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MORPHOMETRIC ANALYSIS OF THE HUMAN BRAIN VENTRICLES IN NORMAL SUBJECTS BY 3.0 T MRI

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ABSTRACT
Aims and objectives: A prospective study was done to establish the range of normal values of measurements of the ventricular system by use of MRI.
Materials and methods: This hospital based cross-sectional study conducted at Department of Radiodiagnosis of Dr. B.V.P. Rural Medical College PIMS (DU), Loni, Maharashtra, India. All patients attending at Radiodiagnosis & Imaging Department of Dr. B.V.P. Rural Medical College and Hospital and had normal MRI scan of brain were the study population.
Results: Only third ventricle width and fourth ventricle transverse width showed statistically significant results with age. Only third ventricle width showed statistically significant results with gender. Frontal Horn Width, Third Ventricle Width and Fourth Ventricle Transverse Width (FVW) showed positive significant correlation with age.
Conclusion: Frontal horn width, third ventricle width and fourth ventricle transverse width (FVW) showed positive significant correlation with age. Thus, knowledge of these parameters is of immense importance while diagnosing various neurological and psychiatric disorders associated with ventriculomegaly.

Key words: Brain ventricles, ventricular size, MRI

1. INTRODUCTION

The ventricular system of the human brain consists of four cavities: two large lateral ventricles and the third and fourth ventricles. All four ventricles contain strands of a highly convoluted and vascular membranous material called choroid plexus, which is a network of ependymal cells involved in the production of cerebrospinal fluid (CSF). The CSF fills the ventricular space within the brain and bathes the entire central nervous system. The entire volume of CSF is renewed two to three times per day and disruption of the flow can cause excess CSF to build up leading to the clinical condition called hydrocephalus.[1] In hydrocephalus, the ventricles expand and press against nearby brain tissue causing the brain shape to become distorted, leading eventually to brain damage. If this happens over a long period of time, the clinical syndrome of normal pressure hydrocephalus (NPH) may result. In conjunction with ventriculomegaly, symptoms of NPH include cognitive impairment, gait dysfunction, and urinary incontinence.[2]
Enlargement of ventricular system in hydrocephalus results from an imbalance between production and absorption of cerebrospinal fluid.[3] It is obvious that for early and precise diagnosis of type of hydrocephalus, knowledge of ventricular size including width of lateral ventricle (LVW) and distance between falx to inner table of skull (FH) in coronal plane, ventricular index (VI)and distance between falx to inner table of skull (FC) in temporal plane, width of lateral ventricle (C) in parasagittal plane, diameter of 3rd ventricle in coronal plane, width of foramen of monro (FM), length (ADL) and width (AD) of aqueduct, distance between foramen of monro and aqueduct (FMAD) and aqueduct to foramen of magnum(ADFM) is mandatory.
Ventricular size measurement is necessary for determination and follow-up many neurological illnesses, and pathologies. Ventricular enlargement is an indicator of brain parenchyma loss.[4] Furthermore, ventricular size measurements are used in studies hydrocephalus, schizophrenia, tumors, trauma, Alzheimer's disease, Parkinson's disease, gender, aging, and atropy which is associated with many neurological diseases such as stroke and dementia, Huntington's disease[5] and provides useful indices of cerebral asymmetry and atrophy. The knowledge of ventricular system anatomy is essential for clinicians, neurosurgeons and radiologists.[6] Due to

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literature findings, the ventricular size is considered as a potential indicator in determination of many diseases related with brain. Additionally, the normal reference values of ventricles obtained by MRI are necessary to form the baseline data for interpreting pathological changes, determining the presence and progress of some neurological diseases and for planning surgery.

Magnetic resonance imaging (MRI) provides clearer and more accurate images due to the high tissue contrast than computerised tomography (CT) images.[7] An MRI presents detailed information on the soft tissue especially for brain structures *in vivo*.[8] 3T MR systems are preferred in psychiatric disorders and neurological research due to its fine image quality in thin thickness.[9] It is frequently used for the early diagnosis of diseases related to the central nervous system in both human medicine and veterinary medicine. It is also known that these types of diseases are easily measured by MRI.[10]

Little work has been done on measurement of cerebral ventricular system in our country. A prospective study was made to establish the ranges of normal values for the measurement of the ventricular system by use of MRI.

2. MATERIALS AND METHODOLOGY

This is a hospital based cross-sectional study conducted at the Department of Radiodiagnosis of Dr. B.V.P. Rural Medical College PIMS (DU), Loni, Maharashtra, India. All patients attending at Radiodiagnosis and Imaging Department of Dr. B.V.P. Rural Medical College and Hospital and had normal MRI scan of brain were the study population. All the individuals of both sexes and age, ranging between 1-60 years and above were included in the study. However, head injuries, cerebral ischemia or haemorrhagic infarction, intracranial space occupying lesion, previous intracranial surgeries were excluded. A total of 357 such individuals were consecutively included. Having obtained ethical clearance from the Ethical Committee and verbal consent from the patients, the data collection was done. MRI was done with PHILIPS INGENIA 3.0T CX MRI machine and T1WI, T2WI and FLAIR sequences were taken. Images were taken from axial, sagittal and coronal planes.

The data was coded and entered into Microsoft Excel spreadsheet. Statistical analysis was performed analysis was done using SPSS version 20 (IBM SPSS Statistics Inc., Chicago, Illinois, USA) Windows software program. Descriptive statistics included computation of percentages, means and standard deviations. The data were checked for normality before statistical analysis using Kolmogorov Simonov test. The unpaired t test (for quantitative data to compare two independent observations) and ANOVA test (for quantitative data to compare two and more than two observations) were applied. Multivariate Pearson correlation test was also done. Level of significance was set at $P \leq 0.05$.

3. RESULTS

Table 1: Age wise distribution of the study

Age (In Years)	Frequency	Percent
<10	38	10.6
10-20	36	10.1
20-30	56	15.7
30-40	76	21.3
40-50	54	15.1
50-60	53	14.8
>60	44	12.3
Total	357	100.0

30-40 years age group (21.3%) was higher than 20-30 years age groups (15.7%) followed by 40-50 years (15.1%) and 50-60 years (14.8%). Mean age was 37.15 years.

Table 2: Sex wise distribution of the study

	Frequency	Percent

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Female	190	53.2
Male	167	46.8
Total	357	100.0

Female had higher (53.2%) amount in study

Table 3: Age wise association with study variables

		N	Mean	Std. Deviation	Maximum	P value
Frontal Horn Width	<10	38	28.892	4.8946	35.6	0.12
	10-20	36	31.856	3.2687	39.4	
	20-30	56	31.259	3.7432	44.5	
	30-40	76	31.034	3.0780	39.2	
	40-50	54	36.741	35.5958	292.0	
	50-60	53	32.349	3.3778	40.1	
	>60	44	35.236	5.0670	50.3	
Maximum Inner Transverse Diameter of the skull	<10	38	148.905	187.3119	1271.0	0.5
	10-20	36	128.625	6.2260	142.3	
	20-30	56	124.889	6.1191	141.1	
	30-40	76	124.316	6.1683	143.7	
	40-50	54	125.472	6.1482	139.1	
	50-60	53	124.091	6.8269	135.0	
	>60	44	123.789	5.5303	135.4	
Third Ventricle Width	<10	38	3.416	1.9226	12.0	0.001 (S)
	10-20	36	2.978	1.0863	5.7	
	20-30	56	3.405	2.9089	21.0	
	30-40	76	2.804	1.0138	6.2	
	40-50	54	3.504	1.5573	10.2	
	50-60	53	3.909	1.5400	8.3	
	>60	44	5.366	2.1108	10.2	
Fourth Ventricle AP Width	<10	38	5.853	2.5394	11.6	0.25
	10-20	36	6.508	2.3268	12.0	
	20-30	56	6.739	2.1156	12.8	
	30-40	76	6.501	2.4254	12.5	
	40-50	54	6.409	2.4006	11.8	
	50-60	53	5.734	1.9366	11.7	
	>60	44	6.398	2.1684	11.0	
Fourth Ventricle Transverse Width	<10	38	8.932	2.2101	14.9	0.02 (S)
	10-20	36	11.122	2.2405	14.9	
	20-30	56	10.841	2.1488	16.0	
	30-40	76	10.758	2.1466	14.5	
	40-50	54	10.961	2.1656	16.3	
	50-60	53	10.953	2.1420	19.0	
	>60	44	12.920	12.3819	92.0	

Only third ventricle width and fourth ventricle transverse width were showed statistically significant results with age.

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Table 4: Age wise correlation with study variables

		Age
Frontal Horn Width	Pearson Correlation	.124
	P value	.01 (S)
Maximum Inner Transverse Diameter of the skull	Pearson Correlation	-.079
	P value	.136
Third Ventricle Width	Pearson Correlation	.271
	P value	.000 (S)
Fourth Ventricle AP Width (FVAP)	Pearson Correlation	-.019
	P value	.716
Fourth Ventricle Transverse Width (FVW)	Pearson Correlation	.138
	P value	.009 (S)

Frontal Horn Width, Third Ventricle Width and Fourth Ventricle Transverse Width (FVW) showed positive significant correlation with age.

Table 5: Gender wise association with study variables

		Mean	Std. Deviation	P value
Frontal Horn Width	M	33.151	4.5903	0.42
	F	31.929	19.2482	
Maximum Inner Transverse Diameter of the skull	M	133.492	88.8877	0.08
	F	122.297	6.3114	
Third Ventricle Width	M	4.099	1.8548	0.001 (S)
	F	3.099	1.9409	
Fourth Ventricle AP Width	M	6.312	2.3529	0.89
	F	6.345	2.2299	
Fourth Ventricle Trransverse Width	M	11.177	6.7231	0.38
	F	10.731	2.1142	

Only third ventricle width was showed statistically significant results with gender.

4. DISCUSSION

The human nervous system is the most complex, widely investigated & less adequately understood physical system known to mankind. According to Taveras and Wood[11] the lateral ventricular contours are relatively constant except occipital horns. Alteration in the brain with ageing has been focused in many investigations. A degree of asymmetry in two lateral ventricular contours is common, partly because of anatomical difference and partly because of obliquity of the head.[12] Considering the asymmetry of the two lateral ventricles, the amount of cerebrospinal fluid also alters because of the change in volumetric capacity. The volumetric changes in the lateral ventricles have been found in diseases like Schizophrenia.[13] This morphometric study of lateral ventricles was conducted based on measurements of MRI of brain which were then correlated with different age and sex groups, with a view to obtain the parameters of normal healthy adults in our population.

The sample size of present study was only 357, whereas the sample size in the study of Mallika[14] was 200 and that in the study of Medora and Prashanth[15] was 1000.

In the study, 30-40 years age group (21.3%) was higher than 20-30 years age groups (15.7%) followed by 40-50 years (15.1%) and 50-60 years (14.8%). Mean age was 37.15 years. Female subjects were recorded higher (53.2%).

In the present study, frontal horn width was 33.15 mm and 31.92 in male and female respectively. The frontal horn width was found as 35 mm and 33 mm in Norway males and females.[16] In South Indians, the corresponding value were found as 34.1 mm and 31.8 mm in males and females respectively.[17] In Germany healthy population, this was 30.1mm, whereas the corresponding value was 35.6 mm in hydrocephalic patients.[18] In the study, the frontal horns of right and left lateral ventricles in male subjects were significantly longer than those in female subjects ($p = 0.002$ and $p = 0.001$ respectively), which were on an average 1-1.5 mm less than those found in the study of Medora and Prashanth[15] (measured by CT scan) and on an average 1-2 mm less than those reported by Mallika[14] by CT scan.

In the present study, up to age 50 years, frontal horn width grew with ageing; after that, it becomes slightly variable. Third ventricle width was significantly increased after age 40 years. Fourth ventricle transverse width remained same at 30 to 60 years age.

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In the present study, third ventricle width was 4.09 mm and 3.09 in male and female respectively (0.001, significant). From several studies about the mean of third ventricle width, they were reported to be 4 mm in males and 3 mm females from Norway (ranged from 1.9 mm to 5.6 mm);[16] whereas, in England, the same dimension was determined as 5.14 mm.[19] Meanwhile the same measurement was found to be 6.39 mm and 5.09 mm in Japanese male and female people.[20] It was found between 3.25 mm and 4.06 mm in Indian females and males.[21] In Turkish females and males the width value was reported as 3.79 mm and 4.12 mm.[22] In Germany population, the same dimension was between 3.3 mm and 7.7 mm in age between 20 - 69 years old.[23] In Goa population, this value was declared as 0.45 cm and 0.39 cm in males and females.[24]According to Gameraddin et al., this measurement is 5.70 mm for men and 5.40 mm for women. These data revealed differences in the average values of the Japanese, British, German, Indian, Turkish, English, and our populations. German, Japanese, and English values are superior to ours. Additionally, males have wider average third ventricles overall than females, which is consistent with literature. We believe that various elements, such as race, genetics, age, and sex, may contribute to these variances.

In the study, the fourth ventricle width (AP width) was found to be 6.312 mm and 6.34 mm in males and females, respectively while the fourth ventricle width (Transverse width) was found to be 11.17 mm and 10.73 mm in males and females, respectively. In Saudi Arabian males and females, the corresponding value was 12.54 mm and 11.60 mm.[25] In Germany healthy population, the corresponding value was 12.5 mm.[18] In Goa population, the same dimension was reported as 1.31 cm and 1.21 cm in males and females.[24] In England population the same value was 0.92 cm.[19] In Indians, the same measurement was found as 12.16 mm and, 11.38 mm in males and females, respectively.[21] This value was higher in males than females and the highest the fourth ventricle values were in age group of 70 years in both genders.[25,21]

5. CONCLUSION

The present study provides baseline values of ventricles which have positive correlation with ages. Thus, knowledge of these parameters is of immense importance while diagnosing various neurological and psychiatric disorders associated with ventriculomegaly. Thus this study will be useful to the radiologists, neurologists, neurosurgeons and psychiatrists.

6. REFERENCES

1 Bradley WG Jr. CSF Flow in the Brain in the Context of Normal Pressure Hydrocephalus. AJNR Am J Neuroradiology. 2015;36(5):831-8.

2 McGirt MJ, Woodworth G, Coon AL, Thomas G, Williams MA, Rigamonti D. Diagnosis, treatment, and analysis of long-term outcomes in idiopathic normal-pressure hydrocephalus. Neurosurgery. 2005;57(4):699-705; discussion 699-705.

3 Haslam RHA. Hydrocephalous. *In:* Nelson Text Book of Pediatrics, 14thedn. Eds. Behrman RE, KliegmanRM,Nelson WE, Vaughan VC. Philadelphia, W.B. Saunders Co, 1992, p 1487.

4 Karakaş P, Koç Z, Koç F, GülhalBozkır M. Morphometric MRI evaluation of corpus callosum and ventricles in normal adults. Neurol Res. 2011;33(10):1044-9.

5 HonnegowdaTM,Nautiyal A, Deepanjan M. A Morphometric study of ventricular system of human brain by computerised tomography in an Indian population and its clinical significance. Austin J Anat. 2017; 4(4): 1075

6 Farheen SS, Sukre SB. Morphometrıc study of frontal horn of lateral ventricle by computerised tomography. Int J Anat Res. 2017;5(3.1):4063-6.

7 Acer N, Ugurlu N, Uysal DD, Unur E, Turgut M, Camurdanoglu M. Comparison of two volumetric techniques for estimating the volume of intracerebral ventricles usingmagnetic resonance imaging: a stereological study. Anatomical Science International 2010;85:131–139.

8 Mayer KN, Latal B, Knirsch W, Scheer I et al. Comparison of automated brain volumetry methods with stereology in children aged 2 to 3 years. Neuroradiology 2016;58:901–910.

9 Furlong C, Garcia-Finana M, Puddephat M, Anderson A et al. Application of stereological methods to estimate post-mortem brain surface area using 3T MRI. Magnetic Resonance Imaging 2013;31:456–465.

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10 Woo DC, Choi CB, Nam JW, Ryu KN et al. Quantitative analysis of hydrocephalic ventricular alterations in Yorkshire terriers using magnetic resonance imaging. VeterinarniMedicina2010;55:125–132

11 Traveras JM and Wood EH. Diagnostic neuropathology. 2nd ed. In: Intracranialpneumography, 1976;1:290-400

12 Gawler J, Bull JWD, Du Boulay GH and Marshall J. Computerized axial tomography: the normal EMI scan.Jour of Neural, Neurosurgery and Psy 1975;38:935-47

13 Srijit D and Shipra P. Anatomical study of anomalous posterior horn of lateral ventricle ofbrain and its clinicalsignificance. British LekListy 2007;108(9):422-4

14 Mallika B. Morphometric study of lateral ventricles of the brain by computerized tomography and dissection method. Department of Anatomy, Mysore Medical College & Research Institute. Myscore 2011;570:1-90

15 Medora DC, Prashanth NE. Morphometric study of the ventricular system of brain by computerised tomography. Journal of Anatomical Society of India 2007;56(1):19-24.

16 Aukland SM, Odberg MD, Gunny R, Chong WK, Eide GE, Rosendahl K. Assessing ventricular size: is subjective evaluation accurate enough? New MRI-based normative standards for 19-yearolds. Neuroradiology 2008;50(12):1005-11.

17 Kumar AS, Kumari SM, Anand MV, Saraswathy R, Rajeshwari M. Evaluation of Evan's index in South Indian population using computed tomography. Int. J. Anat. Radiol. Surg. 2017a;6(3):RO28-31.

18 Duffner F, Schiffbauer H, Glemser D, Skalej M, Freudenstein D. Anatomy of the cerebral ventricular system for endoscopic neurosurgery: a magnetic resonance study. ActaNeurochir. (Wien) 2003;145(5):359-68.

19 Turner B, Ramli N, Blumhardt LD,&Jaspan, T. Ventricular enlargement in multiple sclerosis: a comparison of three-dimensional and linear MRI estimates. Neuroradiology 2001;43(8):608-14.

20 Takeda S, Hirashima Y, Ikeda H, Yamamoto H, Sugino M, Endo S. Determination of indices of the corpus callosum associated with normal aging in Japanese individuals. Neuroradiology 2003;45(8):513-8.

21 Kanakaraj K, Kalaichezhian M, Sunil, K. Morphometric study of the normal third and fourth ventricular sizes on computed tomography. SAS J Med 2016; 2(6):152-6.

22 Karakaş P, Koç Z, Koç F, GülhalBozkır M. Morphometric MRI evaluation of corpus callosum and ventricles in normal adults. Neurol Res 2011;33(10):1044-9..

23 Preul C, Hund-Georgiadis M, Forstmann BU, Lohmann G. Characterization of cortical thickness and ventricular width in normal aging: a morphometric study at 3 Tesla. J MagnReson Imaging. 2006;24(3):513-9

24 D'Souza e Dias Medora C, NatekarPrashant E. Morphometric study of the ventricular system of brain by computerised tomography. JAnatSoc India 2007;56(1):19-24.

25 Gameraddin M, Alsayed A, Ali A, Al-Raddadi M. Morphometric analysis of the brain ventricles in normal subjects using computerized tomography. Open J Radiol2015;5(1):13-9.