MR Elastography as a Method to Estimate Brain Stiffness and its Correlation to Intracranail Pressure in Pseudotumor Ceribri Patients

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Target Audience: Radiologists, Physicians, Biomedical Engineers, Biomedical Researchers, Radiology Technologists.

Introduction: Overall brain stiffness is dependent on the intrinsic mechanical properties of the pia-arachnoid, gray matter, white matter, and cerebrospinal fluid pressure [1] .Therefore, measuring the stiffness of the brain can be used to diagnose different brain disease states. Recently, a novel imaging technique called magnetic resonance elastography (MRE) was developed to measure the stiffness of soft tissues and is currently being used to estimate the stiffness of the brain [2-3]. Our hypothesis is that by measuring brain stiffness the intracranial pressure may be estimated in pseudotumor cerebri patients. Therefore, the purpose of this study is to evaluate the relationship between brain stiffness measured by MRE and the intracranial pressure measured by lumbar puncture in pseudotumor cerebri patients.

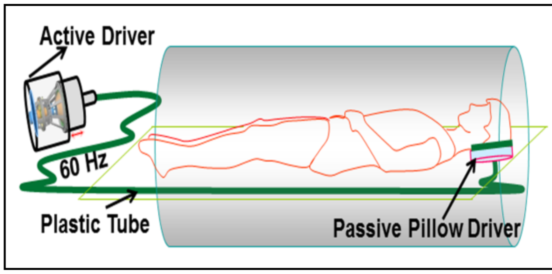

Figure 1. Acoustic Driver. A pillow driver is placed posterior to the brain. Sound waves are noninvasively transmitted to the driver and into the patient's brain. These waves are imaged by MRE and are used to calculate stiffness.

Methods: *In vivo* brain MRE was performed on 7 pseudotumor cerebri patients on a 3.0 T MRI scanner (Vario, Siemens, Erlangen, Germany) before and after lumbar puncture. Patients were laid in supine position with head first into the scanner. A standard gradient echo (GRE) MRE sequence was used to acquire10 axial slices covering the brain. 60 Hz Mechanical waves were introduced into the brain by using a pneumatic pillow driver (Mayo Clinic, Rochester MN) as shown in Figure 1. Imaging parameters included TE: 21ms; TR;25ms; FOV: 256mm; slice thickness:5mm; matrix size: 128x64; grappa acceleration factor:2; 4 MRE phase offsets; 60Hz (16.67ms) motion encoding gradients were applied separately in all the three directions (i.e. X,Y, Z) to encode the motion in in-plane (X,Y) and through plane (z). These displacements are analyzed using custom built software (MRE Lab, Mayo Clinic, Rochester, MN). The curl of the first harmonic displacements are then analyzed using a 3D phase gradient algorithm by applying 2D directional filter to remove the reflected waves to obtain the stiffness maps. The mean stiffness value of the whole brain was measured in the slice showing the major portion of the ventricle before and after lumbar puncture. Furthermore, the opening and closing pressure measurements were recorded by lumbar puncture to determine the correlation between stiffness and pressure measurements.

Results: The opening and closing pressures by lumbar puncture ranged from 1cmH_2O to 38.5cmH_2O and the corresponding mean stiffness value of the brain ranged from 2kPa to 4.3kPa. Figure 2 shows the magnitude, wave images and corresponding stiffness maps in a patient (pre and post lumbar puncture). Our data shows that after relieving the intracranial pressure by lumbar puncture the whole brain stiffness decreased in4 out of 7 patients while in the other 3 patients it increased. However, based on the initial pool of the data the stiffness values between pre and post lumbar puncture were not significantly different.

Discussion: The above data shows that the intracranial pressure does not significantly alter the brain stiffness value before and after lumbar puncture in the initial pool of data. We believe that the amount of decrease in intracranial pressure after lumbar puncture may not have significantly altered the brain stiffness, as brain stiffness depends on other intrinsic structures. However, more studies are warranted in order to determine the relationship between intracranial pressure and stiffness of the brain.

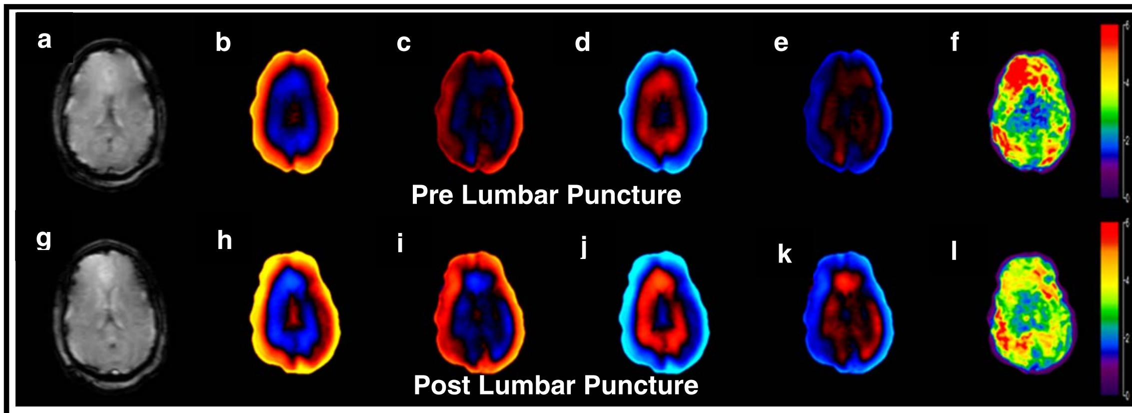

Figure 2. MRE Patient. a,g) Axial magnitude image of the brain pre and post lumbar puncture respectively in one of the patients. **b-e; h-k)** similarly snap shot of in-plane (Y-direction) wave propagation at four time points and **f,l)** Weighted stiffness map from 3 encoding directions with a mean stiffness value of 3.6±1.6 kPa and 3.4±0.9 kPa pre and post lumbar puncture respectively. Colorbar represents the stiffness values ranging from 0-6kPa.

Refrences: 1) Daikel Takada,Surg Neurol Int 2012; 3:11 **2)**Scott A. Kruse, et al.Neuroimage,2008,39(1):231-237
3)Clayton, et al, BPhys Med Biol,2011,,56(8),239-2406