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Original Research Article

Estimation of Normal Values of Evans Index using Computerized Tomography of Brain in South Kerala Population

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Conflict of interest: Nil

Abstract:

Introduction: Knowledge of the morphometry of the lateral ventricles of brain is important for the diagnosis of various conditions with ventriculomegaly. Evans index is the ratio of the maximum width of the anterior horn of the lateral ventricle to the maximum transverse diameter of the inner table of the skull. A clear understanding of the normal values of Evans index and variations of the ventricular system of brain is useful for clinicians, radiologists and neurosurgeons in their daily clinical practice. The present study was conducted to determine the normal values of Evans index using Computerized tomography of brain in South Kerala population.

Materials and Methods: The study was jointly conducted by the Department of Anatomy and the Department of Radiodiagnosis, Government Medical College, Thiruvananthapuram. A total of two hundred CT brain of individuals above ten years of age, were taken. Hundred males and hundred females were included in the study group. The measurements taken for calculating Evans index were Total anterior horn width (TAHW) and Maximum intracranial diameter (MICD).

Results: The mean Evans index in the study was found to be 0.258±0.05 in males, 0.255±0.03 in females and an overall mean of 0.256±0.04 was calculated.

Conclusion: The present study shows that the mean Evans index in South Kerala population was in accordance with other studies, with a mean value of less than 0.3 in both males and females of all age groups. However, Evans index was found to be increasing in individuals who were above 60 years in both males and females when compared to the younger age groups.

Keywords: Evans index, Computerized tomography, ventricles, brain.

Introduction

Evaluation of the size and shape of the ventricles of brain is being performed routinely during diagnostic CT scans (Computerized Tomography) and MRI (Magnetic Resonance Imaging) studies of brain. In the human brain, there are four connected ventricles - two lateral ventricles within the cerebrum, a midline third ventricle between the right and left thalami, and a midline fourth ventricle lying between the cerebellum posteriorly and the pons and medulla anteriorly[1]. Evans index is the ratio of the maximum width of the anterior horn of the lateral ventricle to the maximum transverse diameter of the inner table of the skull. A clear understanding of the normal values of Evans index and variations of the ventricular system of brain is useful for clinicians,radiologists and neurosurgeons in their daily clinical practice[2]. As aging progresses, the brain undergoes many gross and histopathological changes along with regression of the brain tissue, leading to the enlargement of the ventricles[3]. There is a correlation between increase in cerebrospinal fluid spaces and reduction in cerebral volume, that accompanies normal human aging[4,5]. Hydrocephalus is caused by the enlargement of the ventricles of the brain due to imbalance in the production and absorption of cerebrospinal fluid. Enlargement of cerebrospinal fluid spaces during aging is generally diffuse[6]. Various studies clearly show that there is an increase in the CSF spaces in dementia, especially in Alzheimer's disease and Parkinson's disease[7]. This is due to a reduction in the size of the nerve cells[8]. Ventricular enlargement has been found to be a more sensitive indicator of cortical atrophy due to increasing age and dementias[9]. With a

growing aging population, the prevalence of normal pressure hydrocephalus (NPH) is on the rise. Clinical symptoms of NPH include gait disturbance, cognitive impairment and urinary incontinence. Evans index is the most commonly used indirect index to assess the size of the ventricles in NPH patients.

The international guidelines for the diagnosis of normal pressure hydrocephalus defines Evans index as greater than or equal to 0.3. Evans suggested the normal range of the index between 0.20 and 0.25 as the most common[10]. Evans retrospectively assessed 53 encephalograms of normal patients at the Children's Hospital of Michigan and Harper Hospital, and arrived at the conclusion that the ratio of the transverse diameter of the anterior horns to the internal diameter of the skull could be used as an index to evaluate the size of the ventricles. Knowledge of Evans index will help in the diagnosis of idiopathic normal pressure hydrocephalus and in the assessment of outcome of patients with ventriculoperitoneal shunt placement. It also helps in identifying visual complications in children with hydrocephalus. Computerized Axial Tomography is a safe and non-invasive investigative technique by which morphometric evaluation of the ventricles of brain can be done, which was developed by Hounsfield GN.

It is an imaging modality which utilizes X-rays, to provide images of transverse slices of brain without the use of contrast media. It can be used as a screening procedure for many diseases, The ventricular systems of brain have been studied in detail routinely using MRI and CT scan[11].

Materials and methods

The present study was a descriptive cross-sectional study conducted in Department of Radiodiagnosis, Government Medical College, Thiruvananthapuram. CT brain of 200 individuals above 10 years of age, with normal radiological findings, was taken.

The study group included 100 males and 100 females. Informed consent was taken from the patients for the purpose of the conduct of the study. For patients between 10 to 18 years of age, informed consent was obtained from the parents or local guardian.

Methodology

The patient was placed on the CT table and the head was centralized for correct alignment in order to reduce blurring of images. A lateral image was taken for confirming correct position of patient. A line was drawn at an angle of 15-20° and about 1 cm above the canthomeatal line. This line represents the lowest tomographic section which passes through the base of the skull.

The lateral ventricles were seen in 3-4 contiguous slices in CT scan images. From the CT scan of brain, Evans index was calculated by measuring maximum anterior horn width to the maximum transverse diameter of inner table of skull, in the same section. Evans index was derived as total anterior horn width (TAHW) divided by maximum intracranial diameter (MICD).

Figure 1: CT image showing method used to measure Evans index: 1 - Total anterior horn width, 2 - Maximum intracranial diameter

Inclusion criteria

Among all the patients above 10 years of age with neurological complaints who were referred for CT brain to the Department of Radiodiagnosis, only those patients whose CT scans were read as normal by the radiologist, were included in the study.

Exclusion criteria

CT scans of patients with history of head injuries, previous intracranial surgeries or showing local mass lesion and cerebral infarctions, were excluded from the study.

Statistical analysis

All the data collected were entered as mean and standard deviation. It was analyzed and expressed in tables and graphs. The age-wise and gender-wise comparison of Evans index was performed using independent Student's t-test and p-value was calculated. p value less than 0.05 was considered as statistically significant. All the statistical calculations were performed using the software SPSS (Statistical Presentation System Software, SPSS) for windows version 16.

Ethical clearance

Institutional ethics committee clearance was obtained before the start of the study from the Institutional Ethics Committee of Government medical college, Thiruvananthapuram.

Results: In the present study, 200 normal CT scans of brain (100 males and 100 females) in the age group of ten to ninety years were taken for the study.

Table 1: Age-wise and Gender-wise distribution of CT scans of brain

	Sex				Total	
	Male		Female			
Age group	**Number**	**%**	**Number**	**%**	**Number**	**%**
10-19	12	12.0	20	20.0	32	16.0
20-29	26	26.0	21	21.0	47	23.5
30-39	17	17.0	13	13.0	30	15.0
40-49	15	15.0	15	15.0	30	15.0
50-59	15	15.0	20	20.0	35	17.5
60-69	9	9.0	8	8.0	17	8.5
70-79	3	3.0	3	3.0	6	3.0
80-89	3	3.0	0	0.0	3	1.5
Total	**100**	**100.0**	**100**	**100.0**	**200**	**100.0**

Majority of the CT scans belong to the 20-29 years age group.

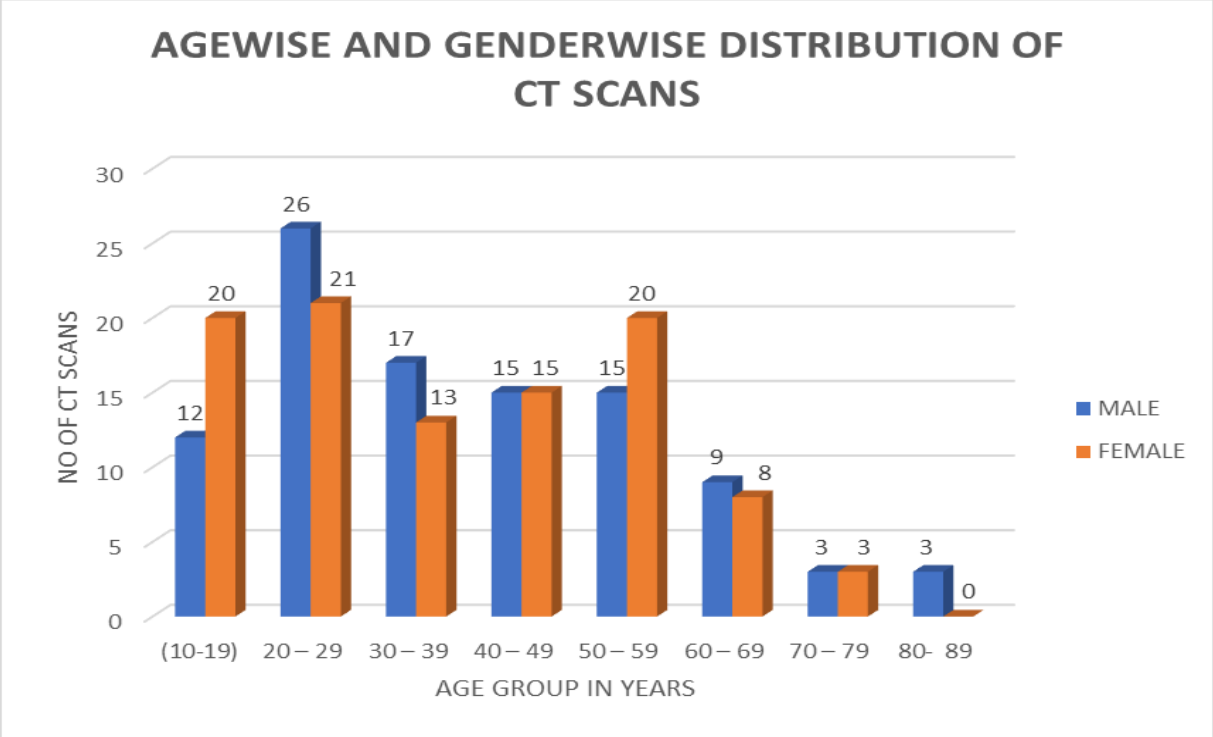

Figure 2: Age-wise and Gender-wise distribution of CT scans

Table 2: Showing Comparison of Evans Index with Age Group and Gender

		Ventricular Parameters (Mean ± SD)		
Age	**Gender**	**TAHW**	**MICD**	**EI**
10-19	Male	28.2 ±4.5	119±7.5	0.25±0.4
	Female	29.1±2.4	116±5.8	0.25±0.2
20-29	Male	30.8±2.2	120±4.8	0.27±0.15
	Female	29.8±2.4	118±4.5	0.25±0.17
30-39	Male	31.7±3.0	121±5.8	0.27±0.23
	Female	30.3±1.9	122±5.7	0.26±0.19
40-49	Male	32.1±2.0	124±5.8	0.27±0.17
	Female	31.6±2.4	122±5.5	0.27±0.16
50-59	Male	33.6±2.5	124±5.8	0.28±0.21
	Female	31.4±2.7	123±6.6	0.27±0.16
60-69	Male	34.8±3.5	127±6.9	0.29±0.25
	Female	32.7±0.9	124±9.4	0.28±0.16
70-79	Male	34.9±2.9	127±6.8	0.29±0.25
	Female	32.9±2.4	125±5.9	0.28±0.17
80-89	Male	35.1±3.1	128±6.7	0.29±0.26
	Female	33.1±2.5	126±5.8	0.28±0.16

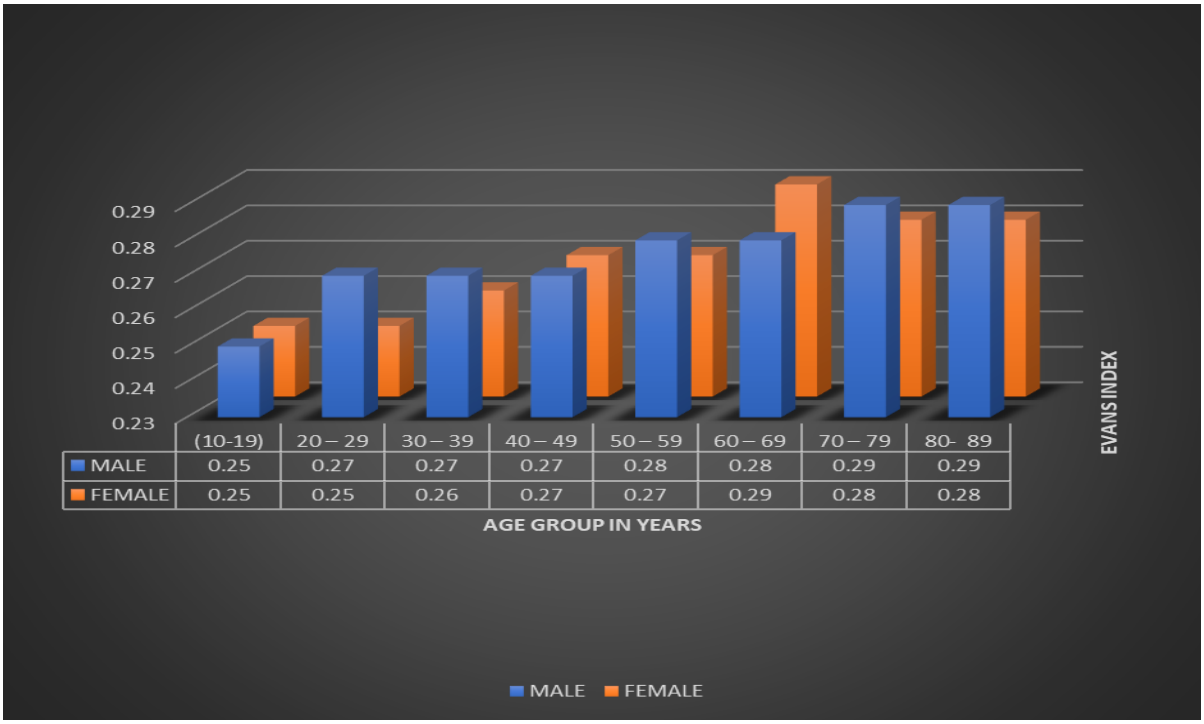

Figure 3: Showing distribution of the mean values of Evans index across age groups and gender

Discussion

With the availability of Computerized tomography, Evans index has become a good modality for measuring the size of the ventricular system of brain. As previously suggested by Evans in a pneumoencephalographic study, index between 0.20-0.25 was considered normal, 0.25-0.30 as borderline ventricular enlargement and more than 0.30 as a pathologic ventricular dilatation [10].

Gawler et al [12] calculated the mean of Evans index as 0.18 to 0.30 in normal subjects. Gyldensted C et al [13] observed that there was a slight increase in Evans index with increasing age. The mean value of the younger age group (17 to 40 years) was 0.26 and in the older age group (41 to 86 years) was 0.275. Jacoby RJ et al [14] observed the value of Evans index to be 0.31 in healthy elderly people. D' Souza et al [15] found that mean Evans index was 0.26 in females and 0.27 in males. Mean Evans index was calculated as 0.27 in a CT scan study by Patnaik P et al [16]. Evans Index can be utilized to differentiate between the normal and enlarged ventricular measurements. In a CT study conducted on 326 healthy Indian individuals by Reddy VU et al [17], Evans index was found to be 0.25 in normal healthy Indian individuals between 1 to 99 years. However, Evans index was

approximately 0.30 in 14 persons, but none of them had any symptoms or signs of ventriculomegaly. Hamidu et al [18] found Evans index to be 0.25 in 448 Nigerian individuals between 18 to 84 years of age by CT scans. They also observed an increase in Evans index values in subjects > 60 years. Brix et al, on the other hand, established that there was a wider range of EI in healthy elderly subjects and the cut off was higher than 0.3 in both men and women [19]. Women have smaller brain size, around 110-115 grams lesser than males. As compared to males, they also have smaller lateral ventricles with a proportionately smaller cerebral hemispheric size [20]. The absence of statistically significant difference in EI value between males and females in our study could probably be due to proportionately smaller size of lateral ventricles and cerebral hemispheric size in females. Increase in Evans index with advancing age is due to the fact that an increase in age and decrease in body mass index could lead to a reduction in the brain weight and increase in the ventricle size [20].

We calculated the Evans' index, observed its association with age and gender and established its normal reference range in South Kerala population, based on our observations. In our study, we observed Evans index with a mean value of 0.25. Mean value did not show any significant correlation with age and was almost similar for all age groups. It was found to be almost equal for males and females of all age groups.

Conclusion

Evans index is a reliable indicator of the volume of the ventricles of brain in healthy adults. EI is easily reproducible, less technical, less time consuming and can be used by physicians, neurosurgeons and radiologists.

In the present study, it was observed that Evans index value was 0.258±0.05 in males and 0.255±0.03 in females. An overall mean Evans index of 0.256±0.04 was calculated in this normal and healthy population. Thus, it supports the international guidelines cut-off value of EI > 0.3 in the diagnosis of hydrocephalus as well. By our study, the normal range of Evans index of healthy adult males and females of South Kerala population was identified. This could be of great use in the routine clinical practice and in the diagnosis of conditions with ventriculomegaly.

Abbreviations

CT: Computerized Tomography
TAHW: Total Anterior Horn Width
MICD: Maximum Intracranial Diameter
SD: Standard Deviation
EI: Evans Index

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