THE VALIDITY OF CRITERIA FOR ESTIMATING THE VENTRICULO-HEMISPHERIC RATIO OF THE BRAIN BY COMPUTERISED TOMOGRAPHY

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ABSTRACT

Computerised Tomographic scans (CT scans) of the brain of 1000 patients were examined for the various indices viz:- Evans ratio, Frontal-horn index, Bi-caudate index and the Cella-media index used in determining the Ventriculo-hemispheric ratio of the brain and it was observed that Evans ratio was 0.27 $\pm$ 0.04 in males and 0.26 $\pm$ 0.03 in females; Frontal-horn index was 0.33 $\pm$ 0.04 in both males and females; Bi-caudate index was 0.13 $\pm$ 0.04 in males and 0.11 $\pm$ 0.02 in females; Cella-media index was 0.18 $\pm$ 0.04 in males and 0.17 $\pm$ 0.03 in females.This study was conducted to determine the Ventriculo-hemispheric ratio of the brain in humans, utilising Evans ratio, Frontal-horn index, Bi-caudate index, and the Cella-media index in its clinical application.

Keywords: Ventriculo-hemispheric ratio, Evans ratio, Frontal-horn index, Bi-caudate index, Cella-media index.

INTRODUCTION

The all important brain is the executive director of the Central Nervous System and is like a vast unexplored continent, with little more known than the rough outlines of the shore. Bullock (1993) and Satz (1993) both defined the 'Brain reserve hypothesis' wherein size did relate to complexity and redundancy, and was a protective factor against ageing, injury and disease [1,2].

No organ including the brain escapes from senile degeneration and hence it undergoes many gross and histopathological changes with advancing age [3]. Burns (1958) stated that "Everyday of our adult life more than 100,000 neurons die"[4].

Earlier studies reveal an increase in the CSF spaces in dementia, especially in Alzheimer's disease and Parkinson's disease [5,6,7]. According to Corsellis (1976) and Creasy and Rapoport (1985) this was due to reduction in the size of the nerve cells. Ventricular enlargement is reported to be a more sensitive indicator of cortical atrophy due to increasing age and dementias [9]. Previous studies also show larger lateral ventricles in epilepsy and depression [10,11].

An earlier report by Haaga et al (1994) revealed that a variable amount of cerebral atrophy occurred as part of the normal ageing process and ventricular dilatation was a part of these changes due to surrounding cerebral atrophy [9]. Quantifying changes in the human brain that occur as part of normal ageing may help in the diagnosis of diseases that affect the elderly, which cause structural changes in the brain. A prior study by D'Souza e Dias and Natekar (2007) defined the morphometric measurements of all the ventricles of the brain i.e. the fourth ventricle, third ventricle and lateral ventricles and reported larger brain ventricles in males as compared to females [12].

The aim of this study is to determine the Ventriculo-hemispheric ratio of the brain using Evans ratio, Frontal-horn index, Bi-caudate index and Cella-media index, and to find any relationship with gender and with patients clinically diagnosed as suffering from Schizophrenia, Epilepsy, Demetia, Alzheimer's disease (SDAT) (Senile Dementia of Alzheimer's Type), Hydrocephalus, Headache and Dizziness, so as to contribute additional information to our existing knowledge, to avoid pitfalls in their diagnosis and also while planning surgical intervention.

MATERIALS AND METHODS

This study was carried out on 1000 patients (500 males and 500 females) in the age group of 30 to 50 years, attending the department of Radiology, at Goa

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Medical College, Bambolim, Goa. The cases were selected from the Goan population which comprised around 60% Hindus, 26% Christians and 14% Muslims. These patients were selected randomly and had no history of cerebral infarction, local mass lesions, probable communicating hydrocephalus, alcoholism, drug abuse, trauma or previous intra-cranial surgery and other hereditary diseases and were not on medication at the time of this study.

CT scans of all patients were reported by individual radiologist scoring, as normal. The CT scanner used in this study was the Siemens Somatom A. R. C. having a fan beam scanner with a scan time of 1 to 10 seconds. The density of Cerebrospinal fluid was 10 Hounsfield units (HU); that of the white matter was 35 45 HU and that of the grey matter was 55 65 HU. The matrix was 256 x 256 with a slice thickness of 10 mm [13]. The patient was placed on the CT table and the head was centralized and supported for correct alignment and to reduce blurring of images. A lateral image was taken to confirm correct position of patient. Canthomeatal line was drawn and a line at an angle of 15 20 degrees to and 1 cm above it was drawn, representing the lowest tomographic section, which passed through the base of skull. A total of 8 to 10 sections were obtained without any overlap [9].

The measurements were taken as follows:-

Fig. 1. Level of the inter-ventricular foramen :-

A)Bi-frontal distance in cms (a- b).

B) Internal diameter of skull vault at the level of the bi-frontal distance in cms (c-d).

C) Bi-caudate distance in cms (e -f).

D) Internal diameter of skull vault at the same level as bi-caudate distance in cms (g-h).

E) Greatest internal diameter of the skull vault in cms (i- j).

Fig. 2. Level of the lateral ventricular body :-

F) Width of the narrowest part of the bodies of the lateral ventricles in cms (k -l).

G) Internal diameter of skull vault at the level of the lateral ventricular body in cms (m-n).

From the above measurements taken, the following is the list of Indices deduced:-

1. **Evans ratio** = Width of the frontal horns / greatest internal diameter of skull vault [14].

2. **Frontal Horn index** = Width of the frontal horns / internal diameter of the skull vault at the same level [15].

3. **Bi-caudate index** = Width of the ventricles between the caudate nuclei / internal diameter of the skull vault at the same level [16,17,18].

4. **Cella-media index** = Width of the narrowest part of the bodies of the lateral ventricles in cella media region / internal diameter of the skull vault at the same level[19,20,21].Statistical analysis of the data was performed by using the SPSS Software package version 7.0[22]. the Mean and Standard Deviation (SD) of all measurements was estimated and 95% Confidence Intervals (CI) both Upper and Lower were calculated for all. The data was also analysed by using the Z-test for significance of difference of the measurements between males and females.

The aim of this present study is to determine the Ventriculo-hemispheric ratio of the brain using Evans ratio, Frontal-horn index, Bi-caudate index and Cella-media index, and to find any relationship with gender and with patients clinically diagnosed as suffering from Schizophrenia, Epilepsy, Dementia, Alzheimer's disease (SDAT) (Senile Dementia of Alzheimer's Type), Headache and Dizziness, so as to contribute additional information to our existing knowledge to avoid pitfalls in their diagnosis and also while planning surgical intervention.

OBSERVATIONS AND RESULTS

Fig.1shows the measurements taken to estimate Evans ratio. When calculated it showed a higher value in males (0.27 $\pm$ 0.04, 95% CI 0.20 -0.24) as compared to females (0.26 $\pm$ 0.03, 95% CI 0.20 0.33) , and this difference was statistically significant (z = > 1.96) (Table no. I).

Fig. 1 also shows measurements taken to estimate the Frontal-horn index. This index in males (0.33 $\pm$ 0.04, 95% CI 0.25 0.42) and females (0.33 $\pm$ 0.04, 95% CI 0.24 0.41) showed no significant difference in the mean values between them (Table no. II).

Table no. I. Evans ratio = Width of frontal horns / greatest internal diameter of skull vault.

Parameters	Evens (1942)	Gawler et al al (1975)	Jacoby et al (1980)	Banes et al (1982)	Present study Males N= 500	Present Study Females N= 500
Mean	<0.29	<0.29	0.310	0.24	0.27*	0.26*
SD	–	–	±0.04	±0.04	±0.04	±0.03
CI (L)	–	–	0.219		0.20	0.20
CI (U)	–	–	0.395 (range)	–	0.34	0.33

***Z = > 1.96 = significant**

Table no. II. Frontal horn index = Width of the frontal horns / internal diameter of the skull vault at the same level.

Parameters	Hahn and Rim (1972)	Brinkman et al (1981)	Soininen et al (1982)	Cala et al (1981)		Present Study	
				Males n = 62	Females n = 53	Males n = 500	Females n = 500
Mean	0.31	0.368	0.32	0.33	0.31	0.33	0.33
SD	–	±0.045	±0.04	±0.06	+0.08	±0.04	±0.04
CI (L)	0.19	–	–	–	–	0.25	0.24
CI (U)	0.39 (range)	–	–	–	–	0.42	0.41

Table no. III. Bicaudate index = Width of the ventricles between the caudate nuclei / internal diameter of the skull vault at the same level.

Parameters	Banna (1977)	Barretal (1978)	Brinkman et al (1981)	Present Study Males n = 500	Present Study Females n = 500
Mean	≤ 0.15	0.092	0.179	0.13*	0.11
SD	–	±0.003	±0.004	±0.04	+0.02
CI (L)	–	–	–	0.06	0.06
CI (U)	–	–	–	0.21	0.15

***Z = > 1.96 = significant**

Table no. IV. Cella media index = Width of the narrowest part of the bodies of the lateral ventricles in cella media region / internal diameter of the skull vault at the same level

Parameters	Haug (1977)	Benes et al (1982)	Soininen et al (1982)	Present Study Males n = 500	Present Study Females n = 500
Mean	0.295	0.19	0.23	0.18*	0.17*
SD	–	±0.03	±0.03	±0.04	±0.03
CI (L)	–	–	–	0.10	0.10
CI (U)	–	–	–	0.26	0.24

*z = > 1.96 = significant

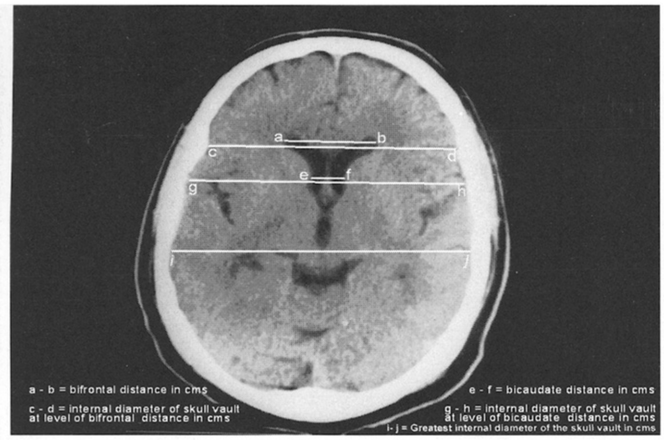

Fig. 1. Level of the inter-ventricular foramen :-

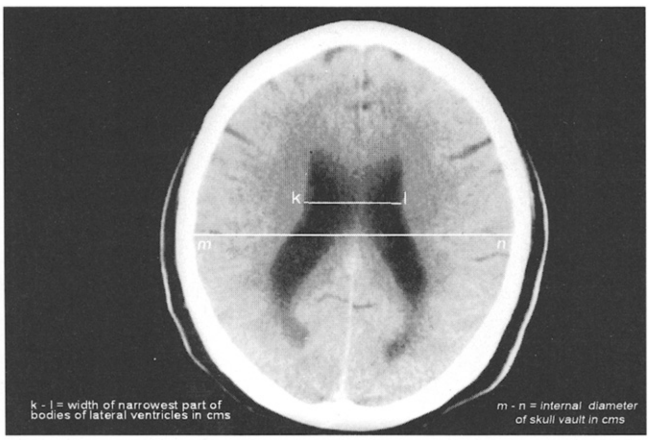

Fig. 2. Level of the lateral ventricular body :-

Fig. 1 also shows the measurements taken to estimate the Bi-caudate index. This index showed higher values in males (0.13 ± 0.04, 95% CI 0.06 - 0.21) as compared to females (0.11 ± 0.02, 95% CI 0.06 - 0.15), with the difference being statistically significant (z = > 1.96) (Table no. III).

Fig. 2 shows the measurements taken to estimate the Cella-media index. This index was seen to be greater in males (0.18 ± 0.04, 95% CI 0.10-0.26) as compared to females (0.17 ± 0.03, 95% CI 0.10-0.24), with the difference being statistically significant (z = > 1.96) (Table no. IV).

DISCUSSION

The human nervous system is the most complex, widely investigated and yet poorly understood physical system known to mankind [23]. Studies by various neuroradiologists revealed that brain regression involving both the cerebrum and the cerebellum usually began by the seventh decade and thereafter accelerated with advancing age [24,25,26,27]

Alterations of the brain with ageing have been the focus of many investigations, according to which modern computerised X-ray tomography allows an easy and safe non-invasive study of the ventricular system without complications, so unlike the Pneumoencephalogram it can be used as a screening procedure for many illnesses [28,29,30,31,32]. Roberts et al (1978) pointed out its value in evaluating dementia and its use in excluding brain diseases that mimic dementia of the Alzheimers type such as neoplasms, subdural hematomas and cerebrovascular disease [33].

A variability in the ventricular size of the brain seen in clinical practice allows most clinicians to make decisions concerning the ventricular size without an exact measure, however there are a number of circumstances where precise measurements would be beneficial.

Evans (1942) was the first to generate a linear ratio named after him and determined it to be ≤ 0.29 in normal individuals, even above the age of 60 years [14]. Gawler et al (1975) determined Evans ratio as ≤ 0.29 = normal, 0.30 = borderline and 0.31 = enlarged [34]. Jacoby et al (1980) showed Evans ratio to range from 0.219 0.395 with a mean value of 0.310 ± 0.04, and Benes et al (1982) found Evans ratio to be 0.24 ± 0.04; however, in our study we found lower values of 0.27 ± 0.04 and 0.26 ± 0.03 in males and females respectively[35,20].

Hahn and Rim (1977) were the first to describe the Frontal-horn ratio finding a range of 0.19-0.39, with a mean value of 0.31 [36]. Brinkman et al (1981) and Soininen et al (1982) found Frontal-horn index as 0.368 ± 0.045 and 0.32 ± 0.04 respectively [18,21]. Although Cala et al (1981) estimated the mean Frontal-horn index as 0.33 ± 0.06 and 0.31 ±0.08 in males and females respectively, in our study we found the Frontal-horn index to be 0.33 ± 0.04 in both sexes [37].

Bana et al (1977) and Barr et al (1978) in their studies, estimated the mean of Bi-caudate ratio to be ≤ 0.15 and 0.092 ± 0.003 respectively [16,17]. Brinkman et al (1981) found values of 0.179 ± 0.004 and 0.180 ± 0.039 in normal patients and patients with dementia respectively [18]. In our study we found lower values of 0.13 ± 0.04 and 0.11 ± 0.02 in males and females respectively.

Haug et al (1977) and Benes et al (1982) estimated the mean Cella-media index as 0.295 and 0.19 ± 0.03 respectively [19,20]. Soininen et al (1982) found values of 0.23 ± 0.03 and 0.32 ± 0.05 in normal patients and patients with Alzheimers disease respectively [21]. In our study we found lower values of 0.18 ± 0.04 and 0.17 ± 0.03 in males and females respectively.

In an earlier morphometric study D'Souza e Dias and Natekar (2007) it was observed that the width and the height of the fourth ventricle were 1.31 ± 0.23 cms and 1.18 ± 0.27 cms in males and 1.21 ± 0.22 cms and 1.11 ± 0.24 cms in females respectively; the width of the third ventricle was 0.45 ± 0.29 cms and 0.39 ± 0.17 cms in males and females respectively; the antero-posterior extent of the lateral ventricles (inclusive of their frontal horns) on the right side was 6.96 ± 0.76 cms and 6.57 ± 0.75 cms in males and in females and on the left side was 7.09 ± 0.78 cms and 6.73 ± 0.77 cms in males and in females; the antero-posterior extent of the frontal horns on the right side was 2.74 ± 0.36 cms and 2.55 ± 0.33 cms in males and females and and on the left side was 2.78 ± 0.37 cms and 2.58 ± 0.35 cms in males and females respectively [12].

In conclusion, the linear ratios so specified in this study i.e. Evans ratio, Frontal-horn index, Bi-caudate index and Cella-media index, would definitely be a very essential aid to an investigating radiologist and would also obliterate the need for subjective estimation of brain atrophy, or an increase in the size of the ventricles of the brain. This would finally eradicate the uncertainty of ventricular size of brain obtained in individual-to-individual radiologist scoring of cortical atrophy, which happens to be of qualitative nature. The ratios can be estimated on a single CT scan section, hence simplifying the procedure of evaluating the ventricles of the brain, when used along with qualitative scoring of the scan. This collaboration of qualitative and quantitative estimations would essentially be more accurate than only a qualitative scoring.

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