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Phase-contrast MRI's Function in the Diagnosis of Abnormalities in Cerebrospinal Fluid Flow

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Key Words:

MRI's Function, Phase-contrast, Abnormalities, Cerebrospinal Fluid Flow

Abstract:

Phase and magnitude information are originally included in the signal. Anatomy and motion data may be visualized in the form of magnitude and phase pictures, respectively. The resulting correlation between CSF speed and greyscale intensity of each pixel is intuitive. The purpose of this research is to determine how well phase contrast MRI can identify various cerebrospinal fluid flow abnormalities. A prospective research design was used for this investigation. The research was place at the Radio-Diagnosis Division and lasted for 18 months. CSF pulsatility and stroke volume across the aqueduct have been associated to a positive response to shunting in individuals with normal pressure hydrocephalus, according to a recent study.

1. Introduction:

It is possible to see the flow of cerebrospinal fluid (CSF) throughout the ventricular system of the brain and spinal cord with the use of phase-contrast MRI (magnetic resonance imaging) [1]. Phase changes in magnetic resonance signals brought on by fluid protons moving through a magnetic field form the basis of this imaging method [2].

Phase-contrast MRI may be helpful in diagnosing CSF flow disorders by revealing the flow's velocity, direction, and volume, as well as any blockages or changes in flow patterns. Hydrocephalus, syringomyelia, Chiari malformation, and spinal cord tumours are only few of the neurological disorders that might be indicated by abnormal CSF flow [3].

Hydrocephalus, in which cerebrospinal fluid (CSF) accumulates abnormally and causes pressure and tissue damage in the brain, may be diagnosed via phase-contrast MRI. Phase-contrast MRI may aid in the diagnosis of hydrocephalus [4] by visualising the CSF flow within the ventricular system and revealing any blockages or abnormalities in flow patterns.

Phase-contrast MRI offers the potential to aid in the accurate identification of CSF flow anomalies and the discovery of new, more effective therapies for these conditions. [5]

Phase-contrast MRI

By making the phase of the transverse magnetization sensitive to motion speed, PC MRI creates signal contrast between moving and still nuclei. Two data sets are collected with contrasting sensitivities, resulting in nuclei that are out of phase while they are moving and in phase when they are at rest. Since the net phase is 0 for non-moving nuclei, their signal is cancelled out in the final picture [6]. Between the first sensitization and the second, however, flowing nuclei change locations along the field gradient. The net phase after subtracting the two data sets is not zero, indicating the presence of a residual signal from the CSF's movement through the body. By subtracting the two datasets, we are left with just the signal contribution from moving nuclei and not from those that remain still. The maximal expected CSF flow velocity must be put into the pulse sequence protocol (velocity encoding (VENC) [7] before PC MRI data can be obtained.

The most effective signal may be obtained if the CSF flow velocity is equal to or slightly less than the chosen VENC. Higher than VENC CSF flow velocities may cause aliasing artefacts, whereas lower

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than VENC velocities lead to a faint signal. For typical CSF flow imaging, the VENC is about 8 cm s1. The distinction between communicative and non-communicating arachnoid cysts, as well as the evaluation of ventriculoperitoneal shunt patency, may be aided by low VENC values (2-4 cm s1). Because of the hyperdynamic CSF flow inside the cerebral aqueduct, much higher VENC values (20-25 cm s1) are recommended for patients with normal pressure hydrocephalus. Phase and magnitude information are included in the signal from the outset [8]. Anatomy and motion data may be visualised in the form of magnitude and phase pictures, respectively. The resulting correlation between CSF speed and greyscale intensity of each pixel is intuitive. On phase pictures, whiter tones indicate CSF moving in the caudal direction, whereas darker tones indicate CSF moving towards the brain. To a far greater extent than the magnitude picture, the PC velocity image is sensitive to CSF flow because it reflects the phase alterations [9]. One set of PC imaging techniques is used to quantify CSF flow in the axial plane with through-plane velocity encoding in the craniocaudal direction, and the other set is used to evaluate CSF flow qualitatively in the sagittal plane with in-plane velocity encoding in the craniocaudal direction. Quantitative analysis benefits more from through-plane assessment, which is conducted in the axial oblique plane perpendicular to the aqueduct. It only takes 8-10 minutes longer than normal MRI to provide quantitative CSF velocity and qualitative flow information [10].

Since cerebrospinal fluid (CSF) flow is pulsatile and coincides with the heart cycle, cardiac gating may be employed to improve sensitivities. There are two ways to deliver cardiac gating: prospectively and retrospectively. The R wave is tracked by the computer in retrospective gating, and data are collected throughout the whole cardiac cycle. Retrospective gating allows for sampling of the full cardiac cycle, however prospective gating requires acquisitions to be finished 100-200 ms before the next expected R wave. Therefore, it would seem that there is a large net flow of CSF in the systolic direction due to the fact that prospective gating only samples a portion of the cardiac cycle. Retrospective gating is superior to prospective gating in terms of accuracy [10].

2. Methodology:

This investigation was designed as a prospective research and sampled participants at their convenience. The research was place over the course of 18 months at the radiology department of Saveetha Medical College and facility (a tertiary care facility) in Thandalam, Kancheepuram district, Tamil Nadu. The research comprised 36 people, 18 of whom had neurological symptoms and 18 of whom were considered controls and had been referred by the Department of Neurology. Radiologists from Saveetha Medical College spearheaded this potential research project.

All patients in the research gave their permission before their participation. Thirty-six individuals with neurological complaints were referred from the Neurological Outpatient Clinic and Neurological Ward. Prior to granting written informed permission, all patients had a comprehensive evaluation that included a full review of their medical history, both past and current. An individual inquiry code is assigned to each patient's file. Confidentiality was guaranteed for all patient information. Participants and the ethics committee were quickly informed of any emergent dangers throughout the course of the investigation.

The 1.5 T PHILIPS MULTIVA MRI system's head coil will be used for the examination. Studies of CSF flow, including CSF DRIVE (DRIVEN Equilibrium), CSF QF (Quantitative flow), and CSF PCA (Phase Contrast Angiography), are performed alongside more common conventional MRI sequences such axial T1, T2, and FLAIR, sagittal T2, and coronal T2. T2 was analysed with the following parameters: TR 5000, TE 105, NEX 2, FA1/100, FOV 240, and matrix 224 x 384. In every case, MR-compatible electrodes were employed for cardiac gating. A localizer was placed on the cerebral aqueduct, perpendicular to the ampullary area, on sagittal T2-weighted images or an SSPS sequence.

The information was analysed using SPSS 21, the Statistical Programme for the Social Sciences.

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3. Result

20 (55.6%) of the 36 patients were male, whereas 16 (44.4%) were female.

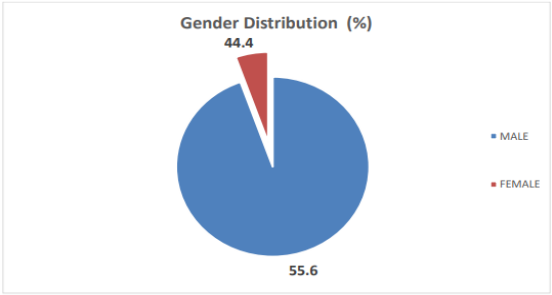

Figure 1: Gender distribution of respondent

From 1 year to 80 years old, we saw patients in the following age groups: 0-20 (25%), 21-40 (22.2%), 41-60 (25%) and 61-80 (27.8%). [Figure 2]

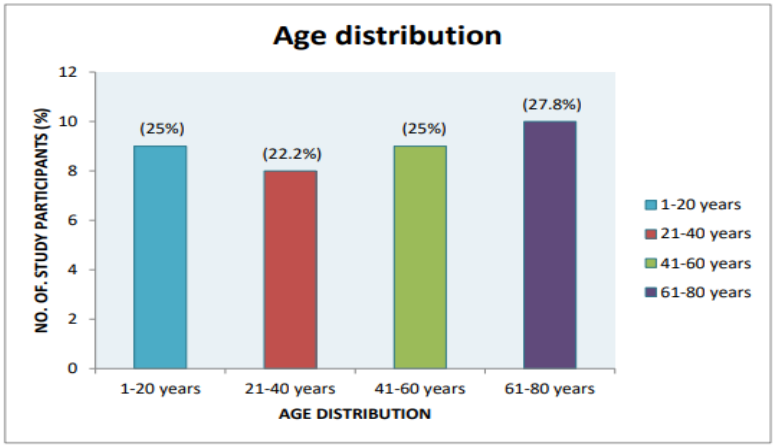

Figure 2: Age distribution of Respondents

The study participants are sub grouped into 18 control (50%) and 18 cases (50%). The study participants are sub grouped into 18 control (50%) and 18 cases (50%) [Figure 3]

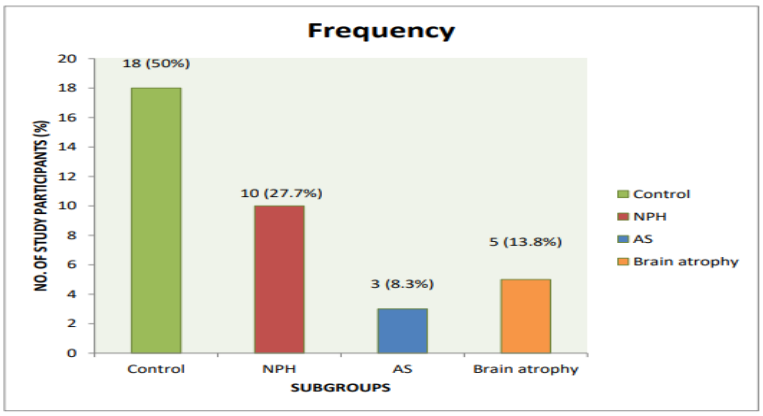

Figure 3: Frequency of subgroups

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There was a statistically significant increase in PDV, PSV, and SV in NPH compared to controls (PDV, PSV, and SV, 9.96 +/-1.73, 4.72+/-0.62, and 63+/-12.88 for NPH vs 4.8 +/-0.39, 3.21 +/-0.55, and 20.72 +/-5.7 respectively) ($p<0.05$) [Figure 4].

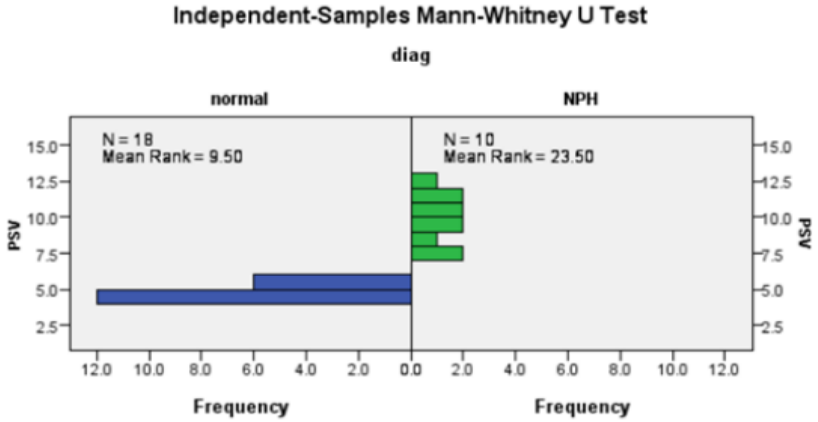

Figure 4: Control and NPH group comparison regarding Peak systolic velocity

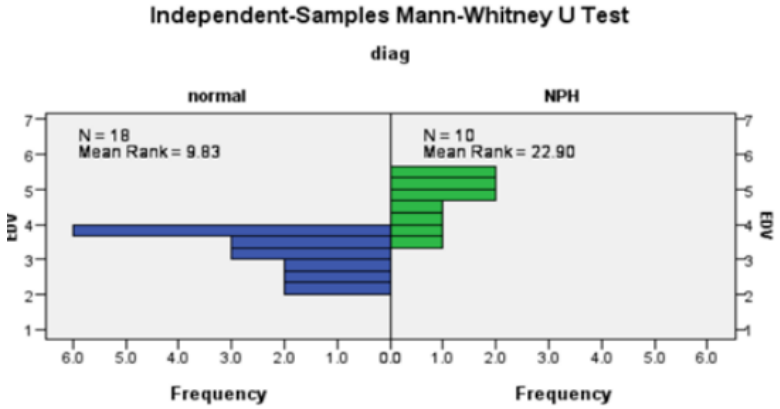

Figure 5: Control and NPH group comparison regarding End diastolic velocity

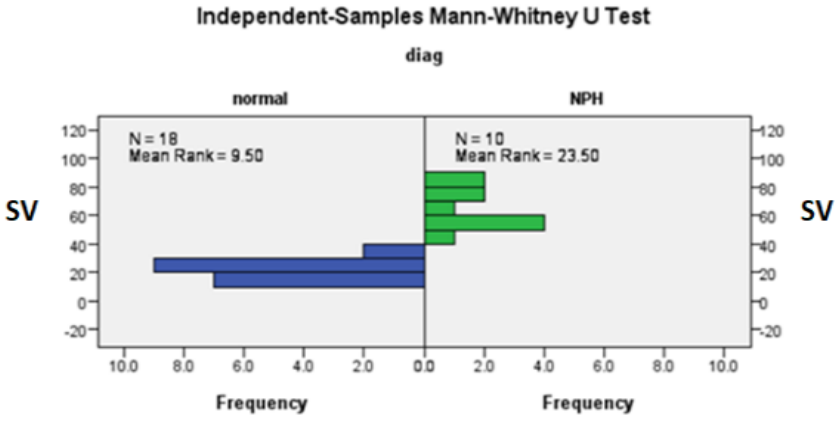

Figure 6: Control and NPH group comparison regarding stroke volume

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Values for Aqueduct stenosis patients were lower than those for controls (Figure 7; 1.6 +/-0.44, 1.13+/-0.09, and 6.33 +/-2.08 vs 4.8 +/-0.39, 3.21 +/-0.55, and 20.72 +/-5.7, respectively; p value <0.05).

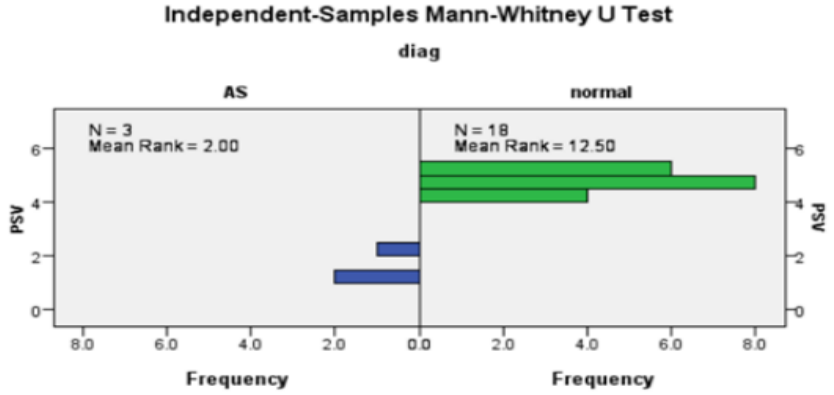

Figure 7: Comparison between control and Aqueduct stenosis group regarding Peak systolic velocity

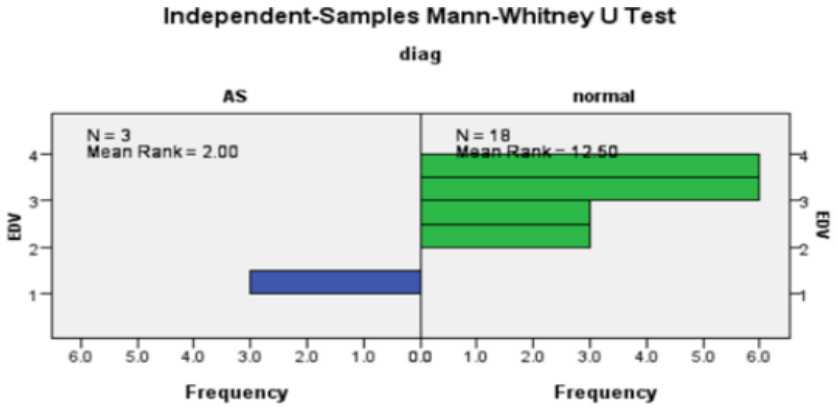

Figure 8: Control and Aqueduct stenosis group comparison regarding End diastolic velocity

Figure 9 demonstrates that the values for patients with age-related brain atrophy were significantly lower than the values for controls (4.8 +/-0.39, 3.21 +/-0.55, and 20.72 +/- 5.7, respectively; p value<0.05).

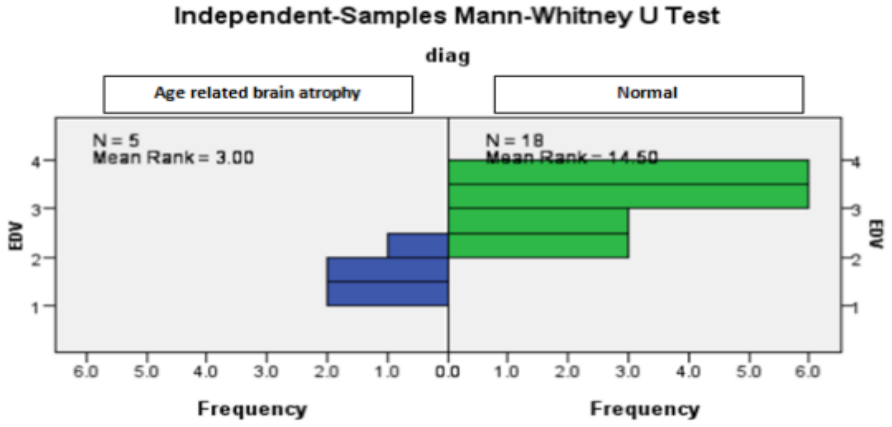

Figure 9: Control and Age related brain atrophy group comparison regarding End diastolic velocity

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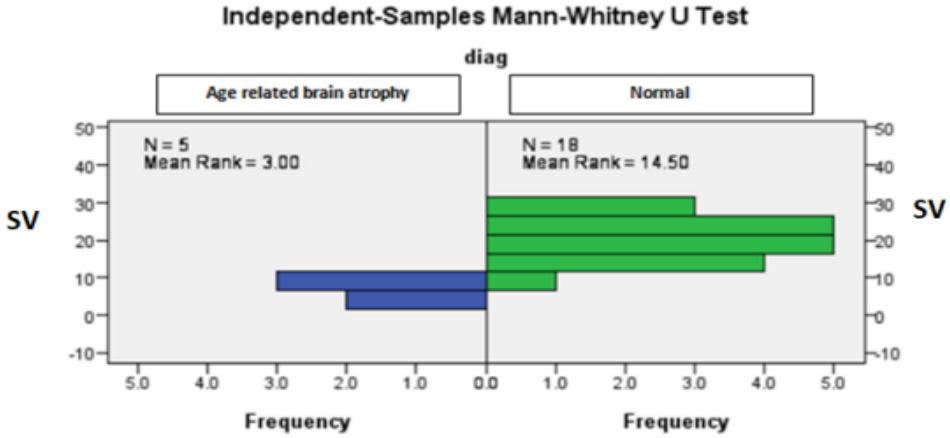

Figure 10: Control and Age related brain atrophy group comparison regarding Absolute stroke volume

4. Conclusion:

PC cine MRI is a useful imaging technique for evaluating CSF dynamics, which play a role in a wide range of illness processes. Evaluation, follow-up, surgical decision, and post-operative surveillance of numerous disease processes may all benefit greatly from the addition of PC MRI to traditional MRI. MRI CSF flowmetry is a noninvasive method for detecting and tracking CSF abnormalities in a number of neurological disorders. CSF flowmetry using MRI is able to differentiate between NPH and atrophy of the brain.

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