DOI: 10.5958/j.2319-5886.3.2.079

International Journal of Medical Research & Health Sciences

www.ijmrhs.com Volume 3 Issue 2 (April - Jun) Coden: IJMRHS Copyright @2014 ISSN: 2319-5886

Received: 14th Feb 2014 Revised: 13th Mar 2014 Accepted: 16th Mar 2014

Research Article

VENTRICLES OF BRAIN: A MORPHOMETRIC STUDY BY COMPUTERIZED TOMOGRAPHY

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ABSTRACT

Introduction: As the human brain ages, characteristic structural changes occur that are considered to be normal and are expected. Thus the thorough knowledge of the age related normal changes that occur in the brain is required before any abnormal findings are analyzed. As ageing advances, the brain undergoes many gross and histopathological changes with regression of the brain tissue leading to the enlargement of the ventricles. To understand these changes the knowledge of normal morphometry and size of normal ventricular system of brain is important. **Materials & Methods:** For the present study 358 (Males - 207 and Females - 151) individuals Computerized Tomography (CT) images of brain studied. Measurements of fourth ventricle, third ventricle and lateral ventricle were noted down from CT images and it was statistically analyzed. **Results:** After analysis it was observed that the height and width of the fourth ventricle was larger in males as compared to females. The length of the third ventricle was observed to be greater in females than in males. The width of the third ventricle it was observed to be greater in males than in females. Antero-posterior extent of the left frontal horn (males = 26.26 ± 2.94, 95% CI 25.86 - 26.66 mm and females = 26.53 ± 3.38, 95% CI 25.99 - 27.08 mm) was greater than that of the right ones (males = 25.00 ± 3.18, 95% CI 24.57 - 25.44 mm and females = 25.34 ± 3.50, 95% CI 24.78 - 25.90 mm). **Conclusion:** Advances in sensitive imaging techniques like the Computerized Tomography helps in dramatic expansion of our understanding of the normal structure of brain. The present study has defined the morphometric measurements of the lateral ventricles, third ventricle, and fourth ventricle of the brain which has clinical correlations in diagnosis and for further line of treatment.

Keywords: ventricular system, morphometric study, human brain

INTRODUCTION

Man has long been fascinated with workings of human brain. The structure of human brain is complicated and not yet fully understood. As the human brain ages, characteristic structural changes occur that are considered to be normal and are expected. Thus the thorough knowledge of the age related normal changes that occur in the brain is required before any abnormal findings are analyzed. There have been a great number of studies examining the anatomical structure of the human brain and the age related changes that occur normally. As ageing advances, the brain undergoes many gross and histopathological changes with regression of the brain tissue leading to the enlargement of the ventricles.[1] Both imaging and autopsy studies revealed that there is correlation with increase in cerebrospinal fluid spaces and reduction in cerebral volume accompanying normal human ageing.[2, 3] Due to these changes that occurs normally with ageing, the diagnosis of diseases in elderly patients is often

complicated. So, the two major changes that may occur in elderly individual without neurologic deficits is enlargement of ventricles and cortical atrophy. However surprisingly, there is lack of clinical, radiologic and pathologic information regarding these changes in humans. The normal ventricular size during life was previously unknown.

In the past, the pneumoencephalogram was the most valuable test for determining ventricular size during life. Advances in sensitive imaging techniques like the Computerized Tomography helps in dramatic expansion of our understanding of the normal structure of brain without the use of contrast media. Computerized Tomography also provided a revolutionary means for morphologic study of the brain in vivo. Some authors found gender differences in brain atrophy with ageing and revealed that the degree of change was milder in women than in men.[5] Enlargement of cerebrospinal fluid spaces during ageing is generally diffused.[6] There is regression of thalamic nuclei after 50 years of age which explains demonstration of early third ventricular enlargement.[4] There is more shrinkage with age in the frontal cortex, brain stem and dienchephalic structure[7]. Also the left lateral ventricle is normally larger than the right.[8] Various studies clearly shows an increase in the CSF spaces in dementia especially in Alzheimer's disease and Parkinson's disease.[9] This was due to reduction in size of the nerve cells.[10] ventricular enlargement to be a more sensitive indicator of cortical atrophy due to increasing age and dementias.[11] Studies show there was enlarger of the lateral ventricles in epilepsy and also in depression.[12] To understand these changes the knowledge of normal morphometry and size of normal ventricular system of brain is important.

Aims and objectives

1) The aim of the study to analyze the morphometric measurements of ventricular systems of the brain in different age group individuals of both genders.

2) To study the symmetry of lateral ventricle on either side and to compare the result of this study with previous study.

MATERIAL AND METHODS

This was the prospective study in which Computerized Tomography images of total 358 (Males - 207 and Females - 151) in which 270 adult individuals (Age Group 20-60 years) and 88 ageing individuals (Age above 60 years) of either sex attending the Department of Radiodiagnosis, A.V.B.R.H., Jawaharlal Nehru medical college from the year between January 2010 to august 2011. The criteria for exclusion of individuals in this study were:

1) Individuals below 20 years of age
2) Any history of local mass lesion in brain
3) Any history of cerebral infarction
4) Any history of hydrocephalus
5) Any history of alcoholism, drug abuse and trauma or previous history of intracranial surgery

Computer tomography of these patients was performed on "PHILIPS BRILLIANCE MULTI SLICE (16 SLICE) MULTI DETECTOR SPIRAL CT SCANNER" with a scan time of 1-10 sec and slice thickness of 5 mm in the posterior cranial fossa and 10 mm in above region. Study protocol was submitted to the institutional ethical committee and their permission was obtained. The patient was placed on the Computerized Tomography table in supine position and head was centered to the cris-cross point of the light beam was made to coincide with the orbito-meatal line. This position represented the zero table position.[13] The Computerized Tomography scan images of the brain taken up to the highest level of cranial vault and it was statistically analyzed.

The following measurements were made from the CT images which obtained by the standard protocol made by the radiological society. :

1. Measurement of the fourth ventricle

a). Vertical diameter - Greatest vertical distance length (mm) of the fourth ventricle (from upper margin of pons to lower limit of open part of medulla oblongata). (Figure no. 4 and 5)

b). Transverse diameter - Greatest transverse diameter measures in mm (maximum transverse distance along the coronal plane). (Figure no.3)

2) Measurement of third ventricle (Figure no.4)

a) Greatest vertical diameter - height (mm) in transverse plane in antero-posterior extent.

b) Greatest transverse diameter - transverse diameter measures in (mm) maximum in coronal plane.

3) Measurement of lateral ventricle of right and left side. (Figure no.5)

a) Greatest anterior-posterior extent measures in (mm) for frontal horn of the lateral ventricle.

b) Greatest anterior-posterior extent measures in mm for frontal horn and including body of the lateral ventricle.

RESULTS

Table no. 1 shows the measurements of height of fourth ventricle. After analysis it was observed that the height of the fourth ventricle was larger in males (12.18 ± 1.54, 95% CI 11.97 - 12.39 mm) as compared to females (12.13 ± 1.41, 95% CI 11.91 - 12.36 mm), which was statistically insignificant (T=0.314 p= 0.753). Table no. 1 shows the measurements of maximum width of fourth ventricle. The width of the fourth ventricle was observed to be greater in males (11.07 ± 1.54, 95% CI 10.85 - 11.28 mm) than in females (11.05 ± 1.31, 95% CI 10.84-11.26 mm), which was also statistically insignificant (T= 0.129 p=0.897).Table no. 2 shows the measurements of length of third ventricle. The length of the third ventricle was observed to be greater in females (18.86 ± 8.36, 95% CI 17.52 – 20.21 mm) than in males (17.97 ± 2.76, 95% CI 17.59 -18.35 mm), which was statistically insignificant (T= -1.429 p= 0.154). Table no. 3 show the measurements taken of the third ventricle. After analysis of the width of the third ventricle it was observed to be greater in males (3.47 ± 1.07, 95% CI 3.32 - 3.62 mm) than in females (3.31 ± 0.94, 95% CI 3.16 - 3.46 mm) and this difference was statistically insignificant (T= 1.470 p= 0.164).Table no. 4 shows various measurements taken of the lateral ventricles. On analyzing these it was observed that the antero-posterior extent of the left frontal horn (males = 26.26 ± 2.94, 95% CI 25.86 - 26.66 mm and females = 26.53 ± 3.38, 95% CI 25.99 - 27.08 mm) was greater than that of the right ones (males = 25.00 ± 3.18, 95% CI 24.57 - 25.44 mm and females = 25.34 ± 3.50, 95% CI 24.78 - 25.90 mm). Same thing also observed in the antero-posterior extent of the left lateral ventricular body including its frontal horn (males = 56.70 ± 6.61, 95% CI 55.79 - 57.61 mm and females = 56.28 ± 7.59, 95% CI 55.06 - 57.50 mm) was greater than the right one (males = 55.78 ± 6.15, 95% CI 54.94 - 56.63 mm and females = 55.10 ± 6.99, 95% CI 53.97 - 56.22 mm).Table no. 5 shows the age wise distribution of the length of right sided lateral ventricle frontal horn with body, right sided lateral ventricle frontal horn, width of the third ventricle and width of the fourth ventricle. It was observed that as the age advances dimensions of the ventricles also enlarges and this difference was statistically significant by ANOVA test for length of right Lateral Ventricle (Frontal horn with body) f=26.77 p=0.000, length of right Lateral Ventricle (Frontal horn) f=15.46 p=0.000, Width of third ventricle f=3.89 p=0.021 and for the Width of fourth ventricle value is f=0.49 p=0.614 (Not significant).

Table 1: Measurements of Fourth Ventricle (mm)

	Height		**width**	
	Males (n=207)	**Females (n=151)**	**Males (n=207)**	**Females (n=151)**
Mean ± SD Units	12.18± 1.54	12.13± 1.41	11.07± 1.54	11.05 ± 1.31
95% CI (L)	11.97	11.91	10.85	10.84
95% CI (U)	12.39	12.36	11.28	11.26
T Value	0.314		0.129	
P Value	0.753		0.897	**<0.05 (Not significant)**

Table 2: Measurements of Third Ventricle (mm)

	Length		**width**	
	Males (n=207)	**Females (n=151)**	**Males (n=207)**	**Females (n=151)**
Mean ± SD	17.97± 2.76	18.86± 8.36	3.47± 1.07	3.31± 0.94
95% CI (L)	17.59	17.52	3.32	3.16
95% CI (U)	18.35	20.21	3.62	3.46
T Value	-1.429		1.470	
P Value	0.154		0.164	**<0.05 (Not significant)**

Table 3: Measurements of Lateral Ventricle (mm)

	Fourth Ventricle							
	Frontal horn				Frontal horn + body			
	Males (n=207)		Females (n=151)		Males (n=207)		Females (n=151)	
	R	L	R	L	R	L	R	L
Mean ± SD	25.00±3.18	26.26±2.94	25.34±3.50	26.53±3.38	55.78± 6.15	56.70± 6.61	55.10± 6.99	56.28± 7.59
95% CI (L)	24.57	25.86	24.78	25.99	54.94	55.79	53.97	55.06
95% CI (U)	25.44	26.66	25.90	27.08	56.63	57.61	56.22	57.50

Table No. 4: Ventricular enlargement (age wise distribution in mm).

Age groups (Yrs)	Length of Rt. Lat. Ventricle (Frontal horn with body)		Length of Rt. Lat. Ventricle (Frontal horn)		Width of 3rd ventricle		Width of 4th ventricle	
	Mean ± SD		Mean ± SD		Mean ± SD		Mean ± SD	
20-40	52.23±4.80		23.93±2.34		3.22±0.76		10.93±1.46	
41-60	55.80	6.18	25.44	3.20	3.33	0.90	11.09	1.38
>61	57.73	6.92	25.92	3.77	3.61	1.30	11.06	1.53

Fig 1: Maximum upper extent of the fourth ventricle for vertical dimension

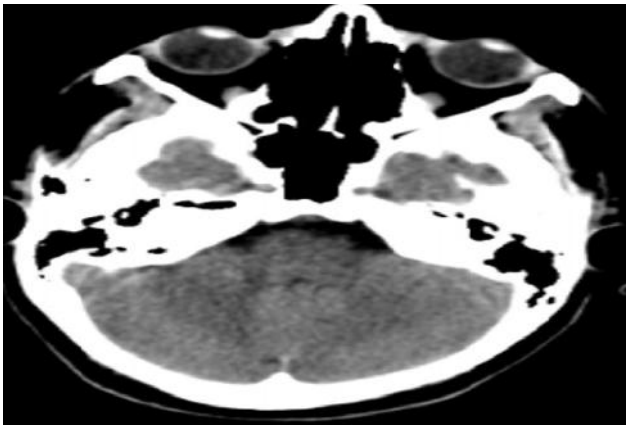

Fig 2: Maximum lower extent of the fourth ventricle for vertical dimension

Fig 3: Maximum width of the fourth ventricle for vertical dimension

Fig 4: a – b = maximum antero-posterior dimension of third ventricle, c – d =maximum width of third ventricle

Fig 5: a – b = maximum antero-posterior dimension of right frontal horn with body at the level of interventricular foramina of the lateral ventricle, c – d =maximum antero-posterior dimension of left frontal horn with body at the level of interventricular foramina of the lateral ventricle

DISCUSSION

The human nervous system is the most complex, widely investigated with recent advance tools like CT and MRI scan but yet poorly understood physical system known to the mankind.[14-18] many studies reveals that brain regression involving cerebrum and cerebellum usually begins at the age in the beginning of seventh decade and thereafter accelerated as age advances. Lateral ventricular contours are relatively constant, except for the occipital horns.[19] The ventricular system can be better visualized by using modern computerized x-ray tomography, which allows easy and safe noninvasive study without complications and it can be used as a screening procedure for many pathological conditions.[4, 20-23] Roberts et al revealed that the value in evaluating dementia and its use in excluding brain diseases like neoplasm's, subdural hematomas, and cerebrovascular disease that may mimic like dementia.[23] The ventricular size changes in the brain encountered in routine clinical practices can mislead to most of the physicians and surgeons to take proper decision. However, there is likely to be an increasing number of circumstances in which precise measurements will be needed. Gawler et al[13] (1976) revealed that the greatest distance between the roof and the floor of the fourth ventricle was less than 1.2 cms with a mean of 1.08 cms; however in the present study this distance is significantly larger in males (12.18 ± 1.54, 95% CI 11.91 - 12.39 mm) than in females (12.13 ± 1.41, 95% CI 11.91 - 12.36 mm) (Table no. 1). In the present study, the height of the fourth ventricle was found to be greater than the width in both genders. Width of the fourth ventricles is more in males (11.07 ± 1.54, 95% CI 10.85 - 11.28 mm) than in females (11.05 ± 1.31, 95% CI 10.84-11.26 mm) (Table no. 2).Brinkman et al [24] (1981), Soininen et al [25] (1982), D'Souza e Dias Medora C.et al [26] (2007) found that the maximum width of the third ventricle had a mean of 0.46 cms, 0.59 cms, 0.92 ± 2.71 cms and 0.45 ± 0.29 cms respectively, with higher values in males. In the present study this measure was found to be significantly higher in males (3.47 ± 1.07, 95% CI 3.32 - 3.62 mm) as compared to females (3.31 ± 0.94, 95% CI 3.16 - 3.46 mm) (Table no. 3).According to Glydensted [8](1977), Gomori et al [27] (1984) Takeda and Matsuzawa [28] (1985), Goldstein et al [29] (2001) and D'Souza e Dias Medora C. et al [26] (2007) the left lateral ventricle was larger than the right one and both were larger in males. In present study, the anteroposterior extent of the left frontal horns (males = 26.26 ± 2.94, 95% CI 25.86 - 26.66 mm and females = 26.53 ± 3.38, 95% CI 25.99 - 27.08 mm) was greater than that of the right ones (males = 25.00 ± 3.18, 95% CI 24.57 - 25.44 mm and females = 25.34 ± 3.50, 95% CI 24.78 - 25.90 mm).The antero-posterior extent of the left lateral ventricular bodies including their frontal horns (males = 56.70 ± 6.61, 95% CI 55.79 – 57.61 mm and females = 56.28 ± 7.59, 95% CI 55.06 – 57.50 mm) was greater than the right ones (males = 55.78 ± 6.15, 95% CI 54.94 – 56.63 mm and females = 55.10 ± 6.99, 95% CI 53.97 – 56.22 mm) (Table no. 5).

CONCLUSION

The structure of human brain is complicated and yet not fully understood till date. As the human brain ages, characteristic structural changes occur that can be considered normal and are expected too. Advances in sensitive imaging techniques like the Computerized Tomography helps in dramatic expansion of our understanding of the normal structure of brain. The purpose of this study was to examine the different dimensions of ventricular system.

The present study has defined the morphometric measurements of the lateral ventricles, third ventricle, and fourth ventricle of the brain which has clinical correlations in diagnosis and for further line of treatment.

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