ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Evaluation of the Evan's and Bicaudate index for South Karnataka Population using computed tomography

Praveen Basavaraj Kumbar[1], Anil Kumar Sakalecha[2], Chaithanya A[3], Rajeswari G[4], Revanth RB[5], Jayendra Mannan[6]

[1,5,6]Postgraduate Student, [2]Professor and Head, [3]Senior Resident, [4]Associate Professor, Department of Radio-diagnosis, Sri Devaraj Urs Medical College, Tamaka, Kolar, Karnataka, India

Submission: 15-02-2023 Revision: 02-05-2023 Publication: 01-06-2023

ABSTRACT

Background: Radiological markers that are useful in the diagnosis of normal pressure hydrocephalus include the Bicaudate index (BCI) and the Evans index (EI), which are practical indicators of ventricular volume. Worldwide, variation exists in normative studies for both these indices. The majority of research for EI and BCI is based on data from the Western population. The study has been performed on the South Karnataka population. **Aims and Objectives:** This study's goal is to derive age and gender specific cutoff values on normative data of Evans and BCI. **Materials and Methods:** This was a prospective and observational study.Patients referred to "RL Jalappa Hospital" for computed tomography (CT) scan of the brain who meet the inclusion criteria will be included in this study. CT brain of all the patients will be performed in Siemens Somatom emotion 16 slice CT scanner. Ninety-seven were selected for this study, and EI and BCI were calculated for them. **Results:** The mean value of EI and BCI in our study was 0.26 ± 0.02 and 0.1167 ± 0.02, respectively. The difference in EI and BCI between males and females shown significant statistical difference between males and females but the values increased as increase in age. **Conclusion:** Our study for South Indian population concludes that EI and BCI have a significant statistical difference between males and females. Both EI and BCI values increase with age. Hence cutoff values of EI and BCI index according to age and gender are important for evaluation of hydrocephalus.

Key words: Evan's index; Bicaudate index; Widest anterior horn width; Inner diameter of the skull

Access this article online

Website: http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v14i6.52526

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

Hydrocephalus is caused by an imbalance in the production and absorption of cerebrospinal fluid (CSF), which results in the swelling of the brain.[1]

Aside from clinical evaluation, radiographic investigations such as computed tomography (CT) and magnetic resonance imaging play a significant role in the diagnosis of hydrocephalus. The size of the ventricle is used to diagnose hydrocephalus on imaging.

CT scanning is the most extensively used and least expensive method for brain imaging. Linear ratio measures on CT can be used to investigate ventricular size. Among these, Evan's index (EI) and Bicaudate index (BCI) are the most basic evaluation. Evan's ratio is calculated by dividing the transverse diameter of the anterior horns of the ventricles by the maximum internal diameter of the skull on encephalographic films.[2]

EI gives the assessment of the degree of ventricular enlargement. The diagnostic cutoff value is >0.3.

BCI is defined as the ratio of the width of bilateral lateral ventricles at the level of the head of the caudate nucleus to distance between inner tables of the skull at the same level.[3] Apart from the evaluation of ventriculomegaly, BCI

Address for Correspondence:
Dr. Anil Kumar Sakalecha, Professor and Head, Department of Radio-diagnosis, Sri Devaraj Urs Medical College Tamaka, Kolar, Karnataka, India. **Mobile:** +91-9844092448. **E-mail:** dranilsakalecha@gmail.com

is used for the diagnosis of Huntington's chorea, cerebral atrophy, and multiple sclerosis.

Aims and objectives

The objectives of the study are as follows:

1. To assess Evans and BCI among South Karnataka population using computer tomography.
2. To derive age and gender specific cutoff values on normative data of Evans and BCI.

MATERIALS AND METHODS

Prospective and observational study

Patients referred to "RL Jalappa Hospital" for CT scan of the brain who meet the inclusion criteria will be included in this study.

CT brain of all the patients will be performed in Siemens Somatom emotion 16 CT scanner. Axial sections will be obtained at 5 mm slice thickness from skull base to the vertex. Images will then be reconstructed to 1.5 mm slice thickness. Then, the DICOM images will be analyzed on viewing console.

Measurements will be 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) will be taken to calculate in EI (Figure 1).

The ratio of the width of bilateral lateral ventricles at the level of the head of the caudate nucleus (ICD) to distance between inner tables of the skull at the same level (IMAX) will be taken to calculate BCI (Figure 1).

Inclusion criteria

Only patients with neurological complaints who were referred for a CT scan to the department of radiology during the study period and whose CT reported to be normal will be included in this study.

Exclusion criteria

Patients suffering from intracranial or intraventricular pathology were excluded from the study.

Analysis and statistical methods

Study design

This was a prospective and observational study.

Sample size

Atul Dhok et al., had reported the mean (SD) EI and BCI to be 0.2707 (0.0304) and 0.112 (0.03368), respectively, among the study subjects.

Assuming the expected population standard deviation to be 0.03 for indices and employing t-distribution to estimate sample size, the study would require a sample size of 97 subjects to estimate a mean with 95% confidence and a precision of 0.006.

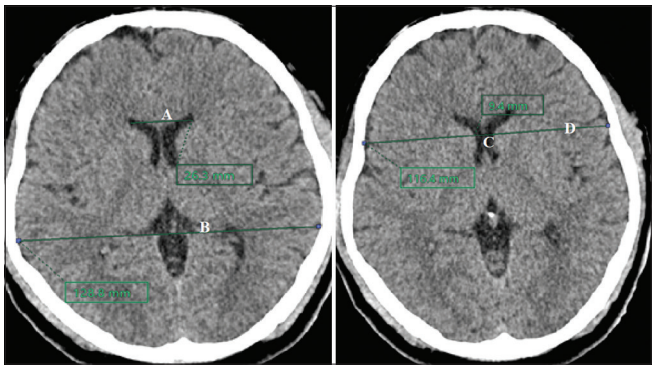

Figure 1: Computed tomography brain axial view A=Maximum width of the frontal horns of the bilateral lateral ventricles, B=Maximum internal diameter of the skull, C=Width of bilateral lateral ventricles at the level of the head of the caudate nucleus, D=Distance between inner tables of the skull at the same level

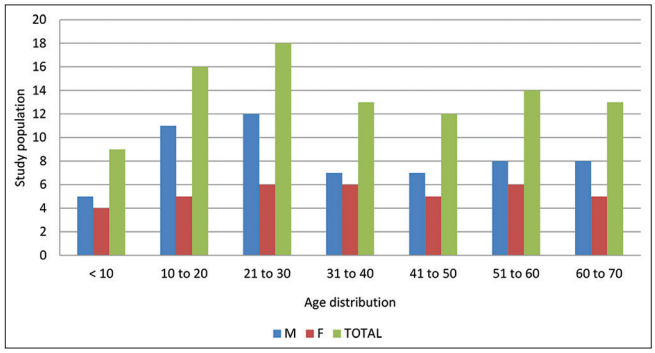

Figure 2: Age-wise distribution of the patients in the study population

The sample size was calculated using the formula:

$$n = \frac{Z^{2}_{1-\alpha/2} a^{2}}{d^{2}}$$

Where,
Z is the standard deviation
d is the absolute precision
$1-\alpha/2$ is the desired confidence level

Statistical analysis

Data will be entered using Microsoft Excel and analyzed using the Statistical Package for the Social Science (SPSS) standard version 20. All continuous variables will be summarized using mean (SD) or median (IQR) depending on the normality of the distribution. Categorical variables will be summarized using proportions. Normality will be assessed using Shapiro–Wilks test and homogeneity of variance will be checked using Levene's test. Comparison of various indices across sub-groups (age categories or sex) will be done using independent samples t-test. $P<0.05$ will be considered statistically significant.

RESULTS

Of total 97 subjects included in study;A total of 97 normal head CT scan images were retrieved and analyzed, comprising 58 (59.7%) males and 37 (38.1%) females.

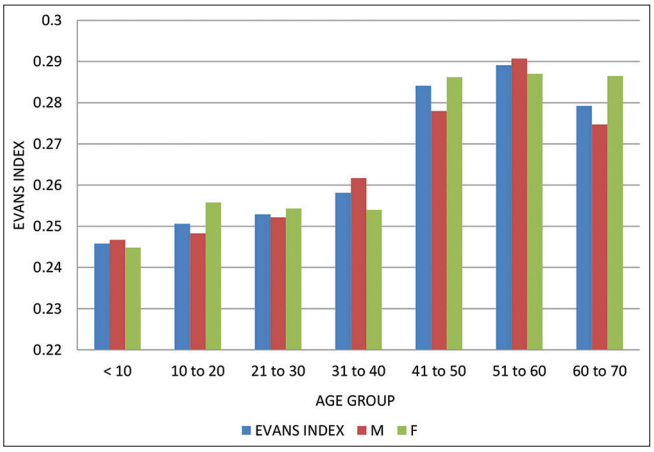

Figure 3: Distribution of Evans index in different age groups

Five and 70 years were the minimum and maximum ages, respectively, and the mean age was 35.81 years (Figure 2). The mean values AHW ~ 28.43, MICD ~ 106.64, EI ~ 0.26, ICD ~ 12.64, IMAX ~107.21, BCI ~ 0.116, respectively. The overall mean value of EI was 0.26±0.02; with a minimum and maximum value of 0.21 and 0.31, respectively. The overall mean value of BCI was 0.1167±0.02; with a minimum and maximum value of 0.09 and 0.18, respectively. The average ages for females and males were 34.9±19.3 and 37.14±18.00 years, respectively (Tables 1 and 2).

DISCUSSION

The practical variables frequently utilized in the diagnosis of hydrocephalus are EI and BCI. There are two types of hydrocephalus: Communicative (or non-obstructive) and non-communicating (or obstructive). Cystic lesions, tumors, or membrane blockage to CSF outflow are the causes of obstructive hydrocephalus. In rare cases,

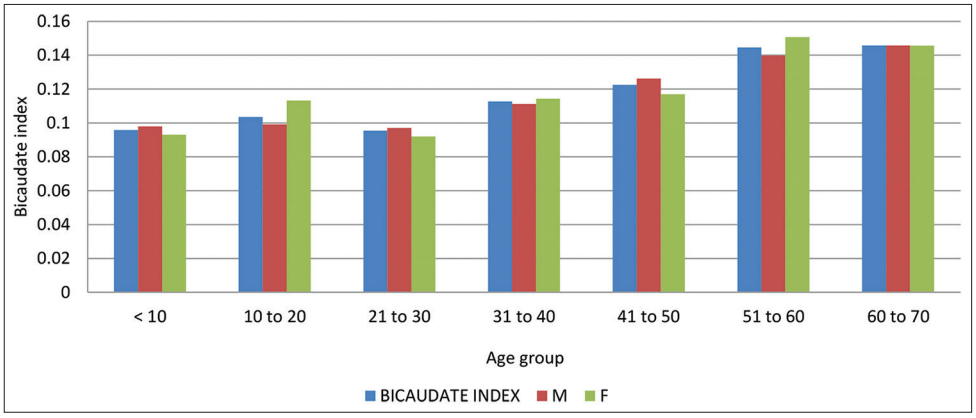

Figure 4: Distribution of Bicaudate index in different age groups

Table 1: The various parameters used in the study and their final values

	Statistics						
Sex	Age	AHW	MICD	EI	ICD	IMAX	BCI
F							
N							
Valid	37	37	37	37	37	37	37
Missing	0	0	0	0	0	0	0
Mean	37.14	28.7681	106.8934	0.2674	12.8592	107.1681	0.1188
Standard deviation	18.805	3.20392	5.83067	0.02054	2.97139	2.45857	0.02596
Minimum	5	24.60	99.80	0.21	9.48	100.10	0.09
Maximum	70	35.60	120.10	0.30	18.90	111.60	0.17
M							
N							
Valid	58	58	58	58	58	58	58
Missing	0	0	0	0	0	0	0
Mean	34.97	28.2284	106.4876	0.2637	12.5019	107.2392	0.1154
Standard deviation	19.364	3.05496	5.43134	0.02155	2.80515	1.94746	0.02492
Minimum	6	24.60	99.88	0.21	9.51	102.00	0.09
Maximum	70	33.10	118.90	0.31	18.00	110.91	0.18

AHW: Anterior horn width, MICD: Maximum intracranial diameter, EI: Evan's index, ICD: Intercaudate distance, IMAX: Distance between inner table at the level of measurement of ICD, BCI: Bicaudate index

Table 2: EI and BCI with respect to the age and sex of the patient

	Statistics	
Age group	**EI**	**BCI**
1–10		
N		
Valid	9	9
Missing	0	0
Mean	0.2458	0.0958
Std. Deviation	0.00442	0.00559
Minimum	0.24	0.09
Maximum	0.25	00.10
11–20		
N		
Valid	16	16
Missing	0	0
Mean	0.2506	0.1036
Std. Deviation	0.00923	0.01526
Minimum	0.24	.09
Maximum	0.27	.14
21–30		
N		
Valid	18	18
Missing	0	0
Mean	0.2529	0.0954
Std. Deviation	0.01217	0.01068
Minimum	0.21	.09
Maximum	0.26	0.13
31–40		
N		
Valid	13	13
Missing	0	0
Mean	0.2581	0.1127
Std. Deviation	0.01739	0.01796
Minimum	0.21	0.10
Maximum	0.29	0.16
41–50		
N		
Valid	12	12
Missing	0	0
Mean	0.2814	0.1225
Std. Deviation	0.02067	0.03036
Minimum	0.22	0.10
Maximum	0.30	0.18
51–60		
N		
Valid	14	14
Missing	0	0
Mean	0.2891	0.1445
Std. Deviation	0.00637	0.01100
Minimum	0.28	0.12
Maximum	0.31	0.16
61–70		
N		
Valid	13	13
Missing	0	0
Mean	0.2792	0.1457
Std. Deviation	0.02100	0.01092
Minimum	0.22	0.12
Maximum	0.30	0.17

increased CSF production may be caused by disease in the choroid plexus, which controls CSF production.[4,5,6] The most typical kind of hydrocephalus in children and young adults is obstructive hydrocephalus. In rare cases, a complicated form of hydrocephalus (such as meningitis) develops when both CSF absorption and flow are disrupted. The frontal horn index, occipital horn index, frontooccipital horn ratio (FOHR), frontooccipital horn index ratio, and decrease FOHR are currently taken into account when making a diagnosis of hydrocephalus.[7]

EI

The maximum frontal horn width divided by the largest inner skull diameter is known as the EI. It was first suggested by Evans in 1942 and is used in encephalography to infer the ventricular system's expansion. Evans came to 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 ventricle size after retrospectively analyzing the 53 encephalograms of normal patients performed at the Children's Hospital of Michigan and Harper Hospital. More notably, this study demonstrated that values over 0.30 indicate definitive ventricular enlargement, whereas values between 0.20 and 0.25 indicate normal ratio, early or doubtful enlargement, and 0.25 to 0.30, respectively. Hamidu et al., discovered that although the mean EI for men was higher than for women, this difference was not statistically significant.[8] The difference in mean EI between males and girls in our study was shown to be statistically significant [Table 2 and Figure 3]. For EI, values above 0.30 indicated pathological ventricular dilatation, whereas values between 0.25 and 0.30 indicated borderline enlargement.

BCI

BCI is used to diagnose Huntington's chorea, cerebral atrophy, and multiple sclerosis in addition to ventriculomegaly examination. The difference in mean EI between males and girls in our study was shown to be statistically significant (Table 2 and Figure 4). The BCI for hydrocephalus has a cutoff value of 0.25. Our study's BCI value was 0.112±0.0337, which is comparable to the results of studies by Dupont and Rabinstein.,[9] and Park et al.[10] Our research's highest value was 0.22, which was somewhat higher than that of Pelicci et al., study.

Limitations of the study

Our findings come from an examination of patients from a particular center. A multicenter analysis would result in a more reliable cutoff index finding. Patients above 70 years of age were not included in study.

CONCLUSION

Our study for south karnataka population concludes that EI and BCI have a significant statistical difference between males and females. Both EI and BCI values increase

with age. Hence, cutoff values of EI and BCI index according to age and gender are important for evaluation of hydrocephalus.

ACKNOWLEDGMENT

We would like to express our deepest gratitude to all faculty, postgraduate residents, and technicians, Department of Radio-Diagnosis, Sri Devaraj Urs Medical College, Tamaka, Kolar, Karnataka.

REFERENCES

1. Bermel RA, Bakshi R, Tjoa C, Puli SR and Jacobs L. Bicaudate ratio as a magnetic resonance imaging marker of brain atrophy in multiple sclerosis. Arch Neurol. 2002;59(2):275-280.
   https://doi.org/10.1001/archneur.59.2.275
2. Evans WA Jr. An encephalographic ratio for estimating ventricular enlargement and cerebral atrophy. Arch Neurol Psychiatry. 1942;47(6):931-937.
   https://doi.org/10.1001/archneurpsyc.1942.02290060069004
3. Barr AN, Heinze WJ, Dobben GD, Valvassori GE and Sugar O. Bicaudate index in computerized tomography of Huntington disease and cerebral atrophy. Neurology. 1978;28(11):1196-1200.
   https://doi.org/10.1212/wnl.28.11.1196
4. Hodel J, Rahmouni A, Zins M, Vignaud A and Decq P. Magnetic resonance imaging of noncommunicating hydrocephalus. World Neurosurg. 2013;79(2):S21.e9-S21.e12.
   https://doi.org/10.1016/j.wneu.2012.02.009
5. Algin O and Turkbey B. Intrathecal gadolinium-enhanced MR cisternography: A comprehensive review. AJNR Am J Neuroradiol. 2013;34(1):14-22.
   https://doi.org/10.3174/ajnr.A2899
6. Hingwala D, Chatterjee S, Kesavadas C, Thomas B and Kapilamoorthy TR. Applications of 3D CISS sequence for problem solving in neuroimaging. Indian J Radiol Imaging. 2011;21(2):90-97.
   https://doi.org/10.4103/0971-3026.82283
7. Algin O. Role of complex hydrocephalus in unsuccessful endoscopic third ventriculostomy. Childs Nerv Syst. 2010;26(1):3-4; author reply 5-6.
   https://doi.org/10.1007/s00381-009-1001-9
8. Hamidu AU, Olarinoye-Akorede SA, Ekott DS, Danborno B, Mahmud MR and Balogun MS. Computerized tomographic study of normal Evan's index in adult Nigerians. J Neurosci Rural Pract. 2015;6(1):55-58.
   https://doi.org/10.4103/0976-3147.143195
9. Dupont S and Rabinstein AA. CT evaluation of lateral ventricular dilatation after subarachnoid hemorrhage: Baseline bicaudate index values [correction of balues]. Neurol Res. 2013;35(2):103-106.
   https://doi.org/10.1179/1743132812Y.0000000121
10. Park CO, Chae KB, Lee SD, Kim Y and Ha YS. The study in frontal ventricular measurement and correlation between cerebroventricular index and cephalic index on normal computed tomography. J Korean Neurosurg Soc. 1990;19(5):608-614.

Authors' Contributions:
PBK- Definition of intellectual content, Literature survey, Prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, manuscript preparation and submission of article; **ARK-** Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **CA-** Design of study, statistical Analysis and Interpretation; **RJ-** Review Manuscript; **RRB-** Review Manuscript; **JM-** Literature survey and preparation of Figures.

Work attributed to:
Sri Devaraj Urs Medical College, Tamaka, Kolar, Karnataka, India.

Orcid ID:
Dr. Praveen Basavaraj Kumbar - https://orcid.org/0009-0008-4654-8481
Dr. Anil Kumar Sakalecha - https://orcid.org/0000-0003-2957-4908
Dr. Chaithanya A - https://orcid.org/0000-0001-5874-0499
Dr. Rajeswari - https://orcid.org/0000-0002-3014-2232
Dr. Revanth RB - https://orcid.org/0000-0002-4021-1545
Dr. Jayendra Mannan - https://orcid.org/0009-0005-0692-5287

Source of Support: Nil, **Conflicts of Interest:** None declared.