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Original Research Article

EVANS' INDEX IN HEALTHY NORTH INDIAN POPULATION: A COMPUTED TOMOGRAPHIC STUDY

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ABSTRACT

Background: As the humans age, there is decrease in size of brain tissue, increase in cerebrospinal fluid volume and enlargement of ventricles. Brain ventricles can be studied by taking linear, planimetric or volumetric measurements. Linear ratios of width of ventricles to the width of skull or brain are considered to be an easy and reproducible measurement for assessment of ventricles. Evans' index is one such linear ratio; it is the ratio of maximum width of frontal horns and maximum transverse internal diameter of skull in the same plane.

Purpose of study: The purpose of our study was to obtain a baseline data of reference values of Evans index, in healthy north Indian population.

Materials and Methods: This study was jointly conducted by Department of Anatomy and Department of Radiodiagnosis, King George's Medical University, U.P, Lucknow. Axial CT scans of head region reported radiologically normal, belonging to 100 individuals of different age groups were retrospectively collected and thoroughly analyzed using Radiant DICOM Viewer Software. Study subjects were categorized into V groups as per age: 18-30years, 31-40years, 41-50years, 51-60years and above 60years. Evans' index was calculated.

Results: Among study subjects, Evans'index ranged from 0.167 to 0.29 with a mean value of 0.23±0.02. No significant association was observed between age and mean Evans' Index ($p>0.05$). Mean Evans' index was equal for male and female and was not found to change with age.

Conclusion: Study provided values for normal range of Evans' index and proposes age dependent values of the same for healthy adult males and females. The data could be utilized in routine radiological practice and by others where required.

KEY WORDS: Evans'index, Ventricles, CT scan, Linear ratio, Brain.

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INTRODUCTION

Evaluation of the size and shape of ventricles is performed routinely during diagnostic CT scan (computed tomography) and MRI (magnetic

resonance imaging) studies of brain. Neuropathological changes associated with atrophy of brain can be objectively assessed by ventricular enlargement [1].

Brain ventricles can be studied taking linear, planimetric or volumetric measurements. Linear ratios of width of ventricles to width of skull or brain are considered to be an easy and reproducible measurement for the assessment of ventricles [2].

One such linear ratio is Evans' index. It is the ratio of maximum width of frontal horns and maximum transverse internal diameter of skull in the same plane. Evans' Index was originally obtained by pneumoencephalographic studies [3]. This index can be used objectively to diagnose hydrocephalus and it was established as Â0.3 in normal adults [4]. Evans' Index is a reliable indirect indicator of ventricular volume in adults on CT [5] and MRI [6] studies.

The purpose of our study was to obtain values of Evan's Index from specific population group and derive a baseline data of reference values of normal range of Evans index in healthy north Indian population.

MATERIALS AND METHODS

Present study was a retrospective study conducted in the Department of Anatomy, King George's Medical University, Lucknow, Uttar Pradesh in collaboration with the Department of Radiodiagnosis after due approval by the review board.

Study group comprised of patients reporting to the Department of Radiodiagnosis for CT scan of head region due to various indications.

All CT scans were performed on 64-slice multidetector spiral CT scanner (Brilliance CT, Philips medical system, Nederland, B.V.5684 PC Best, The Nederlands) by trained and experienced radiographer under standardized conditions. CT study of brain was done in axial transverse scanning. Optimum patient preparation and positioning was taken care of. After obtaining the surview in lateral projection orbito-meatal line was drawn; a line was drawn at an angle of 15 – 20 degrees to and 1 cm above it. This represented the lowest tomographic section, which passed through the base of skull (Fig. 1). The sections were taken with slice thickness of 5mm and increment of 10mm. Images were reconstructed at slice thickness of 1.25mm without any overlap. CT images of the head region belonging to adult subjects of either sex were collected in a DVD for analysis. Scans belonging to patients with H/O alcoholism, past history of severe head trauma or intracranial surgery, any evidence of space occupying lesion were not included in the study and scans that were reported abnormal were also excluded. Finally, a total of 100 scans (51 males and 49 females) belonging to individuals in the age range of 18 years to 76 years were selected for the study. All these scans were reported radiologically normal in terms of cerebral ventricles and brain parenchyma. Analysis of images was done on a personal laptop, using software tool: Radiant DICOM Viewer (64-bit). The measurement was calibrated to the nearest 0.1 mm. All images were studied in axial projection from below upwards.

Maximum width of frontal horns (MaxWF) (Fig. 2) and maximum transverse internal diameter of skull (MaxTD) (Fig.3) were measured at the level of interventricular foramen. Evans' index was calculated as the ratio of maximum width of frontal horns and maximum transverse internal diameter of skull.

Data collected was analyzed statistically to obtain range, mean & standard deviation (SD). Student 't' test was done to compare two groups. P-value was calculated and p-value Â0.05 was taken as significant.

RESULTS

Evans' index was calculated for 100 subjects (51 males, 49 females) ranging in age from 18 to 76 years, and were divided into five age groups; Group A (18-30 years), Group B (31-40 years), Group C (41-50 years), Group D (51-60 years), and Group E (>60 years). Evans' index ranged from 0.167 to 0.29 among study subjects with a mean value of 0.23±0.02. Mean values in different age groups ranged from 0.23±0.02 (Groups A & B); 0.23±0.03 (Groups C & E) and 0.22±0.03 (Group D) (Fig.4). Mean Evans' index was equal for male and female (0.23±0.02). Statistically, no significant association was found between age and mean Evans' Index ($p>0.05$).

Fig. 1: Lateral view of skull with imaging planes indicated by lines.

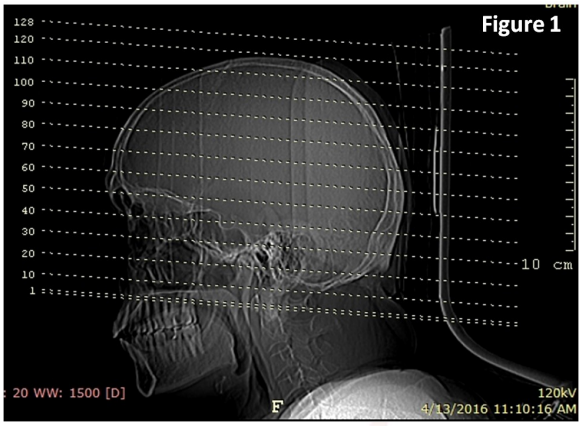


Fig. 2: NCCT Axial Image at the level of Interventricular Foramen: NCCT Axial Image at the level of Interventricular Foramen, showing greatest distance between frontal horns i.e. Bi-Frontal Distance (27.1mm).

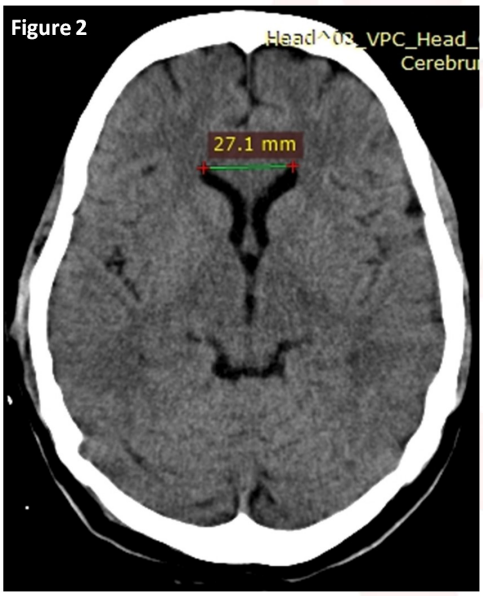


Fig. 3: NCCT Axial Image at the level of Interventricular Foramen: NCCT Axial Image at the level of Interventricular Foramen, showing greatest internal diameter of skull vault at the level of Interventricular Foramen (120.4mm)

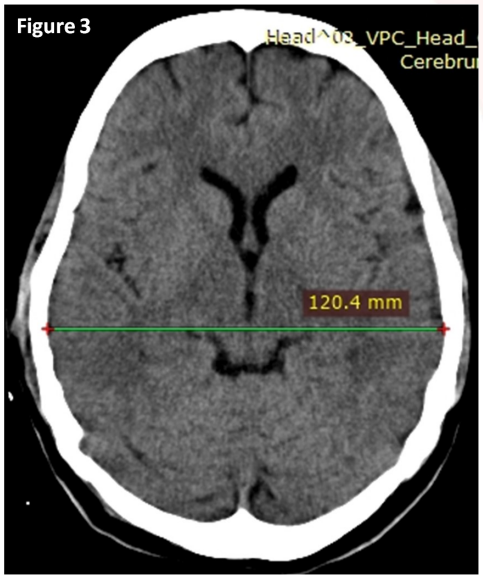
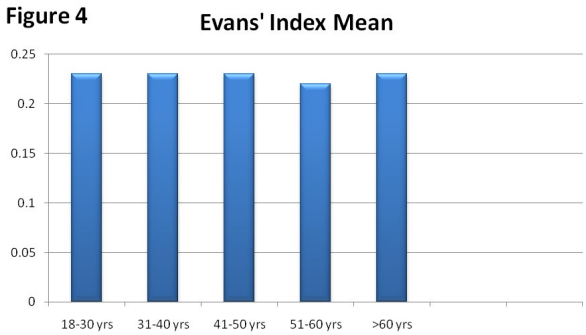


Fig. 4: Bar Graph showing distribution of mean Evans' Index in different age groups



DISCUSSION

Hahn and Rim used linear ratios of ventricular dimensions against the brain diameter on the same plane, to neutralize the effect of particular scale factors utilized in sizing up Computed Tomography scan images on their results. These linear ratios did not bear any unit of measurement. Use of linear ratios in place of absolute measurements also neutralized the influence of anthropometric differences in normal individuals on the variations in the size of ventricles [7]. With wider availability of CT scan studies, Evans' index has become an easy to use modality to measure the size of ventricular system [8].

Evans considered this index between 0.20-0.25 as normal [3]. Gawler et al calculated mean Evans' index as 0.18-0.30 in normal subjects and 0.27-0.44 in subjects with cerebral atrophy on CT scans analysis [9]. Slight increase in Evans' Index with age was observed by Gyldensted C et al. It was 0.26 in younger age (17-40 yrs) and 0.275 in older age (41-86 yrs) [10]. Jacoby RJ et al in a CT study found it to be 31.04 (range=21.9-39.5 expressed in percentage) in healthy elderly [11]. D'Souza et al observed that Evans' index was 0.27 in males and 0.26 in females [12]. Karakas P et al by MRI study estimated it to be 0.25 in both males and females [13]. Mean Evans' index was 0.27 (range=0.14-0.34) in a CT study by Patnaik P et al [14]. Reddy VU et al calculated it as 0.25 in 326 CT scans of normal Indian subjects between 1-99 years [15]. Hamidu et al found this index as 0.25 in 488 Nigerian subjects (319 males and 169 females) between 18-84 years by CT scan. They also reported high Evans' index in individuals >60 years [16].

We calculated the Evans' index, observed its association with age and gender and established

its normal reference range in the north Indian population, based on our observations.

In our study we observed Evans' index ranging from 0.17-0.29 with a mean value of 0.23. 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 for all age groups.

Evans' index observed in our study was comparable to the range stated by Evans [3] & Gawler et al [9]; but it was narrower than the range reported by Gyldensted C et al [10], D'souza et al [12], Karakas P et al [13], Patnaik P et al [14], Reddy VU et al [15] and Hamidu et al [16].

Evans' Index can be utilized to differentiate between normal and enlarged ventricular dimensions. 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. The basis for differentiation between normal index as compared from ventriculomagaly in Evans study was pneumoencephalography. In a CT study conducted on 326 healthy Indian individuals by Reddy VU et al Evans index Ã0.30 was found in 14 persons, but none of them had symptoms of ventriculomegaly [15]. We observed Evans' index ranging between 0.17-0.29 in asymptomatic healthy individuals. Previously reported CT studies as well our study report a higher upper limit of normal Evans index. Missori et al in their study concluded that an Evans' index >0.3 reflects an underlying neurological condition in every individual [17]. On the other hand, Brix et al established that there was a wider range of EI in healthy elderly and the cut off was higher than 0.3 in both men and women [18]. Therefore, based upon our observations among healthy asymptomatic individuals we also infer that further studies are required amongst normal subjects, as well as, further comparisons between normal subjects and cases of cerebral atrophy and ventriculomegaly be made, before setting a range of 0.25-0.30 to diagnose borderline ventricular enlargement in our population.

CONCLUSION

We tried to report normal range of Evans' index and propose age dependent values of the same for healthy adult males and females which could be of use in routine radiological practice. Evans index serves as a reliable indicator of ventricular volume in healthy adults. A suggestion is being made for redefining upper cut off for normal range of Evans' index to 0.30 in our population. Necessary researches may be further conducted in support of the same.

ABBREVIATIONS

CT scan: computed tomography scan
MRI: magnetic resonance imaging
Max WF: maximum width of frontal horns
Max TD: maximum transverse internal diameter of skull
SD: standard deviation

Conflicts of Interests: None

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