Morphometric Analysis of Ventricular System of Human Brain - A Study by Dissection Method

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ABSTRACT

BACKGROUND
It is often a challenge to determine if the brain ventricles are within normal limits or swollen with the age of the patient. With a standardized and comparable system, it is therefore necessary to define normal ventricular size ranges. Cadaveric dissection is always considered the gold standard of anatomical education. Present work is undertaken to study morphometric analysis of lateral, third & fourth ventricles by dissection method. Morphometric assessment of the ventricular system is helpful in the diagnosis as well as classification of hydrocephalus and in the evaluation and monitoring of ventricular system enlargement during ventricular shunt therapy.

METHODS
Different parameters of all parts of lateral ventricle, third and fourth ventricle were measured with digital vernier caliper in cadaveric brain specimens. The brain specimens were obtained from dead bodies subjected to post-mortem examinations in the Department of Forensic Medicine and from the dead bodies voluntarily donated to the Department of Anatomy, Silchar Medical College, Silchar.

RESULTS
37 brain specimens were obtained, out of which 24 were male, 13 were female and were of different age groups. Change in the parameters of different ventricles in relation to gender was found to be significant. Ventricular sizes are also observed to be more after the age of 60 years.

CONCLUSIONS
There is a positive correlation in measurements of the brain ventricles with age and variation in accordance with gender and laterality.

KEY WORDS
Brain Ventricles, Sexual Dimorphism, Age

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BACKGROUND

The ventricular region filled with cerebrospinal fluid is an integral part of the brain.[1,2] The ventricular system comprises a collection of interconnecting spaces that derive from the central lumen of embryonic neural tube. The cerebral ventricular system consists of two lateral ventricles, midline third ventricle in the diencephalon and fourth ventricle between the brain and the pons; connected by interventricular foramen of Monro and aqueduct of Sylvius respectively.[3,4] The lateral ventricles, one in each cerebral hemisphere, are the cavity of the telencephalon.[5] The lateral ventricles contribute approximately 82% of the overall ventricular system[6]. It is divided into a body (in the parietal lobe), anterior horn (in the frontal lobe), posterior horn in the occipital lobe and inferior horn present in the temporal lobe.[7] The brain ventricular function is a brain development marker and also a predictor of the outcome of neurodevelopment.[8] In cases of CNS disorders, ventriculomegaly is commonly considered the ' iceberg tip'.[9] Malformations such as corpus callosum agenesis, spina bifida, and heart defects are associated with ventriculomegaly. Fetuses with ventriculomegaly with other defects have a higher risk of chromosomal abnormality, like Down syndrome.[10]

Extensive ventricular size and/or asymmetry are used as markers for psychiatric disorder like schizophrenia. Ventricular enlargement is an important correlation of Alzheimer's dementia.[11] The brain undergoes several gross and histopathological changes in advanced age and also in dementias with brain tissue regression leading to ventricle enlargement.[12] Abnormal ventricular enlargement was seen as an indicator of cerebral atrophy, partly due to adaptive potential of the fluid-filled ventricular system's adaptive potential or decreased nerve cell size.[13] Thalamic nuclei regression after age of 50 describes the frequency of third ventricular enlargement.[14] Neuroradiologists frequently face the hassle of determining whether the ventricles are in the normal limits or they're swollen with the age of the affected person. Consequently, a standardized technique of measuring ventricular size needs to be used to pick out normal degrees.[15] Morphometric assessment of the ventricular system is helpful in the diagnosis as well as classification of hydrocephalus and in the evaluation and monitoring of ventricular system enlargement during Ventricular shunts therapy.[16]

To the best of our knowledge, very few anatomical studies of ventricular system in cadaveric brain has been done so far, that too in this population of north- east region of India. The present study aims at to examine the range in dimensions of the normal lateral, third and fourth ventricles of the human brain by dissection method and also to observe if there exist any variations in the dimensions of the ventricles with reference to gender, age and laterality (In case of right and left sided lateral ventricles) in this population.

METHODS

The present Study is a cross sectional study and was carried out in the Department of Anatomy, Silchar Medical College, Silchar. The brain specimens were obtained from dead bodies subjected for post-mortem examinations in the Department of Forensic Medicine and from the dead bodies voluntarily donated to the Department of Anatomy, Silchar Medical College, Silchar. The study has been approved by the institutional ethical committee. Brains were removed from the cranial cavity & preserved in 10% formalin solutions. Post-mortem brain specimens with head injury & visible mass lesions were excluded from study. Each brain is divided in the midsagittal plane and the arachnoid and pia mater are removed carefully. Brains were dissected according to the Cunningham's Manual of Practical Anatomy to expose the ventricles.

Parameters Used for Lateral Ventricle

Length of Frontal Horn- Measured from interventricular foramen to tip of frontal horn on both sides.

Length of the Body- From inter ventricular foramen to collateral trigone on both sides.

Length of the Posterior Horn- From collateral trigone to the tip of posterior horn on both sides.

Length of the Inferior Horn- From collateral trigone to the tip of inferior horn on both sides.

Parameters Used for Third Ventricle

Antero-Posterior Length- anterior point marked on the lamina terminalis and posterior point on the posterior commissure.

Superior-Inferior Height- Superior point was taken at the highest curvature of the inferior surface of fornix and inferior point marked on the superior surface of mamillary body.

Parameters Used for Fourth Ventricle

For dissection of the fourth ventricle, the cerebellum is split into two equal parts by a median sagittal section through the vermis which exposes the floor of fourth ventricle.

Height- Measured from the upper end of superior medullary velum to level of obex.

Width- Measured at the level of lateral recesses.

Statistical Analysis

Various parameters were measured with digital Vernier caliper. Statistical analysis of the data was carried out by using SPSS version 18. For all parameters, mean, standard deviation were calculated for males, females and total subjects studied. Student t- test was used to compare the means of different parameters. For P value, level of significance was taken as 0.05.

RESULTS

37 brain specimens were obtained, out of which 24 are male, 13 are female. The brain specimens were found to be of age 20 to 70 years. All parts of the lateral ventricle (frontal horn, body, posterior and inferior horns), third and fourth ventricle showed gradual increase in length as the age increases. Greatest dimensions seen at older age groups.

(Table 1). Dimensions of all ventricles are found to be more in persons above 60 years of age in both male & female (Table 2&3), and the differences were found to be significant when compared with measurements below 60 years of age. ($p<0.05$). The mean lengths of all parts of lateral ventricle (frontal horn, body, posterior horn and inferior horn) are more on left side than right side in both sexes, and the differences were significant. (Table 4)

On comparing the dimensions between male and female, it was observed that both antero-posterior & superior-inferior diameter of third ventricle are more in males, (26.85 ± 3.66 mm and 23.80 ± 2.97 mm) than females (26.62 ± 4.36 mm and 23.13 ± 4.90 mm) although they are statistically insignificant. (Table 5) Height & width of fourth ventricle are also more in male (27.36 ± 3.84 mm and 28.86 ± 3.92 mm) than females (25.98 ± 4.62 mm and 27.21 ± 4.45 mm) which was statistically insignificant). (Table 5). Mean width of the fourth ventricle is more than the height in both sexes. Mean length of all parts of lateral ventricle are also found to be more in male than female and found to be significant in case of frontal horn and body ($p<0.05$). (Table 5)

Age Group	Lateral Ventricle				Third Ventricle		Fourth Ventricle	
	Mean Length Frontal Horn	Mean Length Body	Mean Length Post. Horn	Mean Length of Inf. Horn	Mean Antero-Posterior Diameter	Superior-Inferior Diameter	Height	Width
20 - <30	21.37	23.46	19.62	29.38	17.92	16.38	20.21	21.34
30 - <40	26.31	29.42	24.61	33.71	25.32	22.46	22.13	23.75
40 - <50	27.87	31.78	25.49	40.91	26.18	21.69	24.96	26.30
50 -<60	28.66	30.06	26.04	42.25	26.37	22.85	27.05	28.41
60 - ≤70	31.91	33.44	30.84	46.2	29.49	27.05	31.47	32.66

Table 1. Measurements of Ventricles in Different Age Groups (37 Cases)

Age Group	Length of Frontal Horn		Length of Body		Length of Post. Horn		Length of Inf. Horn	
	Male	Female	Male	Female	Male	Female	Male	Female
<60 years	28.82	26.02	31.50	28.67	26.62	23.73	40.32	37.90
≥60 years	33.15	29.42	34.55	31.54	29.68	29.97	48.59	42.92

Table 2. Comparison of Measurement of Lateral Ventricle below & above 60 Years of Age (37 Cases)

Age Group	Third Ventricle				Fourth Ventricle			
	Antero-Post. Diameter		Superior-Inferior Diameter		Width (mm)		Height	
	Male	Female	Male	Female	Male	Female	Male	Female
<60 years	24.90	25.65	23.63	21.43	26.61	25.78	25.13	24.43
≥60 years	30.72	29.79	28.77	28.40	33.35	31.97	31.81	31.13

Table 3. Measurement of Third and Fourth Ventricle below & above 60 Years of Age (37 Cases)

	Length of Frontal Horn (mm)		Length of Body (mm)		Length of Posterior Horn (mm)		Length of Inferior Horn (mm)	
	Mean ± SD	p value	Mean ± SD	p value	Mean ± SD	p value	Mean ± SD	p value
Right	28.70 ± 3.83	0.002	30.93 ± 4.26	0.014	26.54 ± 4.12	0.028	41.23 ± 6.24	0.0001
left	29.39 ± 4.24		31.86 ± 4.84		27.01 ± 4.11		42.1 ± 6.19	

Table 4. Comparison of Measurement of Lateral Ventricle on Right and Left Side

Parameters	Male (in mm)	Female (in mm)	
Length of Frontal horn	30.26 ± 3.67	26.80 ± 3.68	p=0.0097 (very significant) t=2.734
Length of Body	32.512 ± 3.98	29.33 ± 3.86	p=0.0249, t=2.344 (significant)
Length of Post. Horn	27.64 ± 3.80	25.17 ± 4.19	p=0.0763, t=1.827 (not significant)
Length of Inf. horn	43.08 ± 6.21	39.06 ± 17.17	p=0.0580, t=1.960 (not significant)
Mean Antero-posterior length of third ventricle	26.85 ± 3.66	26.62 ± 4.36	0.8149(not significant)
Mean height of third ventricle	23.80 ± 2.97	23.13 ± 4.90	0.4675(not significant)
Height of fourth ventricle	27.36 ± 3.84	25.98 ± 4.62	0.3382(not significant)
Width of fourth ventricle	28.86 ± 3.92	27.21 ± 4.45	0.2514(not significant)

Table 5. Comparison of Measurement of Ventricles in Male and Female

DISCUSSION

Brain regression involving both cerebrum and cerebellum starts in the seventh decade and then accelerates with age.[17] There is gradual increase in ventricular size between the first and sixth decades accompanied by a dramatic increase in the eighth and ninth decades.[1] Lateral ventricular contours are relatively constant, except for the occipital horns.

According to Glydensted[18], Gomori et al,[19] Takeda and Matsuzawa,[20] Goldstein et al,[21] the left lateral ventricle was larger than the right one and both were larger in males. Both right & left lateral ventricles were larger in males compared to females, because males have heavier and bigger skull.[22] In D'Souza study,[23] (By CT scan), the antero-posterior extent of the right (Males=27.4 ± 3.6 mm and females= 25.5 ± 3.3) and left frontal horns (males=27.8 ± 3.7 mm and females=25.8 ± 3.5 mm) was almost similar and length was more in male. A study by Singh BR et al.[24] (2014) showed that the left frontal horn (males=26.26 ± 2.94 mm and females =26.53 ± 3.38 mm) was greater than the right one (males= 25.00 ± 3.18 mm and females = 25.34 ± 3.50 mm) and lengths were almost similar in male and female. Also, dimensions of the ventricles also enlarge as age advances.

In Bijaylakshmi Parija study[25] (2014), mean length of frontal horn increases as age increases and ranged from 29.5 - 33.3 mm (M) and 28.1 - 30.8 mm (F) on right side and 28.05- 32.5 mm(M)and 27.6- 30.05 mm(F) on left side in the youngest and eldest age group respectively i.e. length of frontal horn increases as age increases. The frontal horn length in males was more than females. Farheen SS,[26] showed the mean length of frontal horn to be more in males (Right Side=28.5 mm, left side=30.3 mm) as compared to females (Right Side=25.9 mm, Left Side= 29.6 mm) and was also more on the left side in both sexes. Moawia Gameraddin,[27] (By CT scan)found no difference in length of frontal horn of right and left sides in both male and female. Although the mean length of the frontal horns in males (28.53+3.88 mm) on both right and left was more than in females (26.16 mm and 26.17 mm on Right and Left Sides).

Yadav A et al.[28] (2015) also showed the size of frontal horn to be more in males as compared to females and more on the left side. In a study done by Mallika, [29] by both CT and dissection method, left frontal horn was found to be longer than the right one and frontal horn measurements on both

sides were more in males. (Left Sided frontal horn length, 27.1 ± 2.2 mm in male, 24.3 ± 2.2 mm in female; right sided frontal horn length= 25.5 ± 2.5 mm in male, and 20.7 ± 2.5 mm in female in dissection method.). Meshram P et al.[30] (2012), showed the mean height and antero-posterior diameter of third ventricle in males (20.08 mm, 24.7 mm) to be greater than in females (19.9 mm, 24.6 mm) (not significant). Both height and AP length showed positive correlation with age.

F. Duffner et al.[31] D'soza et al.[24] found the mean height of 4th ventricle as 38.3 mm and 11.8 mm; mean width were 12.5 mm and 13.1 mm with MRI and CT respectively. Akbari VJ et al.[32] found that width (23.8 mm) is more than height (22.9 mm) of fourth ventricle. D'Souza et al[24] also found the width of fourth ventricle to be greater than the height in both genders.

CONCLUSIONS

There is a positive correlation in measurements of the brain ventricles with age and variation in accordance with gender and laterality.

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