

CT Based Study of Frontal Horn Ratio And Ventricular Index in South Indian Population

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Abstract:

Introduction: Assessment of ventricular morphology and dimensions plays a crucial role in a wide range of clinical conditions associated with ventricular enlargement such as CNS infections, meningitis, and brain tumors. Of all the ventricular dimensions, linear ratios of lateral ventricles are the simplest to enumerate and also to reproduce.

Objective: The aim of our study is to establish standard reference values for Frontal Horn Ratio (FHR) and Bicaudate - Frontal Index or Ventricular index using Computed Tomogram (CT) for normal South Indian population.

Materials And Methods: One hundred subjects, with normal CT brain, were analyzed for this study retrospectively. Plain CT brain of all the patients was performed in Siemens Somatom Scope Multislice CT scanner. Results: In our study there was no statistically significant difference in mean FHR and ventricular index between genders. Steady rise in the mean frontal horn ratio across age groups in males as well as females was observed, which was statistically significant.

Conclusion: The mean frontal horn ratio in our study was 0.31 ± 0.03 for normal South Indian population which conforms to the international guideline value. Mean ventricular index for normal South Indian population in our study was 0.48 ± 0.07 .

Keywords: Bicaudate-frontal ratio, frontal horn ratio, hydrocephalus, Ventricular index, Ventriculomegaly.

I. Introduction

The cerebral ventricular system comprises of interconnecting cavities filled with cerebrospinal fluid and are derived from the central lumen of the embryonic neural tube. The ventricular system in brain consists of two lateral ventricles, midline third and fourth ventricles which communicate via the interventricular foramen [of Monro] and aqueduct of Sylvius respectively[1].Detailed analysis of normal and abnormal morphology of cerebral ventricular system is essential for neurosurgeons and radiologists in routine clinical practice. Older techniques of ventricular assessment like pneumoencephalography and ventriculography have become obsolete and have been replaced by ultrasonography [in children][2],Computed Tomography [CT] scan and Magnetic Resonance Imaging [MRI]. CT and MRI produce cross sectional images which allow real time assessment of ventricular dimensions. Though MRI is far superior to CT, CT scores in view of its easy availability, reduced cost and faster imaging. Assessment of ventricular morphology and dimensions plays a crucial role in a wide range of clinical conditions associated with ventricular enlargement such as CNS infections, meningitis and brain tumors. Of all the methodologies adapted in measurement of ventricular dimensions, linear ratios of lateral ventricles are the simplest to enumerate and also to reproduce.

II. Aim

To establish standard reference values for Frontal Horn Ratio and Bicaudate - Frontal Index or Ventricular Index using Computed Tomogram [CT] for normal South Indian population.

III. Materials And Methods

3.1 Patient selection

CT scans of all the patients referred for Non-contrast CT brain to Department of Radiology, Karpagam Faculty of Medical Sciences and Research, between 1st June 2016 to 31st July 2016 were assessed. Only those patients whose CT were reported to be normal were included in this study. It is a retrospective study. 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 include 54 males and 46 females [TABLE 1]. Patients with intracranial and intraventricular pathology were excluded from the study.

3.2 Ventricle size measurement

Plain CT brain of all the patients was performed in Siemens Somatom Scope Multislice CT scanner, which produced axial sections at 5 mm slice thickness from skull base to the vertex. These images were then reconstructed to 2 mm slice thickness, after which they were analyzed on viewing console. Axial images of non-contrast CT brain were selected at the level of caudate nucleus head, as the lateral ventricular frontal horns are of maximum width at this level. In the selected image section, the following measurements were taken with inbuilt linear calipers. Maximum distance between the tip of frontal horns was measured [Fig. 1] followed by measurement of the inner diameter of the skull along the same line [Fig. 2]. Distance between the caudate indentations of frontal horns was measured which denoted the minimum bicaudate nuclei distance [Fig. 1]. Later, Frontal Horn Ratio [FHR] was obtained by dividing the maximum distance between the tip of frontal horns by the inner diameter of the skull at the same level. The minimum bicaudate nuclei distance was divided by the maximum distance between the tip of frontal horns to calculate Bicaudate-Frontal Index [Ventricular Index].

3.3 Statistical analysis

All measurements were expressed as mean, standard deviation and percentiles. Student's *t* test was used to estimate the difference in ventricular indices based on sex. One way analysis of variance was used to check for differences in ventricular dimensions and indices across age groups. The statistical analyses were performed using software SPSS version 23.

IV. Results

The median age of our study population was 45.01± 20.60 [TABLE1]. In our study there was no statistically significant difference in mean FHR between genders. The mean FHR in males and females was 0.31± 0.04 and 0.31± 0.03 respectively. The overall mean in the entire study population [inclusive of both males and females] was 0.31 ± 0.03. [TABLE 2]. We found that there was a steady rise in the mean Frontal Horn Ratio across age groups in males as well as females which was statistically significant. The highest mean FHR was seen in the ≥ 60 year age group in both genders [0.32 ± 0.03 in females and 0.33 ± 0.03 in males]. [TABLE 3].

Bicaudate - Frontal Index or Ventricular Index showed a mean value of 0.49 ± 0.06 among the males and a mean value of 0.48 ± 0.07 among females, with no significant difference. [TABLE 4]

The mean Ventricular Index was the highest in the ≥ 60 age group in the combined population, where the 10th percentile was 0.45 and 90th percentile was 0.63. The lowest mean Ventricular Index of 0.45 ± 0.05 was observed in the ≤ 20 age group [range of 0.40-0.55]. [TABLE 5]

The mean Ventricular Index demonstrated gradual progression with increase in age across all age groups among males and in the entire population [males and females]. Similar pattern was also observed among the females across all age groups, except in the ≤ 20 age group. [TABLE 6]

V. Discussion

The ventricles are four CSF-filled cavities located within the neuroparenchyma and consist of two lateral ventricles, third ventricle and fourth ventricle. The two lateral ventricles communicate through the interventricular foramina with the third ventricle, which is connected to the fourth ventricle by the narrow cerebral aqueduct. The fourth ventricle, in turn, is continuous with the narrow central canal of the spinal cord. The ventricles are lined throughout with ependyma and are filled with cerebrospinal fluid[3]. There are two large lateral ventricles, one in each cerebral hemisphere. The lateral ventricle is a roughly C-shaped cavity and may be divided into body, which occupies the parietal lobe and from which anterior, posterior and inferior horns extend into the frontal, occipital and temporal lobes respectively[3]. Cerebrospinal fluid [CSF] is produced within the ventricles by the choroid plexuses which is absorbed at the cranial vertex and in the spinal canal via arachnoid villi. Any disturbance of formation, flow or absorption of CSF that leads to an increase in CSF volume is defined as hydrocephalus[4]. Hydrocephalus may be congenital or it may be acquired due to various conditions including primary tumors such as primitive neuroectodermal tumors and ependymomas, meningitis, intracranial hemorrhage and trauma. Visualization of temporal horn tips [measuring ≥2 mm in width] and the symmetrical enlargement of lateral ventricles with frontal horn ratio of ≥0.50 are indicative of hydrocephalus[5]. Accurate assessment of ventricular morphology and dimensions in CT sections plays a crucial role in diagnosis and grading of hydrocephalus. Of all the methods used in assessment of ventricular dimensions such as linear, planimetric or volumetric measurements, linear ratios of ventricular width to cerebral width are the simplest to measure and to reproduce. Frontal Horn Ratio (FHR) is the ratio of maximum distance between the tips of frontal horns to internal diameter of the skull in the same line.

We found that there was no statistically significant difference in mean FHR between males and females [TABLE 2]. This confirms the findings of Poonam Patnaik et al[6], though it is in conflict with the observations made by Zilundu, that FHR value was higher in males than in females[7]. The mean FHR in our study was in the range of 0.30 to 0.32 across age groups from 21 to > 60 years. This mean value was consistent with the findings of Hahn and Rim[8], Gyldensted[9] and Haug[10]. Hahn et al.,[11] studied the Frontal Horn Ratio in 388 normal non-contrast CT scans and concluded that the mean FHR was 0.32 ± 0.04 . Though the mean FHR was slightly lower at 0.23 ± 0.03 in ≤ 20 year age group among females in our study, it could probably be attributed to the limited sample size of 2 in this age group. In our study there was a steady rise in the mean frontal horn ratio across all age groups in males, females and in the combined study population, which was statistically significant. This correlates with the findings of Doraiswamy et al., [12] that mean frontal horn ratio progresses with age. Few studies observe slight increase in mean frontal horn ratio from 4th decade, followed by a sudden fall in 6th decade and a steep rise later in 7th decade[7,13]. However, in our study, among the combined study population [inclusive of males and females] the mean FHR was static at 0.32 ± 0.03 in the 41-60 and ≥ 60 years age group with no appreciable increase. This needs to be further validated with a larger sample size.

Bicaudate-Frontal Index, otherwise known as Ventricular Index, is the ratio between minimum bicaudate nuclei distance and maximum distance between tip of frontal horns of lateral ventricles. We did not observe any significant difference in Ventricular Index between males and females. We found gradual progression in the mean Ventricular Index with increase in age across all age groups among males and in the combined population. Though females also demonstrated similar progress with increase in age in 20-40, 40-60 and ≥ 60 age groups, the mean value in ≤ 20 age group was much higher at 0.50 ± 0.08 . This could be explained by the limited sample size [Two] in this category. [TABLE 6] The mean value of ventricular index in our study population [with mean age 45 years] was in the range of 0.45 to 0.53. Renata Wilk et al.,[14] in their study conducted on paediatric population reported that the normal value of the ventricular index ranged from 0.212 in the >3–6 years group to 0.524 in the 0–12 months group.

Figures And Tables

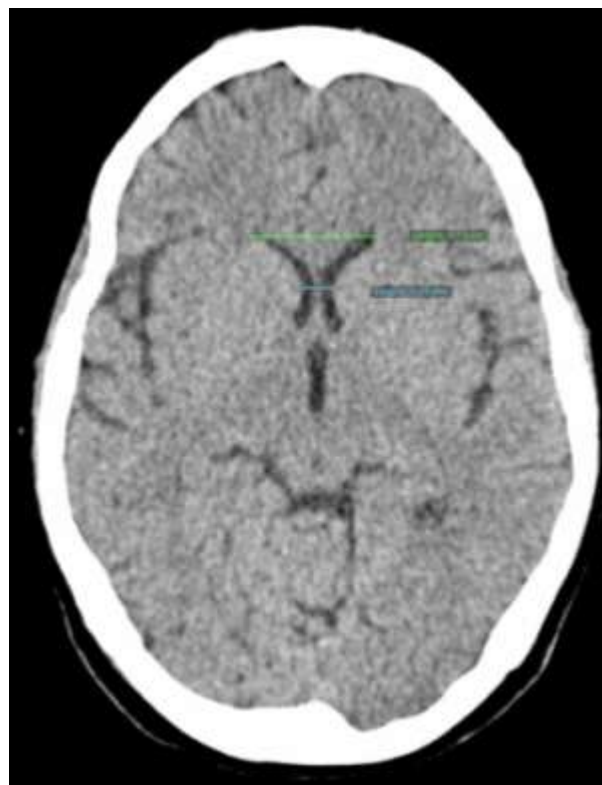


Figure 1: Axial CT image of brain shows maximum distance between the tip of frontal horns [Green line] and minimum bicaudate nuclei distance [Blue line].



Figure 2: Axial CT image of brain shows inner diameter of the skull at the level of maximum distance between the tip of frontal horns.

Table 1: Age distribution of patients

Age Group [years]	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

Mean age: 45.01 ± 20.60

Table 2: Descriptive Statistics of ventricular dimensions versus sex

	Male + Female	Male	Female	P value
A [mm]	3.3 ± 0.42	3.41 ± 0.45	3.18 ± 0.34	0.005**
B [mm]	10.79 ± 0.66	11.12 ± 0.54	10.40 ± 0.57	0.000**
FHR	0.31 ± 0.03	0.31 ± 0.04	0.31 ± 0.03	0.947

** Significant at 1% level.

A - Maximum distance between the tip of frontal horns. B - The inner diameter of the skull at the same level.

Table 3: Frontal Horn Ratio (FHR) measurements based on age groups in males and females

	Age group in years				P
	≤ 20	21 – 40	41 – 60	≥ 60	
Females (n)	2	20	15	9	
A [mm]	2.45 ± 0.35	3.17 ± 0.34	3.22 ± 0.23	3.28 ± 0.35	0.012*
B [mm]	10.60 ± 0.14	10.52 ± 0.65	10.31 ± 0.57	10.26 ± 0.44	0.579
FHR	0.23 ± 0.03	0.30 ± 0.03	0.31 ± 0.03	0.32 ± 0.03	0.001**
Males (n)	12	13	14	15	
A [mm]	3.07 ± .037	3.34 ± 0.40	3.52 ± 0.43	3.63 ± 0.42	0.006**
B [mm]	11.25 ± 0.45	11.21 ± 0.58	10.97 ± 0.61	11.09 ± 0.52	0.559
FHR	0.27 ± 0.03	0.30 ± 0.03	0.32 ± 0.04	0.33 ± 0.03	0.000**
Male + Female (n)	14	33	29	24	
A [mm]	2.98 ± 0.42	3.24 ± 0.37	3.37 ± 0.37	3.50 ± 0.42	0.001**
B [mm]	11.16 ± 0.48	10.79 ± 0.70	10.63 ± 0.67	10.78 ± 0.64	0.109
FHR	0.27 ± 0.03	0.30 ± 0.03	0.32 ± 0.03	0.32 ± 0.03	0.000**

* Significant at 5% level ** Significant at 1% level

A - Maximum distance between the tip of frontal horns. B - The inner diameter of the skull at the same level.

Table 4: Descriptive statistics of ventricular index versus sex

	Mean ± SD			P value
	Males	Females	Males+Females	
Ventricular index	0.49 ± 0.06	0.48 ± 0.07	0.48 ± 0.07	0.382 NS

*Significant at 5% level NS – Not Significant

Table 5: Reference values of ventricular index

Age group	10	25	50	75	90	Mean ± SD
≤ 20	0.40	0.41	0.43	0.48	0.55	0.45 ± 0.05
21 – 40	0.39	0.43	0.45	0.49	0.54	0.46 ± 0.05
41 – 60	0.14	0.45	0.50	0.54	0.59	0.50 ± 0.07
≥ 60	0.45	0.49	0.52	0.60	0.63	0.53 ± 0.07

10 [10th percentile], 25 [1st quartile], 50 [median], 75 [3rd quartile], 90 [90th percentile], SD – Standard deviation.

Table 6: Ventricular index measurements based on age groups in males and females

	Age group in years				P
	≤ 20	21 – 40	41 – 60	≥ 60	
Females [n]	2	20	15	9	
Ventricular index	0.50 ± 0.08	0.44 ± 0.04	0.49 ± 0.08	0.53 ± 0.07	0.007**
Males [n]	12	13	14	15	
Ventricular index	0.44 ± 0.05	0.48 ± 0.06	0.50 ± 0.05	0.53 ± 0.66	0.002**
Male + Female [n]	14	33	29	24	
Ventricular index	0.45 ± 0.05	0.46 ± 0.05	0.50 ± 0.07	0.53 ± 0.07	0.000**

**Significant at 1% level

VI. Conclusion

The mean Frontal Horn Ratio in our study was 0.31 ± 0.03 for normal South Indian population which conforms to the international guideline value. Mean Ventricular Index for normal South Indian population in our study was 0.48 ± 0.07 .

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