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Original Research Article

Morphometric Study of the Third Ventricles in Apparently Normal Subjects Using Computerized Tomography

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ABSTRACT

Purpose: The aim of the study was to examine the indices of the normal third ventricle of brain, its variation with age and discuss clinical application.
Methods: In a retrospective, cross-sectional, non-interventional study, the CT images of 60 patients (mean age 36.22+/-15.44 years) were subjected to morphometric analysis by dicom image software, and the 3rd ventricle indices, namely, third ventricle width (TVW), third ventricular sylvian fissure distance index (TSFI) and third ventricle ratio (TVR) were studied and correlated to age by finding Pearson correlation coefficient at 0.05 significance level.
Results: Mild positive non- significant correlation was observed between third ventricle widths with age. TSFI showed negative significant moderate correlation with age (r=-0.396, p= 0.0017) and TVW (r= - 0.340, p=0.007) whereas TVR showed no correlation with age. The distance between margin of third ventricle and respective sylvian fissure was more on left side with statistically non-significant difference.
Conclusion: The present study shows that TVW increases only mildly and TSFI decreases with age. TVR does not depend upon age.

Key words: Third ventricle indices, Third ventricle sylvian fissure distance index.

INTRODUCTION

The third ventricle of brain is a median cleft present between two thalami. It communicates antero-superiorly with lateral ventricles through interventricular foramina and postero-inferiorly with fourth ventricle via cerebral aqueduct and thus extends from foramen of monro to superior colliculus. Third ventricle is important surgically not only for its critical relationship with fornix and thalamus but also physiologically as its role in body fluid homeostasis by receptors in antero ventral third ventricle region [1] and probable role in infant satiety control mechanism. [2] As ageing advances, the human brain undergoes many gross and involutionary changes that are considered to be normal and are expected. Third ventricle is widened with physiological ageing, brain atrophy diseases, narrowing of aqueduct and obstructive hydrocephalus. Thus, the knowledge of normal Morphometry and size of third ventricle is required before any abnormal findings are analyzed. In the routinely done non contrast CT scans of head, the axial views are available usually at all the three levels, at the level of superior colliculus, at the level of thalamus and at the level of foramen of monro. Several authors have proved that with increasing age, there

is enlargement of ventricular system. [3-6] But to date enough base line data is lacking on the linear measurements of third ventricle with relation to increasing age. We intend to find the correlation of third ventricle indices with increasing age, if any, so as to distinguish the third ventricle enlargement in pathologic and physiologic cases.

MATERIALS AND METHODS

For the present study, TVW, TSFI, TVR were calculated by taking Measurements on the CT images in the radiology archive of 60 patients (28 female, 32 male), mean age, 36.22 ± 15.44 (range: 5-75) years, with no disorders affecting the ventricles such as neoplastic diseases, cerebral infarction, trauma etc and whose CT findings were evaluated as within normal ranges by the experienced radiologists. All sixty patients underwent clinical CT imaging of the cranium at the department of radiology and imaging, G.B. Pant Hospital, New Delhi between February and March 2014. A written standard consent was taken from all participants willing to be part of the study. All non-contrast CTs were performed by the trained radiographers under all standardized conditions with slice thickness of 8 mm. CT scans was selected out of the routinely done investigations. No extra scans were indicated for the purpose of study, to avoid unnecessary radiation exposure. With the permission of Institutional Ethical Committee, the study was conducted in the department of Anatomy, Santosh medical college and hospitals, NCR, in collaboration with Jamia Millia Islamia, New Delhi.

The following indices were calculated using Dicom image software on the axial views for dimensions of the third ventricle, in a method described previously (Patnaik et al). [7]

1. At the level of superior colliculus: Third ventricle width (TVW)
2. At the level of Thalami: Third Ventricle sylvian fissure distance index (TSFI),
3. At the level of foramen of Monro: Third ventricular ratio (TVR)

Image selection: CT images of 49 patients of earlier study done in 2015, for whom images were available at all the three levels, and 11 more patients for whom images were available at level (1) and (2) were included in the study. The subjects whose images were not available at atleast two of the three levels were excluded.

Statistics

Normal distribution of data was checked by Lilliforce Test. Descriptive statistics was used to find mean, standard deviation, 95% confidence intervals and cumulative frequency distribution. Correlation with age was seen by calculating Pearson correlation coefficient. Unpaired student t- test was applied to see difference between margin of third ventricle and sylvian fissure on right and left side (Rth and L_{th}). Threshold value for statistical significance was set at 0.05.

RESULTS

Table I: The correlation coefficient between age and third ventricle indices and their relations with each other

variable	Third ventricle width (TVW)	Third ventricle sylvian fissure distance index (TSFI)	Third ventricle ratio (TVR)
Age r p- value	 0.166 0.204	 -0.396 0.0017*	 -0.09 0.53
TVW r p- value	 1	 -0.340 0.007*	 0.025 0.86
TSFI r p- value	 -0.34 0.007*	 1	 -0.031 0.83

*significant at two tailed probability

The mean TVW was 7.14 +/- 2.71 mm (95% Confidence interval 6.44 to 7.84), mean TSFI was 0.549 +/- 0.06 (95%CI 0.391 to 0.707) and mean TVR was 0.0686 +/- 0.024with 95% CI being 0.0614 to 0.0758. Mean R_{th} was 32.40+/- 4.05 mm and mean Lth was 33.14+/- 3.44 mm. All the data showed normal distribution.

Results of Correlation coefficient with age were as per table I.

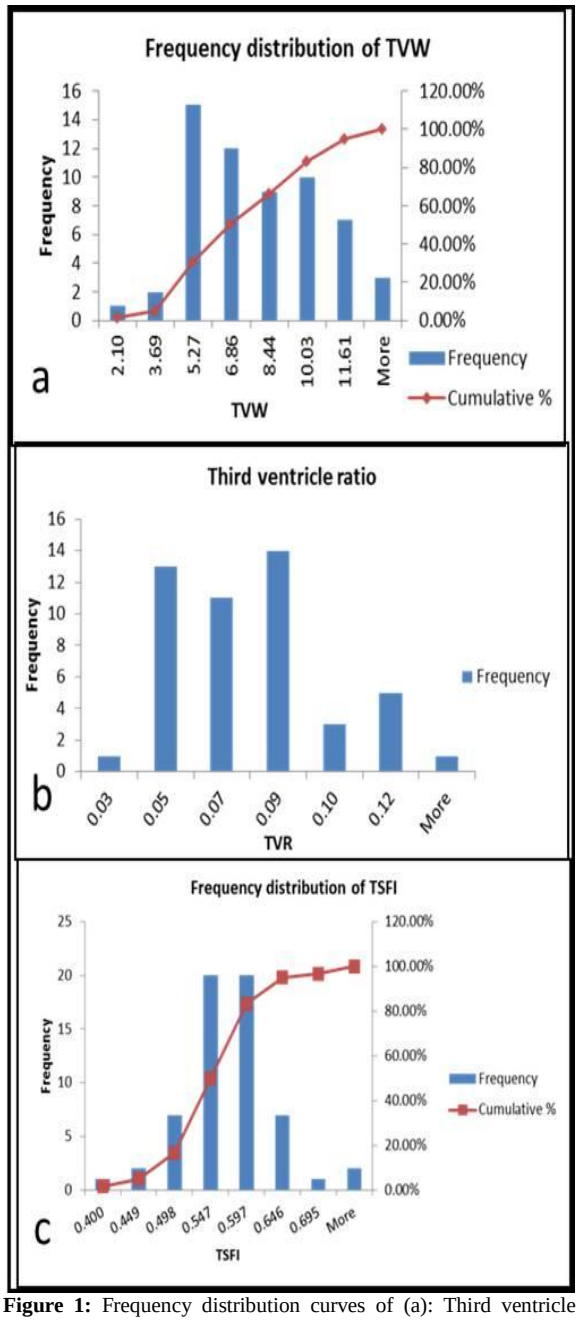

Figure 1: Frequency distribution curves of (a): Third ventricle width: 96% of patients had width less than 11.6mm. 95% Confidence interval being 6.44 to 7.84 mm; (b): Third ventricle ratio: mean = 0.0686 +/- 0.024 with 95% CI being 0.0614 to

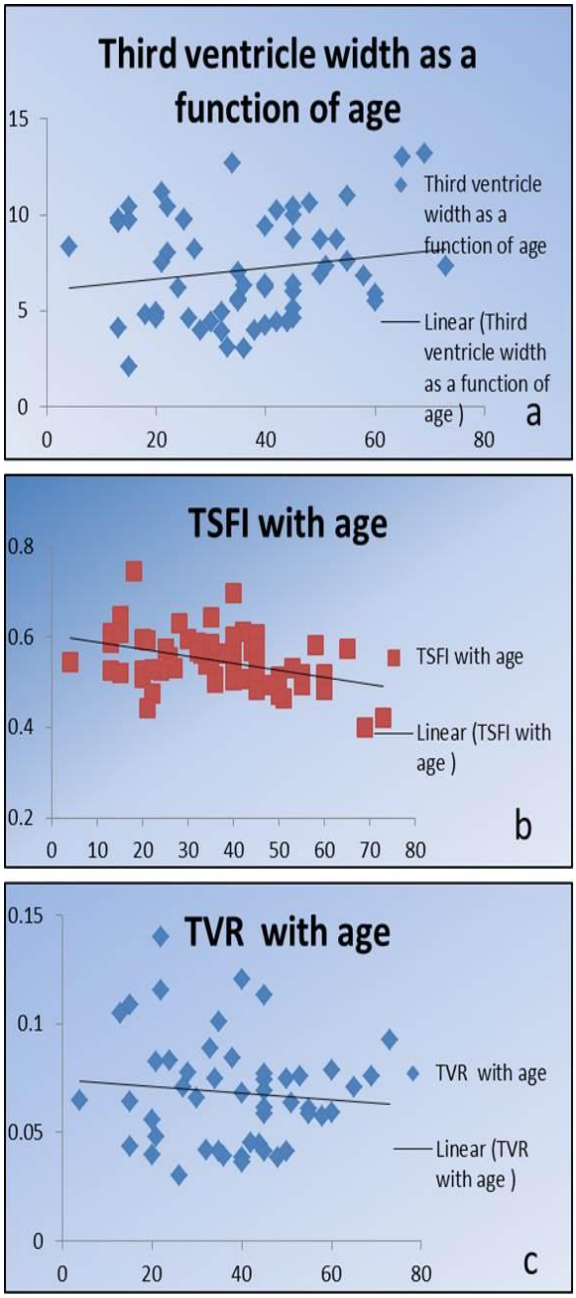

Figure 2: Scatter diagrams depicting variation of third ventricle parameters with age . a: third ventricle width shows only mild positive correlation (r=0.16); b.: Third ventricle sylvian fissure distance index shows moderate negative correlation

DISCUSSION

In literature, the mean width of third ventricle has been reported to vary from 2.25 mm [Benedict] [8] to 9.2 mm [Soininen et al], [9] however the level not being specified. In our study it was 7.14 mm, at the level of superior colliculus, and the frequency distribution curve (figure-1a) shows that maximum no of patients had mean width 5.27 mm. Our findings are in accordance with another Indian study done

by Meshram P [10] in 2012, who reported third ventricle width to be 0.77 cm in males and 0.67 cm in females. In our study the lower limit of 95% confidence interval was 6.44 and upper limit was 7.84. In their CT-based study Medora and Prashant [11] concluded that the width of the third ventricle among females was smaller than among males, whereas, Mathew et al. (2012) [12] in their study reported the width of third ventricle, posterior to inter-thalamic adhesions, 6.02+/- 1.42 mm in males and 6.08+/- 1.49 mm in females with significant gender variation from 6 years and above. According to Usman JD, [13] though the Antero-posterior length of third ventricle has been reported to have statistical difference ($P<0.05$) between male and female in the age ranges 11-15 to >25, there was no statistical difference ($P>0.05$) in width of third ventricle between male and female in these age ranges. On normal CT scans, Third ventricle is invisible or minute before fourth decade but is commonly seen clearly by fifth decade as reported by Le may [14] in 1984. Cotton et al. (2005) [15] studied third ventricular size in relation to cranial vault size and concluded that with advancing age there is gradual widening of the third ventricle. According to our study, third ventricle width showed mild positive non significant correlation with age ($r=0.166$, $p>0.05$) Fig.2a, table I. According to Meese (1980) [16] also, the normal size of the third ventricle on CT and MRI was shown to be <5 mm in children, <7 mm in adults <60 years of age and <9 mm in adults above 60 years. The highest of the dimensions in the 3V and 4V occurred in the highest age group of ≥60 years, confirming that ventricular dimensions increase in size with increasing age. This agrees with Celik *et al.* [17] who examined 100 voluntary individuals with no physical or neurological deficit and discovered that the sizes of the cerebral ventricles increase with age in both sexes. The scatter diagram in fig 2a shows a mild slope and r of regression also 0.16, confirming that there is nonsignificant increase in the width of third ventricle with age. Schimmels [18] studied the length and width of the third ventricle among infants with Trisomy and healthy control using ultrasound, and reported the width of the third ventricle of the control as 0.19 ± 0.06 cm. To comment upon the measurements in infants are beyond the scope of this article because we limited our study to age group 5 to 75 years of age. Even in clinically severe dementia young patients, in whom the changes because of age are excluded, third ventricular width changes only slightly within one Standard deviation of width in normal patients. [19] It means that it does not change significantly in CT in atrophy related to dementia. It is not a good indicator of atrophy related to dementia.

Third ventricle sylvian fissure distance index (TSFI) is calculated at the level of thalami where they are widest and sylvian fissure is well depicted. The sum of the distance between margin of third ventricle and lowermost point of sylvian fissure on both sides is divided by the inner diameter of brain in the same line. Brinkman et al, [20] found TSFI to be 0.59 or less in 77% of demented patients but in only 24% of their non demented elderly patients. In our study, TSFI was less than 0.55 only in 16% and more than 0.55 in 84% of apparently healthy subjects. (Fig.1c) The difference may be attributed to the different age group, since they had taken only elderly patients. TSFI showed negative moderate significant ($r= -0.396$, $p = 0.0017$) correlation with age (table I). These findings are in accordance with Gomori et al, [21] reported in 1984. Reduction in brain weight by shrinkage results in compensatory enlargement of ventricles usually in sixth decade as a physiological process of ageing. [22] With increasing age there is progressive increase in TVW, which may be accompanied by reduction in thalamic mass width, at certain decade of age. This reduction in numerator of TSFI, together with increase in cranial vault diameter with age can explain the moderate negative correlation of TSFI with age. The 95%

confidence intervals were from 0.391 to 0.707.

Inter ventricular foramen is bounded antero-superiorly by fornix, inferolaterally by anterior pole of thalamus and choroid plexus connects the fornix to anterior thalamus. Fornix damage can cause memory dysfunction and injury to anterior thalamus can also lead to memory and conscious impairment. In many surgical procedures e.g. removal of tumors around foramen of monro, there is need to widen the foramen, which is done mostly by opening the choroidal fissure from the rear of foramen without damaging fornix or thalamus. [23] Therefore baseline data of width of third ventricle at this level also is important for neurosurgeons. Third ventricle ratio (TVR) is measured at this level. In our study, 95% confidence interval for TVR was 0.0614 to 0.0758. TVR showed no correlation with age (figure 2c) moreover TVR does not depend upon age (r= -0.09, table I). It remains almost constant for a patient in normal cases. It may be presumed that it changes only in pathological conditions. So deviation from normal ranges should be taken to suspect pathology. Thus TVR may be an important objective indicator of progression or deterioration or improvement of individual patients in clinical follow up studies.

When correlated with each other, TSFI showed significant (r= -0.340, p< 0.05) negative moderate correlation with TVW in two tailed probability test whereas nonsignificant correlation with TVR.(Table I).

In the ageing brain involutionary changes in the temporal lobes with widening of anterior ends of sylvian fissures is one of the earliest changes seen on CT, commonly seen in the fifth decade and left sylvian fissure being more frequently wider than right [14] So we also compared the distance between margin of third ventricle and respective sylvian fissure on right and left side and found distance on left side being more than right however the difference was statistically nonsignificant (p value = 0.28) .

Studies have also reported that greater intellectual enrichment done by educational attainment moderates the negative effect on cognition (Daniela Pinta) [24] done by many factors including regional brain atrophy, measured by third ventricle width in patients with multiple sclerosis, that is why it becomes all the more necessary to have a base line data on these parameters in the present high intellectual and global scenario as compared to ancient less informed and less educated population. This study showed the strength of correlation between the ages of subjects involved and the indices of the third ventricle.

CONCLUSIONS

Measurements of the third ventricle indices in normal head CT provide a useful guide to compare with deranged parameters in pathologic cases. The result of our study revealed mild positive non-significant correlation of Third ventricle width with age. Third ventricle sylvian fissure distance index decreases with age and with third ventricle width, whereas third ventricle ratio showed no correlation with age. Thus the present study has described the Morphometric measurement of the third ventricle of the brain, which has clinical correlation in diagnosis and for further line of treatment.

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