IJHSR International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

Original Research Article

Age and Gender Related Variations in Lateral Ventricle Brain Ratios

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Received: 20/03/2016 *Revised: 19/04/2016* *Accepted: 19/04/2016*

ABSTRACT

Aim and Objective: To find the variation of lateral ventricle brain ratios, namely, frontal horn ratio, bicaudate ratio, and Evan's ratio with respect to gender and age and discuss their clinical relevance.
Material and method: Head CT images collected from department of radiology and imaging, G.B. Pant Hospital, of 120 patients, with age range 5-75 years (64 males, mean age 34.3+/-16.4 yrs. and 56 females, mean age 38.1+/-14.08 yrs.) were analysed by dicom image software for morphometric measurements after taking the institutional ethical committee clearance. Mean and standard deviation were calculated for each parameter. Lilliefors test was used to check normality of data. Independent sample t-test was used to find difference in males and female for bicaudate ratio (BCR) and Evan's ratio(ER). Mann-Whitney U test was applied for frontal horn ratio (FHR) in two tailed analysis. Significance level was taken as 0.05. Regression analysis was applied to find correlation with age.
Results: Mean FHR was 0.30 with higher variation in females, difference being statistically nonsignificant ($p > 0.05$). BCR and ER showed significant difference between two genders, values being higher in males. Regression correlation coefficient for FHR, BCR and ER with age was -0.093, 0.420 and 0.2164 respectively.
Conclusions: FHR does not change with age and is same in males and females. BCR moderately increases with age and is slightly higher in males whereas Evan's Ratio shows mild nonsignificant correlation with age and is higher in males.

***Key words**:* lateral ventricle brain ratio, bi-caudate ratio, Evan's ratio, Frontal horn ratio.

INTRODUCTION

Striking normal variations exist across individuals in the brain which have complicated the goals of developing standardized representations of human neuroanatomy. A common coordinate system is required to express the quantitative variability of features from different individuals (Evans et al., 1996). [(1)] Ventricles of the brain constitute about 2% volume of the total brain volume. Lateral ventricles, the cavities of cerebral hemisphere, contribute about 82% of total ventricular system. [(2)] Though modern whole brain imaging have facilitated detailed information on the anatomical structure of individual brains, computed tomography remains the most easily available, affordable, accessible and fast mode of brain imaging in Indian scenario. A well defined reference system able to represent and classify age-related, gender related or developmental changes in anatomy of brain ventricles should facilitate diagnosis of variations in the pathologic cases.

Lateral ventricles are enlarged in a wide variety of diseases such as hydrocephalus either primary or secondary to trauma, meningitis, tumors etc, neurodegenerative diseases like schizophrenia, Alzheimer's disease or neuropathies secondary to alcoholism and type 2 diabetes mellitus. [3-6]

Morphometric study of lateral ventricles is done by estimating ventricle brain ratio such as frontal horn ratio, bicaudate ratio and Evan's ratio and many others. In the past some authors have reported age related enlargement in brain ventricle volumes and in linear parameters of lateral ventricles taking a small no. of subjects. [7,8] We extend our study to find the strength of correlation of linear lateral ventricle brain ratios to age, as a part of PhD thesis work of first author under the supervision of second, third and fourth authors.

Some authors have reported linear dimensions of ventricles to be higher in males than in females, but not many studies are available on ventricle brain ratios in relation to age and gender.

We aim to describe the range of lateral ventricle brain ratios in both genders and find the correlation with age if any.

MATERIALS AND METHODS

The study group was drawn from patients reporting to the Department of Radiology and Imaging, SMC & H, and G.B Pant Hospital, for head CT examination for various indications during Feb 2014 to Jan 2015. Institutional ethical committee clearance was duly obtained and the study was conducted in Department of Anatomy, Santosh Medical College and Hospital in collaboration with Jamia Millia Islamia, Central University at Delhi.

120 virtually normal head CT scans without changes (as reported by Radiologists) were collected on DVD. Patients of both sex with mean age 35.4+/-15.02 and age group 5-75 years were included in the study. CT scans showing gross pathological changes affecting the normal anatomy of ventricles (e.g. due to large metastasis etc.) were excluded from the study group.

Methodology: All CT scans were taken by trained and experienced radiographer in standardized condition and manner. CT study of brain was done in axial transverse scanning on the multi slice CT scanner. The scans were obtained on a plane at an angle of 15 degree to and 1 cm above the infra-orbitomeatal line. All other technical parameters of the scans were as per the established standards with slice thickness of 8 mm. CT scans were selected out of the routinely done investigations. No extra scans were indicated for the purpose of study, to avoid unnecessary radiation exposure. The linear measurements were taken in CT images with the help of Dicom Image Software. The parameters, namely, Frontal horn ratio (FHR), bicaudate ratio (BCR) and Evans' Ratio (ER) were calculated and analyzed as described previously (Patnaik P). [9]

Image selection: Axial images of non-contrast head CT were selected at the level of head of caudate nucleus, where frontal horns of lateral ventricle are widest.

Statistics

Mean standard deviation and 95% confidence limits were calculated for each parameter using descriptive statistics. Lilliefors test was used to check normality of data. Independent sample t-test was applied to find difference in males and female for bicaudate ratio and Evan's ratio. Mann-Whitney U test applied for FHR in two tailed analysis. Significance level was taken as 0.05. Regression analysis was applied to find correlation with age.

RESULTS

The data for BCR and ER showed normal distribution by Lilliefors test. Results of parameters of 64 males (mean age 34.3 +/-16.4 yrs) and 56 females (mean age 38.1+/-14.1 yrs) were as per table I.

Table I: Descriptive statistics of all the three parameters

Parameter	Total Mean+/s.d	Male n=64	Female n=56	T value M vs F	P value two tailed	df	95% Confidence limits
FHR	0.30+/-0.041	0.30+/0.029	0.30+/-0.05	Z= 0.6964	0.48 NS	85.66	0.294 to 0.308
BCR	0.12+/-0.03	0.13+/-0.03	0.11+/-0.03	3.6434	0.0004 S	115.89	0.1151 to 0.1261
ER	0.27+/-0.035	0.28+/-0.04	0.26+/-0.03	3.1208	0.0023 S	115.40	0.264 to 0.276
M:Male, F: Female, df: degree of freedom, S: Significant, NS: Nonsignificant							

Since the data of FHR was not normally distributed, we applied non-parametric test for it.

Mann Whitney U test applied to FHR showed statistically nonsignificant difference in FHR values in males and females. (p=0.48).

Results of regression analysis with age were as per table II.

Table II: Results of regression analysis of lateral ventricle brain ratios with age

	FHR	BCR	ER
Multiple R	0.093	0.420	0.2164
R square	0.0087	0.1767	0.0468
P value	0.476	0.0008*	0.096
t- stat	0.77	3.52	1.68
*Significant relationship			

DISCUSSION

Frontal horn ratio (FHR), interpreted as the maximum distance between apical margins of frontal horns is normally one third of the width of brain as reported by some authors. [10-12] We found the values of frontal horn ratio to be 0.30. The finding is consistent with the widely reported ventricular brain ratio for FHR.

In our study the average of FHR was same in males, females separately and taken together. However the variation was more in females than in males. There was no statistically significant difference in values of FHR in males and females. However Zlindu, [13] reported FHR values higher in males than in females.

Regression analysis with age showed negative non significant correlation. Increase in the frontal horn distance in the absence of increase in brain width with advancing age, explains the negative correlation with age. Residual plot shows clumping of residuals along a straight line (Fig 2b). It does not depend upon age significantly (p>0.05). Frontal horn ratio is a linear ratio, with no unit, so the influence of variation in the size of ventricle due to anthropometric difference in normal individual is minimized. [10] Literature reports slight progression from 4th decade onward, sharp fall in 6th decade and rapid rise in 7th decade. [10,13]

Bicaudate ratio (BCR), the ratio of minimum intercaudate distance to brain diameter in the same line, is a fairly good measure of caudate atrophy. It is increased in patients with Huntington's chorea, cerebral atrophy or in multiple sclerosis. In our study on apparently normal patients, it was found to be 0.12+/-0.03. The maximum value was 0.21. Our findings are in accordance to those of Pellici, [14] who declared the upper limit of bi-caudate ratio as 0.20. Aylward EH et al (1991) [15] reported BCR to be 0.09+/- 0.02 in 24 normal controls. The difference could be because of relatively small sample size or the used investigational modality (MRI by them).

The increase in BCR is caused by widening of inter-caudate distance but is not significantly related to caudate volume. BCR may be closely related to frontal horn ventricular enlargement due to atrophy of deep frontal subcortical white matter. Increased BCR in patients with MS represents caudate nuclei moving apart due to adjacent white matter atrophy and ventricular enlargement. [16] Atrophy of white matter axonal tracts in the frontal subcortical and periventricular region, including those connecting the caudate nucleus probably explains association between increased BCR and cognitive dysfunction. Frontal subcortical circuits are known to play a role in informational processing speed which forms the basis for cognitive tests. Likewise disruption of dorsolateral pre-frontal circuits occurs in diseases affecting caudate nuclei including stroke, Huntington's disease and neuroacanthocytosis. [16] Interruption of this pathway causes deficiency in retrieval and verbal fluency. Thus BCR, an easily obtained measure of subcortical atrophy, explains cognitive dysfunction in patients with multiple sclerosis.

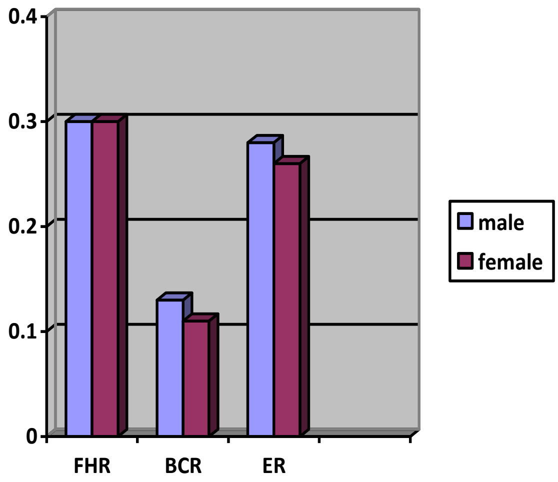

Figure 1: The mean of three parameters showing difference with gender.

Our study showed BCR significantly higher (Fig 1) in males than in females (p=0.0004).

Recently there have been studies using more advanced techniques such as voxel based morphometry reporting gender-specific neural basis of reasoning ability. Dorsolateral prefrontal cortex is associated with visuospatial ability; inferior frontal cortex is related to verbal reasoning ability whereas medial frontal cortex is engaged in information binding. [17] Males rely more upon visuospatial ability and females more on verbal processing and information binding ability to achieve the same level of overall reasoning performance. [17] The difference in the regional volumes in parts of frontal cortex in male and females could explain the gender difference in bi-caudate ratio.

According to our study BCR showed moderate positive correlation with age which was statistically significant (table II). Regression equation for BCR with age was y'=0.090+0.00083x and the residual plot showed no definite pattern. So the regression model for BCR appears a good fit. Taken together all the three parameters, BCR showed maximum correlation with age. Robert A Bermal et al [16] showed that BCR is positively correlated with age (r=0.33, p=0.02). Doraiswamy et al [18] in 1995 had also reported positive correlation of BCR with age in normal volunteers without any neurological disorders. Our finding for age correlation is consistent with the reported literature.

Evan's ratio is a quantitative criterion which is used extensively for assessing ventricular enlargement, which can be associated with normal ageing, neurodegenerative diseases, tumors, trauma and hydrocephalus of varying etiology including tubercular meningitis or idiopathic normal pressure hydrocephalus.

In our study, the mean Evan's ratio in total population studied was within the limits as given by Gawler and synek (0.29 or lower.). [19,20] Ahmed Umdagas (2015) [21] reported ER to be 0.252+/-0.04 in adult Nigerian population with mean age 37.26 yrs. Difference could be because of dominance of middle age subjects and racial differences in skull size. The international guideline for diagnostic cut off value for hydrocephalus is ER > 0.30. (Toma AK). [22] Besides ER is also of good predictive index in follow up of post traumatic ventriculomegaly patients and to see the correlation with visual function in children with hydrocephalus. [23,24] Linear measurements of ventricles taken with the help of ER and others are more reliable than volumetric ratios for hydrocephalus developed in tubercular meningitis patients. [25]

In our study, Evan's ratio was more in males than in females with statistically significant difference (p<0.05). The findings agree with those of Haug, [26] who reported a smaller ventricular system in females than in males in individuals above 15 yrs. Recently Ahmed Umdagas et al (2015) [21] in the CT based study reported ER higher in males than in females , the difference being statistically non significant (p=0.08).

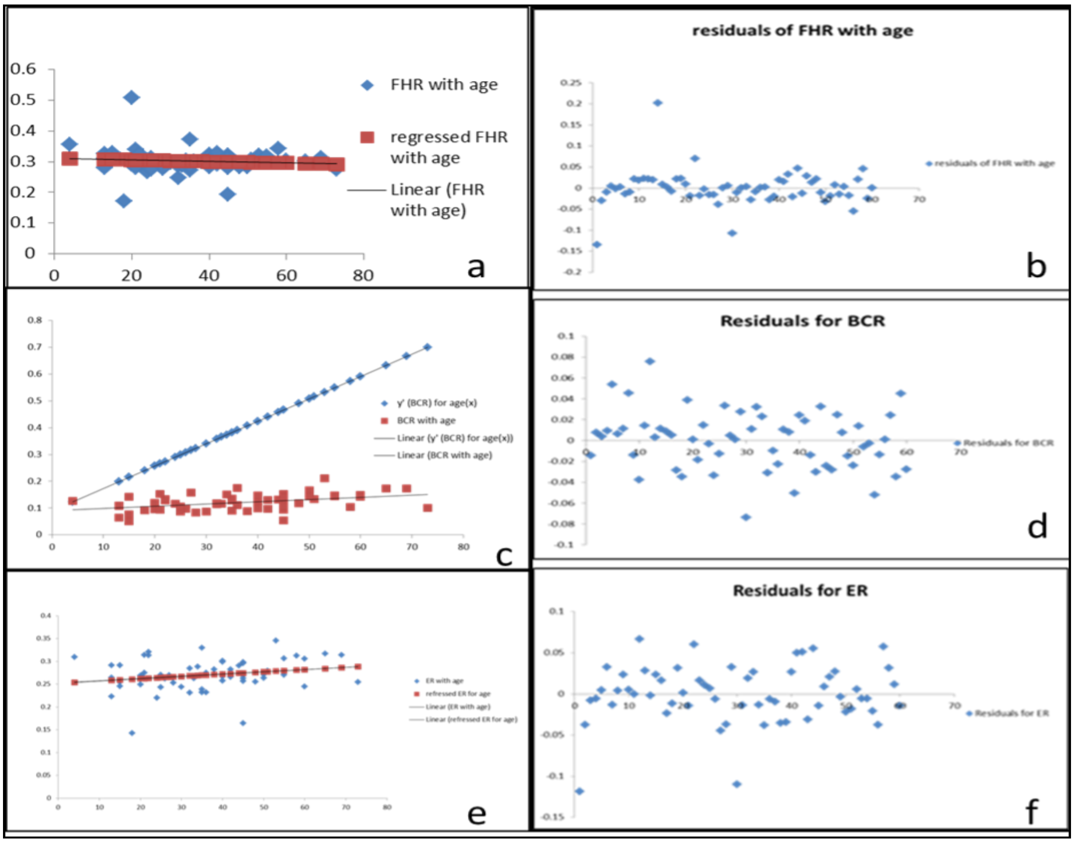

Figure 2: (a) regression equation for FHR: Y'=0.310- 0.00025 x ; (b) residuals of FHR clustered around neutral line; (c) regression equation for BCR: y'= 0.090+ 0.00083 x ; (e) regression equation for ER : y' = 0.252 + 0.000496 x ; (d, f) residuals for BCR and ER show no obvious pattern i.e. they are good fit to linear regression model.

With advancing age, as the brain shrinks, there is a compensatory increase in amount of CSF thus leading to ventricular enlargement and an increase in Evan's ratio, as reported by many authors. [27,28] We found that ER increases with age, however the correlation being mild and non significant ($r=0.216$, $p=0.096$). Residual plots of ER shows no obvious pattern of any kind, so the linear fit looks okay. (Fig 2f)

Evan's ratio is also increased in Idiopathic normal pressure hydrocephalus, which is a syndrome of ventriculomegaly, gait impairment, incontinence and cognitive impairment seen in elderly. Average lateral ventricle volume was significantly larger in NPH patients as compared to Alzheimer disease patients and vascular dementia patients as reported by Chaarani Bedar et al. [29] In this age group to differentiate the enlargement of ventricles from brain atrophy, evidence based expert analysis is required which can be done by taking into consideration the effect on many indices including cortical sulci, temporal horns of ventricles, etc. More research is needed with the help of biomarkers in CSF, SPECT and perfusion emission tomography with amyloid tracers and direct volumetric assessment using diffusivity histogram analysis as an adjunct to sensitive and specific imaging parameters to differentiate the ventriculomegaly because of different pathophysiology especially in elderly.

CONCLUSIONS

Our study has described the lateral ventricle brain ratios with respect to gender and age. FHR decreases only very mildly with age and is same in males and females. BCR and ER are more in males. BCR moderately increases with age whereas Evan's Ratio shows mild correlation with age. Taking all the measurements in baseline preliminary CT in routine normal appearing reports might help the neurosurgeons and radiologists to compare the follow up findings in cases with lateral ventriculomegaly.

ACKNOWLEDGEMENTS

The authors acknowledge the invaluable support of the technical staff of department of radiology and imaging, G.B. Pant Hospital, Delhi for data collection and technical assistance.

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How to cite this article: Patnaik P, Singh V, Singh D et al. Age and gender related variations in lateral ventricle brain ratios. Int J Health Sci Res. 2016; 6(5):78-84.

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