

Assessment of Lateral Ventricle Brain Indices In Indian Population Based On Age And Gender Using Computed Tomography

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ABSTRACT

Background: Bicaudate index, Bicaudate - temporal index and Huckman number were commonly used radiological indices to accurately evaluate intracranial ventricular volume. Established normal values for these indices were based on study done among western population. Reference values were not established for these indices in Indian population. Hence this study is undertaken to establish the new reference values for Bicaudate index, Bicaudate - temporal index and Huckman number, based on age and sex in Indian population.

Methods: The retrospective study was done in Department of Radiology, Karpagam Faculty of Medical Sciences and Research, Coimbatore during the period between 1st June 2016 to 31st July 2016. One hundred subjects, aged between 5 to 90 years, with normal CT brain performed in Siemens SomatomScope multislice CT scanner were analyzed for this study and Bicaudate index, Bicaudate - temporal index, Huckman number were calculated.

Results: Mean Bicaudate Index was 0.14 +/- 0.03. The mean Bicaudate - Temporal Index was 0.13 +/- 0.03. The mean Huckman number in male was 5.09 +/- 0.76 and in female was 4.70 +/- 0.57.

Conclusion: The new reference values for Bicaudate index, Bicaudate - temporal index and Huckman number in Indian population based on age and gender was established in our study.

KEY WORDS: Bicaudate index, Bicaudate - temporal index, Huckman number, Computed Tomography, Brain.

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INTRODUCTION

Various imaging methods such as CT, MRI and USG are used in the CNS evaluation of pediatrics and adult population. These imaging modalities images the human central nervous system non invasively and also produce the detailed anatomy and pathological

changes.

In Indian scenario, CT is the primary modality of choice in evaluation of brain morphology including the size and shape of the ventricles, which will be useful in the diagnosis of conditions like hydrocephalus, age related brain atrophy and also in other pathological

conditions producing ventriculomegaly. To evaluate intracranial fluid spaces, it is essential to establish the reference value which determines their normal size. Many indices are available to evaluate the ventricular system based on linear measurement such as: Evans index, Bifrontal index, Bicaudate index, ventricular index, Bicaudate - temporal index, Bioccipital index, Schiersmann's index and Huckman number.

So, the present study was undertaken to establish the new reference value of the selected linear indices for intracranial fluid spaces based on the age, sex and race.

Objective:

To establish the new reference values for Bicaudate index, Bicaudate - temporal index and Huckman number based on age and sex in Indian population.

MATERIALS AND METHODS

Patient selection: Of all the patients referred for CT brain to Department of Radiology, Karpagam Faculty of Medical Sciences and Research, Coimbatore, during the period between 1st June 2016 to 31st August 2016 with neurological complaints, only those patients whose CT were reported to be normal were included in this study. It is a retrospective study, hence ethical committee clearance has not been obtained.

One hundred subjects, aged between 5 to 90 years, with normal CT brain were analyzed for this study. All the subjects were divided into subgroups based on age and sex. The study subjects comprise of 54 males and 46 females [Table 1].

Exclusion criteria:

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

CT brain of all the patients was performed in Siemens SomatomScope 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 analyzed on viewing console. Measurements were taken with in-built linear calipers which are calibrated to 0.1 mm.

Following measurements were taken:

- A. Minimum Bicaudate nuclei distance [Fig. 1].
- B. Maximum internal diameter of the skull along the same line of minimum Bicaudate nuclei distance [Figure 2].
- C. Maximum internal diameter of the skull [Figure 2].
- D. Maximum distance between the anterior horns of cerebral lateral ventricle [Figure 1].

Following indices are calculated:

1. Bicaudate Index: A/B - Minimum bicaudate nuclei distance divided by maximum internal diameter of the skull along the same line.
2. Bicaudate - Temporal Index: A/C - Minimum bicaudate nuclei distance divided by maximum internal diameter of the skull.
3. Huckman Number: A+D - Sum of the minimum bicaudate nuclei distance and maximum distance between the anterior horns of cerebral lateral ventricle.

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

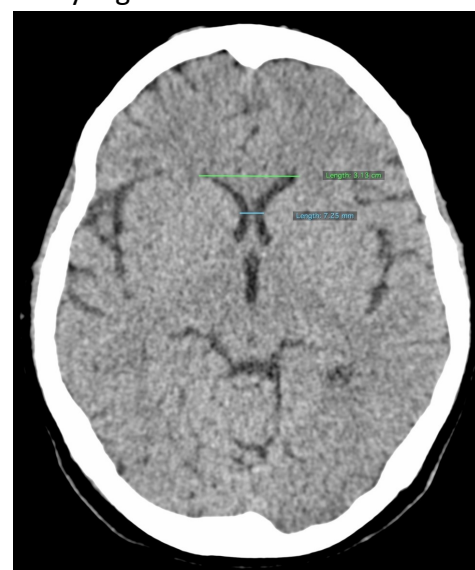


Fig. 1: Axial CT image of brain shows maximum distance between the anterior horns of cerebral lateral ventricle (Green line) and minimum bicaudate nuclei distance (Blue line).



Fig. 2: Axial CT image of brain shows maximum inner diameter of the skull along the same line of minimum bicaudate nuclei distance (Blue line) and maximum inner diameter of the skull (Orange line).

RESULTS

Bicaudate Index: The mean Bicaudate Index in our study was 0.14 +/- 0.03. No statistical significant difference was found between male and female in the mean bicaudate index [Table 2]. Bicaudate index changes between age groups were statistically significant (P < 0.001). Index value showed increase according to the advancing age [Table 3,4]. 10 - 90th percentile reference value for age group < 20 years is 0.10 - 0.13 and for rest of the age group is 0.11 - 0.16.

Bicaudate - Temporal Index: The mean Bicaudate - Temporal Index in our study was 0.13 +/- 0.03. Mean bicaudate - Temporal index shows no statistical significant difference

among male and female. [Table 5]. 10 - 90th percentile reference value for age group < 20 years was 0.10 - 0.13, 21 - 40 years was 0.10 - 0.16 and for rest of the age group is 0.11 - 0.18 [Table 6]. Difference in the Bicaudate - Temporal index changes between age groups were statistically significant (P < 0.001) [Table 7]. With advancing age increase in the index value was observed.

Huckman Number: Statistical significant difference in the mean Huckman number was found between male and female. The mean Huckman number in male was 5.09 +/- 0.76 and in female was 4.70 +/- 0.57 [Table 8]. Statistical significant difference in the mean Huckman number exists among consecutive age groups in male, female and in overall population. Increase in the Huckman value with increase in the age was noted [Table 9, 10].

Table 1: Distribution of Patients.

Age Group	Male + Female	Male	Female
≤ 20	14	12	2
21 – 40	33	13	20
41 – 60	29	14	15
≥ 60	24	15	9
Total	100	54	46

Overall Age – 45.01 ± 20.60

Table 2: Descriptive Statistics of Bicaudate index versus sex.

	Mean ± SD			P value
	Males	Females	Males+Females	
Bicaudate distance	1.68 ± 0.35	1.53 ± 0.29	1.61 ± 0.33	0.018*
Hemispheric distance	11.60 ± 0.52	11.13 ± 0.49	11.39 ± 0.56	0.000**
Bicaudate index	0.15 ± 0.03	0.14 ± 0.03	0.14 ± 0.03	0.178 NS

*Significant at 5% level, **Significant at 1% level, NS – Not Significant

Table 3: Bicaudate Index versus age group and sex.

Age group (years)	Sex	N	Mean ± SD		
			Bicaudate distance	Hemispheric distance	Bicaudate index
≤ 20	Male	12	1.35 ± 0.15	11.82 ± 0.31	0.11 ± 0.01
	Female	2	1.20 ± 0.0	11.10 ± 0.28	0.11 ± 0.00
	Male + Female	14	1.33 ± 0.15	11.71 ± 0.39	0.11 ± 0.01
21 – 40	Male	13	1.61 ± 0.27	11.77 ± 0.52	0.14 ± 0.02
	Female	20	1.41 ± 0.17	11.36 ± 0.52	0.12 ± 0.01
	Male + Female	33	1.49 ± 0.23	11.52 ± 0.55	0.13 ± 0.02
41 - 60	Male	14	1.78 ± 0.33	11.42 ± 0.64	0.16 ± 0.03
	Female	15	1.60 ± 0.34	10.91 ± 0.45	0.15 ± 0.03
	Male + Female	29	1.68 ± 0.34	11.16 ± 0.60	0.15 ± 0.03
≥ 60	Male	15	1.93 ± 0.33	11.46 ± 0.47	0.17 ± 0.03
	Female	9	1.74 ± 0.27	11.00 ± 0.36	0.16 ± 0.03
	Male + Female	24	1.86 ± 0.32	11.29 ± 0.48	0.17 ± 0.03

Table 4: Reference values of the Bicaudate Index.

Age group	10 th percentile	25 th percentile	Median	75 th percentile	90 th percentile	Mean ± standard deviation
≤ 20	0.1	0.11	0.11	0.12	0.13	0.11 ± 0.01
21 – 40	0.11	0.11	0.13	0.14	0.16	0.13 ± 0.02
41 - 60	0.11	0.11	0.13	0.14	0.16	0.15 ± 0.03
≥ 60	0.11	0.11	0.13	0.14	0.16	0.17 ± 0.03

Table 5: Descriptive Statistics of Bicaudate – Temporal Index (BTI) versus sex.

Parameter	Mean ± SD			P value
	Males	Females	Males+Females	
BTI	0.13 ± 0.03	0.13 ± 0.02	0.13 ± 0.03	0.152 NS

NS – Not Significant

Table 6: Reference values of the Bicaudate - Temporal Index.

Age group	10 th percentile	25 th percentile	Median	75 th percentile	90 th percentile	Mean ± Standard deviation
≤ 20	0.1	0.1	0.1	0.11	0.13	0.11 ± 0.01
21 – 40	0.1	0.11	0.12	0.13	0.16	0.12 ± 0.02
41 - 60	0.11	0.12	0.13	0.16	0.18	0.14 ± 0.03
≥ 60	0.11	0.13	0.16	0.16	0.18	0.15 ± 0.03

Table 7: Bicaudate temporal index (BTI) versus age group and sex.

	Age group in years				P
	≤ 20	21 – 40	41 - 60	≥ 60	
Females (n)	2	20	15	9	
BTI	0.10 ± 0.00	0.12 ± 0.01	0.14 ± 0.03	0.14 ± 0.02	0.001**
Males (n)	12	13	14	15	
BTI	0.11 ± 0.01	0.13 ± 0.02	0.14 ± 0.03	0.15 ± 0.03	0.000**
Male + Female (n)	14	33	29	24	
BTI	0.11 ± 0.01	0.12 ± 0.02	0.14 ± 0.03	0.15 ± 0.03	0.000**

**Significant at 1% level

Table 8: Descriptive Statistics of Huckman number versus sex.

Parameter	Mean ± SD			P value
	Males	Females	Males+Females	
Huckman Number	5.09 ± 0.76	4.70 ± 0.57	4.91 ± 0.70	0.006 *

*Significant at 5% level

Table 9: Reference values of the Huckman Number.

Age group	10 th percentile	25 th percentile	Median	75 th percentile	90 th percentile	Mean ± Standard deviation
≤ 20	3.45	4.05	4.2	4.8	5.05	4.31 ± 0.53
21 – 40	4.2	4.3	4.6	5	5.82	4.72 ± 0.56
41 - 60	4.3	4.5	4.8	5.65	6	5.05 ± 0.68
≥ 60	4.25	4.93	5.5	5.7	6.4	5.36 ± 0.69

Table 10: Huckman number versus age group and sex.

	Age group in years				P
	≤ 20	21 – 40	41 - 60	≥ 60	
Females (n)	2	20	15	9	
Huckman Number	3.65 ± 0.35	4.58 ± 0.48	4.82 ± 0.54	5.02 ± 0.55	0.007**
Males (n)	12	13	14	15	
Huckman Number	4.42 ± 0.48	4.95 ± 0.62	5.30 ± 0.74	5.56 ± 0.70	0.000**
Male + Female (n)	14	33	29	24	
Huckman Number	4.31 ± 0.53	4.72 ± 0.56	5.05 ± 0.68	5.36 ± 0.69	0.000**

**Significant at 1% level

DISCUSSION

Ventricular system volume is affected by various pathological conditions. An accurate assessment of the change in the ventricular system volume could be achieved by quantitative evaluation of the cerebral fluid compartments [1,2,3].

Quantitative assessment of ventricular volume is important particularly in paediatric population with hydrocephalus [4,5]. Several imaging parameters such as Frontal horn index, Occipital horn index, Fronto-occipital horn ratio (FOHR), Fronto-occipital horn index ratio, Bicaudate index, Bicaudate - temporal index and Huckman number were used for assessment of ventricular volume [6,7].

Among these indices Bicaudate index, Bicaudate - temporal index and Huckman number were the commonly used tools. Reference values for Bicaudate index, Bicaudate - temporal index and Huckman number based on age and sex was not established in Indian population.

Bicaudate index 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 [8].

Bicaudate - temporal index is defined as the minimum Bicaudate nuclei distance divided by maximum internal skull diameter [9].

Huckman Number is defined as the Sum of the maximum distance between anterior horns and minimum Bicaudate nuclei distance [10].

The value of Bicaudate index in our study was 0.14 ± 0.03 , which is similar to the study by Dupont and Rabinstein [9], Dhok et al., [10] and Park *et al.*, [12] The maximum value in our study was 0.17, which was less than the study conducted by Pelicci *et al.* [13].

In our study, there was a positive correlation between age and Bicaudate index. This observation was similar to other studies conducted by Dhok et al., [10] Dupont and Rabinstein [11]. Park *et al.* [12] and Kukuljan *et al.* [14].

Park *et al.* [12] showed that there is no difference in sex for Bicaudate index values which is similar in our study.

The mean Bicaudate - Temporal Index in our study was 0.13 ± 0.03 which is similar to the study by Kosourow et al. [9] which ranged from 0.05 to 0.13. The results in our study also showed index increases with age and the changes between the consecutive age groups were statistically significant which was similar as reported by Kosourow et al. [9].

Huckman Number is a useful parameter to evaluate the diameter of the anterior ventricular horn. The mean Huckman number in our study was 5.09 ± 0.76 in male and 4.70 ± 0.57 in female which is within the range from 3.3 cm to 5 cm as described by Kosourow et al. [9] and wilk et al. [15] Increase in the Huckman value with increase in the age was noted as observed by wilk et al. [15] Statistical significant difference in the mean Huckman number was not seen among consecutive age groups in the study by wilk et al.^[15] But our study shows statistically significant difference in the mean Huckman number among consecutive age groups.

CONCLUSION

The new reference values for Bicaudate index, Bicaudate - temporal index and Huckman number in Indian population based on age and gender was established in our study. The mean bicaudate index was 0.14 ± 0.03 and the upper limit was 0.17 ± 0.03 which was well within the declared upper limits of 0.20. The mean Bicaudate - temporal index in our study was 0.13, ranging from 0.10 to 0.18. The mean Huckman number in our study was 4.91 with range from 3.45 to 6.40.

Author Contributions

P. Sabari Arasu – Concept Design

S. Arun Kumar – Acquisition of the Data

A. Pavithra - Acquisition & interpretation of the Data

M. Vijaiand – Manuscript drafting the critical analysis of the Data & corresponding with the journal.

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Conflicts of Interests: None

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