Clinical Correlation of Magnetic Resonance Elastography in Normal Pressure Hydrocephalus

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Introduction

Normal pressure hydrocephalus (NPH) is a potentially reversible cause of ventriculomegaly that characteristically presents with dementia, urinary incontinence, and gait disturbance. We compared magnetic resonance elastography (MRE) in NPH prior to shunting with normal controls, and evaluated associations between MRE and clinical findings, to determine whether MRE abnormalities predict outcomes after shunting, or correlate with NPH signs and symptoms.

Methods

10 patients with NPH who were scheduled for ventriculoperitoneal shunting underwent preoperative MRE and were correlated with 21 age- and sex-matched controls (IRB approved protocol). Corrected stiffness values were compared between subject and control regions-of-interest (ROI) including cerebrum, cerebellum, frontal, temporal, parietal, occipital, and deep grey/white. Associations were tested with cognitive decline, urinary incontinence, gait disturbance, falls, Parkinsonism, Mini-Mental score, CSF flow rate, hydrocephalus, duration-of-symptoms, opening pressure, improvement after LP, and postoperative improvement. Statistical analysis included t test and linear regression.

Results

MRE demonstrated significantly increased parenchymal stiffness in NPH over multiple ROI including cerebrum, occipital, and parietal (p=0.04, p=0.002, p=0.01). Univariate analysis showed associations including urinary incontinence with cerebrum, frontal, and cerebellum (p=0.005,p=0.04, p=0.03); Parkinsonism with occipital (p=0.04); and Mini-Mental score with parietal (p=0.0180). Postoperative improvement was associated with increased deep grey/white stiffness, whereas postoperative failure was associated with increased temporal stiffness (p=0.01, p=0.0002). Multivariate analysis showed associations between the clinical triad and increased stiffness in cerebrum, frontal, and cerebellum (p=0.005, p=0.04, p=0.03).

Table 1 – Brain Elasticity in iNPH Patients and Healthy Controls

	NPH (n=10)	Control (n=21)	p-value
Region-of-Interest			
Cerebrum	**2.64 (±0.11)**	**2.55 (±0.11)**	**0.04**
Frontal	2.65 (±0.05)	2.74 (±0.03)	0.1
Occipital	**2.97 (±0.15)**	**2.75 (±0.16)**	**0.002**
Parietal	**2.63 (±0.18)**	**2.45 (±0.12)**	**0.01**
Temporal	2.79 (±0.48)	2.73 (±0.03)	0.3
Deep Grey/White	2.91 (±0.09)	3.00 (±0.06)	0.4
Cerebellum	2.20 (±0.04)	2.23 (±0.03)	0.6

Corrected stiffness reported as mean (±standard error)

Table 2 – Clinical Symptoms and Brain Elasticity in iNPH

	Symptom Present	Symptom Absent	p-value
Urinary Incontinence			
Cerebrum	**2.67 (±010)**	**2.53 (±0.01)**	**0.005**
Frontal	**2.67 (±0.16)**	**2.53 (±0.02)**	**0.04**
Cerebellum	**2.23 (±0.09)**	**2.11 (±0.03)**	**0.03**
Parkinsonism			
Occipital	**3.10 (±0.08)**	**2.92 (±0.16)**	**0.04**
	Linear Fit	**Root Mean Sq Error**	**p-value**
Mini-Mental Score			
Parietal	**R^2=0.04**	**0.13**	**0.02**

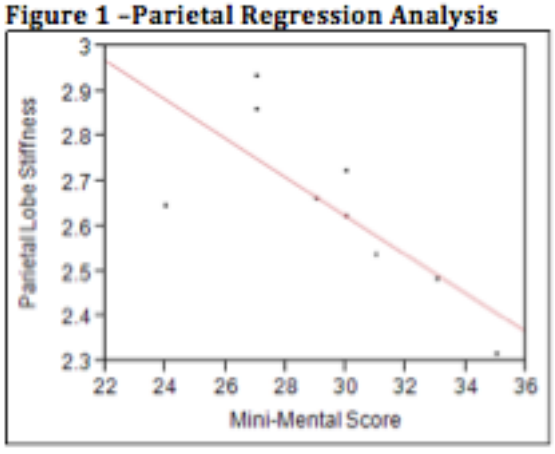
Corrected stiffness reported as mean (±standard error)

Table 3 – Postoperative Improvement and Brain Elasticity in iNPH

	Improved (n=8)	Not Improved (n=2)	p-value
Region-of-Interest			
Cerebrum	2.61 (±0.04)	2.73 (±0.07)	0.2
Frontal	2.64 (±0.06)	2.67 (±0.11)	0.8
Occipital	2.95 (±0.06)	3.03 (±0.12)	0.6
Parietal	2.63 (±0.07)	2.66 (±0.13)	0.9
Temporal	**2.75 (±0.11)**	**3.00 (±0.02)**	**0.0002**
Deep Grey/White	**2.98 (±0.05)**	**2.60 (±0.11)**	**0.01**
Cerebellum	2.19 (±0.03)	2.28 (±0.06)	0.2

Corrected stiffness reported as mean (±standard error)

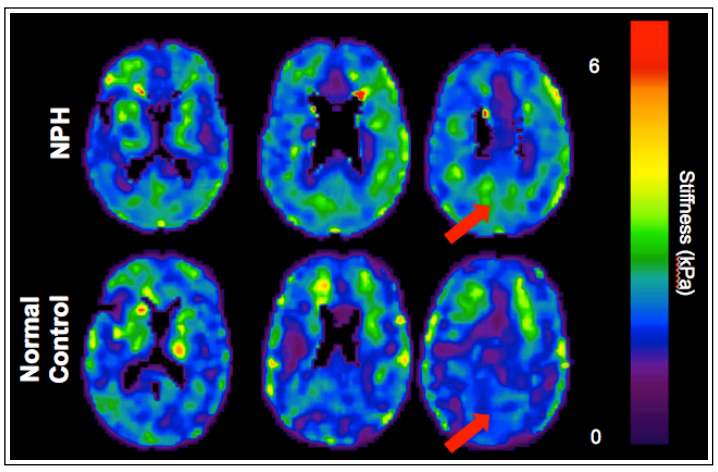
Figure 1 –Parietal Regression Analysis



$R^2 = 0.04$, $p = 0.02$

Conclusions

MRE demonstrates significantly increased cerebral, occipital, and parietal stiffness in NPH, with significant associations between symptoms and increased parenchymal stiffness, indicating that MRE provides diagnostically valuable information in NPH. While surgically responsive NPH was associated with deep grey/white stiffness, surgical failure was associated with temporal stiffness, suggesting an alternative dementing pathology. Correspondingly, MRE may guide selection of patients for shunting in the setting of equivocal diagnoses of NPH.



References

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Learning Objectives

By the conclusion of this session, participants should be able to: 1) Describe the typical MRE abnormalities observed in NPH, 2) Discuss the potential role for MRE in diagnosing NPH, 3) Identify the key MRE findings distinguishing patients likely to benefit from ventriculoperitoneal shunting.