

Correlations between brain stiffness, headaches and ventricular size using magnetic resonance elastography in children with hydrocephalus

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Background

Chronic headaches in treated hydrocephalus patients may be related to changes in brain elastance (stiffness, compliance), which may occur at the onset of hydrocephalus or develop chronically over the course of shunt treatment. Magnetic Resonance Elastography (MRE) is a new tool to measure brain elastance non-invasively. We employed MRE to test the hypothesis that brain tissue elastance is altered in hydrocephalus.

Materials and Methods

Twenty-seven shunt-dependent patients (age 14-35, median 19) who developed hydrocephalus as infants and had chronic headaches were selected and compared to 20 healthy controls (age 8-46, median 22). MRE was performed by inducing a 30Hz vibration transmitted through the zygomatic arches via MRI-compatible pneumatic pistons. Tissue elastance was calculated through Algebraic Helmholtz Inversion. The Headache Disability Index (HDI) and Hydrocephalus Outcome Questionnaire (HOQ) were collected in all patients, as well as other clinical data. Brain elastance (G^*), averaged separately across white and grey matter masks and within lobar regions-of-interest, was compared to healthy controls, and linear associations of elastance with ventricular size, HDI and HOQ were investigated.

Results

Overall, brain tissue elastance was reduced in patients compared to controls (WM - $G^* = 1.83 \pm 0.18$ kPa vs. 2.01 ± 0.12 kPa, frontal GM - $G^* = 1.40 \pm 0.14$ kPa vs. 1.55 ± 0.12 kPa, occipital GM - $G^* = 1.18 \pm 0.20$ kPa vs. 1.36 ± 0.12 kPa, $p < 0.001$). Occipital grey matter elastance was negatively correlated with ventricular size ($R^2 = 0.23$, $p < 0.001$). There was a weak positive correlation between occipital grey matter elastance and HOQ ($R^2 = 0.16$, $p < 0.05$), and a negative trend correlation between occipital grey matter stiffness and HDI ($R^2 = 0.14$, $p = 0.056$).

Conclusions

Brain elastance was reduced in hydrocephalus patients, possibly indicating impaired biomechanical integrity of brain tissue.