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Original Research Article

Imaging Characteristics in Patients with Normal PressureHydrocephalus at Tertiary Health Care Hospital

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Conflict of interest: Nil

Abstract:

Background: Normal pressure hydrocephalus (NPH) is a syndrome found in the elderly, which is characterized by the clinical triad of gait disturbance, dementia, and urinary incontinence without overt signs and symptoms of elevated intracranial pressure. According to estimates, NPH can cause up to 10% of dementia cases. It is important because ventriculoperitoneal shunting can be used to cure NPH.

Aim and Objective: To describe the various imaging patterns helpful in the diagnosis of normal pressure hydrocephalus.

Materials and Method: It was a prospective study. Inpatients and outpatients of age group more than 40 years of age, of both gender (males and females) diagnosed with normal pressure hydrocephalus as per consensus criteria were referred to Department of Radiodiagnosis from the Department of Neurology of Chalmeda Anand Rao Institute of Medical Sciences were enrolled in the study for the duration of 6 months. The patients underwent Magnetic resonance imaging / computed tomography study of brain. Computed tomography (CT) and Magnetic resonance imaging (MRI) show ventricular enlargement disproportionate to cerebral atrophy, with associated ballooning of frontal horns, periventricular hyperintensities, thinning and elevation of the corpus callosum, and widening of temporal horns without evidence of hippocampal atrophy in NPH.

Results and Conclusion: Despite the fact that a diagnosis can be made solely on the basis of CT findings, MRI is more reliable for revealing concomitant illnesses (such as cerebrovascular disease) and for detecting NPH characteristic indications of prognostic value, in addition to avoiding exposure to ionizing radiation. The best imaging technique for capturing anatomical changes is MRI, which can also support the diagnosis with CSF flow investigations.

Keywords: Normal pressure hydrocephalus, neuro imaging, magnetic resonance imaging, computed tomography, cerebrospinal fluid pressure, shunt surgery.

Introduction

Normal pressure hydrocephalus is characterized by a triad of dementia, gait ataxia and urinary incontinence without overt signs and symptoms of elevated intracranial pressure. The triad is famously referred to as Hakim's triad for NPH. [1-4] NPH can be idiopathic or can be secondary. The secondary causes are: traumatic brain injury, meningitis, subarachnoid hemorrhage (SAH) or intracranial surgery. The exact pathology of idiopathic normal pressure hydrocephalus (I NPH) is still unclear. [4]

The underlying pathophysiological mechanism points to decreased cerebral vascular compliance, poor cerebrospinal fluid (CSF) absorption through the arachnoid granulation, and impaired cerebrospinal fluid (CSF) flow within the ventricles or subarachnoid space, or both. [4] There are no accepted pathological criteria for postmortem diagnosis of iNPH. While potentially harmful abnormalities, suchas arachnoid fibrosis, have been seen in the brain autopsies of some individuals with iNPH, these findings have not undergone systematic research; therefore they cannot support a clinical diagnosis of iNPH.

The following CT or MRI criteria are required by worldwide standards for the diagnosis of NPH: ventricular expansion disproportionate to cerebral atrophy (Evans index > 0.3), with accompanying frontal horn ballooning; periventricular hyperintensities; and thinning and elevation of the corpus callosum. Callosal angle between 40º and 90º and widening of temporal horns not fully

explained by hippocampal atrophy; and aqueduct or fourth ventricular flow void; enlargedSylvian fissures and basal cistern, and narrowing of sulci and subarachnoid spaces over the high convexity and midline surface of the brain. [5]

The newer MRI applications provides indications of abnormal CSF flow by using Proton Density MRI, Phase Contrast MRI, Radionuclide cisternography documenting CSF flow void, ventricular reflux and hyperdynamic flow. Various Advanced MRI measurements can be performed as adjuncts to conventional clinicalsequences in patients suspected of having NPH: Volumetric MRI, Diffusion Tensor Imaging, Arterial Spin Label and Phase Contrast Imaging. [6] iNPH is an important cause of motor disturbances and cognitive impairment in elderly patients, the social and economic burden attributable to iNPH cannot be ignored. Therefore, any kind of research effort aimed at improving the understanding of the epidemiology of iNPH is important. [7]

Materials and Method

It is a prospective cross-sectional study. Inpatients and outpatients of age group more than 40 years of age, of both gender (males and females) diagnosed with normal pressure hydrocephalus as per consensus criteria were referred to Department of Radiodiagnosis from the Department of Neurology of Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar Were enrolled in the study.

Study Design: Prospective cross-sectional study.

Source of Data:

The prospective study was performed in the Department of Radiodiagnosis, Chalmeda Anand Rao institute of medical sciences, Karimnagar on patients with normal pressure hydrocephalus as per consensus criteria

Study Design: From July 2022 to December 2022, for a period of six months.

Sample Size: 40

Study Centre: Department of Radiodiagnosis, Chalmeda Anand Rao institute of medical sciences, Karimnagar.

Inclusion Criteria:

- Patients diagnosed with normal pressure hydrocephalus as per consensus criteria and referred to Department of Radiodiagnosis from the department of Neurology, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar.
- Both male and female patients.

Exclusion Criteria:

- Patients who are having other causes of dementia.
- Patients having other significant neurological illness.
- Patients not willing to participant.

Sampling Technique: Convenient sampling technique

Study Methods: After approval by institutional ethical committee, patients of age group more than 40 years of age,of both gender (males and females) diagnosed with normal pressure hydrocephalus as per consensus criteria and referred to Department of Radiodiagnosis from the department of Neurology were enrolled in the study with a written informed consent.

All patients were subjected to Computed Tomography (CT)/ Magnetic Resonance Imaging (MRI) after approval of the study protocol by our institutional research & human ethical committee, thepatients who fulfilled the inclusion criteria were included in the study. Written informed consentwas taken and all the selected patients were explained in detail about the procedure. Magnetic resonance imaging / computed tomography study of brain were performed once.

Observation and Results

A cross-sectional observational study was done in the department Radiodiagnosis, Chalmeda Anand Rao Institute of Medical Sciences, Karimnagar, Telangana, India, from November 2022 to April 2023. The trial was approval by the institutional review board and the Ethics committee. A written informed consent was obtained from all participating patients in accordance with the tenets of the declaration of Helsinki. The number of valid cases with normal pressure hydrocephalus who fulfilled the inclusion criteria were forty.CT and MRI evaluation of brain was done using T1W, T2W, FLAIR, ADC, DWI, GRE, D CISS sequences. The mean age of patients was 65.8±19.2 (range, 42-85 years). Table 1 and Figure 1 shows the age and sex distribution of patients. There were 21(52.5%) males and 19 (47.5%) females, respectively.

Table 1: Distribution of Age among study Population

Age	Frequency	Percent
42	3	7.5
55	6	15
60	6	15
65	6	15
70	8	20

75	6	15
80	4	10
85	1	2.5
Total	40	100

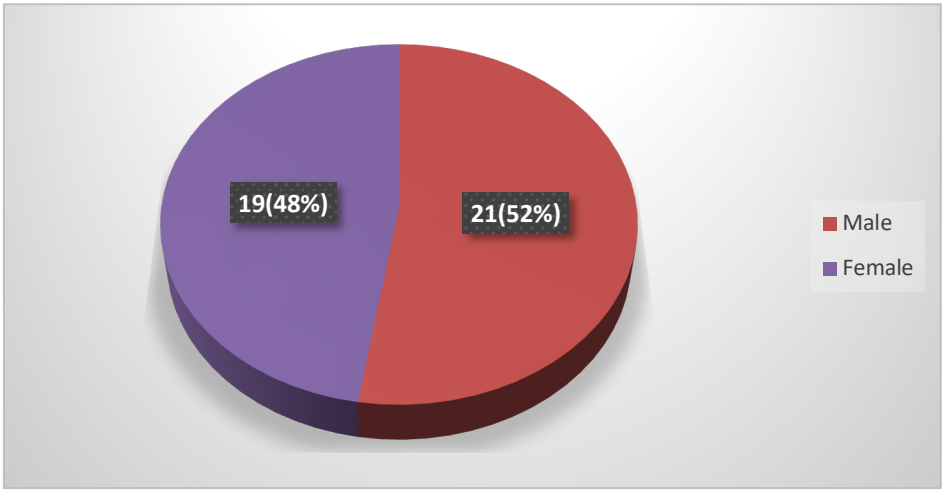

Figure 1: Distribution of Age among study Population

The mean Evan's index of patients was 0.35±0.04 (range, 0.27-0.44). The distribution of Evans index is shown in Table 3 and Figure 3, respectively. The mean Evan's index in males was 0.35±0.04 and in females was 0.34±0.03.

Table 2: Distribution of Evan's Index among study population

Evan's Index	Frequency	Percent
0.28	2	5
0.3	4	10
0.31	5	12.5
0.35	9	22.5
0.37	8	20
0.39	7	17.5
0.44	5	12.5
Total	40	100

The mean Callosal angle of patients was 64.7±15.5 (range, 47-95 degrees) and the mean size of third ventricle was 10.4±1.6 (range, 7-13 mm) shown in bellow.

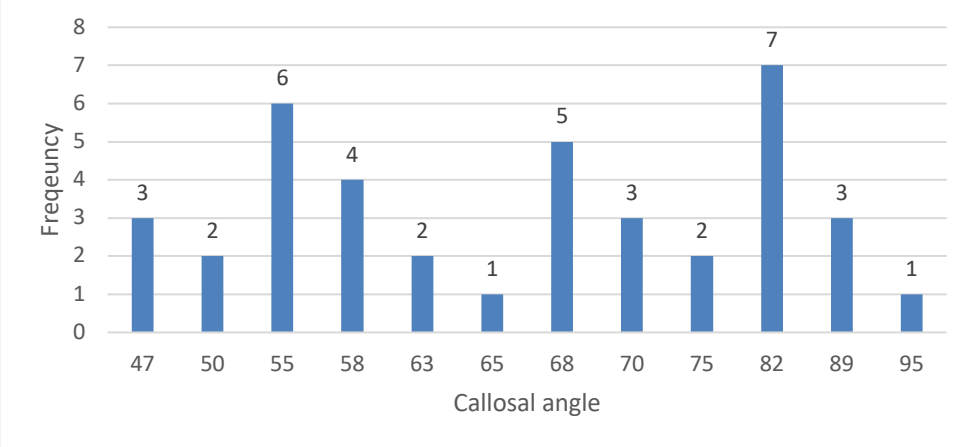

Figure 2: Distribution of Callosal Angle among study population

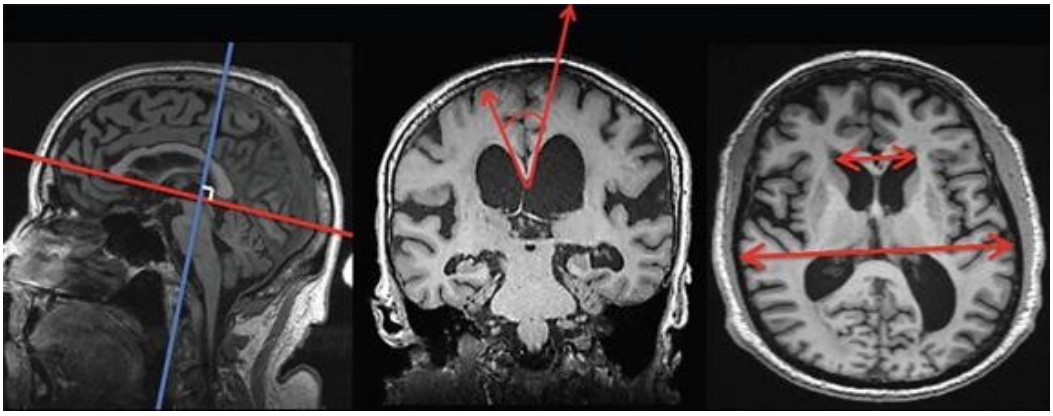

Image 1: MRI, TWI Showing AnteriorCommissure-Posterior commissure (AC-PC) Plane at the level of posterior commissure, Callosal angle and Evan's index

Table 3: Distribution of the size of third ventricle (mm) among patients

Ventricle Size(mm)	Frequency	Percent
7	1	2.5
8	4	10
9	6	15
10	9	22.5
11	11	27.5
12	4	10
13	5	12.5
Total	40	100

Table 4: Distribution of the size of temporal horn

Size (mm)	Frequency	Percent
2	1	2.5
10.1-15	2	5
3	3	7.5
4	6	15
5	9	22.5
6	5	12.5
7	5	12.5
8	6	15
9	1	2.5
10	1	2.5
11	1	2.5
Total	40	100

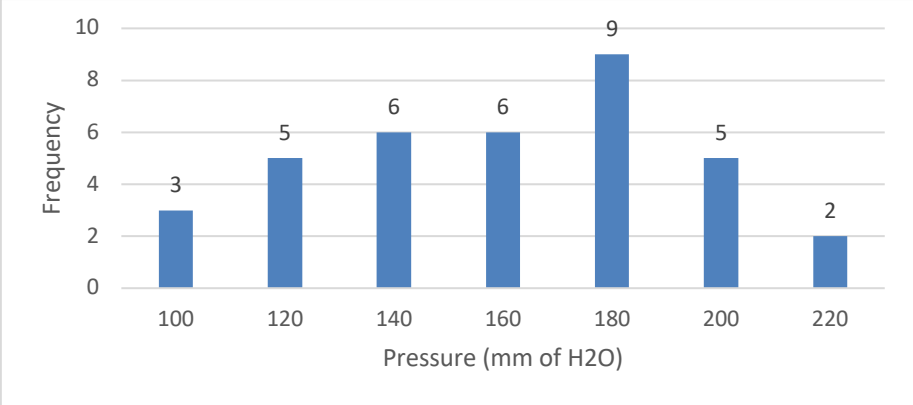

Figure 3: Distribution of cerebrospinal fluid (CSF) pressure

The mean size of temporal horn was 5.7±2 (range, 2-11 mm). The mean cerebrospinal fluid (CSF) pressure was 162±35.7 (range, 100-230 mm of H2O).

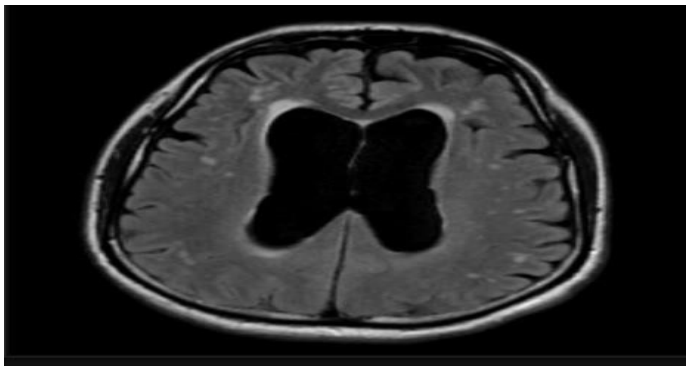

Image 2: Dilated lateral ventricles

The sulci were graded from 0-2. The sulci were normal (0) in 13(32.5%), slight compression (1) in 12 (30%) and definitive compression (3) in 15 (37.5%) patients, respectively.

Table 5: Distribution of the Sylvian fissure dilatation

Findings	Frequency	Percent
Normal	10	25
Mildly Enlarged	13	32.5
Highly enlarged	17	42.5
Total	40	100

Table 5 showed that Dilation of the Sylvian fissure was graded as normal or narrow (0), mildly moderately enlarged (1) and highly enlarged (2). Ten (25%) had a normal, 13(32.5%) moderately enlarged and 17(42.5%) patients had a highly enlarged sylvian fissure, respectively. Completely Disproportionately enlarged subarachnoid space hydrocephalus (DESH) was graded as absent (0) and present (1), if both narrow sulci at the high convexity and the Sylvian fissure.

Amongst the study participants, DESH was noted in 57.5%, incomplete DESH in 27.5%, and no DESH in 15%.

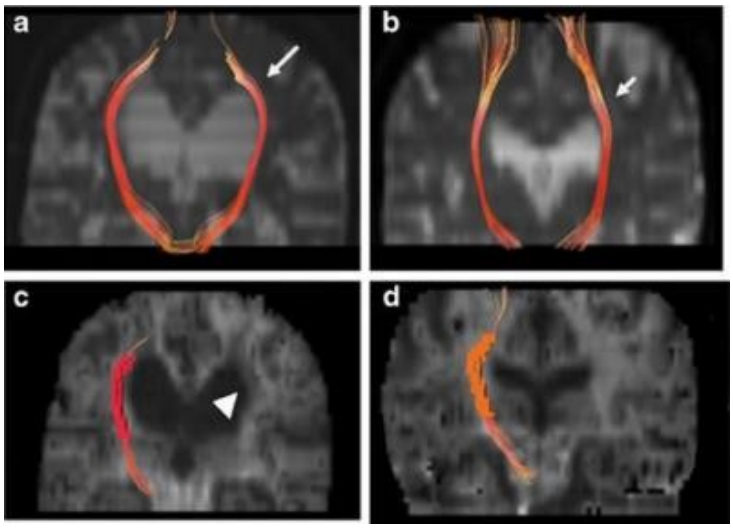

Image 3: Anisotropy color-coded MRI tractography of the corticospinal tract (CST) at the level of the lateral ventricle (arrows) (a) in a patient with idiopathic normal pressure hydrocephalus (iNPH) and (b) in a control subject. These tractography on coronal mean kurtos Is images are shown without diffusion encoding images (b=0s/mm2). Diffusional kurtosis images of (c) the iNPH patient and (d) the control subject. The diffusional kurtosis images of the iNPH patient (c) shows the relative low intensity (arrow head) of the periventricular areascompared to control subjects (d).

Table 6: Completely disproportionately enlarged sub arachnoid space

	Frequency	Percent
Absent	16	41
Present	23	59
Total	39	100

Discussion

Normal pressure hydrocephalus is also known as syndrome of gait ataxia, dementia, and urinary incontinence syndrome associated with normal CSF pressure and dilated ventricles. This condition mainly affects the elderly. [8] Imaging techniques are increasingly being used for diagnostic and prognostic evaluation of NPH due to lack of a single standard test [9-10] Computed tomography (CT and magnetic resonance imaging (MRI) shows ventricular enlargement disproportionate to cerebral atrophy, with associated ballooning of frontal horns, periventricular hyperintensities, thinning and elevation of the corpus callosum, and widening of temporal horns without evidence of hippocampal atrophy. Although CT findings alone can suggest a diagnosis of NPH, MRI may be more useful for disclosing associated pathologies (such as cerebrovascular disease), prognostic signs, avoiding exposure to ionizing radiations.[11]

This cross-sectional study evaluated the imaging characteristics (CT and MRI) of patients with normotensive hydrocephalus. The evaluated outcome variables were the Evan's index ,Callosal angle, sylvian fissure dilation, diameters of third ventricle and temporal horns of lateral ventricle flow voids through aqueduct of sylvius ,deep white matter hyperintensities, periventricular hyperintensity, disproportionately enlarged subarachnoid hydrocephalus(DESH).The effects of independent variables such as age and gender on these indices were also evaluated. Evan's Index(the ratio which compares the maximum width of the frontal horns of the lateral ventricle to themaximum transverse diameter of the inner table of the skull) is an important parameter for diagnosis of NPH and ventriculo peritoneal shunt surgery follow-up. [12-13]

Samuel et al conducted a case control study to define the value of quantitative MRI biomarkers (Evans 'Index(EI).The authors found a significant difference in EI between cases and controls .For patients presenting with signs and symptoms of NPH, readings on MRI greater than 0.3 for EI, further reinforces the diagnosis. The mean EI of 0.35±0.04 in our study was comparable to the observations by Samuel and co-authors. [14] Arun Kumar et al evaluated EI in South Indian population using computed tomography. One hundred subjects (5 to 90 years) with normal CT brain were analyzed retrospectively. There were 54 males and 46 females. The authors found that the mean EI was 0.27 ± 0.04 in males, 0.26 ± 0.03 in females, respectively. No significant statistical difference was observed in the EI between males and females. However, with advancing age, mild increase in Evan's index was seen. In our study, no significant difference (P=0.342) was observed in between males and females. [15]

Conclusion

Despite the fact that a diagnosis can be made solely on the basis of CT findings, MRI is more reliable for revealing concomitant illnesses (such as cerebrovascular disease) and for detecting NPH characteristic indications of prognostic value, in addition to avoiding exposure to ionizing radiation. The best imaging technique for capturing anatomical changes is MRI, which can also support the diagnosis with CSF flow investigations.

Limitation of Study

The limitations of this study were the small sample size of patients. Second, NPH patients were not evaluated for shunt surgery. Thus, the suitability of MRI markers for shunt surgery could not be evaluated. Third, advanced MRI techniques such as CSF flow studies and diffusion tensor imaging were not performed.

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