

Role of MRI in the Evaluation of Normal Pressure Hydrocephalus

Surbhi Kumari¹, Raju Ranjan²

¹Senior Resident, Department of Radiodiagnosis, Shri Ramkrishna Institute of Medical Sciences, Durgapur, West Bengal, India

²Assistant Professor, Department of General Surgery, Shri Ramkrishna Institute of Medical Sciences, Durgapur, West Bengal, India

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Corresponding Author: Dr. Raju Ranjan

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Abstract

Aim: The aim of the present study was to assess the role of CSF flow indices in patients with symptoms of normal pressure hydrocephalus.

Methods: The present study was conducted at Radiology Department of Apollo Main Hospitals from March 2016 to November 2016. The study was approved by the scientific committee and the ethical committee clearance was obtained before the study. Total no of 60 participants age range was between 38 to 88 were enrolled into the study.

Results: 58.3% population was >60 years, 26.7% population group was in between 51-60 years and 15% population was < 50 years age. Overall gender distribution in case group (n=30) 25 was male and 5 was female and in control group(n=30) 22 was male and 8 was female. Gait Disturbances was present in 86.7%, Dementia was present in 73.3% and Urinary Incontinence was present in 70% in Case Population. Ventriculomegaly was present in 93.3%, Symmetrical trans ependymal edema was present in 90%, Sulcus effacement was present in 90%, Corpus callosal thinning was in 83.3%, Corpus callosal angle was between 50 -80 degree in 83.3% and Flow Void at cerebral aqueduct was present in 62.2%.

Conclusion: Our study showed five patient gait disturbance only by clinically, conventional MRI also showed only ventriculomegaly and sulcus effacement. Ventriculomegaly was present in 93.3%, Symmetrical trans ependymal edema was present in 90 %, Sulcus effacement was present in 90%, Corpus callosal thinning was in 83.3%, Corpus callosal angle was between 50 -80 degree in 83.3 % and Flow Void at cerebral aqueduct was present in 62.2%.

Keywords: CSF flow indices, symptoms, normal pressure hydrocephalus, diagnostic value

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Introduction

The production and flow of human cerebrospinal fluid has been studied since the 1940s, however, early investigations were hampered by a lack of non-invasive studies. [1] Magnetic resonance investigation in CSF flow began with the qualitative observation of the degree of flow void in the aqueduct of Sylvius and adjacent third and fourth ventricles. [2]

Although this early MR method was useful in the evaluation of patients with suspected NPH, the clinical success was limited and this observational method was not significantly used because the presence of flow void phenomenon in the aqueduct is a qualitative measure, which is influenced by many acquisition parameters and often may be difficult to quantify. [3] Phase contrast cine MR flow imaging provides a simple way to better characterize CSF flow. The application of cine phase-contrast MRI technique in patients with NPH holds great promise for improvement of the

diagnosis, especially in those cases where the differentiation from atrophy on clinical and conventional radiological basis is difficult.

In the normal patient, consistent flow patterns are observed and are quite different from those patterns that are seen in CSF flow disorders. [3] The phase contrast technique is extremely sensitive even to slow flow and provides the potential for noninvasive flow quantification. The results of these measurements have yielded considerable information on the physiology of the normal CSF circulation. In addition, pathological CSF flow dynamics in normal pressure hydrocephalus has been analyzed. [4]

MRI is a noninvasive test and it can better detect ventriculomegaly, periventricular hyperintensity (symmetrical trans ependymal edema),sulcus effacement, Callosal angle , Callosal thinning and flow void on cerebral aqueduct than other modality.

But conventional MRI alone cannot reliably detect all NPH patients. PC cine MRI can provide valuable additional information to conventional MRI. It has emerged as a more sophisticated technique of examining the flow of CSF through different regions of the brain such as extra ventricular (Precor space, post cord space, the prepontine cistern, and the interpeduncular cistern) and cerebral aqueduct. PC cine MRI is a useful imaging technique in evaluating CSF dynamics that affects various disease processes and for evaluation, follow-up, surgical decision and postoperative survey of NPH case and other various disease process which dynamically affect CSF flow. CSF pulsatility and stroke volume through the aqueduct has been correlated with a positive response to shunting in patients with normal pressure hydrocephalus.

The aim of the present study was to assess the role of CSF flow indices in patients with symptoms of normal pressure hydrocephalus.

Materials and Methods

The present study was conducted at Radiology Department of Apollo Main Hospitals from March 2016 to November 2016. Total no of 60 participants age range was between 38 to 88 were enrolled into the study. All 60 cases were referred to the department of radiology from neurosurgery and neurology outpatient clinics, 30 patients referred with symptoms of normal pressure hydrocephalus .30 healthy volunteers without neurological symptoms and with normal MRI imaging findings, were included as the control. These normal volunteers were in good health and denied any present or previous spinal or neurologic problems or hypertension.

Inclusion Criteria

1. Patients clinically diagnosed as idiopathic normal pressure hydrocephalus(NPH)
2. Patients with MRI features of NPH.

Exclusion Criteria

1. All the patients whose MR images were degraded by artefacts making evaluation impossible.
2. Deviation of image planning from study protocol.
3. Lack of cooperation to complete the MRI examination.

Methodology:

Phase Contrast Mriimage Acquisition

The study was conducted using MRI machine3 Tesla, (PHILIPS MR SYSTEMS Ingenia, - Release 4.1.3.2 2014 -05- 01 SRN : 42407). A circular polarized head-array coil and ultra-gradients were chosen. First conventional magnetic resonance

imaging of the brain was Performed. Standard axial T1 WI (TR = 2000 – TE = 20 /slice thickness = 5 mm/Number of acquisition = 2), axial and sagittal T2WI (TR = 3000 – TE = 80 /slice thickness = 5 mm/Number of acquisition = 2) and axial FLAIR (TR = 11000 – TE = 125 /slice thickness =5mm) images were obtained before CSF flow measurements were made.

Phase-contrast MR imaging: It divided in to three group based on MRI sequence.

(1)CSF Drive(2) Phase contrast and (3) CSF Q flow. Velocity encoding (VENC) 5 cm/s was taken for control group and VENCs (up to 20 cm/s) for case group. CSF flow velocities greater than VENC can produce aliasing artefacts, whereas velocities much smaller than VENC result in a weak signal. Pulse oximetry was used to get MRI images synchronous to cardiac cycle of patient.

1. CSF Drive

It is 3D T2Weighted turbo spin echo sequence in the sagittal plane. It is small volume with very high in plane resolution. Image sequence is used to visualize CSF in aqueduct of Silvius.

2. Phase Contrast

It is In plane, sagittal weighted image, perpendicular to the proximal 1/3 of the cerebral aqueduct, Cardiac gated (ECG being used for cardiac synchronization) were used, 15 phase images were calculated. Single slice phase contrast angiography was used to visualize CSF flow. Based on the flow differences of flowing spins compared to static spins, images were typically presented in 3 sets:

a. **Re-phased image** (magnitude of flow compensated signal) flow is of high signal, background is visible

b. **Magnitude image** (magnitude of difference signal) flow is of high signal (regardless of direction), background is suppressed

c. **Phase image** (phase of difference signal) signal is dependent on direction: forward flow is of high signal: reverse flow is of low signal, background is mid-grey

3. CSF Q flow

It is a high resolution axial weighted image perpendicular of the cerebral aqueduct, cardiac gated (ECG being used for cardiac synchronization),12 images were obtained. Images were presented in sets of 3 (a. Re-phased image magnitude image c. Phase image). Transverse single slice quantitative flow measurement information on flow direction and velocity based on flow differences of flowing spins compared to static spins.

Csf flow quantification process

A circular (ROI)Region of interest was placed in the aqueduct with the aid of a mouse driven cursor shown on a magnified image and was substituted for the diameter of the aqueduct, because the phase images did not show the real anatomical lumen of the aqueduct, but only the CSF flow. The area of the circular ROI was controlled to be between 1 and 5 mm² it was slightly smaller than the diameter of the aqueduct . Phase contrast images were displayed on a gray scale, where low signal intensity indicated caudal flow and bright signal intensity represented cranial flow.

Post processing calculations

Following the acquisition of the CSF flow velocity curves in cases of NPH and control where the mean velocity was automatically determined from the mean value of the measured velocities of each cardiac phase and the area of ROI measured by the MR unit. Temporal parameters evaluation involved determination of R-S interval (on set of CSF

systole), R-PS interval (time of CSF peak systole), and duration of CSF systole.

Finally systolic stroke volume was calculated from the following equation: -Systolic stroke volume = mean systolic flow (flux) x duration of CSF systole

Statistical Analysis:

All the continuous variables were assessed for normality using Shapiro wilk’s test.

If the variables were normally distributed they were being expressed as mean ± standard deviation. All the categorical data were expressed as percentages comparison of normally distributed continuous variables were done by independent sample t test. Comparison off categorical variables were done by chi square test. Data entry was done in MS – excel spread sheet data analysis was carried out by SPSS version 16.0 all p value < 0.05 was considered as statistically significant.

Results

Table 1: Demographic data

Age	Cases	Control
<= 50 yrs	9	15.0
51-60 yrs	16	26.7
>60 yrs	35	58.3
Sex		
Male	25	83.3
Female	5	16.7

58.3% population was >60 years, 26.7% population group was in between 51-60 years and 15 % population was < 50 years age. Overall gender distribution in case group (n=30) 25 was male and 5 was female and in control group(n=30) 22 was male and 8 was female.

Table 2: Symptoms

Symptoms	%
Gait disturbances	86.7
Dementia	73.3
Urinary Incontinence	70

Gait Disturbances was present in 86.7%, Dementia was present in 73.3% and Urinary Incontinence was present in 70% in Case Population.

Table 3: MRI findings

MRI FINDINGS	%
Ventriculomegaly	93.3
Symmetrical trans ependymal edema	90
Sulcus effacement	90
Symmetrical trans ependymal edema	90
Corpus callosal angle	83.3
Corpus callosal thinning	83.3
Flow void at cerebral aqueduct	63.3

Ventriculomegaly was present in 93.3%, Symmetrical trans ependymal edema was present in 90%, Sulcus effacement was present in 90%, Corpus callosal thinning was in 83.3%, Corpus callosal angle was between 50 -80 degree in 83.3% and Flow Void at cerebral aqueduct was present in 62.2%.

Discussion

During the last two decades, cardiac gated phase-contrast MRI has emerged as a fascinating technique for dynamic imaging of the CSF flow and evaluating different parameters of CSF dynamics, both qualitatively and quantitatively. The technique has

been successfully used in evaluating patency of endoscopic 3rd ventriculocisternostomy. [5] It is being increasingly used as an alternative to traditional CSF shunting in non-communicating hydrocephalus, measuring aqueduct CSF flow in patients with IAHS and predicting successful response to CSF shunting, and characterizing the flow of CSF in the foramen magnum in patients with Chiari 1 malformations. [6]

58.3% population was >60 years, 26.7% population group was in between 51-60 years and 15% population was < 50 years age. Dixon et al [7] studied forty-nine patients with NPH. The mean age of patients in their study was 72.9 years with a range of 54 to 88 years. Bradley et al [8] studied eighteen patients with NPH. Their mean age was 73 years with a range between 54 to 83 years. Overall gender distribution in case group (n=30) 25 was male and 5 was female and in control group (n=30) 22 was male and 8 was female. Gait Disturbances was present in 86.7%, Dementia was present in 73.3% and Urinary Incontinence was present in 70% in Case Population. Boon AJ et al and Mori K observed Gait disturbances are typically the first signs of INPH. [9,10] Ahlberg J et al. observed Urinary incontinence as the third primary symptom of INPH. [11]

Ventriculomegaly was present in 93.3%, Symmetrical trans endymal edema was present in 90%, Sulcus effacement was present in 90%, Corpus callosal thinning was in 83.3%, Corpus callosal angle was between 50 -80 degree in 83.3% and Flow Void at cerebral aqueduct was present in 62.2%. Holodny AI et al [12] observed patients with NPH, the CSF volume was significantly increased in the ventricles and decreased in the superior convexity and medial subarachnoid spaces as compared with other causes of hydrocephalus.

Conclusion

Our study showed five patient gait disturbance only by clinically, conventional MRI also showed only ventriculomegaly and sulcus effacement. Ventriculomegaly was present in 93.3%, Symmetrical trans endymal edema was present in 90 %, Sulcus effacement was present in 90%, Corpus callosal thinning was in 83.3%, Corpus callosal angle was between 50 -80 degree in 83.3 % and Flow Void at cerebral aqueduct was present in 62.2%.

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