Periventricular Apparent Diffusion Coefficient, Cerebrospinal Fluid (CSF) Aqueductal Flow Rate and Evan's Index - Value of Pre and Post Shunt Comparison in Idiopathic Normal Pressure Hydrocephalus (NPH)

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Introduction: Idiopathic Normal Pressure Hydrocephalus (NPH) is a debilitating condition that afflicts predominantly the elderly. The patient typically presents with the triad of (a) Loss of bladder and bowel control (wet) (b) Abnormal broad based gait (wobbly) (c) dementia (wonky). The diagnosis is supported by the radiologic finding of dilated ventricles without a demonstrable cause. Patients with newly diagnosed NPH typically respond to ventriculo-peritoneal shunting (VPS). NPH related dementia is possibly the only surgically reversible dementia. An elevated CSF Flow Rate (FR) is associated with a positive response to shunting. However, post shunting FRs are unpredictable [1]. We believe that the symptoms of NPH are caused not by ventriculomegaly, but predominantly by a blockage to the flow of extracellular fluid in the brain, leading to its subsequent accumulation. If the former were true, all responders should post an interval decrease in FR and Evan's Index (EI). Moreover, the reverse would hold true for non-responders. If the latter were true, all responders would post an interval decrease in Apparent Diffusion Coefficient (ADC), with the reverse holding true for non-responders. This study attempts to correlate clinical findings in pre and post shunting NPH patients with 3 measurements (the ADC, FR and EI) to establish their value in assessing shunt response.

Materials and Methods: 9 patients (age 57-79 years: Male/Female 2:1) were studied with a 1.5T whole body MR scanner (GE Signa, General Electric Medical Systems, Milwaukee, WI). Scans were acquired between 1 to 7 days prior to VPS, as well as 6 to 12 months post VPS. Aside from conventional orthogonal sections, the following MR measurements were made:

1. ADC value of the periventricular region. This was computed by placing a 45mm^2 circular region of interest (ROI) in the periventricular region adjacent to the tip of the frontal and occipital horns of each lateral ventricle. An average of these four readings was then computed. A Diffusion Weighted Imaging (DWI) sequence was applied over the entire brain TR/TE = 10/0.125 sec, FOV = 34cm, matrix =128x128, slice thickness = 5mm, b=1000s/mm^2.
2. FR at the level of the cerebral aqueduct using prospectively cardiac gating PC – MRI. Parameters are: TR/TE: 19/8msec, FA= 20^o, section thickness=7 mm, matrix=256x128 matrix and FOV=16cm. Venc = 20cm/s.
3. EI – Maximal frontal horn ventricular width divided by the transverse inner diameter of the skull.

Flow rates were deemed normal or hyperdynamic based on computations from a previous study [2]. Similar readings of 9 age and gender matched controls were also recorded. Clinical grading of symptoms pre and post shunting were assessed using a scale developed by Krauss et al [3]. Score assignment was based on the clinical examination as well as interviews with the patient and the primary caregiver.

Results: 6 patients posted positive clinical improvement post shunting. Post-operative improvement in MRI readings for ADC, FR and EI was seen in 6 (100%), 4 (67%) and 6 (100%) patients respectively. For the 3 clinical non-responders, similar readings ADC, FR and EI were seen in 0 (0%), 2 (67%), and 2 (67%) patients respectively [Figure 1]. In all non-responders, the post shunt ADC was elevated compared to its pre shunt counterpart.

Conclusion: These preliminary results demonstrate that of the 3 measurements evaluated, only the ADC readings showed total concordance with the clinical post shunt response. For all 6 shunt responders, the post shunt ADC showed a decrease. Conversely, for all non-responders, the post shunt ADC posted an interval elevation.

FR and EI could not differentiate between responders and non-responders. This leads us to believe the symptoms of NPH are not related to ventriculomegaly. Rather the primary cause is due to a block in the normal transport of extracellular fluid within the brain. Fluid accumulates within the extracellular space and elevates the ADC. The intraventricular shunt provides an alternative pathway for this, explaining the subsequent drop in ADC. The shunt is likely to act more as a capacitor rather than a diversion of fluid from the ventricle to the peritoneum.

In addition, a post-operative elevation of ADC may be an early marker of shunt failure in patients presenting with recurrent symptoms of NPH.

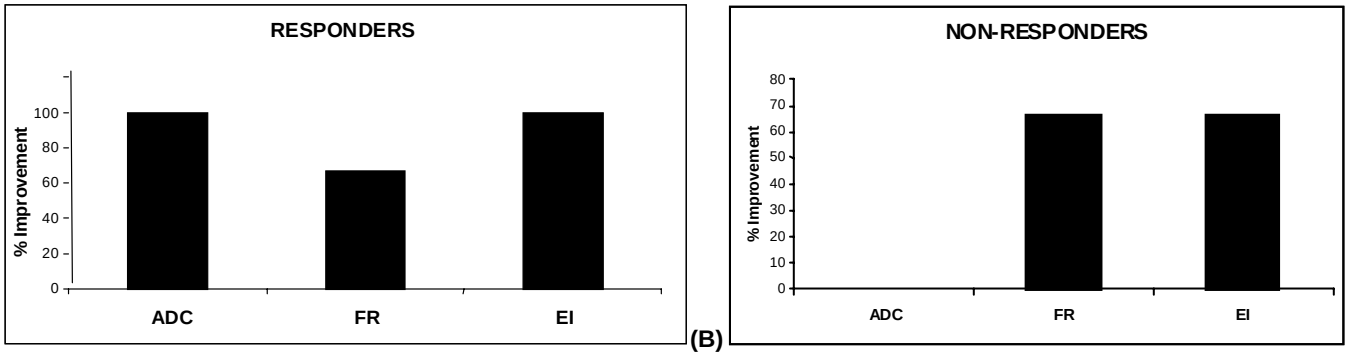

Figure1: Improvement of MR (Pre vs Post VPS) readings in Responders (A) v Non Responders (B) showing 100% concordance between response and decrease in ADC. Conversely ADC showed interval elevation in all non-responders.

References: (1) Parkkola et al. European Radiology 2000;10:1442-1446. (2) SES Ng et al. Neuroradiology 1999;41(S1):17. (3) Krauss et al. Neurosurgery 1997;40:67-74.