https://doi.org/10.46351/jas.v31i1pp20-31

JAS Journal of Anatomical Sciences (U.P. Chapter of Anatomical Society of India)

Original Article

TO ESTIMATE AGE AND GENDER RELATED MORPHOMETRIC CHANGES IN LATERAL VENTRICLE OF BRAIN BY EVANS INDEX IN NORTH INDIAN POPULATION

Jyoti Sharma[1], Pradeep Singh[1], Anshu Gupta[1], Anjali Gupta[1], Hari Singh[2], Kamal Bhardwaj[1]

1. Department of Anatomy, S. N. Medical College, Agra, India
2. Department of Radiodiagnosis, S. N. Medical College, Agra, India

ABSTRACT

Introduction: Several histopathological and gross changes are seen in human brain as age increases, causing enlargement of the lateral ventricles. Morphometric measurement and ventricular size of lateral ventricle is of trivial importance to identify certain changes and correlate it with clinical significance. This study is designed to provide a normal data of Evans Index of lateral ventricle of brain and its association between both the genders and its correlation with different age group of North Indian Population.

Materials and methods: This study was carried out in the Department of Anatomy & Department of Radiodiagnosis, S.N Medical College, Agra, U.P. In this prospective study, Computed Tomography Scans of 200 patients between the age 18 – 75 years (120 Males and 80 Females) were done and measurements of lateral ventricle of Brain and were analyzed statistically.

Results: The overall mean value of Evans Index is 0.23 ± 0.02. Evans Index in males is 0.23 ± 0.02 and mean Evans Index in females is 0.22 ± 0.01, the difference being statistically significant between both the genders as p = 0.0001* ($p \leq 0.05$).

Conclusions: Evans Index is a widely and most commonly used linear measurement for the determination of ventricular dilation which is helpful in diagnosis of neurological conditions (e.g. schizophrenia, bipolar disorder and Non Pressure Hydrocephalus). If the Evans Index ranges from 0.25 to 0.30 represented early ventricular enlargement and if the Evans Index value is more than 0.30, it suggests Hydrocephalus.

Keywords: Lateral Ventricle, Brain, Morphometry, Ventricular system, CT, Evans Index

Address for Correspondence:
Dr. Pradeep Singh, Assistant Professor & Head, Department of Anatomy, S. N. Medical College, Agra, India
Email: psingh2336@gmail.com Mob: 9897008462

Date of Receiving: 22 Jan 2023
Date of Acceptance: 06 Mar 2023
ISSN: 0970-1842

INTRODUCTION

Anatomists and Researchers have always been enthralled to study human brain. Human brain structure is complex, and no one is completely aware of its function. Structural changes occur which are normal and expected as age increases. Before any aberrant findings are interpreted, comprehensive knowledge of normal changes occurring in the brain with increase in age is necessary to be understood [1]. In the 4th century B.C. scholars and physicians started learning about cerebral ventricles [2]. Initially it was believed that lateral ventricle harbored the soul and vital spirits. Anatomists like Constanzo Varolio and Andreas Vesalius in 16th century discovered ventricles are filled with CSF [3].

Later it was discovered that, Human Brain has two lateral ventricles, forming a 'C' shaped cavity in the cerebral hemisphere containing 3 horns divided into anterior horn, posterior horn and inferior horns and body occupying the parietal lobe (Fig. 1). The "body" and "atrium" are situated between the anterior and posterior horns and the atrium continues as posterior horn in the occipital lobe [4].

Both the ventricles communicate with the third ventricle through foramen of Monro [5]. The cavity within the brain ventricles is filled with Cerebrospinal Fluid (CSF). The lateral ventricles are the largest paired ventricles present within the cerebrum [6].

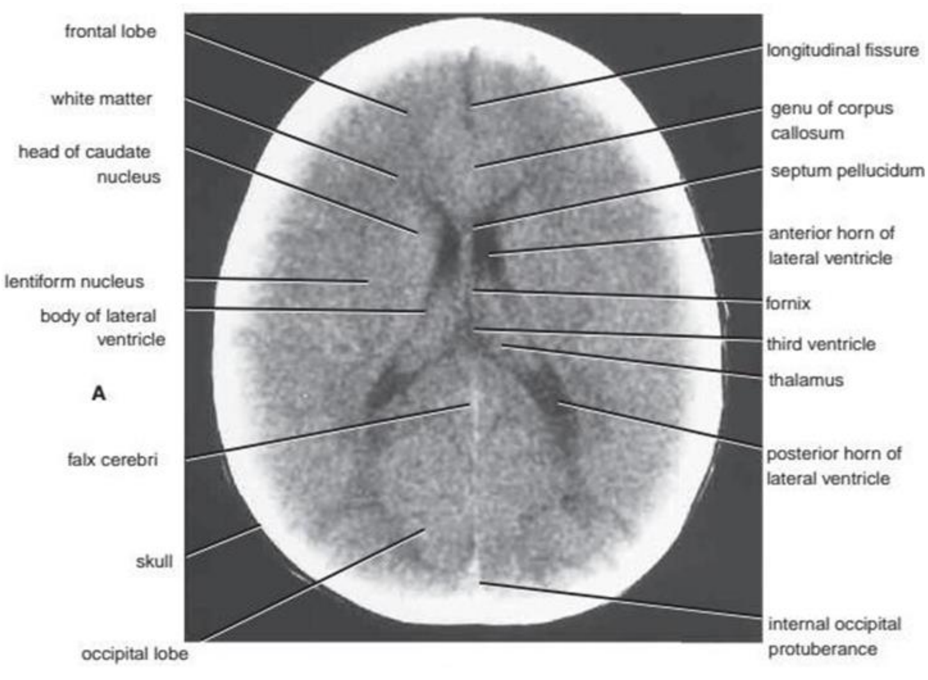

Fig. 1. Transverse section of Brain at Mid – Ventricular Level
Snell's Clinical Anatomy, 9th ED, 2012, Page No – 678

Cortical atrophy and enlargement of ventricles are major changes that may occur without neurologic deficits [7]. CT Scan is a non-invasive technique developed by Hounsfield GN, it provides transverse slices images of brain utilizing X-ray with or without the use of contrast media8.CT is preferred as its non-invasive and no artifacts are produced, with this technology measuring ventricles became effortless [9-11].

Pneumoencephalography and ventriculography are the older techniques of visualizing the ventricular system by injecting air through lumbar puncture under local anaesthesia [12]. In recent years, CT scan have replaced the older methods of studying ventricular system. Objective and morphometric studies of human brain ventricles is under limelight, recently due to it is relation with several pathological evidences such as schizophrenia, hydrocephalus, tumors, trauma and as well as gender and aging which could lead to dementia [13].

Studying normal and abnormal anatomy of ventricular system is helpful for clinicians, neurosurgeons, and radiologists in diagnosing such pathological diseases [14]. Knowing the normal measurements of the cerebral ventricles in the living human has great importance in the diagnosis and monitoring of several pathologies [15]. It should be noted that there is a continuous debate in the literature of neuroanatomy, psychiatry, neuroradiology and neurology over the best method of assessing the various parts of the cerebral ventricular system and the information known regarding the accurate measurements of the brain ventricles is very limited [16]. Since very little work has been done on measurement of cerebral ventricular system in India the present work is undertaken to study morphometric analysis of the lateral ventricle of the brain in normal Indian subjects using CT scan [17].

So, this study is to determine association of both the genders and correlation of age with increase or decrease in size of Lateral Ventricle of brain in adult human population of North India.

AXIAL VIEWS OF CT SCAN FOR DETERMINING EVANS INDEX:

The frontal horns of lateral ventricle are best seen in axial view at the level of head of caudate nucleus (Fig. 2).

MATERIALS AND METHODS

This cross - sectional prospective study composed of two hundred Brain Computerized Tomograms (CT) of North Indian Population aged between 18 to 75 years were obtained from a Government based diagnostic Radiology Centre, S.N Medical College, Agra, Uttar Pradesh, India. The brain CT scans were taken from patients complaining of headaches, migraines or came due to road traffic accidents. But CT scan readings which were found to be normal by a qualified radiologist between 01 January 2021 to 30 June 2022 were only considered in this research.

DICOM Software was used to visualize normal brain CT scans and for recording of measurements of different parameters. All brain CT scans that met the inclusion criterion below, were only considered in this study. The research started, only after the clearance by the Ethic Committee of our college. The clearance was given on 7 December 2020.

INCLUSION CRITERIA: CT scans without any pathological findings reported normal by radiologist was only considered for this study. Both the genders was taken for this study. CT Scans of only North Indian individual was taken up for this study.

EXCLUSION CRITERIA: Any history of Cerebral Infarction, Local mass lesions in brain, Hydrocephalus, Trauma , Drug abuse , Alcoholism, Previous Intra cranial surgery or individuals below 18 years of age.

CT SCAN MACHINE: In this study, CT scanner utilized was 64 Slice GE OPTIMA 660 CT scan machine. Exposure factors for the CT scan were set at 140 kvp and 160 mAs, slice thickness set at 5 mm. With iterative reconstruction algorithm all CT Scans were carried out in axial mode.

CT Scan procedure was explained to the patient, consent was taken prior to CT scan . Patient was asked to remove any metallic items (e.g. earrings, hairpin, dentures etc)

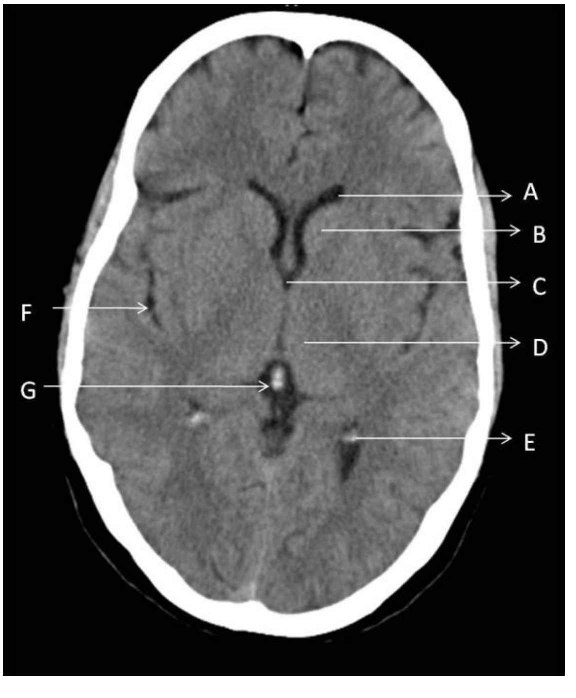

Table 3. Frequency of RT ovarian arteries in the present study.

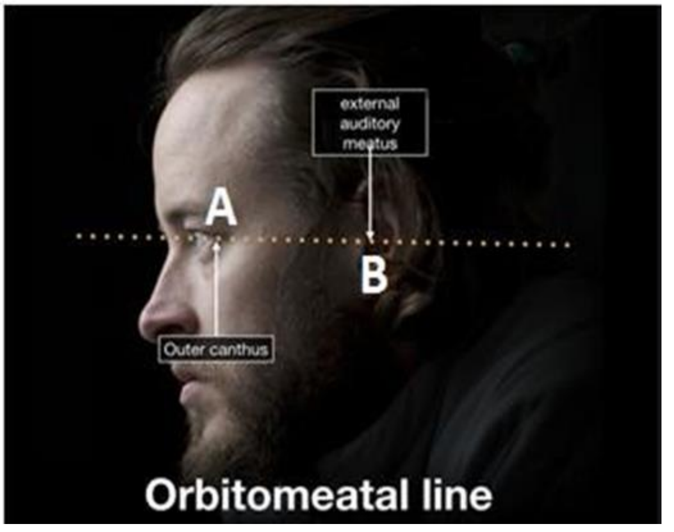

Fig. 3. Orbitomeatal line [18,19]
A – Outer Canthus of the eye, B – External Auditory Meatus

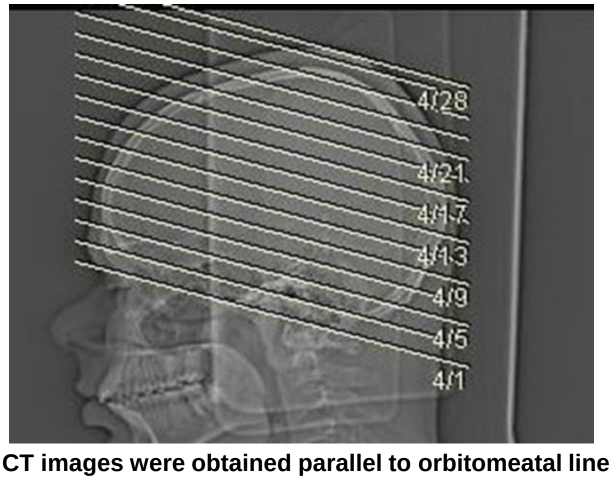

Fig. 4. CT images were obtained parallel to orbitomeatal line from foramen magnum to the vertex of the skull 20.

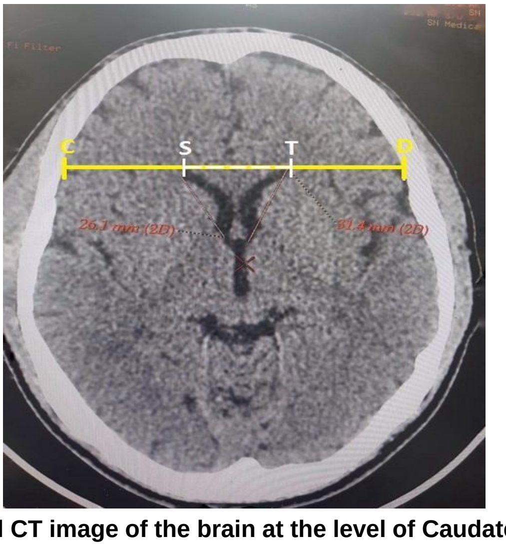

Fig. 5. Axial CT image of the brain at the level of Caudate nucleus when the ventricular system is maximum dilated. [21]

before entering CT scan room and to remain NPO for few hours before the examination, if contrast CT was required.

Patient was asked to lie down on the CT table in supine position, head was centralized and for its correct positioning, support was provided to the patient. To confirm correct positioning of patients, lateral scout image was captured to verify suitable exposure factors.

The scans was obtained parallel to the orbito-meatal line18 19, it is defined as the line drawn from the outer canthus of the eye to the centre of external auditory meatus (Fig. 3).

The scans were obtained from the base of the skull considering the lowest tomographic section to the vertex of the skull running parallel to the orbitomeatal line (Fig. 4), without coinciding, 10 to 12 axial images of brain were obtained. All other technical parameters of the scans were as per the established standards. (Ex. time in ms, potential in k v, current in mA) and slice thickness of 5 mm. CT scan total duration was 20 - 30 seconds.

Patients' CT scan was read by the radiologist and if found to have no pathological disease and if reported normal, such patients' reports were viewed in DICOM Image Software, and with the help of measurement tool installed in the DICOM software, measurement of lateral ventricle of brain was recorded in millimeter (mm).

MEASUREMENT TAKEN

EVAN'S INDEX 21: It is defined as the ratio of the distance between tip of bilateral frontal horns (S - T) and the distance between the maximum internal diameter of skull (C - D). Both the measurements are taken at the same level. Both the measurement is taken in a section, above the level of head of caudate nucleus where the ventricular system is most dilated. (Fig. 5)

Evan's Index Formula:[21]

$$S - T \,/\, C - D$$

Normal Range [21] = 0.20 – 0.25

RESULTS

This data analysis of 200 patients is performed using SSPS 16th version. The overall 200 data was distributed in 5 different age group. To compare the results between the 5 different age group, also mean and standard deviation was calculated for each parameter. ANOVA and t – test was used for calculating 'p' value .

DISCUSSION

Evans Index is widely and most commonly used linear measurements for the assessment of ventricle size and detect ventriculomegaly due to cerebral atrophy .

GENDER	EVANS INDEX MEAN ± SD	p-value
MALE	0.23 ± 0.02	0.0001*
FEMALE	0.22 ± 0.01	

Table 1. Evans Index according to gender

AGE GROUP (IN YRS)	EVANS INDEX MEAN ± SD	p-value
18 – 30	0.23± 0.01	0.00001*
31 – 40	0.23 ± 0.02	
41 – 50	0.22 ± 0.02	
51 – 60	0.22 ± 0.01	
61 – 75	0.22 ± 0.02	

Table 2. Evans Index according to different age group

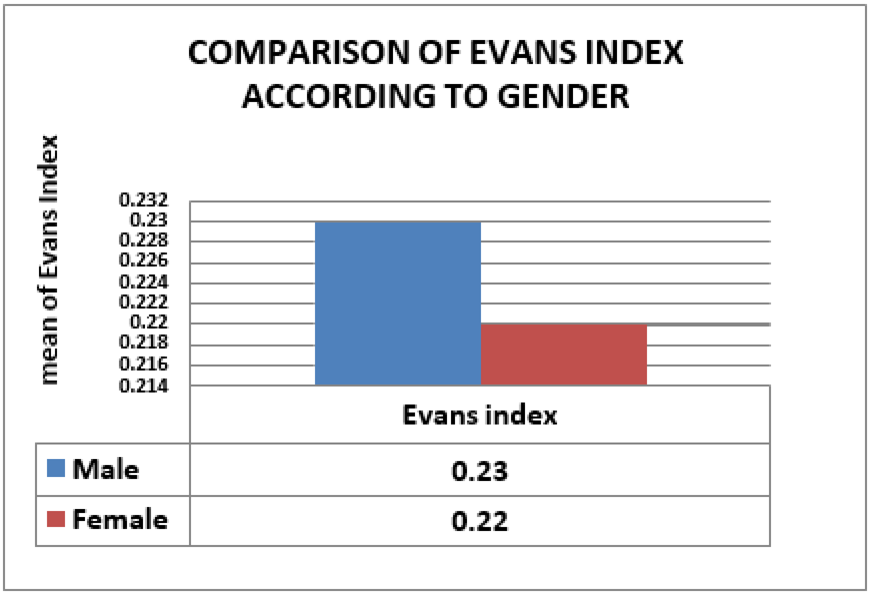

Fig. 6. Comparison of Evans Index according to gender

In our study, the mean value of Evans Index in males is 0.23 ± 0.02 and females is 0.22 ± 0.01 (Table 1). The overall mean value of Evans Index in comparison to 5 different age group is 0.23 ± 0.02 (Table 2). The normal Evans Index value is 0.20 – 0.25.

In relation to gender, the p value was found to be statistically significant, as $p = 0.0001$ ($p<0.05$*) signifying that there was statistical difference in the size of Evans Index in both the genders of North Indian Population (Table 1).

In relation to age, the p value was found to be statistically significant, as $p = 0.00001$ ($p < 0.05$*) signifying that there was statistical difference in the size of Evans Index in different age groups of North Indian Population (Table 2).

According to William [4], Evans was the first person who felt the need to define normal limits of the cerebral ventricles, and linear measurements were adopted in children. He found that the normal range of Evans index was 0.20 to 0.25. If the Evans Index ranges from 0.25 to 0.30 represented early ventricular enlargement and if the Evans Index value is more than 0.30, it suggest ventricular enlargement.

Evans Index increases with increase in age due to the fact that the brain shrinks with age while the ventricles dilates to compensate the loss, leading to increase in Evans Index [22]. Our findings are consistent and similar, with those given by Gawler [22] with the upper limit of Evans Index being 0.25. The international guidelines for diagnostic cutoff value for ventriculomegaly / hydrocephalus is ER>0.30 (Toma - AK) [23].

In the study by Vishram Singh [24], the normal mean value of Evans Index is 0.269 +/- 0.03, being higher in males than in females, however the difference being statistically non- significant ($p>0.05$). The range was also wider in males. It also showed statistical difference in different age group as $p = 0.013$ ($p<0.05$). Whereas in the study by Namrata Kolsur [25] mean value of Evans index was 0.25 ± 0.03.

Chandrani Bader [26] reported that the average lateral ventricle volume was significantly larger in normal pressure hydrocephalus (NPH) patients as compared to Alzheimer's disease patients and vascular dementia.

Evan's ratio is also increased in Non Pressure Hydrocephalus. Recently authors have shown the association between ventriculomegaly (ER>0.30) with or without hydrocephalus related symptoms after subarachnoid haemorrhage (cortical atrophy) [27].

Evans index was one of the older ventriculographic indices which represented ventricular volume [28] hence widely used in the diagnosis of idiopathic normal pressure hydrocephalus, in the assessment of outcome of patients with shunt placement which is the primary mode of treatment [23]. Patients with more than > 0.30 ER may indicate hydrocephalus, also may have one or more components of Balint's syndrome

AUTHOR	YEAR OF PUBLICATION	ETHNICITY	EVANS INDEX
Kosourov AK [29]	2002	RUSSIANS	0.22 ± 0.28
PATNAIK P [30]	2014	NORTH INDIA	0.25 ± 0.04
SARI [31]	2015	TURKISH	0.23 ± 0.28
HAMIDU [32]	2015	NIGERIAN	0.25 ± 0.04
KUMAR S A [33]	2017	SOUTH INDIA	0.27 ± 0.03
NAMARATA [25]	2018	NORTH INDIA	0.25 ± 0.031
JEHANGIR [34]	2018	KASHMIRI	0.26 ± 0.03
PRADHAN A [35]	2021	NEPALESE	0.25 ± 0.035
PRESENT STUDY	2022	NORTH INDIA	0.23 ± 0.02

Table 3. Comparison of Evans Index present study with other studies

CONCLUSION

Ventricular enlargement in adults could be as a result of aging, neurodegenerative diseases, cerebrovascular conditions, tumors and trauma. Evans Index is the most useful quantitative criterion to assess ventriculomegaly or hydrocephalus in today scenario. If the Evans Index ranges from 0.20-0.25 it will be considered normal, if the Evans Index ranges between 0.20 – 0.25 it may indicate ventriculomegaly. If the Evans Index ranges more than 0.30 indicate ventricular enlargement.

REFERENCES

1. Schochet SS. Neuropathology of aging. Neurologic clinics 1998;16:569-80
2. Engelhardt E. Cerebral localization of the mind and higher functions: the beginnings. Dement Neuropsychol2018;12:321–25 doi:10.1590/1980- 57642018dn12-030014 pmid:30425797
3. Schiller F. The cerebral ventricles: from soul to sink. Arch Neurol 1997; 54:115862 doi:10.1001/archneur.1997.00550210086

018 pmid:9311361

4. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, et al. Gray's Anatomy. The Anatomical basis of Medicine and Surgery. 38th ed. Edinburgh: Elsevier Churchill Livingstone; 1995. pp. 1205-9.
5. Andre Parent. Carpenter's Human neuroanatomy. 9th ed. USA: Williams &Wilkins A Warley Company; 1996, pp. 43-5.
6. Gyldensted C. Measurements of the normal ventricular system and hemispheric sulci of 100 adults with computed tomography. Neuroradiology. 1977 Dec 31;14(4):183-92. doi: 10.1007/BF00496982. PMID: 304535.
7. Barrett L, Drayer B, Shin C. High-resolution computed tomography in multiple sclerosis. Annals of neurology 1985;17:33-38
8. Torkildsen A. The gross anatomy of the lateral ventricles. J Anatomy 1934 Jul;68:480- 91.
9. Anik Y, Demirci A, Anik I, Etus V, Arslan A. Apparent diffusion coefficient and cerebrospinal fluid flow measurements in patients with hydrocephalus. J Comput Assist Tomogr. 2008;32:392–6.
10. Hashimoto M, Ishikawa M, Mori E, Kuwana N. Study of INPH on Neurological Improvement (SINPHONI). Diagnosis of idiopathic Normal pressure hydrocephalus is supported by MRI-based scheme: A prospective cohort study. Cerebrospinal Fluid Res. 2010;7:18.
11. Moore DW, Kovanlikaya I, Heier LA, et al., "A Pilot Study of Quantitative MRI Measurements of Ventricular Volume and Cortical Atrophy for the Differential Diagnosis of Normal Pressure Hydrocephalus," Neurology Research
12. Kulkarni NV. Clinical Anatomy for students problem solving Approach. 1st ed. New Delhi, India: Jaypee Brothers Medical Publishers (p) Ltd; 2007:438-9.
13. Duffner F, Schiffbauer H, Glemser D, Skalej M, Freudenstein D. Anatomy of the cerebral ventricular system for endoscopic neurosurgery: a magnetic resonance study. Acta Neurochir (Wien). 2003 May;145(5):359-68. doi: 10.1007/s00701-003- 0021-6. PMID: 12820042.
14. Schmahmann JD, Smith EE, Eichler FS, Filley CM. Cerebral white matter: neuroanatomy, clinical neurology, and neurobehavioral correlates. Ann N Y Acad Sci. 2008 Oct;1142:266-309. doi: 10.1196/annals.1444.017. PMID: 18990132; PMCID: PMC3753195.
15. Smith EE, Salat DH, Jeng J, McCreary CR, Fischl B, Schmahmann JD, Dickerson BC, Viswanathan A, Albert MS, Blacker D, Greenberg SM. Correlations between MRI white matter lesion location and executive function and episodic memory. Neurology. 2011 Apr 26;76(17):1492-9. doi:

10.1212/WNL.0b013e318217e7c8. PMID: 21518999; PMCID: PMC3087468.

16. Nautiyal A. (2017). Citation: Honnegowda TM, Nautiyal A and Deepanjan M. A Morphometric Study of Ventricular System of Human Brain by Computerised Tomography in an Indian Population and its Clinical Significance Austin Journal of Anatomy. Austin Journal of Anatomy.
17. Srijit D, Shipra P. Anatomical study of anomalous posterior horn of lateral ventricle of brain and its clinical significance. Bratislleklisty 2007;108(9):422-4.
18. Kim YI, Ahn KJ, Chung YA, Kim BS. A New Reference Line for the Brain CT: The Tuberculum Sellae-Occipital Protuberance Line is Parallel to the Anterior/Posterior Commissure Line. American Journal of Neuroradiology. 30 (9): 1704. doi:10.3174/ajnr. A1676 - Pubmed
19. Yeoman LJ, Howarth L, Britten A, Cotterill A, Adam EJ. Gantry angulation in brain CT: dosage implications, effect on posterior fossa artifacts, and current international practice. Radiology. 184(1): 113-6. doi:10.1148/radiology.184.1.1609066 - Pubmed
20. Ragan L, Waczulikova I, Guller L, Bilicky J, Benuska J. Cella media distance in human brain in relation to age and gender. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2009 Dec;153(4):307-13. doi: 10.5507/bp.2009.053. PMID: 20208973.
21. Keats TE, Sistrom C. Atlas of Radiologic Measurement. Mosby. (2001); Seventh Edition; ISBN:0323001610; Page No : 39 – 40
22. Gawler J, Bull JWD, Du Boulay GH, Marshall J. Computerized axial tomography: The normal EMI scan. J Neurol Neurosurg Psychiatry. 1975;38(10):935–47.
23. Toma AK, Holl E, Kitchen ND, Watkins LD. Evans' index revisited: The need for an alternative in normal pressure hydrocephalus. Neurosurgery. 2011;68:939– 944 [PubMed].
24. Singh V, Singh S, Singh, D, Patnaik P. (2018). Morphometric Analysis of Lateral and Third Ventricles by Computerized Tomography for Early Diagnosis of Hydrocephalus. Journal of the Anatomical Society of India. 67. 10.1016/j.jasi.2018.11.004.
25. Kolsur N, Radhika P.M, Shetty S, Kumar A. Morphometric Study of Ventricular Indices in Human Brain Using Computed Tomography Scans in Indian Population. Int J Anat Res 2018;6(3.2):5574-5580. Doi: 10.16965/Ijar.2018.286
26. Bader C, Cyrille C, Jadwiga Z, et al. Estimation of the lateral ventricles volumes from a 2D image and its relationship with cerebrospinal fluid flow.

Bio Med Res Int. 2013;10.1155/2013/215989 Article ID 215989, 9 pages.

27. Zilundu Prince LM. Morphometric Study Of Ventricular Sizes On Normal Computed Tomography Scans Of Adult Black Zimbabweans At A Diagnostic Radiology Centre In Harare-A Pilot Study: JUNE 2012; Thesis. University Of Zimbabwe.
28. O'Hayon BB, Drake JM, Ossip MG, Tuli S, Clarke M. Frontal and Occipital Horn Ratio: A Linear Estimate of Ventricular Size for Multiple Imaging Modalities in Pediatric Hydrocephalus. Pediatr Neurosurg [Internet]. 1998.
29. Kosourov AK, Gaivoronskij IV, Rokhlin GD, Blagova IA, Panfilenko AF. In vivo assessment of various parameters of the brain ventricles with magnetic resonance tomography. Morfologiia. 2002;122:71-73.
30. Patnaik P, Singh V, Singh S, Singh D. Lateral ventricle ratios correlated to diameters of cerebrum-A study on CT scans of head. J Anat Sciences. 2014; 22:5.
31. Sarı E, Sarı S, Akgün V, Özcan E, Ìnce S, Babacan O, Saldır M, *16+ et al., measures of ventricles and Evans' Index: From neonate to adolescent. PediatrNeurosurg. 2015;50:12-17
32. Hamidu AU, Olarinoye-Akorede SA, Ekott DS, Danborno B, Mahmud MR, Balogun MS. Computerized tomographic study of normal Evans index in adult Nigerians. J Neurosci Rural Pract [Internet]. 2015 Jan ;6(1):55–8. Available : http://www.ncbi.nlm.nih.gov/pubmed/25552852
33. Kumar SA, Kumari SM, Anand VM, Sarawathy R, Rajeshwari M. Evaluation of Evan's Index in South Indian Population using Computed Tomography. Int'l J Ant Radio Surg 2017; 6: 28-31.
34. Jehangir M, Dar IH, Sahota A, Hassan GH, Mustafa K, Javaid A. Normative Parameters of Evans Index using Computerized Tomographic Scan in Individuals of Kashmiri Ethnicity. Int'l J Cont Med Res 2018; 6: 77-83.
35. Pradhan A, Chalise U, Shrestha A, Dhungel S; Study of Normal Values of Evan's Index on Brain CT Scan in Individuals attending Nepal Medical College Teaching Hospital, Kathmandu, Nepal; Nepal Med Coll J 2021; 23 (1): 41-7.