Original research article

Morphometric Study of Lateral Ventricles of the Brain by Computerised Tomography and Dissection Method

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Abstract

Background and Objectives: The cerebral ventricular system contains a series of interconnecting spaces and channels which originates from the central lumen of embryonic neural tube. Cerebrospinal fluid filled ventricular system is an essential part of the brain. The evaluation of the size of the encephalic ventricle has great importance in diagnosis and monitoring of several pathologies. Hence this study wasundertaken, To examine the range in size of the normal lateral ventricles of the humanbrain.

Methods: The study was done for the duration of Two years. Data for the present study was collected from the CT images done in the Department of Radiology, DMCH Darbhanga. The study group includes 100 males and 100 females.

Conclusion: present study, it was concluded that there was great variation in measurements of parts of lateral ventricles of brain which showed statistically significant correlation with one another. The left lateral ventricle was shown to be larger than right in either sex while both lateral ventricles were larger in males.

Keywords: CT, MRI**,** Echoencephalography.

Introduction

The cerebral ventricular system contains a series of interconnecting spaces and channels which originates from the central lumen of embryonic neural tube. Cerebrospinal fluid filled ventricular system is an essential part of the brain. The ventricular system in the cerebral hemispheres consists of two lateral ventricles, midline third and fourth ventricles connected by interventricular foramen of Monro and aqueduct of Sylvius respectively.[1] Understanding the normal and abnormal anatomy of the ventricular system of the brain is helpful for clinicians, neurosurgeons and radiologists in day-to-day practice.[2] The cerebral ventricular system is a marker of brain development and a predictor of neurodevelopment outcome.[3] Morphometric analysis of cerebral ventricular system is important for evaluating changes due to growth, ageing, intrinsic and extrinsic pathologies.[4] Neuroradiologists are frequently faced with the problem of deciding whether the ventricles are within the normal limits or enlarged with the patient's age. Therefore it is necessary to define normal ranges with a uniform,

comparable and exact method of measuring ventricularsize.[5] There will be alteration in the brain matter morphology, size and shape of ventricular system in chronic alcoholism.[6] Morphometric analysis of brain structures suchasvolume,shapeandsizeofventricularsystemespeciallylateralventricle, recently has become a main focus of interest in studies of some neuropsychiatric diseases like Schizophrenia and Alzheimer's disease.[7] Morphometric analysis of ventricular system helps neurosurgeons for localization and total removal of space occupying lesions around ventricular system like craniopharyngiomas and gliomas. Knowledge of anatomy of cerebral ventricular system is important for endoscopic neurosurgery.[8]Visualisation of cerebral ventricle is an essential investigation of child with suspected hydrocephalus. Morphometric analysis of ventricular system is helpful in the diagnosis and classification of hydrocephalus and it is also helpful in assessment and follow-up of enlargement of ventricular system during therapy (ventricular shunts).[9] Gross anatomy of cerebral ventricles can be studied either by casts or dissection of human brain.[10] In cadaver brain, very few anatomical study of ventricular system has been done so far. The present work is undertaken to study morphometric analysis of the lateral ventricles of brain both by CT scan and dissection method.

Objectives

1) To examine the range in size of the normal lateral ventricles of the humanbrain.
2) To examine the various dimensions of the normal lateral ventricles by CT scan and by dissectionmethods.
3) To compare the results obtained by CT scan and dissectionmethod.
4) To compare the results of the present study with otherstudies.

Material and Method

The study was done for the duration of Two years. Data for the present study was collected from the CT images done in the Department of Radiology, Darbhanga Medical College and Hospital Darbhanga. The study group includes 100 males and 100 females. CT scans done for various indications from other departments were taken. The CT scans were randomly selected, which were reported by radiologists as normal. Two hundred (200) CT scans in the age group of 10-80 years were taken.

Inclusion criteria

1. CT scans and postmortem brain specimens of both sexes werecollected.
2. CT scans and postmortem brain specimens of 10-80 years age group were collected.

Exclusion criteria

1. CT scans with history of head injuries, cerebral infarctions, local mass lesions and previous intracranial surgeries were excluded from thestudy.
2. Postmortem brain specimens with history of head injuries, local mass lesions and cerebral infarctions were excluded from the study.
3. The details of the case such as name, age, sex, address, inpatient or outpatient number and indications for CT were collected.

The CT scan machine used for this study was GE High Speed Dual Slice Version 2.0, having a fan beam scanner with a scan time of 1 to 10 seconds. The density of cerebrospinal fluid was 10 Hounsfield Units (HU); that of white matter was 22-32 HU and that of grey matter was 36-46 HU. The matrix was 256 x 256 with a slice thickness of 10 mm in supratentorial region and 4 mm in infratentorial region. The patient was placed on CT table and the head

was centralised for correct alignment to reduce blurring of images. A lateral image was taken to confirm correct position of patient. The lateral ventricles on CT were seen in 3-4 contiguous slices; the highest tomogram to pass clearly through them contains superior segments of cellaemediae, with the corpus callosum in-between and the superior segments of the trigones and occipital horns. The next descending continuous tomogram incorporates the frontal horn anteriorly and the occipital horn posteriorly. Temporal horns were not seen in some CTfilms.

DissectionMethod

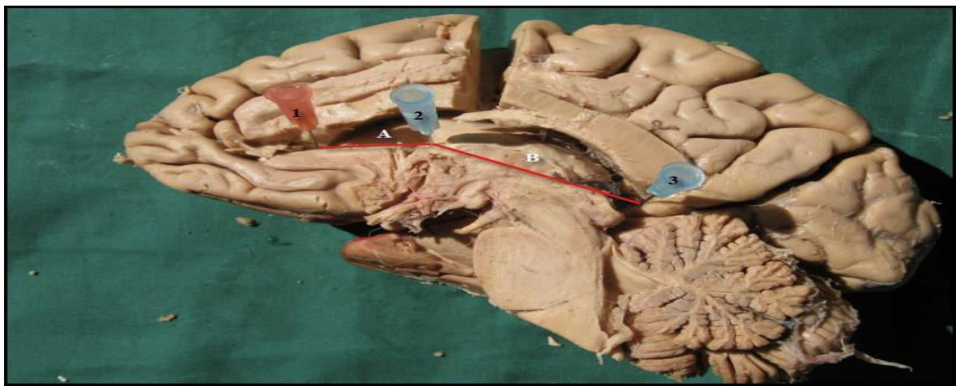
In postmortem specimens the age, sex and cause of death were noted. In none of the cases death was attributed to the diseases of brain nor there was any autopsy evidence of cerebral disease.

Brain specimens studied

Brain was removed as per standard text book of practical anatomy. The brain was washed under running water for half an hour. After labelling the specimens, brains were preserved in 10% formalin solution for 1 month. To avoid distortion of the ventricles, brains were suspended by a thread under the basilar artery during the fixation.

Median sagittal section showing frontal horn and body of lateral ventricle

1-2: A (Length offrontalhorn) **2-3: B (Length of body)**



RESULTS

Two-hundred normal CT scans in the age group of 10-80 years were taken for the study in which 100 were CT scans of males and 100 were CT scans of females.

By CT methods

Table 1: Agewise and genderwise distribution of ct scans

Age group (years)	Male	Female	Total
10 to 19	20	12	32
20 to 29	21	26	**47**
30 to 39	13	17	30
40 to 49	15	15	30
50 to 59	20	15	35
60 to 69	08	09	17
70 to 79	03	06	09
TOTAL	**100**	**100**	**200**

The mean length of right frontal horn is 29.34 mm and range is 23-35 mm. There is gradual increase in the length of right frontal horn as age increases. Length is almost same in 20-49 years age group.

Table 2:Genderwise and sidewise changes in the length of frontal horn

MALE					FEMALE				TOTAL	
	No.	Mean [mm]	SD	p-value	No.	Mean [mm]	SD	p-value	No.	Mean [mm]
RIGHT	100	29.8	2.6	<0.0001	100	28.9	2.3	<0.002	200	29.3
LEFT	100	31.1	2.5		100	29.9	2.3		200	30.5

The mean length of frontal horn in male is 29.8 mm on right side and 31.1 mm on left side. The mean length of frontal horn in female is 28.9 mm on right side and 29.9 mm on left side. There is significant difference seen in right and left sides, males and females, that is length is more in males and length of frontal horn is more on left side. The mean length of body of right lateral ventricle is 48.4 mm and range is 40-54 mm. Length is almost same in 20-59 year age groups. Minimum length is seen in 60-69 year age group. Maximum length is seen in 70-79 year age group. Themeanlengthofposteriorhorninmaleis26.9mmonrightsideand 28.4 mm on left side. The mean length of posterior horn in females is 26.3 mm on right side and 27.3 mm on left side. The length of posterior horn is more in males. Length of right posterior horn is almost same in both sexes. Length of left posterior horn is more than right in both sexes more so in males. The mean height of inferior horn in males is 3.3 mm on right side and 3.0 mm on left side. The mean height of inferior horn in female is 3.1 mm on right side and 3.0 mm on left side. The height of inferior horn is more in males on right and is equal in both sexes on left side. By CT study it was observed that the measurements of frontal horn, body and posterior horn of lateral ventricle were more in males compared to females, whereas the transverse diameter of inferior horn was more in females than in males on both the sides. The height of inferior horn was more on right side when compared to left side.

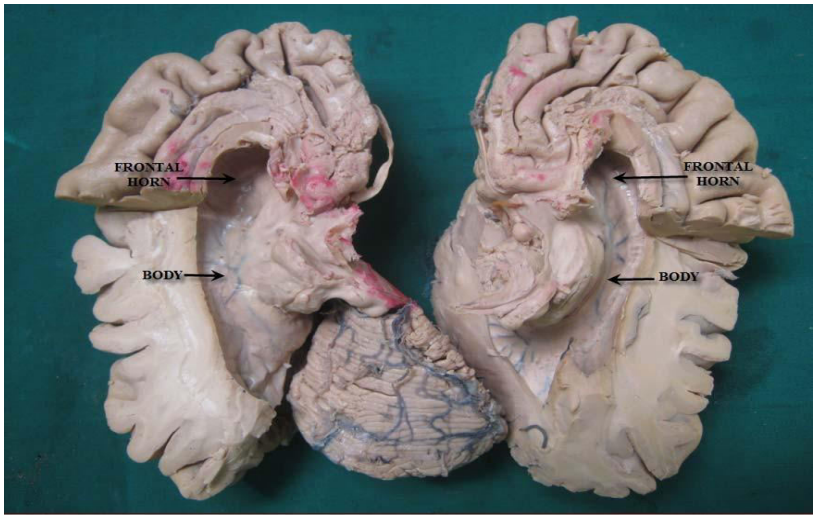
Twenty-five formalin fixed brain specimens were taken for the study of which 11 brain specimens were females and 14 were males.

Table 3:Genderwise length of right frontal horn of the lateral ventricle

Sex	No.	Mean [mm]	SD	Minimum [mm]	Maximum [mm]	p-value
MALE	14	25.5	2.5	23	28	<0.003
FEMALE	11	20.7	2.5	18	22	
TOTAL	**25**	**23.1**	**2.5**	**18**	**28**	

The mean length of right frontal horn in male is 25.5 mm and the range is 23-28 mm. The mean length of right frontal horn in females is 20.7 mm and range is 18-22 mm. The length is more in males compared to females.

The mean length of left frontal horn in males is 27.1 mm and range is 25-30 mm. The mean length of left frontal horn in females is 24.3 mm and range is 20-30 mm. The length of left frontal horn is more in males compared to females. When we compare right and left frontal horn in both sexes, measurements were more in males and also on leftside.



Dissected brain specimens showing dilated frontal horn and body of lateral ventricle on both sides

Table 4: Comparison of length of posterior horn of the lateral ventricle by ct and dissection method

CT SCAN					DISSECTION			
	No.	Mean [mm]	SD	p-value	No.	Mean [mm]	SD	p-value
RIGHT	200	26.4	2.1	<0.001	25	20.5	4.3	<0.001
LEFT	200	27.8	2.6		25	22.4	4.2	

The mean length of right posterior horn by CT is 26.4 mm and by dissection is 20.5 mm. The mean length of left posterior horn by CT is 27.8 mm and by dissection is 22.4 mm. Significant difference was observed (p-value <0.0001). The length of left posterior horn is more in CT compared to dissection method. When we compare the measurements of lateral

ventricles by CT and dissection method, it was observed that all the measurements were more in CT than dissection method and measurements were more on left side in both CT and dissection method.

Discussion

The human nervous system is the most complex widely investigated and yet poorly understood physical system known to mankind. According to Taveras and Wood (1976)[11] the lateral ventricular contours are relatively constant except occipital horns. Alterations in the brain with ageing have been focus of many investigations. A degree of asymmetry in two lateral ventricular contour is common, partly because of anatomical difference and partly because of obliquity of the head will result in slightly different ventricular segments being incorporated on the two sides.[12] Considering the asymmetry of the two lateral ventricles, the amount of cerebrospinal fluid also alter because of change in volumetric capacity. The volumetric changes in the lateral ventricles have been found in diseases like Schizophrenia. Any enlargement of lateral ventricles present in young Schizophrenia patients, suggests aberrant neuro developmental process in the pathologies of these disorders.[2] In order to assess the true prevalence of dilated ventricles, enlargement beyond normal range must be shown. This study provides such a range of ventricular size in various age groups. The range of changes in the ventricular size of the brain encountered in clinical practice can lead most people to believe that a decision can be taken without an exact measure of ventricular size. However, there is likely to be an increasing number of circumstances in which precise measurements will be ofvalue.[12] According to Gylensted (1977), Gomori et al. (1984), Takeda and Matsuzowa (1985) and Goldstein et al. (2001) the left lateral ventricle was larger than right one. This reflects general experience that the ventricular system is usually larger in dominanthemisphere. Both left and right lateral ventricles were large in males compared to females. This is because males have heavier and bigger skull, the capacity of skull is 10% more compared to female skull and also because the brain size is more in males compared tofemales.[1] The present study has demonstrated one-way in which simple but objectivemeasurementscanbemadeonacomputerisedtomogramtoestablishthesizeofventricular system and also establish the size of lateral ventricle by dissection method.In the present study, the length of frontal horn increases as the age increases. The length of left frontal horn is more compared to right in both CT and dissection method. This is in par with the reported literature.[13] In a necropsy study of cerebral ventricular volume, it is important to consider the effect of postmortem decay for CT scans indicate that the ventricles become smaller after death. This is due to the shift of cerebrospinal fluid into brain tissue after death. The sequential CT scans confirm that much of the ventricular contraction has taken place by 5-6 hours postmortem. Torkildsen (1934)[14] reported a study done by two methods and the measurements were more on right side compared to left side. The measurements were more in Torkildsen study because the sample size in cast method was 11 and in ventriculogram was 13 and they have mentioned that it was difficult to determine the border between posterior horn, inferior horn and the body of the ventricle, therefore the findings were approximate value only. In the present study, exact measurements were taken in both CT and dissection method and measurements were 2-3 mm more on left side than right side.

The posterior horn of lateral ventricle usually diamond shaped or square in outline. Considerable degree of normal variation is seen in occipital horn. Marked asymmetry of occipital horn is common and frequently one or both contains insufficient CSF for clear delineation on the CT scan. Colpocephaly is an abnormal enlargement of the occipital horn of the lateral ventricle, also described as persistence of fetal configuration of the lateral ventricle. It is usually associated with a number of abnormalities of brain. It is merely a

marker of disordered brain formation and that, insults occurring any time between 4-16 weeks of gestation, may result in this anomaly.[15] The knowledge of normal and abnormal anatomy of the lateral ventricles especially posterior horn, which is adjacent to a very important functional area (visual area), is useful while diagnosing any visual disturbances schizophrenia and other psychotic disorders. It is also helpful for neursurgeons operating on the brain and the radiologists performing CT and MRI scans for diagnostic purpose.

Conclusion

From the present study, it was concluded that there was great variation in measurements of parts of lateral ventricles of brain which showed statistically significant correlation with one another. The left lateral ventricle was shown to be larger than right in either sex while both lateral ventricles were larger in males. The size of the ventricular system varies with age (increased steadily with age). All the measurements of lateral ventricle were more in CT compared to dissection method.

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