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Original Research Article

Gender Related Differences in Third Ventricle Parameters with Correlation to Cerebrum Size - A Study on Head CT Scans

Poonam Patnaik[1], Vishram Singh[2], Dalvinder Singh[3], Satbir Singh[4]

[1]Assistant Professor, Department Of Anatomy, Faculty of Dentistry, Jamia Millia Islamia, New Delhi, India. Research Scholar at SMC &H, NCR.
[2]Professor and Head, Department Of Anatomy, Santosh Medical College and Hospital, Ghaziabad, NCR, India
[3]Associate Professor, Department Of Anatomy, Jamia Millia Islamia, New Delhi, India.
[4]Director Professor, Department Of Radiology and Imaging, G.B.Pant Hospital, New Delhi, India.

Corresponding Author: Poonam Patnaik

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ABSTRACT

Background: The ventricular system of brain can be visualized by using modern computerized x-ray tomography, an easy and safe available noninvasive technology and it can be used as a screening procedure for many pathological conditions. Cerebral ventricular enlargement has been associated with many neurological disorders. Whether this enlargement is primary or secondary to these pathological conditions remains controversial. To define such enlargement, one must have measurements in normal subjects (controls). Present article describes the third ventricle parameters correlated to cerebrum dimensions as part of PhD thesis work of 1st author under the supervision of 2nd, 3rd and 4th author.
Material and Methods: Fifty nine apparently normal axial non-contrast head CT scans of patients (32 males, 27 females) with age range between 5-70 years were subjected to morphometric measurements using dicom image software. Third ventricle width (TVW), third ventricle sylvian fissure distance index (TSFI), third ventricle ratio (TVR) were calculated. The data collected was statistically analyzed using student t- test to compare means in males and females and Spearman’s Rank correlation coefficient to find relationship with cerebrum dimensions taking level of significance as 0.05.
Results: Mean third ventricle width was found to be 6.86 +/- 2.74mm, Mean Third ventricle sylvian fissure distance index was found to be 0.55+/-0.06 and Third ventricle ratio was observed to be 0.07+/-0.02. The values were slightly higher in males. TVW and TVR showed weak positive significant correlation whereas TSFI showed negative weak non significant correlation to transverse diameter of cerebrum.
Conclusion: Measurements of all the three parameters in males and females of the apparently normal groups revealed no significant difference. However measurement of third ventricle at all the three levels provides comprehensive data especially in elderly which might help in distinguishing third ventricle enlargement in hydrocephalus and brain atrophy diseases.

Keywords: third ventricle width (TVW), third ventricle sylvian fissure distance index (TSFI), third ventricle ratio (TVR).

INTRODUCTION

Third ventricle of brain is a narrow median cleft in the diencephalon between two thalami and communicates anteriorly to lateral ventricles through foramen of monro and posteriorly to fourth ventricle through narrow cerebral aqueduct, the cavity of midbrain. [1] Blockage of cerebral aqueduct can lead to widening of third ventricle and accumulation of excess amount of CSF in 3rd and lateral ventricles leading to a condition known as hydrocephalus. Third ventricle is related to many important brain structures including anterior commissure, fornix, tela choroidea, pineal body, hypothalamic structures, optic chiasma, infundibulum, mammillary bodies, tegmentum of midbrain. [2] Therefore it can be easily obstructed by brain tumors in these regions and thus cause hydrocephalus in infants and raised intracranial pressure in adults. Build up of pressure in third ventricle can also cause hypothalamic symptoms like diabetes insipidus and obesity.

Besides, ventricular enlargement has been associated with many neuro-degenerative disorders e.g. Brain atrophy diseases, basal ganglia atrophy, hutingtons chorea, alcoholic brain dementia etc. This enlargement may be primary or secondary to these pathological conditions. The importance of base line data on ventricle measurements in normal living human for diagnosing and monitoring of several pathologies cannot be denied. Third ventricle width has been reported by various authors [3-11] to be from 2.29mm to 9.2 mm but data on gender related differences is scanty (table- I). [12-15]

Our study aimed to provide normal data range of third ventricle width, third ventricle sylvian fissure distance index and third ventricle ratio to allow their assessment in patients with hydrocephalus and degenerative brain diseases. In literature none of the study is available where all the three indices of third ventricle are studied in the same patient. Also to see whether they are dependent upon cerebrum size , they are correlated with linear dimensions of cerebrum - maximum anteroposterior (AP) and transverse diameter (TD) since linear dimensions are probably most easily made and reproducible.

MATERIALS AND METHODS

This is a retrospective, cross-sectional, non-interventional study. The study group was drawn from patients reporting to the Department of Radiology and Imaging, G.B Pant Hospital, for head CT examination for various indications during Feb- March 2014. Institutional ethical committee clearance was duly obtained and the study was conducted in Department of Anatomy, Santosh Medical College and Hospital, NCR, in collaboration with Jamia Millia Islamia, Central University at Delhi.

59 virtually normal head CT scans (32 males, 27 females), without changes (as reported by Radiologists) were collected on DVD. Patients of both sex and age group 5-70 years were included in the study. CT scans showing gross pathological changes affecting the normal anatomy of ventricles (e.g. due to large metastasis etc.) were excluded from the study group.

All CT scans were taken by trained and experienced radiographer in standardized condition and manner. CT study of brain was done in axial transverse scanning on the multi slice CT scanner.

The scans were obtained on a plane at an angle of 15 degree to and 1 cm above the infra-orbitomeatal line. All other technical parameters. (Time in ms, potential in kv, current in mA) of the scans were as per the established standards with slice thickness of 8 mm.

CT scans were selected out of the routinely done investigations. No extra scans were indicated for the purpose of study, to avoid unnecessary radiation exposure.

The linear measurements were taken in CT images as per table II with the help of Dicom Image Software. The parameters were calculated and analyzed as per Table- III.

Image interpretation for third ventricle:

1. Maximum width of third ventricle at superior colliculus (TVW) **Figure 1.**

2. Third Ventricle sylvian fissure distance index: (TSFI): The measurements were taken on the CT scan at the level of Thalami in their largest dimensions where the third ventricle and sylvian fissure are well depicted. The distance between the lateral border of third ventricle and the lowermost point of sylvian fissure were measured on each side. The sum of the two was divided by internal diameter of skull in the same line **Figure 2.**

3. Third ventricular ratio (TVR) taken at the level of foramen of Monro = Greatest width of 3rd ventricle / internal diameter of skull at the same level **Figure 3.**

For Anteroposterior and transverse diameter of cerebrum axial image selected was at the level of head of caudate nucleus, because at this level cerebrum dimensions are maximum and image at this level is available in almost all the patients **Figure 4.**

Statistical Methods: For all the three parameters, mean, standard deviations were calculated for males, females and total subjects studied. Student t- test was used to compare means in males and females. Data of all the three parameters was correlated to dimensions of cerebrum using Spearman's rank correlation coefficient. For P value, level of significance was taken as 0.05.

Figure 1: axial view at the level of superior colliculus; marked line denotes the third ventricle width (TVW)

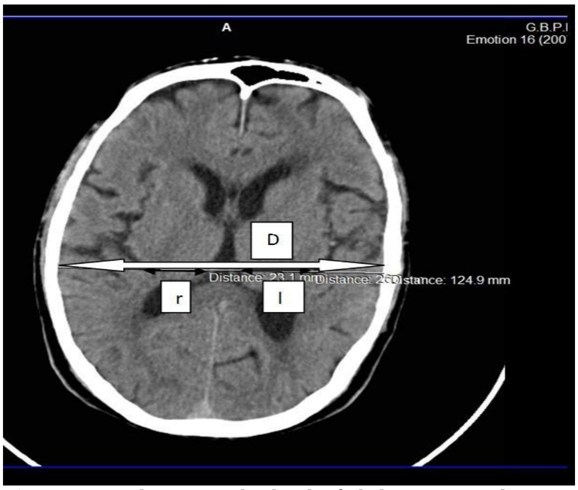

Figure 2: axial view at the level of thalamus in its largest dimensions; r (black arrow) is the distance between lowermost point of right sylvian fissure and right margin of third ventricle; l (black arrow) is the distance between lowermost point of left sylvian fissure and left margin of third ventricle; D (white arrow) is the inner diameter of skull in ssme line ; TSFI = (r+l) / D

Figure 3: axial view of brain at the level of foramen of Monro. White arrow shows width of 3rd ventricle. Black arrow shows inner diameter of the skull in the same line.

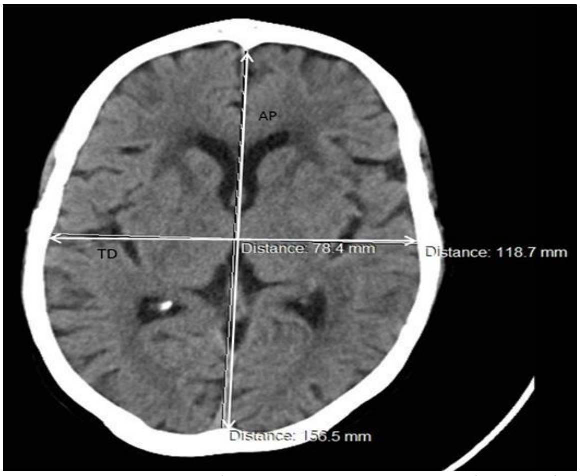

Figure 4: axial view of brain taken at the level of head of caudate nucleus, AP:anteroposterior diameter of cerebrum,TD: Transverse diameter of cerebrum at midpoint of AP .

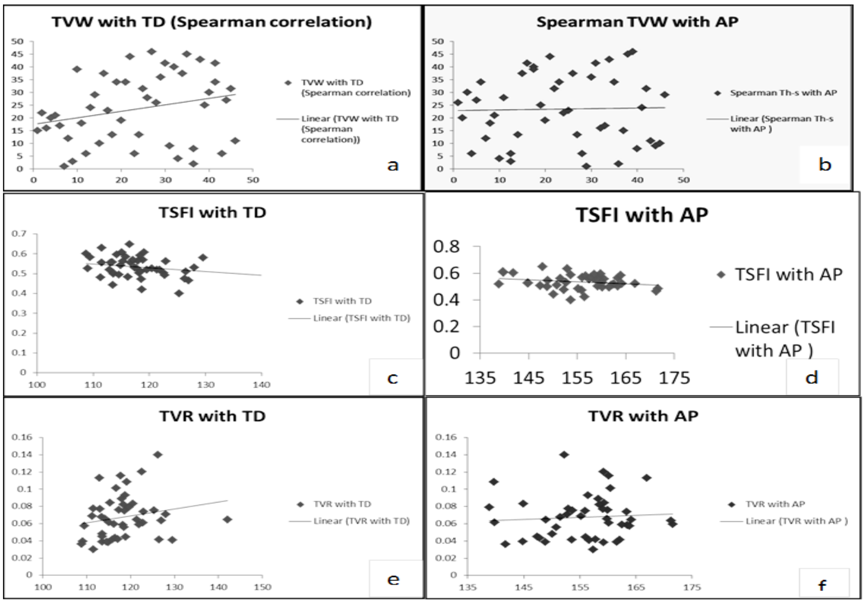

Figure 5: Third ventricle parameters correlated to Anteroposterior (AP) & Transverse diameter (TD) of cerebrum.a,c,e: all three graphs show mild change with TD. b,d,f: almost straight line shows there is no dependency on AP.

RESULTS

Average third ventricle width (TVW) was found to be 6.86mm with s.d. of 2.74mm and revealed no significant difference in males and females (p value 0.07).

Mean Third ventricle sylvian fissure distance index (TSFI) was found to be 0.55+/-0.06 and no significant difference was noticed between males and females (p value 0.49)

Third ventricle ratio (TVR) was observed to be 0.07+/-0.02 being slightly higher in males than in females, however the difference being non-significant (Table- III).

Table I: Third ventricle width as reported by different authors.

Author, year, area	3rd ventricle width	Technology, sample size
Gawler J et al4 (1976) London	0.46 cm	CT, 78
Soininen H et al 8 (1982)Finland	0.92 cm	CT, 85
Seidel (1995)	6.2 ±1.9 mm	-
Berg D (2000)	4.5 ± 1 mm	-
Duffner F et al3 (2003) Germany	0.33	MRI , 30
Hernández NL (2007)	3.9 ± 2.5 mm	-
Zauhair A. (2009)	2.298±0.619 mm	-
Wollenweber (2011)	3.6 ±1.8 mm	-
Vidya K. Satapara, 2014,Gujrat India	0.52 cm,	MRI , 83
D'souza e DMC & Natekar PE 1 (2007)Goa, India	Male 0.45., Female 0.39	CT, 1000
Meshram P & Hattangdi S5 (2012)Mumbai India	Male 0.77; Female 0.67	CT, 200
Martin Muller (2013)	Males 3.4+/-0.92 mm Females 3.4+/- 0.78 mm	TCSS, 70
Brij et al 2014	Males 3.47 ± 1.07mm ; females 3.31 ± 0.94	CT, 358
Present study ,2015, India	Males 7.47+/-2.81mm; females 6.39+/-2.6	CT, 59,

Table II: Images selected and measurements taken

Image selection	Measurements taken
At the level of superior colliculus	Maximum diameter of third ventricle =Th_s
At the level of thalamus in its largest dimension where Sylvian fissure is well depicted	Distance between the right margin of third ventricle and lowermost point of right sylvian fissure = R_t Distance between the left margin of third ventricle and lowermost point of left sylvian fissure = L_t Inner diameter of the skull in the same line = D_t
At the level of foramen of Monro	Maximum diameter of third ventricle = Th_F Inner diameter of skull at the same level = D_F
At the level of head of caudate nucleus	Anteroposterior diameter of cerebrum= AP At midpoint of AP, Transverse diameter of cerebrum = TD

Spearman's rank correlation coefficient with anteroposterior and transverse diameter of cerebrum for all the three parameters was as per table IV. TVW and TVR showed weak significant correlation with transverse diameter whereas nil with anteroposterior diameter. TSFI showed very weak negative non-significant correlation with cerebrum dimensions.

Table III: Parameters of third ventricle in male and female

Parameter	Mean+/-s.d.		Mean +/- S.D.	Range Min. Max		P value
Maximum diameter of 3rd ventricle Th_S (TVW)	6.86+/-2.74	Male (n=27)	7.47+/-2.81	2.1	13.2	P=0.07
		Female(n=26)	6.39+/-2.6	3.0	11.2	
Third ventricle sylvian fissure distance index = $(R_t + L_t) / D_t$ (TSFI)	0.55+/- 0.06 n=59	Male (n=32)	0.549+/-0.69	0.399	0.744	P=0.499
		Female (n=27)	0.548+/-0.052	0.421	0.631	
Third Ventricle Ratio = Th_F / D_F (TVR)	0.07+/-0.02	Male (n=29)	0.069+/-0.027	0.030	0.1398	P=0.444
		Female (n=20)	0.068+/-0.022	0.038	0.1155	

For TVW and TVR n=53 & 49 respectively, because appropriate images were not available at these level in rest of the patients.

Table IV: Spearman's Rho with AP and TD

Parameter	Spearman's rank correlation coefficient (rs)		p-value	P value
	With AP	With TD	With AP	With TD
TVW	0.02	0.25	0.44	0.04*
TSFI	-0.18	-0.24	0.11	0.05
TVR	0.08	0.27	0.29	0.03*

* Significant p value <0.05

DISCUSSION

Narrowing of cerebral aqueduct can lead to third ventricle enlargement. Third ventricle can also be dilated in atrophic diseases of grey matter including basal ganglion e.g. multiple sclerosis. Therefore, the relation of the cerebral ventricular system to that of the brain tissue as a whole may provide much less error and can be considered more reliable. [16]

The mean width of 3rd ventricle varies between 2.30+/- 0.64 mm and 9.2+/-2.71 mm with several studies in between 3.6 mm and 6.2+/-1.9mm.(table-I). In our study mean TVW was 6.86+/-2.74mm at the level of superior colliculus. Significant sex-related differences in measurements of the ventricular system, using a rather small sample of adults, were reported by Gyldensted and Kosteljanetz, 1976. [17] In our study mean third ventricle width at the level of superior colliculus was apparently larger in men than that of their women counterparts, however no significant difference was found statistically (p>0.05) between the two genders (7.47+/- 2.81mm in males and 6.39+/- 2.6 mm in females). The range of TVW was also higher in males, the maximum being 13.2 mm. Earlier also TVW was reported to be slightly higher in males than in females. (D'souza, Meshram, Brij) in all Indian studies. However Vidya K (2014) in MRI study reported TVW to be same in males and females. When correlated to linear dimensions of cerebrum, TVW showed weak positive significant correlation to transverse diameter of cerebrum whereas nil to anteroposterior diameter.

TSFI: Third ventricle sylvian fissure ratio index serves as an index on brain CT to give the predictive value for improvement after shunt surgery in elderly patients with normal pressure hydrocephalus based upon their symptoms. (Dementia, incontinence, gait disturbance). In cases of NPH, where TSFI was lower than 0.50, complete inability to walk was observed by E.Chatzidakis et al. [18] Since the diagnosis of NPH has been based mainly upon the brain CT Scan. [19,20] Large sizes of the ventricles, periventricular lucency and the presence of a small degree or the absence of cortical atrophy are considered characteristic evidence of communicating hydrocephalus. [21,22] Thus there is an effect of the size of the ventricles and the cerebral mantle measured in CT images, in the presentations of clinical symptoms and the outcome of patients after drainage procedures. The depth of the cerebral mantle, calculated by TSFI has a significant correlation to the severity of the symptom 'gait disturbances'. This is again probably the result of dilatation of 3rd ventricle, which causes displacement and stretching of the fibres of the internal capsule, which originate from the precentral motor cortex. Additionally, alterations in the vascularity of the periventricular parenchyma structure can explain the mobility dysfunction. [23] In our study, TSFI was calculated to be 0.55+/-0.06, being slightly higher in males (0.549+/-0.69) than in females (0.548+/-0.052), the difference being statistically non significant. (p>0.05). TSFI index ranges were less in females than in males. The minimum and maximum TSFI both were found in males showing higher ranges. However more investigations are needed to see the changes with age in both sexes.

TSFI showed negative non significant weak correlation with TD (rs -0.24, p=0.052) and very weak with AP (rs -0.18, p=0.11).

TVR: Third ventricle ratio is the product of third ventricle width at the level of foramen of monro divided by the internal diameter of the skull in the same line. Third ventricle measurement at this level is supposed to be a good indication of third ventricle enlargement. Further, tumor or cyst at this region can lead to dilation of Lateral ventricles causing pressure changes also in cerebrum. In our study TVR was found to be 0.07+/-0.02, mean being slightly higher in males than in females, though statistically non significant. Correlation to cerebral size demonstrated positive weak statistically significant (rs=0.27, p=0.033) correlation with TD, whereas almost nil with AP (rs=0.08, p=0.29).

All the three parameters of third ventricle do not depend upon the anteroposterior diameter of cerebrum. They show a weak correlation with transverse diameter. This could be because transverse diameter of brain at respective level is the denominator itself in calculating TSFI and TVR.

Anterior inferior 3rd ventricle is dilated in advanced hydrocephalus, but it remains normal in atrophy patients. The appearance of the anterior third ventricle is a helpful feature in distinguishing atrophy from CSF obstruction. [24] The posterior third ventricle and upper aqueduct may also dilate with significant atrophy of the quadrigeminal plate. [25] Therefore it is essential that measurements of third ventricle are available at all the levels- superior colliculus, thalamus and foramen of monro, so that appropriate diagnosis and management can be initiated. Further research in this area should prove rewarding. In elderly patients with dilated ventricles, the differential diagnosis of atrophy versus hydrocephalus remains a difficult diagnostic problem because CSF obstruction may be associated with brain atrophy. We recommend further studies on 3rd ventricle in sagittal plane in relation to anteroinferior part, posterior part and mamillopontine distance, so that comprehensive data is available which will be rewarding for surgical procedures like third ventriculostomy and intra - ventricular placement of implants in future.

CONCLUSIONS

Measurements of all the three parameters of third ventricle in both males and females of the apparently normal groups revealed no significant difference. They have no monotonic relationship with anteroposterior diameter of cerebrum, however they show weak correlation with transverse diameter of cerebrum. Measurement of third ventricle at all the three levels provides comprehensive data especially in elderly which might help in distinguishing third ventricle enlargement in hydrocephalus and brain atrophy diseases.

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