), and combined ($r = 0.534$, $p < 0.001$), consistent with a moderate correlation.

Conclusion and Potential Impact:

This study supports the hypothesis that SWE-derived brain stiffness does significantly correlate with ventricular volumes. SWE has the potential to be used as a bedside tool for detecting neonatal hydrocephalus. SWE could reduce the need for MRI exams and invasive intraventricular catheter placements, allowing for more rapid diagnosis and thus intervention for newborns with hydrocephalus.