Age-related Changes in Ventricular System of Brain in Normal Individuals Assessed by Computed Tomography Scans

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ABSTRACT

Background: Normal ageing and dementia cause the increase of ventricular size in brain, and it is necessary to ascertain ageing related changes in ventricle size in normal Indo-Dravidian people of southern Odisha, India.
Objective: To find out age-related changes in ventricular system of brain in normal individuals from younger to elderly groups in both sexes.
Methods: Sixty normal females and males within ages, 15 to 70 years were examined by computed tomography (CT) scan of brains. Measurements of lateral, third and fourth ventricles were considered by arranging the subjects into 3 age-groups, 15 to 30, 31 to 50 and 51 to 70 years. After taking due measurements, Schaltenbrand index was calculated.
Results: Size of all ventricles had insignificant increase or no change from the youngest (15 to 30 years) to the middle age-group (31 to 50 years), but the width of third ventricle was found to increase in most males and females in the elderly group. Males had higher values of enlargement than females in all ventricles. Measurements of AP length of frontal horn and frontal horn with body remained almost constant in the youngest age-group, which increased with ageing. Schaltenbrand index values decreased steadily from younger to higher age-groups.
Conclusion: Sizes of all three ventricles were more in elderly individuals. In both higher age-groups, males had more expansion of ventricular system than females. Increase in ventricular size was more evident in the lateral ventricle. Changes in ventricular size did not show any effective change in cranial diameters.

Keywords: Third ventricle, fourth ventricle, lateral ventricle, computed tomography, Schaltenbrand index

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INTRODUCTION

Ageing or increasing age expectancy observed in the recent years has resulted in the increased incidences of dementive disorders, which are more common in elderly individuals leading to serious diagnostic problems, for which, much effort has been focused on the possibility of early detection of dementive disorders and their diagnosis.[1] Occurrence of ventricular enlargement in dementia, Alzheimer's disease and Parkinson's disease was established.[2] Further, gross and histopathologic changes occur in the brain, in ageing and diseases. Dementia leads to the regression and ballooning of the third ventricle with rounding of the angles of the lateral ventricle, assessed in computed tomography (CT) scans.[3] Increased volume of ventricular cerebrospinal fluid (CSF) may be indicative of degenerative changes in the white

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matter.[4] Indeed, age related structural changes reflect specific histologic changes of brain[5]; concomitantly, the lateral ventricular enlargement during ageing is frequently evident.[6] Moreover, the ventricular enlargement is known as a sensitive indicator of cortical atrophy in elderly normal individuals as well as, patients with dementia.[7] However, confounding superimposed changes of brain atrophy in patients over 60 years of age, often are reported in the normal ageing process.[7] Healthy ageing in humans is generally associated with a decreased brain tissue size, increased CSF volume, cerebral atrophy and ventricular enlargement.[8] Moreover, the two hallmarks of brain ageing are cerebral atrophy – measured by decreased volume of cerebral hemisphere, along with increased volume of peripheral CSF and ventricular enlargement.[8]

The present study evaluated the morphometry by CT scan of age-related changes in size of the ventricular system of the brain in 120 randomly selected normal individuals of the eastern-coastal India, from 15 to 70 years of age. CT scan results could be used to assess the changes in ventricular size and analyze the differences in both male and female subjects. Schaltenbrand index was calculated from the different measurements of the ventricular system of their brains. This study describes changes in size of brain ventricles in normal ageing individuals that are different from similar changes in patients due to dementive disor-ders. Such a study, not being reported earlier in normal Indo-Dravidian people from central India (southern odisha), provides a basis of differentiation from some diseased condition of the brain in a cohort of healthy elderly people.

MATERIALS AND METHODS

CT scans of all 120 subjects divided into 3 groups, 15 to 30, 31 to 50, and 51 to 70 years of age were analyzed during January 2013-July 2013. Finalization of samples size was done based upon the age factor. The three ranges of age group were categorized based on the development of the brain. In the age group of 15-30 years, the brain is fully developed and there would not be any degeneration. Similarly, in the age group of 31-50 years, the degeneration process may get initiated in some, as with the aging process the brain starts degenerating. After 50 years of age, the degeneration would be evident in the majority of people. Thus in this study, subjects were divided in these 3 age groups. Subjects beyond 70 years of age were not considered in the study, as changes in the brain are commonplace in the elderly. In each group 40 subjects were taken, 20 males and 20 females. Though this study included more patients, extra subjects of certain age groups were not considered to maintain the equality in sample size. Morphometric measurements of third, fourth and lateral ventricles of the brain were recorded at the Department of Radiodiagnosis, IMS and Sum Hospital, Bhubaneswar. For further analysis and comparison, the Schaltenbrand index was calculated.[9] The subjects included in the study were all patients attending IMS and Sum hospital. All subjects were selected randomly from these patients who were not having any history of cerebral infarction, drug abuse, trauma, previous intracranial lesion or psychiatric disorders. None of the subjects had dementia, as recorded from symptoms. Thus they were not under any medication at the time of study. The CT scanner used in the study was G. E. Systems Hi-speed Dual (Model no: 13188-2002), having a scan time of 2 to 3 seconds. Slice thickness was 4 mm in the posterior fossa region and 5 mm in the rest part of the skull. In the tomogram, the frontal horn was identified anteriorly, whereas the occipital horn was identified posteriorly, but the temporal horn could not be identified or measured properly in these subjects. The third ventricle was found between the thalami, the fourth ventricle was seen at the centre of posterior cranial fossa, between cerebellum and pons. The morphological feature/measurements of young adults without any pathological symptoms were taken as standard for the radiologists.

The measurements were taken as follows: at the fourth ventricle, its greatest height and maximum width were recorded. The AP length measurement of lateral ventricular body including the frontal horn in left and right sides, along with AP length of frontal horn on both left and right

sides were measured. Length of the third ventricle could not be measured, but its width was measured in all subjects. Further, maximum values of measurement of outer and inner skull diameters were recorded. The 'two-tailed test of significance' was performed for the recorded data. These measurements were subjected to the computation of the Schaltenbrand index:

Schaltenbrand index = Maximum external cranial breadth/ maximum width of third ventricle. This study was approved by the institutional ethical committee.



Fig 1. Measurement of length & width of third ventricle.



Fig 2. Measurement of length & width of fourth ventricle.

RESULTS

Measurement values of tomograms of ventricles

Mean values with standard deviations of width of the third ventricle (Fig 1) were from 3.2 ± 0.7 mm (15 to 30 years group, i.e., the youngest age group), through 4.4 ± 0.8mm (31 to 50 years group, i.e., the middle age group) to 5.4 ± 0.8 mm (51 to 70 years group, i.e., the eldest age group) in males; and 3.1 ± 1.2 mm in the youngest years' group, through 3.6 ± 0.6 mm in the middle group to 4.7 ± 1.5 mm in the eldest years' group, in females (Table 1). Mean measurement values of the fourth ventricle (Fig 2) in males were from 11.1 ± 1.4 mm in the youngest age group, to 11.6 ± 1.8 mm in the middle age group, and to 13.5 ± 2.1 mm in the eldest years' group, and in females similar values were 11 ± 0.9 mm in the youngest years' group, to 11.1 ± 1.3 mm in the middle years' group, and 11.5 ± 1.5 mm in the eldest years' group (Table 1). In lateral ventricle, mean AP length of frontal horn in males ranged from 29.5 ± 2.1 mm to 33.3 ± 1.8 mm on the right side, and in females AP length ranged from 28.1 ± 1.9 mm in the youngest age group, to 30.8 ± 2.0 mm in the eldest age group, and data of left side horn was given too (Table 2). Further in the frontal horn with body, the mean AP length of the

TABLE 1. CT scan measurements (mean ± standard deviation) of third and fourth ventricle of brain.

Ventricle	Age group (years)	Mean measurement values (mm)			
		Male		Female	
		Width	Height	Width	Height
Third	15-30	3.2 ± 0.7	-	3.1 ± `1.2	-
	31-50	4.4 ± 0.8	-	3.6 ± 0.6	-
	51-70	5.4 ± 0.8	-	4.7 ± 1.5	-
Fourth	15-30	11.1 ± 1.4	4.7 ± 0.8	11.0 ± 0.9	4.3 ± 0.8
	31-50	11.6 ± 1.8	4.8 ± 0.8	11.1 ± 1.3	4.6 ± 1.0
	51-70	13.5 ± 2.1	6.0 ± 1.8	11.5 ± 1.5	4.9 ± 1.3

TABLE 2. CT scan measurements (mean ± standard deviation) of frontal horn of lateral ventricle.

Age group (years)	Frontal horn of lateral ventricle			
	AP Length (mm) right side		AP Length (mm) left side	
	Male	Female	Male	Female
15-30	29.5 ± 2.1	28.1 ± 1.9	28.05 ± 2.1	27.6 ± 1.7
31-50	32.6 ± 1.9	27.9 ± 1.6	31.7 ± 2.3	28.0 ± 1.7
51-70	33.3 ± 1.8	30.8 ± 2.0	32.5 ± 2.3	30.05 ± 2.0

TABLE 3. CT scan measurements (mean ± standard deviation) of frontal horn with body.

Age group (years)	Frontal horn with body			
	AP Length (mm) right side		AP Length (mm) left side	
	Male	Female	Male	Female
15-30	78.6 ± 3.7	77.4 ± 3.5	78.3 ± 3.4	76.6 ± 3.5
31-50	82.9 ± 4.1	78.3 ± 4.15	81.85 ± 3.9	77.55 ± 3.5
51-70	88.05 ± 4.5	83.2 ± 4.5	87.25 ± 4.2	82.6 ± 4.1

TABLE 4. Scaltenbrand index.

Age group (years)	Scaltenbrand index	
	Male	Female
15-30	3.9	3.4
31-50	3.6	3.1
51-70	2.4	2.4

right side was found to be from 78.6 ± 3.7 mm to 88.05 ± 4.5 mm in males and 77.4 ± 3.5 to 83.2 ± 4.5 mm in females in the youngest and the eldest groups, respectively (Table 3). In measurements of lateral ventricle, AP length values of both frontal horn and frontal horn with body were recorded, and those were found more in right side than left side or sometimes the same. In addition, these values were found higher in males than in females. Increase in measurements of lateral, third and fourth ventricles with ageing were recorded. The increased ventricular size in the elderly group was correlated to the maximum outer skull diameter values and the maximum inner skull diameter values, which had no appreciable change in skull size, in normal aging (Table 3). Schaltenbrand index values were 3.9 in males and 3.4 in females of the youngest group, while those were 2.4 in the elderly group in both males and females, with intermediate values of 3.6 in males and 3.1 in females of the middle group (Table 4).

Statistical considerations

In both males and females, the data of width of the third ventricle in the three age groups were statistically insignificant, but for the fourth ventricle, height data had *p*-values between 0.008 and 0.001 in the elderly group. In the fourth ventricle, the width data in both younger and middle groups was not statistically significant, but in the elderly group the data was significant with $p = < 0.0001$. In lateral ventricle, right frontal horn data was not significant for the first (younger) group, but, for the second (middle) group $p = < 0.0001$ and for the elderly (third) group, $p = < 0.002$. Further, data of the left lateral ventricle and of the left frontal horn were not statistically significant for the youngest group, whereas recorded data were significant for the middle group with $p = < 0.0001$ and for the eldest group with $p = < 0.001$. In the frontal horn with body, the *p* value of the right side was not significant for the youngest group, while *p* values were < 0.001 and < 0.008 for the middle and the eldest groups, respectively. Similarly, data of frontal horns with body on the left side were statistically significant as follows: in the youngest group, $p = < 0.02$; in the middle group, $p = < 0.002$; and in the eldest group, $p = < 0.014$.

Thus, measurements of AP length of frontal horn and frontal horn with body remained almost constant in the youngest age group, which increased in elderly persons. Further, the width of third ventricle was found to increase after 50 years of age, in most cases of males and females. The size of ventricles had insignificant increase or no change in the middle age-group. With individuals of the highest age group, there was a greater increase of ventricular size along with higher readings in males than females in all ventricles.

DISCUSSION

Higher values in males from the measurements of width of third ventricle recorded herein are consistent with similar studies done in England[10] and the US.[11] Values of width of the fourth ventricle in this study were almost closer to the findings of similar studies of Caucasians, England[10] and of mixed ethnic groups, Goa, India[12], but our results with Indo-Dravidians were different from those of England and Goa for measurements of the fourth ventricle, with higher values in males compared to those in females as recorded herein. Further, the report on CT scan findings that larger ratios of lateral ventricular size to intracranial size were found in elderly individuals compared with younger subjects of the US were consistent with those, in the present study.[13] In addition, a greater age related increase of ventricular size in males than in females was seen. An increased ratio of total CSF volume to brain volume was recorded with healthy volunteers between 31 to 87 years of age, elsewhere.[14] However, an average ventricular volume increased approximately two-fold between young (ages, 20 to 30 years) and elderly (ages, 60 to 80 years) in normal subjects, and after 60 years of age, there was an accelerated increase in ventricular size, universally.[7] Often, the ventriculomegaly is the result of atrophy of white matter of cerebral hemisphere usually attributed to diffused axonal injuries and associated with atrophy of the corpus callosum.[15] The increased area of anterior horns indicated frontal lobe atrophy.[16] In the present study, individuals between eldest age group, there was a greater increase of ventricular size along with higher readings in males than females in all ventricles. Further, the Schaltenbrand index was highest in individuals of the youngest age group, and values gradually decreased in both higher age groups.

Increase of the diameter of the third ventricle except its height by ageing, revealed in CT scans, has been documented in both sexes[17], which was consistent with the present study. Further, the enlargement of lateral ventricles between 62 and 88 years of age monitored through CT scans of subjects without any neurological illness or psychiatric disorders was recorded, and ageing was correlated to the total cortical atrophy score.[18] As it is known, different horns of the lateral ventricular system except the occipital horn are constant in contours.[19] In the present study, the measurement of AP length of the frontal horn and frontal horn with body remained almost constant in a particular age group.

The brain structure constantly changes from birth throughout lifetime, i.e., normal ageing process free from dementia is associated with structural brain changes. However, the profile of ventricular dilatation in patients with dementia was found different from patients with brain atrophy, as recorded from a quantitative and qualitative analysis comparing patients of neurodegenerative diseases with healthy subjects.[20] In a study on age-related changes in the brain based on MRI results, shrinkage of brain volume and the expansion of ventricular system with ageing were confirmed.[21]

CONCLUSION

This analysis revealed no remarkable differential effect with respect to sex in the youngest age group whereas, in the subsequent higher age groups, males had higher ventricular size than that of females. Sizes of all three ventricles increased with ageing which was specifically accelerated in subjects above 50 years of age. Increase in ventricular size was more evident in the lateral ventricle with subjects of the eldest age group. Schaltenbrand index was in a discernable decreasing trend from young to elderly ages. However, changes in ventricular size did not record any effective change in cranial diameters. These findings could have a gross differentiation in the

patients with neurological and psychiatric disorders from normal elderly individuals. AP length of frontal horn with body on the left side of brain increased signficantly with ageing.

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