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

Original Research Article

Morphometric Study of Fourth Ventricle Indices by Computed Tomography

Poonam Patnaik[1], Satbir Singh[2], Dalvinder Singh[1], Vishram Singh[3]

[1]Assistant Professor Anatomy, Jamia Millia Islamia, New Delhi.
[2]Director Professor, Department of Radiology and Imaging, G.B.Pant Hospital, New Delhi.
[3]Professor and Head Anatomy, Santosh Medical College, Ghaziabad, U.P.

Corresponding Author: Poonam Patnaik

Received: 23/06/2016 *Revised: 13/07/2016* *Accepted: 13/07/2016*

ABSTRACT

Aim: The present study aimed to find range of fourth ventricle indices, their variation with age and gender and to correlate these indices with the cerebrum dimensions in apparently normal patients.
Material And Methods: With the Institutional ethical committee clearance, soft copies of head CT scans of hundred patients (50 males, mean age 33.77+/-15.06 yrs; and 50 females, mean age 36.22 +/- 11.4 yrs) were subjected to morphometric analysis of fourth ventricle's length (AP-4) and width (W-4) using dicom image software. Mean, standard deviation, ranges and 95% confidence intervals were calculated. Two sample independent student t -test, Pearson's correlation coefficient and Regression analysis were applied to find the gender variation, correlation with diameters of cerebrum and correlation with age respectively at 0.05 significance level.
Results : Mean AP-4 was 7.24 +/- 2.18 mm with 95% CI being 6.81 to 7.67 mm. Mean W-4 was 13.70+/- 2.26 mm with 95% CI being 13.25 to 15.15 mm. Length showed non-significant correlation with AP (r=0.087, p=0.54) and with TD (R=0.18, P=0.21). Width showed negative correlation with anteroposterior diameter (r= -0.08, p=0.54) but positive correlation with transverse diameter of cerebrum (r=0.25, p= 0.08). Length showed almost nil correlation with age whereas width showed negative correlation with age (t stat = -1.68, p = 0.09).
Conclusion: Diameters of cerebrum and 4th ventricle width were significantly higher in males. 4th ventricle width showed maximum correlation with transverse diameter of cerebrum. 4th ventricle length does not depend upon age but width decreases with age.

Key words: 4th ventricle indices, AP-4, W-4, cerebrum diameters.

INTRODUCTION

Fourth ventricle of brain, a rhomboid shaped small cavity containing cerebrospinal fluid, communicates anterosuperiorly with third ventricle through narrow cerebral aqueduct, inferiorly with central canal of spinal cord and superolaterally with subarachnoid space through foramen of Luschka and Magendie in its roof. [1] It is present in posterior cranial fossa between the pons and medulla ventrally and cerebellum dorsally, thus it becomes difficult to visualize during routine head CT study. Its dimensions may change with intracranial hypertension, psychiatric alterations, hydrocephalus, epilepsy, meningoencephalitis, migraine, spinal cord injuries and neurocysticercosis. [2] Further, it is important to distinguish between obstructive and communicating hydrocephalus since in acute obstructive hydrocephalus, external ventricular drainage remains the treatment of choice whereas patients with communicating hydrocephalus

can be managed by lumbar puncture alone which is less risky. Size of ventricles in such cases may be of some help to come to a conclusion.

In past some researchers have reported width of fourth ventricle to be greater than its height, and both width and height being higher in males than in females. [3-5] Though the width is always measured in axial views, there has been confusion about its length and height. Relatively few authors have reported the age changes [5,6] in the dimensions of 4th ventricle and its correlation to skull size. In this study we have correlated the fourth ventricle length and width with the linear dimensions of cranial cavity between the inner tables, which can be taken as equal to anteroposterior and transverse diameter of cerebrum in normal brain CT for all practical purposes. In literature none of the study is available where these parameters are correlated to cerebrum size. This paper aimed to provide data on strength of relationship of fourth ventricle indices to linear dimensions of cerebrum or cranial cavity in apparently normal head CT scans as part of the PhD thesis work of first author under the supervision of second, third and fourth authors.

MATERIALS AND METHODS

The study group was drawn from patients reporting to the department of Radiology and Imaging, G. B. Pant Hospital, New Delhi for a head CT examination for various indications between January 2014 and August 2015. The study was conducted in the department of Anatomy, Santosh Medical College and Hospital, Ghaziabad in Collaboration of Jamia Millia Islamia, Central University, Delhi.

Study Design: It was a retrospective, cross-sectional, non interventional study.

Sampling: Soft copies of virtually normal head CT scans of total one hundred patients were selected for the measurements for the purpose of this work. Fifty patients were males and fifty were females.

Inclusion criteria: The patients of both sex and age group from 2 year to 60 years, with virtually normal head CT scan were included in the study .Only unenhanced CT scans taken by a trained and experienced radiographer, in a standardized condition and manner. Only CT scans interpreted by experienced radiologist were included in this study.

Exclusion criteria: 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.

Ethical considerations: Before starting the work on the project, study protocol was submitted to the institutional ethical committee of Santosh Medical College and Hospital and the approval was taken for the same.

CT study: All patients had undergone axial transverse scanning of the brain performed on available multi slice CT scanner. The scans were obtained on a plane at an angle of 15 degree to and 1cm above the infra-orbitomeatal line. All other technical parameters of the scans were as per the established standards. (e.g. time in ms, potential in k v, current in m A) and slice thickness of 8 mm. Images for the study were selected out of the routinely done investigations. No extra scans were indicated for the purpose of this study to avoid unnecessary radiation exposure.

Image selection: For the present study two images were selected for each patient.

1. Axial view at the level of head of caudate nucleus (Fig. 1): In this view, anteroposterior diameter of cerebrum (AP) was measured, as the maximum distance between the inner tables of skull in midline. The transverse diameter (TD) was measured at the midpoint of AP.
2. Axial view for 4th ventricle measurements (Fig. 2): The view was selected in which pons, cerebellum, petrous bone, mastoid antrum, temporal lobes, sphenoid sinus and orbits were

visible clearly along with the widest part of fourth ventricle.

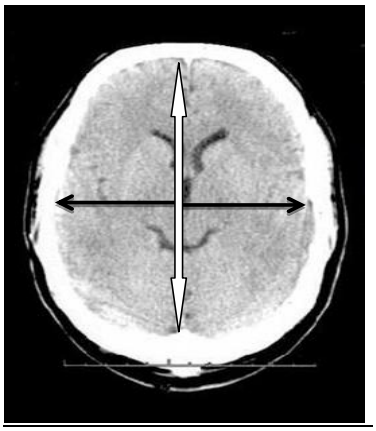

Fig: 1: Axial view of brain at the level of head of caudate nucleus.
White arrow: AP; Black arrow**:** TD**;**

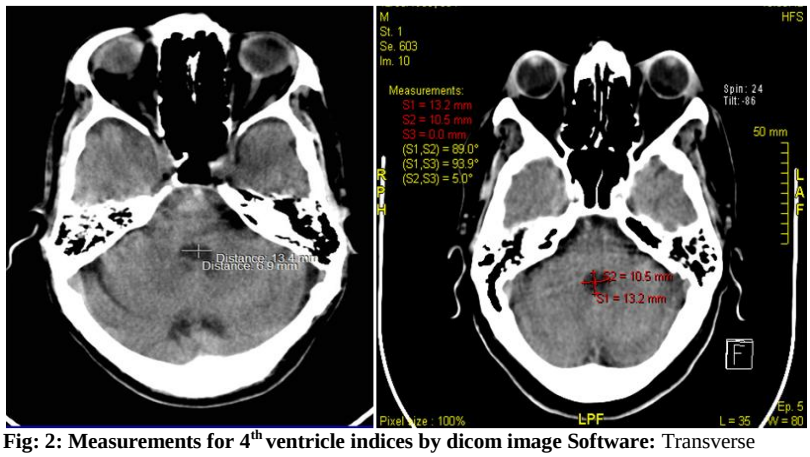

Fig: 2: Measurements for 4th ventricle indices by dicom image Software: Transverse width was measured at the midpoint of the ventricle = (W-4); Antero posterior width of fourth ventricle. = (AP-4)

Statistical evaluation

All the data was checked by Lilliefors test for normal distribution. Mean, standard deviation, ranges and 95% confidence intervals were calculated for all the parameters. Two sample independent student t -test was used to find the difference in males and females in these indices. Correlations with diameters of cerebrum /skull were found by calculating Pearson's correlation coefficient. Correlation with age was found by studying regression statistics. The level of significance was taken as 0.05.

RESULTS

Results of fourth ventricle parameters were as per Table I to IV.

The study showed that transverse width of fourth ventricle was more than the antero-posterior length of it and both were greater in males than in females. Width was significantly higher in males. Width showed maximum correlation with transverse diameter of cerebrum, and negative correlation with antero-posterior diameter of cerebrum. Length showed no correlation with diameters of cerebrum. Length showed slight positive correlation with age whereas width showed negative correlation with age.

Table I : Measurements of parameters of fourth ventricle in males and females

Parameter	Population	Mean+/- s.d. (mm)	S. E.	Range (mm)		95% CI (mm)		P-value
				Min	Max	Lower	Upper	
AP-4	T	7.24+/-2.18	0.22	3.3	16.4	6.81	7.67	
	M	7.622+/-2.56	0.36	3.3	16.4	6.89	8.35	0.07
	F	6.85+/-1.66	0.23	4.3	10.1	6.38	7.32	
W-4	T	13.70+/-2.26	0.23	9.2	23.5	13.25	15.15	
	M	14.70+/-2.30	0.32	10.3	23.5	14.05	15.35	<0.0001*
	F	12.7+/-1.73	0.24	9.2	19.6	12.21	13.19	

Table II: Descriptive statistics of diameters of cerebrum

Parameter		Mean +/- s.d.	S.E.	Range		95%CI		p-value
				Min	Max	Lower	Upper	
Anteroposterior Diameter (AP)	T	155.27+/-7.44	0.74	134.9	171.6	153.8	156.74	0.0002 S
	M	157.94+/-6.54	0.92	144.9	171.6	156.08	159.80	
	F	152.6+/-7.38	1.04	134.9	163.9	150.51	154.69	
Transverse Diameter (TD)	T	117.8+/-5.27	0.52	108.8	129.6	116.76	118.84	<0.0001 S
	M	121.15+/-4.87	0.68	109.1	129.6	119.77	122.53	
	F	114.48+/-3.13	0.44	108.8	119.6	113.59	115.37	
S: Significant difference ;T: Total; M: Male ; F : Female								

Table III: Pearson Correlation coefficient with AP and TD

	r with AP	p- value	R with TD	P-value
Length of fourth ventricle	0.087	0.54 (NS)	0.18	0.210 (NS)
Width of fourth ventricle	-0.088	0.54(NS)	0.25	0.08 (NS)

AP: Anteroposterior diameter of skull; TD:Transverse diameter of skull; NS:NonSignificant

Table IV: Results of regression statistics with age

	Length of fourth ventricle	Width of fourth ventricle
Multiple R	0.046	0.168
R Square	0.002	0.028
Standard Error	2.18	2.24
T-stat	0.46	-1.68
P-value	0.64	0.09
Regression equation	y'=6.97+0.007 x	y'=14.69 - 0.029 x

DISCUSSION

Fourth ventricle is enlarged in brain stem tumors, blockage of foramen of luschka and Magendie, Arnold Chiari malformations, autism, etc. In the context of increased brain ventricle size seen in routine clinical practices knowledge of normal range of precise measurement is needed before taking the appropriate decisions for further management.

Length of fourth ventricle

The present study showed mean antero-posterior length of fourth ventricle as 7.24+/-2.18 mm, the maximum value being 16.4mm. Akbari VJ et al (2011) [7] by plastination method found the mean height of fourth ventricle as 2.29+/-0.30 cm (range 1.9 to 2.7 cm), D'souza, [8] Gawler, [9] and F Duffner [10] reported height as 1.18 cm, 1.08cm, and 3.83 cm by CT, Ventriculography and MRI respectively. Gamereddin et al (2015) [11] found maximum mean height as 9.68 +/- 2.155 mm in Saudi population by CT. My findings are in accordance with those of D'souza and Gamereddin.

In the present study, mean length of fourth ventricle was higher in males than in females, but the difference was non-significant. Range and variation was also higher in males than in females (Table I). The finding are in accordance with those of study by Brij Raj et al [12] [mean height: 12.18± 1.54 (males); 12.13± 1.41(females)] by CT. and by Meshram preeti [13] (2015) by CT (mean height 1.06+/-0.146 cm in males, and 0.94+/-0.217cm in females), where the height of the fourth ventricle was larger in males as compared to females. In contrast, Gamereddin M et al (2015) [11] found slightly higher maximum height of fourth ventricle in females (9.70+/- 2.21) than in males (9.66+/-2.12) by CT, however the difference was non significant. Length of fourth ventricle showed very mild non-significant correlation (r=0.18, p=0.21) with transverse diameter of skull whereas nil with antero-posterior diameter of skull. Length of fourth ventricle showed positive very weak correlation with age, which was statistically non significant (r2 = 0.002, p=0.64). It does not depend upon age. (Fig.3)

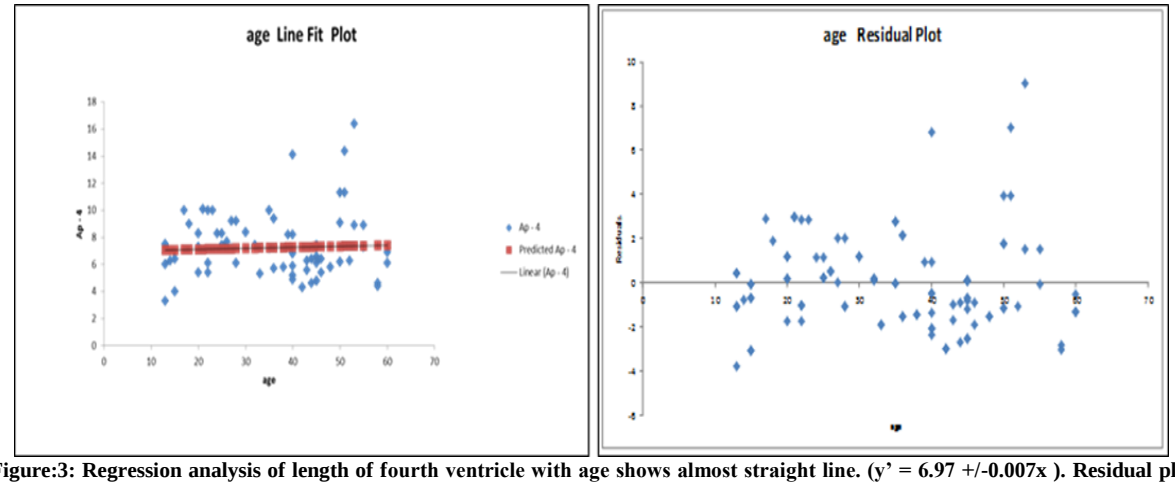

Figure:3: Regression analysis of length of fourth ventricle with age shows almost straight line. (y' = 6.97 +/-0.007x). Residual plot shows clumping arround zero line .

Width of fourth ventricle

The present study showed mean width as 13.70 +/- 2.26 mm in the studied population. The maximum value being 23.5mm. The findings are in accordance with those of Akbari [7] [2.38+/-0.44cm (range 1.75 to 3.0 cm)], F. Duffner [10] (1.25cm), D'souza [8] (1.31 cm) and Gamereddin [11] (12.15+/- 2.032 mm). The width of fourth ventricle was higher than the anteroposterior length of it.

Analyzing the gender variations, we found that width was higher in males than in females, the difference being statistically highly significant (p< 0.0001). The similar studies had reported mean width 11.07± 1.54 mm in males and 11.05 ± 1.31 mm in females by brij raj et al, [12] 1.32+/-0.201 cm in males, higher than in females (1.19+/-0.171 cm) by Meshram Preeti [13] by CT study, the difference being non- significant. The findings of the present study are consistent with those of Gamereddin M et al [11] (2015) in Saudi Arab population, who found mean width of fourth ventricle 12.54+/-1.901 mm in males whereas in females it was 11.60+/-2.099 mm with significant statistical difference (p=0.005).

In the present study, width showed moderate correlation with transverse diameter of skull but it was non-significant (r= 0.25, p=0.08) whereas it showed almost nil correlation with antero-posterior diameter of skull. (r= -0.08, p= 0.54).

In the past few authors have investigated the correlation of width with the age of the subjects, and found a moderate positive significant (p<0.01) correlation between fourth ventricle width and age. [11] Others reported that height and width of fourth ventricle both showed low positive correlation with age in both the sexes, which was statistically significant. [13] I report a negative mild correlation with age which was statistically non-significant (table IV). Regression plot with age (Fig 4) shows very minimal negative slope. Age residual plot shows no definite pattern. In the past brij raj et al [12] had found fourth ventricle width in 41-60 years to be 11.09 mm whereas in >60 years it was 11.06 mm. (slightly less in higher age group).

Regression of the brain involves both cerebrum and cerebellum [14] and it accelerates with seventh decade. [15] The age ranges taken in our study has limited the findings of age related changes. Though the margins of ventricles are less sharply defined on CT because of partial volume averaging or change in shape of ventricle due to slight variation in angulation in individual patients [16] due to subjective body build up, CT remains the most accessible, affordable and widely available investigation for brain imaging in Indian scenario.

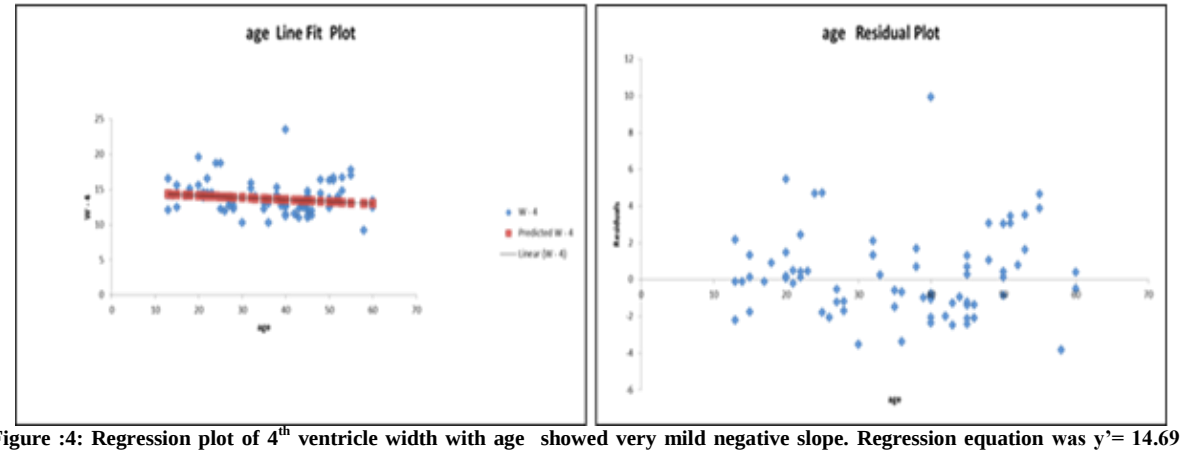

Figure :4: Regression plot of 4th ventricle width with age showed very mild negative slope. Regression equation was y'= 14.69 - 0.029x

Clinical relevance: Ventricle size is increased in various obstructive lesions, neurodegenerative diseases and physiological changes with age. Ventricle

size is changed even according to the hydration status of the patient. [17] It gets increased in first 48 hours of dehydration and then again decreases. Acute dehydration also increases serum osmolality (hypernatremia), which generates an osmotic gradient and therefore results in an increased diffusion of water from intracellular stores into extracellular space. This process causes cell shrinkage, in particular of astrocytes, which play an important role in water transport, and thereby leads to an expansion of the ventricular system. [18]

Fourth ventricle size may remain normal in spite of lateral and third ventricles being enlarged as can happen in cases of spinocerebellar ataxia type 2, an autosomal dominant neuro degenerative disease, where there is significant loss of cerebellar white matter and cortical gray matter in infratentorial compartment, but cerebral aqueduct and fourth ventricle are normal in size. [19] Children with new onset idiopathic generalized epilepsy also exhibit significant enlarged lateral and third ventricle relative to healthy controls wherein fourth ventricle remains normal. [20] Recently a teenage case had been reported with hypertensive emergency, posterior reversible encephalopathy syndrome and acute hydrocephalus due to fourth ventricle outlet obstruction due to localized bilateral cerebellar oedema. Lateral and third ventricles were markedly dilated and there was tightness of inferior most posterior fossa (Ettinger Nicholas). [21] A well known neurodegenerative disease, schizophrenia is also accompanied by normal fourth ventricle whereas enlarged lateral and third ventricle. [22] Therefore complete clinical assessment of patient is necessary before coming to a conclusion for management.

CONCLUSION

The present study concluded that the width of fourth ventricle possess moderate positive correlation with transverse diameter of cerebrum whereas almost nil correlation with anteroposterior diameter of cerebrum. It decreases with age slightly. Length of 4th ventricle shows no monotonic relation with diameters of cerebrum / skull. It does not depend upon age.

ACKNOWLEDGEMENTS

The authors appreciate the role of staff of the Radiology and Imaging Department at G. B. Pant Hospital for their cooperation, help and support during data collection.

Conflict of interest: The authors declare that they have no conflict of interest.

REFERENCES

1. Williams PL, Bannister LH, Berry M M, Collins P, Dyson M, DussekJ E, Ferguson MWJ. Grays Anatomy, Churchill Livingstone 38th edition, 486-490; 1205-1206.
2. Agapejev Svetlana: Fourth ventricle computed tomography indexes; Standardisation and characteristics in neurocysticercosis: Arq Neuropsiquiatr 2002, 60 (2-A): 211-218.
3. Gyldensted C. Measurements of the normal ventricular system and hemispheric sulci of 100 adults with computed tomography. *Neuroradiology 1977; 14*: 4; 183-192.
4. Haug G. Age and sex dependence of the size of normal ventricles on computed tomography. *Neuroradiology 1977;* 14:201-204.
5. Meese W, Kluge W, Grumme IT, Hopfermuller W. CT evaluation of the CSF spaces of healthy persons. *Neuroradiology 1980*; 19: 131-135.
6. LeMay, M: Radiological Changes of the ageing brain and skull. American Journal of Roentgenology. 1984; 5:383-389.
7. Akbari V J, Saiyad S S, Pandya A M, Solanki S V, Dangar K P (2011) :A Morphometric Analysis Of Fourth Ventricle Of Human Cadaveric Brain By Plastination; *National Journal Of Medical Research* Vol 1 Issue 2 Oct - Dec ISSN 2249 4995, pg 48-50.
8. D'Souza C, Dias Medora C and Natekar Prashant E; the Morphometric Study of the Ventricular System of Brain by Computerised Tomography. Journal of

Anatomical Society India; 2007; 56(1): 19-24
9. GawlerJ, du Boulay GH, Bull JWD, Marshall J. Computerized tomography (the EMI scanner): a comparison with pneumoencephalography and ventniculography. J Neurol Neurosurg Psychiatry 1976; 39:203-211.
10. Duffner F, Schiffbaur H, Glemser D, Skalei M, Freudenstein D. Anatomy of Cerebral Ventricular System for Endoscopic Neurosurgery: a magnetic resonance study. ActaNeurochir (Wien) 2003 May; 145(5):359-68.
11. Gameraddin, M., Alsayed, A., Ali, A. and Al-Raddadi, M. (2015) Morphometric Analysis of the Brain Ventricles in Normal Subjects Using Computerized Tomography. Open Journal of Radiology, 5, 13-19.http://dx.doi.org/10.4236/ojrad.2015.51003.
12. Brij Raj Singh, Ujwal Gajbe, Amit Agrawal, Anilkumar Reddy Y, SunitaBhartiya Ventricles Of Brain: A Morphometric Study By Computerized Tomography Int J Med Res Health sci.2014; 3(2):381-387.
13. Pritee M. Meshram, Shanta S. Hattangdi. Morphometric Study of Fourth Ventricle By Computerised Tomography. Int J Anat Res 2015; 3(3):1273-1277. DOI: 10. 16965/ijar.2015.208.
14. Ellis AJ. Norms for some structural changes in the human cerebellum from birth to old age. *J Comp Neurol* 1920; 32; 1-35.
15. De Kaban AS, Sadowsky BS. Changes in brain weights during the span of human life: relation of brain weights to body heights and body weights. *Ann Neurol Psychiatr* 1978; 4:345-356.
16. Sabattini L. Evaluation and measurements of the normal ventricular system and subarachnoid spaces by CT. *Neuroradiology* 1982; 23: 1-5.
17. Streitbu¨ rger D-P, Mo¨ ller HE, Tittgemeyer M, Hund-Georgiadis M, Schroeter ML, et al. (2012) Investigating Structural Brain Changes of Dehydration Using Voxel-Based Morphometry. PLoS ONE 7(8): e44195. doi: 10.1371/ journal. pone.0044195
18. Simard M, Nedergaard M The neurobiology of glia in the context of water and ion homeostasis. J. Neuroscience 2004; 129: 877-896.
19. Mascalchi M, Diciotti S, Giannelli M, Ginestroni A, Soricelli A, et al. (2014) Progression of Brain Atrophy in Spinocerebellar Ataxia Type 2: A Longitudinal Tensor-Based Morphometry Study. PLoS ONE 9(2): e89410.doi:10.1371/journal.pone.0089410 Pubmed.
20. Daren C. Jackson, William Irwin, Kevin Dabbs, Jack J. Lin, Jana E. Jones, David A. Hsu, Carl E. Stafstrom, Michael Seidenberg, and Bruce P. Hermann (2011) Ventricular enlargement in new-onset pediatric epilepsies: *Epilepsia*, 52(12):2225–2232.
21. Ettinger Nicholas, Matthew Pearson, Fred S. Lamb, and John C. Wellons III: Pediatric posterior reversible encephalopathy syndrome presenting with isolated cerebellar edema and obstructive hydrocephalus: *J Neurosurg Pediatr*. 2014 October; 14(4): 344–347.
22. Robert W. Mc Carley, Cynthia G. Wible, Melissa Frumin, Yoshio Hirayasu, James J. Levitt, Iris A. Fischer, and Martha E. Shenton (1999) MRI Anatomy of Schizophrenia: *Biol Psychiatry*. 1999 May 1; 45(9): 1099-1119.

How to cite this article: Patnaik P, Singh S, Singh D et al. Morphometric study of fourth ventricle indices by computed tomography. Int J Health Sci Res. 2016; 6(8):128-134.

****