International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Morphometric Analysis of Fourth Ventricular System of Human Brain: by Magnetic Resonance Imaging and Dissection Method

Prabahita Baruah[1], Pradipta Ray Choudhury[2], Krishna Kanta Biswas[3]

[1,2] Associate Professor, Department of Anatomy, Silchar Medical College and Hospital, Silchar, Assam, India.
[3] Assistant Professor, Department of Anatomy, Silchar Medical College and Hospital, Silchar, Assam, India.

OPEN ACCESS

Corresponding Author:

Krishna Kanta Biswas
Assistant Professor, Department of Anatomy, Silchar Medical College and Hospital, Silchar, Assam, India.

Received: 22-12-2025
Accepted: 13-01-2026
Available online: 31-01-2026

ABSTRACT

Introduction: The ventricular system is a predictor of brain development and a signifier of neurodevelopmental outcome. The fourth ventricle enlarges in various conditions like hydrocephalus, dementias etc. So, it is necessary to know the normal range of dimensions of fourth ventricle. Very few studies of Assamese population are available on fourth ventricle comparing the parameters in dissection and radiological methods.
Aim: The present study was conducted to determine any difference in the measurements of the fourth ventricle between formalin-fixed brain specimens and Magnetic Resonance Imaging (MRI) scans in our population.
Materials and Methods: This cross-sectional study was conducted in the Department of Anatomy at Silchar Medical College and Hospital, Assam, India. 127 formalin-fixed cadaveric brain specimens were used to measure the height and width of fourth ventricle. Additionally, MRI scans of 35 patients were used to measure the same parameters.
Results: The fourth ventricular mean width of 127 cadaveric brain specimens was 25.49 mm with standard deviation of 6.10 and the mean height was 26.94 mm with standard deviation of 6.12. The fourth ventricular mean width (at the level of lateral recess) in MRI was 20.99 mm with standard deviation of 4.59 and the mean height was 24.15 mm with standard deviation of 4.58.
Conclusion: In the present study, the measurements of 4th ventricle showed sexual dimorphism as male gender had predominance over female in both dissection and MRI procedures. The findings obtained from formalin fixed brains in dissection method showed greater measurements than MRI method for the parameters of fourth ventricle.

Keywords: *4th Ventricle, morphometry, dissection, MRI.*

INTRODUCTION

The ventricular system, a network of interconnected cavities littered with cerebrospinal fluid (CSF), is one of the highly conserved aspects of the vertebrate brain [1]. The ventricular system is a predictor of brain development and a signifier of neurodevelopmental outcome [2]. For evaluating the changes brought by growth, aging, innate and external pathologies, morphometric assessment of the cerebral ventricular system is relevant [3]. The brain endures various gross and histo-pathological transitions in older age, as well as in various dementias, with reduced brain tissue relating to ventricular widening [4]. Unusual widening of the ventricles was addressed as a predictive indicator of cerebral degeneration, which may be due in part to the adaptive potential of the ventricular system or to a reduced size of neurons [5]. Several authors found gender disparities in brain degeneration with age, and suggested that female change was relatively mild than male [6].

Fourth ventricle of brain, a rhomboid shaped small cavity, communicates antero-superiorly with third ventricle through narrow cerebral aqueduct, inferiorly with central canal of spinal cord and supero-laterally with subarachnoid space through foramen of Luschka and Magendie in its roof [7].

In past some researchers have reported width of fourth ventricle to be greater than its height, and both width and height being higher in males than in females [8,9]. Relatively few authors have reported the age changes in the dimensions of 4th ventricle [10].

Although, the results of post-mortem studies are substantiated by neuroimaging methods, dissection of cadaver is always regarded as a classic method of anatomical education. To the best of our ability and what has been encountered in the relevant literary works; limited report is available for the Assamese population concerning morphometric estimation of brain ventricles, capable of representing and classifying age and gender related physiological changes in ventricular anatomy by dissection procedure. Therefore an effort has been made in the present study to evaluate the various morphometrc dimensions of the fourth ventricle in individuals of different age group from both genders belonging to this specific population, primarily by dissection approach in formalin-fixed cadaveric brain which is then compared to the findings of MRI scans in vivo.

MATERIALS AND METHODS

This cross-sectional study was conducted from April 2014 to March 2019 after obtaining Institutional Ethical Committee (IEC) clearance. Brain specimens for the dissection method were obtained from deceased individuals who underwent postmortem examinations in the Department of Forensic Medicine, Silchar Medical College, Silchar, as well as from bodies voluntarily donated to the Department of Anatomy, Silchar Medical College, Silchar. In all cases, age, sex, and cause of death was recorded. Normal MRI scans of 35 cases from different age groups, performed in the Department of Radiology, Silchar Medical College and Hospital, were collected for radiological comparison.

Sample size calculation was done by using the formula $n=z2\ \sigma2/d2$, where 'z' represents the desired level of confidence, 'd' represents the desired width of the confidence interval, and 'σ' represents the standard deviation. For this study, 'z' was set to 1.96, 'σ' was 26, 'd' was 5, and 'n' was approximately 104.

Inclusion criteria: Postmortem brain specimens and MRI scans of individuals belonging to age groups 10-70 years and above, of both genders, were included in the study.

Exclusion criteria: Postmortem brain specimens with head injury and visible mass lesions were excluded from the study. The MRI scans with a history of head injury, cerebral infarction, local mass lesion, and prior intracranial surgery were also excluded from the study.

The brains were labelled and preserved in 10% formalin solution after removal during postmortem examination. Subsequently, the brains were dissected according to Cunningham's Manual of Practical Anatomy [11].

Dissection of Fourth Ventricle:

Through the vermis, the cerebellum was divided into two equal parts via a median sagittal section. The incision was deepened and the two parts of the cerebellum were carefully separated. This displayed the floor of the fourth ventricle.

For measurement of fourth ventricular dimension, the parameters taken into consideration were:
• Height: of 4^{th} ventricle measured from the upper end of impression for superior medullary velum to the level of obex.
• Width: measured across the level of lateral recesses.
Digital Vernier caliper was used to measure the various parameters of the ventricles and all the parameters were recorded in mm. Once collected, statistical analysis of the data was carried out.

Collection of data for MRI scans (for radiological comparison):

Similar points were taken into consideration in MRI scans as in case of dissection method. MRI scan of the patients were carried out in the Siemens Abanto Fit 1.5 tesla machine in the Department of Radiology, Silchar Medical College and Hospital. Sagittal and transverse axial planes were used in MRI scanning.

Statistical analysis

Statistical Package for Social Sciences (SPSS) Version 18 was used for Statistical analysis of the data. Statistical parameters, the mean, standard deviations and standard errors of mean of all measurements were estimated. The data was analyzed and compared by using Student's t-test for measurement of significance. Measurements of the parameters were correlated to the age by using Spearman's rank correlation coefficient. For P value, level of significance was taken as 0.05. Statistical significance was defined as $P< 0.05$ for all analyses.

RESULTS

During the study, 127 brain specimens were obtained belonging to the age groups of 10 years to more than or equal to 70 years of age. Among the 127 specimens, 78 were of male and 49 were of female brain.

For radiological comparison, normal MRI scans of 35 cases from similar age groups (as for dissection) were taken, including 23 male brains and 12 female brains.

Results in dissection method

The fourth ventricular mean width of 127 cadaveric brain specimens was 25.49 mm with standard deviation of 6.10 and the range was 13.25 mm to 39.80 mm. Similarly, the mean height of fourth ventricle was found to be 26.94 mm with standard deviation of 6.12 and the range was 14.36 mm to 41.76 mm. (**Table 1)**

There was gradual increase in the average width and height of the fourth ventricle as the age increased. Minimum width and height were found in 10-19 years of age group whereas the maximum values were found in the age group of more than 70 years. (**Table 2, Figure 6**)

It was also observed that in all cases (127 brain specimens), the average height being greater than the average width, but the difference was found to be statistically non-significant (p value 0.0591).

The average width and height are slightly more in male (25.93 mm & 27.37 mm) as compared to female (24.78 & 26.26 mm); although differences were found to be statistically non-significant.($p>0.05$). (**Table 3**)

Results in MRI

The fourth ventricular mean width (at the level of lateral recess) was 20.99 mm with standard deviation of 4.59 and the range was 14.63 mm to 37.44 mm. Similarly, the mean height of fourth ventricle was found to be 24.15 mm with standard deviation of 4.58 and the range was 19.24 mm to 40.18 mm. (**Table 4)**

The fourth ventricular width and height also showed positive correlation with age i.e. both the dimensions gradually increased as the age advanced; to be minimum in 10-19 years and maximum in ≥70years of age.(**Table 5)**

Though the width and height were found greater in male, no statistically significant difference was found in comparison with female. ($p>0.05$).(**Table 6)**

In case of fourth ventricle, the average width (at the level of lateral recess) was found to be more in cadaver by dissection method (26.94 mm ± 6.12) than in MRI (20.99 mm± 4.59), with the difference being statistically extremely significant($p<0.0001$).

Similarly, the average height of fourth ventricle was found to be more by dissection method (25.49 mm ± 6.10) than in MRI (24.15 mm± 4.58), and the difference was significant ($p<0.05$). **(Table 7, Figure 7)**

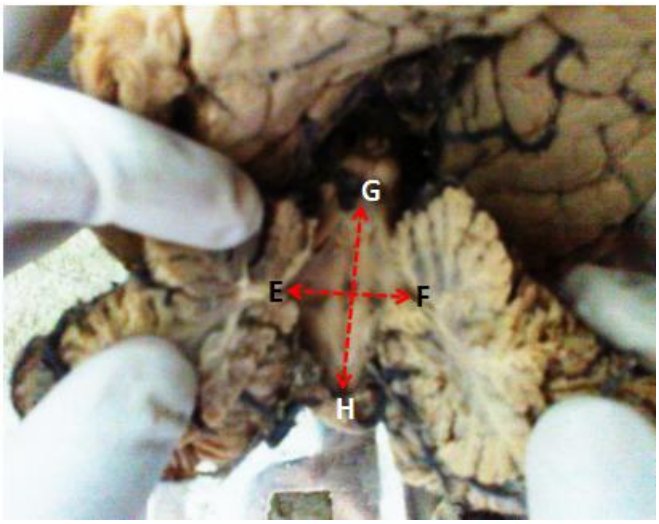

Figure 1: Measurements to be taken for 4th ventricle: G- upper end of superior medullary velum, H- obex, E, F- lateral recess of 4th ventricle. GH- Height & EF- Width of 4th ventricle.

Figure 2: Showing width of fourth ventricle measured at the level of lateral recesses

Figure 3: Showing height of fourth ventricle.

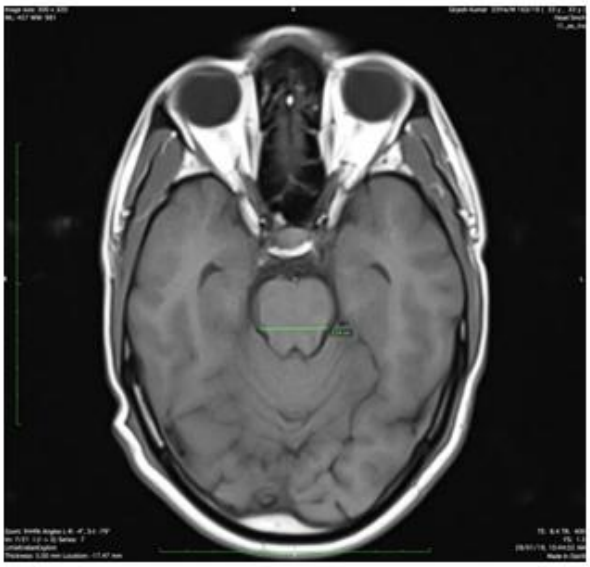

Figure 4: Showing width of fourth ventricle in MRI (at the level of lateral recess) (green line)

Figure 5: Showing height of fourth ventricle (yellow line).

Table 1: Showing average dimensions of different parameters of fourth ventricle in 127cases (By dissection method).

Statistical parameters	Fourth ventricle	
	Width	Height
Mean	25.49	26.94
SD	6.10	6.12
Minimum	13.25	14.36
Maximum	39.80	41.76

Table 2: Showing average width (at the level of lateral recess) and height of fourth ventricle in various age groups.

Age group (years)	Width		Height	
	Mean (mm)	SD	Mean (mm)	SD
10-19	15.42	2.60	16.81	2.61
20-29	16.72	2.26	18.22	2.09
30-39	21.37	1.44	22.54	1.76
40-49	24.61	2.31	26.32	2.31
50-59	27.51	2.10	28.99	1.95
60-69	32.55	2.36	33.93	2.52
≥70	34.02	8.11	35.45	8.06

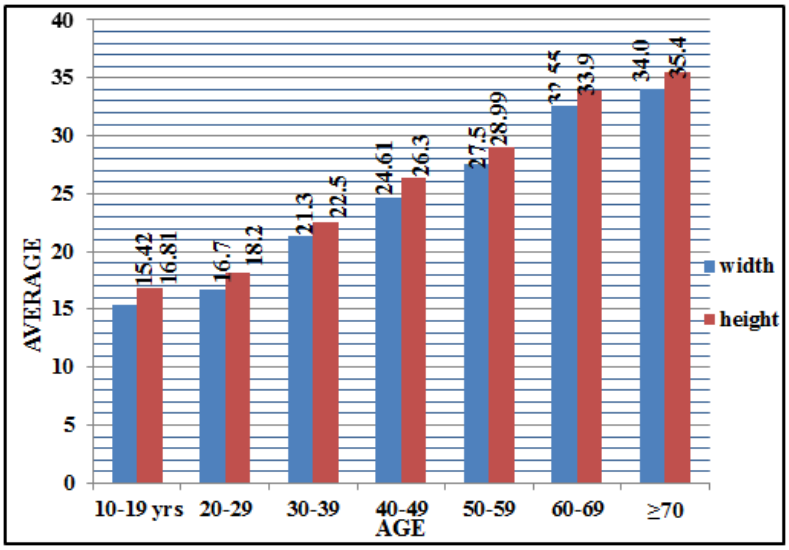

Figure 6: Average width (at the level of lateral recesses) and height of fourth ventricle in different age groups.

Table 3: Showing gender wise comparison of different dimensions of fourth ventricle.

Statistical parameter	Average width (latero-lateral diameter)(mm)		p value	Average height (mm) (Superior-inferior diameter)		p value
Mean	**Male**	**Female**		**Male**	**Female**	
	25.93	24.78		27.37	26.26	
SD	6.19	5.95	0.3034	6.27	5.87	0.3183
SEM	0.701	0.850		0.710	0.839	
Minimum	14.36	13.25		15.33	14.36	
Maximum	39.80	37.39		41.76	39.19	

Table 4: Showing average dimensions of different parameters of fourth ventricle (By MRI).

Statistical parameters	Fourth ventricle	
	Width	**Height**
Mean	20.99	24.15
SD	4.59	4.58
Minimum	14.63	19.24
Maximum	37.44	40.18

Table 5: Showing the average dimensions of fourth ventricle in various age groups (in MRI).

Age group (years)	Fourth Ventricle	
	Width (mm)	**Height (mm)**
10-19	19.0	22.4
20-29	18.16	20.96
30-39	20.99	25.10
40-49	19.84	22.60
50-59	20.76	22.91
60-69	19.99	25.4
≥70	35.92	38.99

Table 6: Gender wise comparison of mean dimensions of fourth ventricle (in MRI).

Ventricles	Dimensions	Male	Female	p value
Fourth ventricle	**Width**	22.03±5.01	19.01±2.89	>0.05 (not significant)
	Height	24.85±5.21	22.82±2.74	>0.05 (not significant)

Table 7: Comparison of mean measurements of fourth ventricle in MRI and dissection method.

Parameter	MRI		In Cadaver		p value
	Mean (mm)	**SD**	**Mean (mm)**	**SD**	
Width	20.99	4.59	26.94	6.12	**<0.0001 (extremely significant)**
Height	24.15	4.58	25.49	6.10	**0.0131 (significant)**

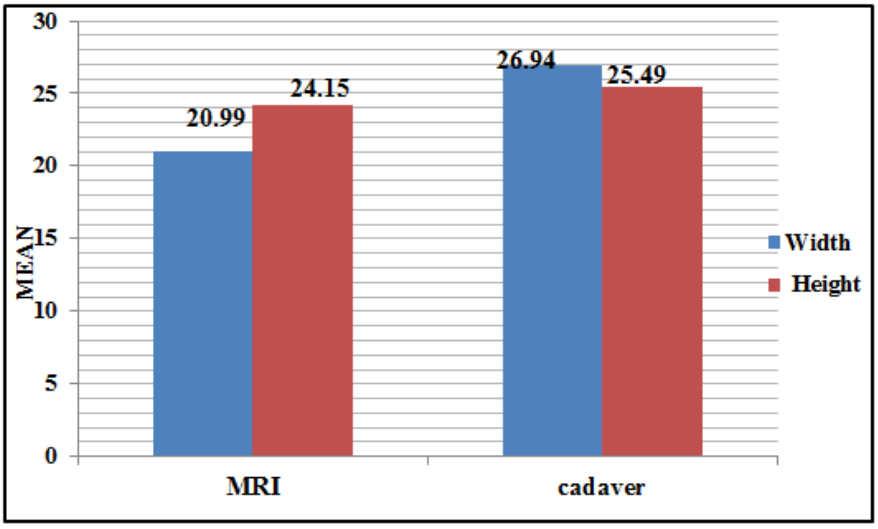

Figure 7: Comparison of average width and height of fourth ventricle between measurements in MRI and cadaveric brain specimens.

DISCUSSION

The fourth ventricle is a tent-shaped space between cerebellum and brainstem [12]**.** Cerebral atrophy has long been recognized as a prominent feature of normal aging process. [13]. With aging there will be generalized atrophy of brain, and this in turn would result in enlargement of the ventricular system. Morphometric study of cerebral ventricles provides useful indices of cerebral atrophy [14]. Despite many authors contributed in this domain, the gender and age impact in ventricle and brain changes is still obscure, therefore further studies may be needed in this regard [15].

Effects of Aging on fourth Ventricular Morphometry: Brain regression involving both the cerebrum and the cerebellum usually begin by the seventh decade and thereafter accelerated with advancing age [16].

Vinoo Jacob et al., in their study conducted on 112 cases, showed that there was progressive increase in the size of the ventricles with each decade, extending from the first to the fifth decade. There was a dramatic increase in the size of ventricles in the sixth and seventh decades of life [17].

Barron et al. by CT study in normal ventricles, found a progressive increase in ventricular size from first to the sixth decade followed by a dramatic increase in the eighth and ninth decades [18].

Parija et al**.,** in their study, calculated the mean measurement of width of the fourth ventricle in males as follows, from 11.1 ± 1.4 mm in the youngest age group (15-30 years), to 13.5 ± 2.1 mm in the eldest years' group (51-70 years), and in females similar values were 11 ± 0.9 mm in the youngest years' group, to11.5 ± 1.5 mm in the eldest years' group. Similarly, the height also ranges in males, from 4.7 ± 0.8 mm in the youngest age group to 6.0 ± 1.8 mm in the eldest years' group, and in females from 4.3 ± 0.8 mm in the youngest years' group, to 4.9 ± 1.3 mm in the eldest years' group. Thus gradual increase in measurements was observed [19].

Effects of Gender on Morphometry of Fourth Ventricle:

The study by Singh et al**.** by computed tomography showed the height of 4th ventricle (measured from the upper margin of the pons to the lower limit of open part of medulla oblongata), in females, ranged from 6-12 mm with mean (± SD) 8.59 ± 1.20 mm while in males; it ranged from 7- 12 mm with mean (± SD) 9.36 ± 1.17 mm.; thus the mean of 4th ventricle height of males was comparatively higher than females and the difference being significant. ($p<0.001$). Similarly, they also showed that the 4th ventricular width (measured as the distance between roof and floor of the fourth ventricle) in females, ranged from 6-12 mm with mean (± SD) 9.39 ± 1.14 mm while in males, it ranged from 8- 13 mm with mean (± SD) 10.21±1.09 mm. Thus, the mean width of 4th ventricle in males was comparatively higher than females and the difference was significant [20].

In a study done by Akbari et al. on fourth ventricle of human cadaveric brain by plastination, it was observed that, the 4th ventricular mean height (mean 2.29 cm) was slightly less than mean width (mean 2.38 cm) [21].

In a study by D'Souza et al. they showed that the height of the fourth ventricle was larger in males (1.18 ± 0.27 cm) as compared to females (1.11 ± 0.24 cm), which was statistically significant. The width of the fourth ventricle was also observed to be greater in males (1.31 ± 0.23 cm) than in females (1.21 ± 0.22 cm), which was also statistically significant [22].

A study by Singh et al. showed that height of the fourth ventricle (Greatest vertical distance) was larger in males (12.18 ± 1.54 mm) as compared to females (12.13 ± 1.41 mm), which was statistically insignificant ($p= 0.753$). Similarly, maximum width of fourth ventricle (taken as maximum transverse distance along the coronal plane) was observed to be greater in males (11.07 ± 1.54 mm) than in females (11.05 ± 1.31 mm), which was also statistically insignificant ($p=0.897$) [23].

In our present study, both by dissection and MRI, mean height was greater in male (27.37 ± 6.27mm in dissection, 24.85±5.21 mm in MRI) than female (26.26 ± 5.87 mm in dissection, 22.82± 2.74mm in MRI). The average width was also more in male (25.93±1.09 mm in dissection and 22.03±5.01 mm in MRI) than female (24.78±5.95 mm by dissection and 19.01±2.89 mm by MRI). This gender dimorphism was similar to D'Souza et al (2007) but was in contrast to Brij Raj Singh et al. (2014) where male & female dimensions were almost equal.

Though in our study, the width and height were found comparatively greater in male, no statistically significant difference was found in comparison with female. ($p>0.05$) (in both dissection and MRI).

Table 8: Comparative measurements of 4th ventricle with other studies.

Studies	Height(mm)		Width(mm)	
	Males	Females	Males	Females
D'souza et al., by CT (2007)	11.8±2.7	11.1±2.4	13.1±2.3	12.1±2.2
B.R. Singh et al., (2014) by CT	12.18± 1.54	12.13± 1.41	11.07± 1.54	11.05 ± 1.31
Singh A. (by CT) (2017)	9.36±1.17	8.59±1.20	10.21±1.09	9.39±1.14
Honnegowda (by CT) (2017)	10.0 ± 2.1	9.6 ± 2.2	13.0 ± 1.9	12.0 ± 2.0
Present study (by dissection)	27.37±6.27	26.26±5.87	25.93 ± 1.09	24.78 ± 5.95
Present study (by MRI)	24.85±5.21	22.82±2.74	22.03±5.01	19.01±2.89

CONCLUSION

This analysis revealed (in both dissection and MRI procedures) that sizes of the 4th ventricle increased with ageing which was specifically accelerated in subjects above 70 years of age. In the present study, sexual dimorphism was observed as male gender having predominance over female in both the measurements of the 4th ventricle. (In both dissection and MRI procedures). The findings obtained from formalin fixed brains in dissection method showed greater measurements than MRI method for both the parameters of fourth ventricle. The data of the present study will be helpful to radiologists, neurosurgeons and psychiatrists for diagnosis and treatment purposes.

REFERENCES

1. Lowery, L.A., & Sive, H. (2009). Totally Tubular: The mystery behind function and origin of the brain ventricular system. *Bioessays.* 31(4), 446-458. doi: 10.1002/bies.200800207.
2. Roza, S.J., Govaert, P.P., Vrooman, H.A., Lequin, M.H., Hofman, A. & Steegers, E.A.P. et al. (2008). Foetal growth determines cerebral ventricular volume in infants The Generation R Study. *Neuroimage.* 39(4), 1491-1498. doi: 10.1016/j.neuroimage.2007.11.004.
3. Aziz, M.D.A., Hu, Q.M., & Nowinski, W.L. (2004). Morphometric analysis of cerebral ventricular system from MR images. *Medical Imaging*. 5369, 574-582. doi: 10.1117/12.533209.
4. Schochet, Jr S.S. (1998). Neuropathology of aging. *Neur Clin*. 16(3), 569-580.
5. Corsellis, J.A.N. (1976). Ageing and the dementias. In: Blackwood, W., Corsellis, J.A.N., (Eds.), *Greenfield's Neuropathology*. (pp. 797-848). London: Arnold.
6. Kaye, J.A., DeCarli, C., Luxenberg, J.S., & Rapoport, S.I. (1992). The significance of age-related enlargement of the cerebral ventricles in healthy men and women measured by quantitative computed X-ray tomography. *J Am Geriatr Soc*. 40(3), 225-231. doi: 10.1111/j.1532-5415.1992.tb02073.x.
7. Standring, S. (1995). *Gray's Anatomy The anatomical basis of clinical practice*. (38th ed., pp. 1205-1209). Elsevier.
8. Gyldensted, C. (1977). Measurements of normal ventricular system and hemispheric sulci of 100 adults with CT. *Neuroradiology.*14(4), 183-192. doi: 10.1007/BF00496982.
9. Haug, G.. (1977). Age and sex dependence of the size of normal ventricles on computer tomography. *Neuroradiology.* 14(4), 201-204. doi: 10.1007/BF00496984.
10. LeMay, M. (1984). Radiologic changes of the aging brain and skull. Am J Roentgenol. 143(2), 383-389. doi: 10.2214/ajr.143.2.383.
11. Romanes, G.J. (2009). *Cunningham's Manual of Practical Anatomy: Head and Neck and Brain*. (15th edition., pp. 230). Oxford Medical Publication.
12. Honnegowda, T.M., Nautiyal, A., & Deepanjan, M.A. (2017). Morphometric Study of Ventricular System of Human Brain by Computerised Tomography in an Indian Population and its Clinical Significance. *Austin J Anat.* 4(4), 1075. www.austinpublishinggroup.com.
13. Fjell, A.M., Westlye, L.T., Grydeland, H., Amlien, I., Espeseth, T., & Reinvang, I. et al. (2013). Critical ages in the life course of the adult brain: nonlinear subcortical aging. *Neurobiol Aging.* 34(10), 2239-2247. doi: 10.1016/j.neurobiolaging.2013.04.006.
14. Buckley, M.J. (2009). The role of the perirhinal cortex and hippocampus in learning, memory, and perception. *The Quarterly Journal of Experimental Psychology B: Comparative and Physiological Psychology*. 58B(3-4), 246–268.
15. Fjell, M.A., & Walhovd, K.B. (2010). Structural brain changes in aging: courses, causes and cognitive consequences. *Rev Neurosci.* 21(3), 187-221. doi: 10.1515/revneuro.2010.21.3.187.
16. Gawler, J., Boulay, G.H.D., Bull, J.W.D., & Marshall, J. (1976). Computerized tomography (the EMAI Scanner): a comparison with pneumoencephalography and ventriculography. *J Neurol Neurosurg Psychiatry.* 39, 203-211. doi: 10.1136/jnnp.39.3.203.

17. Jacobs, L., Kinkel, W.R., & Heffner, R.R. (1976). Autopsy correlations of computerized tomography Experience with 6,000 CT scans. *Neurology.* 26(12), 1111-1118. doi: 10.1212/wnl.26.12.1111.
18. Barron, S.A., Jacobs, L., & Kinkel, W.R. (1976). Changes in size of normal lateral ventricles during aging determined by computerized tomography. *Neurology.* 26(11), 1011-1013. doi: 10.1212/wnl.26.11.1011.
19. Pariza, B., Sahu, N., Rath, S., & Padhy, N.R. (2014). Age related changes in ventricular system of brain in normal individuals assessed by computed tomography scans. *Siriraj Med*. 66(6), 225-230. http://www.sirirajmedj.com.
20. Singh, A., Singh, A.K., & Singh, H. (2017). Morphometric study of fourth ventricle indices in normal subjects by computed tomography. *Int J Multidiscip Res Dev*. 4(10), 135-139.
21. Akbari, V.J., Saiyad, S.S., Pandya, A.M., Solanki, S.V., & Dangar, K.P. (2011). A morphometric analysis of fourth ventrical of human cadaveric brain by plastination. *Natl J Med Res*. 1(2), 48-50. https://njmr.in/index.php/file/article/view/877.
22. D'Souza, D.M.C., & Natekar, P.E. (2007). Morphometric study of the ventricular system of brain by computerised tomography. *J Anat Soc India.* 56(1), 19-24.
23. Singh, B.R., Gajbe, U., Agrawal, A., Reddy, Y.A., & Bhartiya, S. (2014). Ventricles of brain: a morphometric study by computerized tomography. *Int J Med Res & Health Sci.* 3(2), 381-387. doi: 10.5958/j.2319-5886.3.2.079.