Original Article

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Radiology Section

Evaluation of Evan's Index in South Indian Population using Computed Tomography

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ABSTRACT

Introduction: Imbalance in the production and absorption of cerebrospinal fluid results in the enlargement of ventricular system called hydrocephalus. For the early and precise diagnosis of type of hydrocephalus, knowledge of ventricular size is mandatory. Ventricular size can be studied by linear or volumetric measurements, out of which linear ratios of the width of ventricles to the width of skull or brain is the easiest reproducible method. Evan's Index (EI) is one such ventriculo graphic index. Evan's index is an important parameter in the diagnosis of normal pressure hydrocephalus, in follow up cases of ventriculoperitoneal shunt, alcoholism, dementia and many more conditions. Therefore, developing a baseline reference data of Evan's index will be useful in a wide range of clinical conditions.

Aim: To establish normal baseline value for Evan's index in South Indian population with respect to gender and age.

Materials and Methods: Total 100 subjects aged between 5 to 90 years, comprising of 54 males and 46 females, with normal CT brain were analysed retrospectively. Subjects with intracranial and intraventricular pathology were excluded. Axial CT brain was obtained in Siemens Somatom scope multislice CT scanner. EI was measured as the linear ratio of the widest anterior horn width of the cerebral lateral ventricles to the widest inner diameter of the skull. Student's 't' test and one-way-ANOVA was used to estimate the difference in ventricular size based on sex and across the age groups respectively.

Results: The mean EI in our study population was 0.27 ± 0.04 in males, 0.26 ± 0.03 in females and an overall mean is 0.27 ± 0.03. No significant statistical difference was observed in the EI between males and females. With advancing age, mild increase in Evan's index was noted.

Conclusion: Mean EI of 0.27 ± 0.03 in our study supports the adaptation of international guideline cut-off value of EI > 0.30 in the diagnosis of hydrocephalus in our South Indian population as well. EI is less technical, easily reproducible, less time consuming and can be used in routine practice.

Keywords: Brain atrophy, Frontal horn, Hydrocephalus, Lateral ventricle, Normal pressure hydrocephalus, Ventriculomegaly

INTRODUCTION

Two percent of brain volume is constituted by ventricles of the brain. Lateral ventricles contribute about 82 % of the total ventricular system [1]. Imbalance in the production and absorption of cerebrospinal fluid results in the enlargement of ventricular system called hydrocephalus [2]. For the early and precise diagnosis of type of hydrocephalus, knowledge of ventricular size is mandatory. Computed Tomography (CT) is an accepted procedure in identifying a wide range of pathologic processes and measuring the ventricular size. In Indian scenario, as compared to MRI, CT still remains an easily available, affordable and faster mode of brain imaging. Ventricular size can be studied by linear or volumetric measurements, out of which linear ratios of the width of ventricles to the width of skull or brain is the easiest reproducible method. Evan's Index is one such ventriculo graphic index. It is the ratio which compares the maximum width of the frontal horns of the lateral ventricle to the maximum transverse diameter of the inner table of the skull [3]. Evan's index is an important parameter in the diagnosis of Normal Pressure Hydrocephalus (NPH), in follow-up cases of ventriculoperitoneal shunt [4], alcoholism, dementia and many more conditions. Therefore developing a baseline reference data of Evan's index will be useful in a wide range of clinical conditions.

MATERIALS AND METHODS

Patient selection: This retrospective study was conducted in the Department of Radiology, Karpagam Faculty of Medical Sciences and Research, Coimbatore during the period between 1st June 2016 and 31st July 2016. Total 100

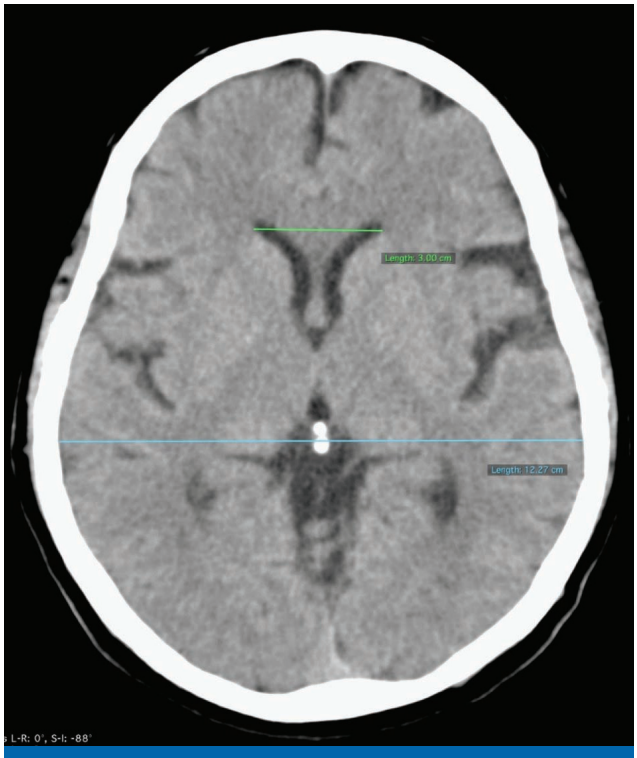
subjects, aged between 5 to 90 years, with normal CT brain were analysed for this study. All the subjects were divided into sub groups based on age and sex. The study subjects comprise of 54 males and 46 females. The study included seven paediatric patients. Out of it two patients were between 5-10 years of age and five patients were between 11-18 years of age.

Inclusion Criteria: Of all the patients referred for CT brain to Department of Radiology, between the study period with neurological complaints, only those patients whose CT were reported to be normal were included in this study.

Exclusion Criteria: Patients with intracranial and intraventricular pathology were excluded from the study.

CT brain of all the patients was performed in Siemens Somatom Scope multislice CT scanner. Axial sections were obtained at 5 mm slice thickness from skull base to the vertex. Images were then reconstructed to 2 mm slice thickness. Then the DICOM images were analysed on viewing console. Measurements were taken with in-built linear calipers which are calibrated to 0.1 mm. Widest Anterior Horn Width (AHW) of the cerebral lateral ventricles and widest Inner Diameter of the Skull (IDS) were taken as shown in [Table/Fig-1].

Evan's Index is derived by AHW divided by IDS.



[Table/Fig-1]: Axial CT image showing the widest anterior horn width of the cerebral lateral ventricles (green line) and widest inner diameter of the skull (blue line).

STATISTICAL ANALYSIS

The statistical analyses were performed using software SPSS version 23. All data were expressed as mean and standard deviation, and presented in tables. Student's 't' test was used to estimate the difference in ventricular size based on sex. One-way ANOVA was used to check for differences in ventricular dimensions across the age groups. The p-value < 0.05 was considered as statistically significant.

RESULTS

The mean Evan's index in our study population was 0.27 ± 0.04 in males, 0.26 ± 0.03 in females and an overall mean is 0.27 ± 0.03. No significant statistical difference was observed in Evan's index between males and females [Table/Fig-2]. With advancing age, mild increase in Evan's index was noted [Table/Fig-3] with statistically significant difference among the age groups (p < 0.001). Males have larger widest AHW of the cerebral lateral ventricles and widest IDS as compared to females across all age groups [Table/Fig-3].

	Mean±SD			p-value
	Males	Females	Males+Females	
AHW (mm)	3.41±0.45	3.18±0.34	3.3±0.42	0.005*
IDS (mm)	12.51±0.52	12.06±0.47	12.30±0.54	< 0.001*
Evan's Index	0.27±0.04	0.26±0.03	0.27±0.03	0.161 NS

[Table/Fig-2]: Descriptive statistics of ventricular dimensions versus sex.
*Significant at 1% level NS – Not Significant

Age group (years)	Sex	n	Ventricular Parameters Mean±SD		
			AHW	IDS	EI
≤ 20	Male	12	3.07±0.37	12.67±0.42	0.24±0.02
	Female	2	2.45±0.35	12.05±0.07	0.21±0.04
	Male + Female	14	2.98±0.42	12.58±0.44	0.24±0.03
21 – 40	Male	13	3.34±0.40	12.45±0.59	0.27±0.03
	Female	20	3.17±0.34	12.27±0.46	0.26±0.02
	Male + Female	33	3.24±0.37	12.34±0.52	0.26±0.02
41 - 60	Male	14	3.52±0.43	12.43±0.53	0.28±0.04
	Female	15	3.22±0.23	11.82±0.43	0.27±0.02
	Male + Female	29	3.37±0.37	12.11±0.56	0.28±0.03
≥ 60	Male	15	3.63±0.42	12.51±0.54	0.29±0.03
	Female	9	3.28±0.35	12.0±0.46	0.27±0.03
	Male + Female	24	3.50±0.42	12.32±0.56	0.28±0.03

[Table/Fig-3]: Ventricular parameters versus age group and sex.

DISCUSSION

Hamidu AU et al., [3] in 488 subjects of adult Nigerian population observed an increase of Evan's Index with advancing age with mean EI of 0.252 ± 0.04. Similar increase of EI with advancing age is observed in our study too [Table/Fig-3]. However, mean EI in our study is 0.27 ± 0.03. This difference in the mean EI between these two studies could be due to dominant middle age population with mean age of 37.26 years in study by Hamidu AU et al.,[3] and also due to ethnic difference in size of the skull.

Increase in EI with advancing age is due to the following facts. With increasing age and decreasing body mass of index, there is reduction in the brain weight and increase in the ventricle size [5]. Brain atrophy is compensated by increase in the ventricle size, however still, the EI does not exceed 0.3 [3].

In the Indian study by Patnaik P et al., [6] in 120 patients mean EI was 0.27 ± 0.035. This value is identical to the mean EI of our study, which is 0.27 ± 0.03. However, statistically significant difference was noted in the EI value between males and females in study by Patnaik P et al., with EI value of 0.28 ± 0.04 in males and 0.26 ± 0.03 in females [6]. In our study, no statistically significant difference was observed in EI value between males and females.

Women have smaller brain size, around 110-115 gm lesser than males. As compared to males, they also have smaller lateral ventricles with proportionately smaller cerebral hemispheric size [5]. The absence of statistically significant difference in EI value between males and females in our study could probably be attributed to proportionately smaller size of lateral ventricles and cerebral hemispheric size in females.

Another Indian study by Patnaik P et al., [7] in 60 patients also shows mean EI as 0.27 ± 0.035. Evan index of > 0.30 is the cut-off value for the diagnosis of hydrocephalus as per international guidelines [8,9]. According to the study by Synek et al., [10] and Gwaler J et al., [11], normal EI should be 0.29 or lower. Kosourov Ak et al., [12] in 2002, in their study observed a mean Evan's Index ranging from 0.22 to 0.28 in adults.

Normal pressure hydrocephalus comprises of ventricular enlargement, gait disturbance and urinary incontinence [13]. The commonest problem in diagnosing NPH lies in the method of proving the degree of hydrocephalus which is in excess of the degree of atrophy. EI of > 0.30 with presence of clinical symptoms confirms the diagnosis of NPH.

Von Bezing H et al., [14] in their study concluded that linear measurements of hydrocephalus in tuberculous meningitis were more reliable than volumetric ratios.

A Study by Wilk R et al., [15], on 507 children, was divided into two groups of children's with normal CT brain (381 patients) and with abnormal CT brain (126 patients). Data's from children with normal CT brain was used to establish the reference values. Mean reference value of Evan's index was 0.263 ± 0.034 for 0 – 12 months of age, 0.253 ± 0.028 for >12 – 36 months of age, 0.247 ± 0.019 for > 3 – 6 years of age, 0.248 ± 0.028 for > 6 – 9 years of age, 0.250 ± 0.023 for > 9 – 12 years of age, 0.252 ± 0.019 for > 12 – 15 years of age and 0.251 ± 0.022 for > 15 – 18 years of age. According to this study, Evan's Index was only weakly age dependent, however no statistically significant difference in the Evan's index among consecutive age groups was observed. In our study, Evan's Index in age group of <20 years was 0.24 ± 0.03. In this age group, two patients were between 5-10 years, five patients were between 11-18 years and seven patients were between 18- 20 years in our study.

Sari E et al., [16], in study on 517 patients aged between 0-18 years, mean Evan's Index was between 0.23 and 0.28. In paediatric population, brain parenchyma grows more than the ventricles, hence the Evan's Index decreases with age [16]. Comparison of Evan's Index between present study and other similar studies were represented in [Table/Fig-4].

Author	Evan's Index
Present study	0.27 ± 0.03
Hamidu AU et al., [3]	0.252 ± 0.04
Patnaik P et al., [7]	0.27 ± 0.035
Kosourov AK et al., [12]	0.22 to 0.28
Wilk R et al., [15] (Paediatric sample)	0.218 to 0.312
Sari E et al., [16] (Paediatric sample)	0.23 to 0.28

[Table/Fig-4]: Comparison of Evan's Index between present study and other similar studies.

Evan's Index can be used in both pediatric and adult population in assessing the degree of hydrocephalus [3], and in many other neurological and psychiatric disorders producing ventriculomegaly like cerebral atrophy, dementia, normal pressure hydrocephalus, multiple sclerosis, autism disorders [17] etc., and also in follow-up cases of ventriculoperitoneal shunt [4].

LIMITATION

Relatively small paediatric sample size is one of the limitations of our study. Isolated use of Evan's Index can lead to missing of ventriculomegaly in cases where occipital horn of lateral ventricle expands earlier than the frontal horns is considered as a limitation.

CONCLUSION

Our study has established the normal range of Evan's index in South Indian population with respect to age and sex. Mean EI of 0.27 ± 0.03 in our study supports the

adaptation of international guideline cut-off value of EI > 0.30 in the diagnosis of hydrocephalus in our South Indian population as well. EI is less technical, easily reproducible, less time consuming and can be used in routine practice.

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