Original Article

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Evaluation of Cella Media Index by Computed Tomography in Hydrocephalic Children in Tertiary Hospital of Telangana- A Retrospective Study

Anatomy Section

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ABSTRACT

Introduction: Hydrocephalus is a common clinical condition in children with a mortality rate of 0-3%. Any obstruction in the flow of Cerebrospinal Fluid (CSF) in the ventricular system leads to its collection and accumulation in the brain causing its compression. Such ventricular enlargement can be studied by many linear and volumetric measurements out of which the Cella Media Index (CMI) is one. Computed Tomography (CT) scan is the safest non invasive investigation commonly used by radiologists to study the ventricular system.

Aim: To evaluate CMI in hydrocephalic children by CT and also to compare with the control group, attending tertiary hospital in Telangana state.

Materials and Methods: A retrospective study was conducted by obtaining CT Scans of 50 normal children and 50 hydrocephalic children within the age group of 0-12 years, from the Department of Radiology, Niloufer Hospital, Hyderabad, Telangana from November 2013 to August 2014. The CT scans were studied and analysed between August 2014 to November 2014. Maximum transverse inner diameter of the skull and maximum width of the cella media were measured and cella media index was calculated. The data was statistically analysed by using T test. One way Analysis of Variance (ANOVA) was used to check for differences in ventricular dimensions across age groups.

Results: The mean age of the subjects was 2.9±3.0 years with 51 female and 49 male children. Mean of cella media index in cases (3.02±1.24, 95% CI 2.66-3.37) was less than in controls (11.9±2.87, 95% CI 11.1-12.7) with p-value <0.001. The mean cella media index of males (2.74±0.93, 95% CI 2.66-3.14) was less than in females (3.28±1.40, 95% CI 2.88-3.37) with p-value=0.1. Among the hydrocephalic children there was no significant difference of mean of cella media index between males and females. The mean cella media index in children below three years (2.81±1.36, 95% CI 2.66-3.12) was less than in children above three years (3.43±0.87, 95% CI 3.09-3.37) with p-value=0.049. Among the hydrocephalic children there was significant difference of mean of cella media index between two age groups.

Conclusion: The present study concluded that cella media index in hydrocephalic children was decreased in comparison with the control group.

Keywords: Cerebrospinal fluid, Obstruction, Shunt, Ventricular enlargement, Ventricular system

INTRODUCTION

Human brain is a highly complex structure which requires depth knowledge in the field of Anatomy, Surgical Anatomy, Neural Cell Biology and Radiology to understand the normal structural changes occurring as the brain ages. With ageing, the brain undergoes many gross and histopathological changes with regression of the brain tissue leading to enlargement of the ventricles [1]. Two percentage of brain volume is constituted by the ventricles of the brain [2].

The ventricles of the brain are formed due to flexures of the primitive brain tube [3]. The ventricles of brain consists of a series of interconnecting spaces and channels which are filled with CSF. It is developed from the central lumen of embryonic neural tube [4]. Lateral ventricles contribute about 82% of the total ventricular system [2]. The ventricular system of the cerebral hemisphere consists of two lateral ventricles which connect with the third ventricle by interventricular foramen of Monro and in the midline third and fourth ventricle are connected by the Aqueduct of Sylvius [3-5].

Ventricular enlargement is commonly seen in children presenting with clinical neurologic and psychiatric disorders [4]. Hydrocephalus is one such commonly seen clinical condition in children presenting with many complications with a mortality rate of 0-3% and with elevated intracranial pressure leading to deterioration in motor, intellectual, cognitive and neuropsychological functions [6,7,8]. Hydrocephalus results from imbalance between production and absorption of CSF [2,9]. Key and Retzeus had established the modern concept of CSF circulation [10]. Any obstruction in the flow of CSF in the ventricular system leads to its collection and accumulation in the brain causing its compression leading to structural changes in the white matter, cortex and seepage of CSF into the periventricular spaces through ependymal tears [8].

Brain ventricles can be studied by taking linear, planimetric or volumetric measurements and various linear ratios like Evans Index, Third Ventricular Index (3VI), Frontal and Occipital Horn Index (FOHR) [7,4,2]. Cella media index can be obtained from CT scans which helps in understanding the etiology, age and sex-wise differentiation among hydrocephalic patients. CT is the safest non invasive investigation commonly used by radiologists to study the ventricular system. CT has wide role and rapidly advanced the early detection and treatment of hydrocephalus and also useful in determining the etiology of hydrocephalus in children [10,11]. CT is useful for evaluation of brain morphology including size and shape of the ventricular system and remains the most widely accessible and affordable tool in Indian scenario [11,12].

Many studies are available on CMI, which defines CMI as maximum transverse inner diameter of the skull divided by maximum width of

the cella media and it measures more than 4 in normal cases and it increases with age [3,11]. On literature search, no similar study was conducted in the Telangana, hence, present study was done to evaluate the CMI in hydrocephalic children of tertiary hospital in Telangana and to compare it with the healthy controls.

MATERIALS AND METHODS

A retrospective study was conducted in the Department of Radiology, Niloufer Hospital for Women and Children, Hyderabad, Telangana, India. Data were collected from November 2013 to August 2014 and CT scans were studied and analysed between August 2014 to November 2014. Study was commenced after obtaining approval from the Ethical committee of Osmania Medical College, Telangana and written consent from the parents was taken.

Inclusion criteria:

Controls (n=50): Children within the age group of 0-12 years with no clinical history of hydrocephalus and which were diagnosed as normal scans by the radiologists of the institution were randomly picked for the study .

Cases (n=50): Children within the age group of 0-12 years who were clinically diagnosed as hydrocephalic by the paediatricians and on CT scans by the radiologists of the institution.

Exclusion criteria: CT scans showing features of skull fractures, brain atrophy, head injury, internal haemorrhage, postoperative scans, and scans of adults and teenagers were excluded from the study.

Study Procedure

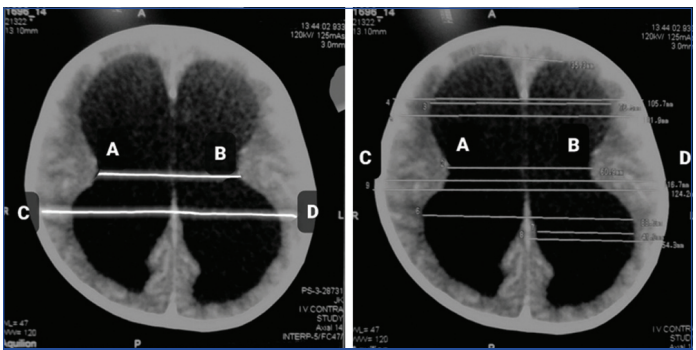
A total of 100 CT scans were analysed and divided into two groups: 50 cases and 50 controls. Maximum transverse inner diameter of the skull and maximum width of the cella media were measured and CMI was calculated. Axial CT scans were taken with the patient in supine position with slice thickness of 5 mm from cranial to caudal direction with a scan time of 0.5 sec on standard resolution by using department's Toshiba, Aquilion, TSX-101A, Multi slice Detector [Table/Fig-1].

The parameters used are:

1. Maximum Width of Cella Media [Table/Fig-1].
2. Maximum Transverse Inner Diameter of Skull [Table/Fig-1].

CMI is maximum transverse inner diameter of the skull divided by maximum width of the cella media [11]. CMI=CD/AB [Table/Fig-1]. Swati G et al., Ventricular/Biparietal Ratio (V/BP Ratio) is computed at the mid-portion of bodies of lateral ventricles showing the maximum ventricular dilatation in axial section.

- Mild hydrocephalus- 3.5-2.3,
- Moderate hydrocephalus- 2.4-1.6,
- Severe hydrocephalus- 1.9-1.2 [11].



[Table/Fig-1]: A-B Maximum width of Cella Media. C-D Maximum transverse inner diameter of skull.

STATISTICAL ANALYSIS

Data were collected and statistically analysed by using Statistical Package for Social Sciences software version 22.0. The Mean and Standard Deviation (SD) of all measurements were calculated and 95% Confidence interval (CI) of both upper and lower limits were calculated. The data was also analysed by using T test for significance of difference of the measurements between males and females. One way ANOVA was used to check for differences in ventricular dimensions across age groups. The p-value <0.05 was considered as statistically significant.

RESULTS

A total of 100 children were analysed with the mean age of 2.9±3.0 years. Their age and sex distribution was studied and were divided into different groups and the mean CMI was calculated. Transverse Inner Diameter of Skull was higher in controls as compared to cases and Maximum Width of Cella Media was higher among cases. Mean CMI in cases (3.02±1.24, 95% CI 2.66-3.37) was significantly decreased than in controls (11.9±2.87, 95% CI 11.1-12.7) [Table/Fig-2].

Parameters		Cases (n=50)	Control (n=50)	p-value
Transverse inner diameter of skull [mm]	Range	64.6-139.6	109.0-127.0	0.069
	Mean	112.1±14.6	117.3±5.4	
Maximum width of cella media [mm]	Range	14.6-77.2	7.1-11.9	0.001
	Mean	41.5±15.1	9.2±1.6	
Cella media index	Mean	3.02±1.24	11.9±2.87	<0.001
	95% CI	2.66-3.37	11.1-12.7	

[Table/Fig-2]: Measurements of cella media index in total study population including cases and controls (N=50).
T-Test, ANOVA; p-value <0.05 was statistically significant

The mean CMI of males (2.74±0.93, 95% CI 234-3.14) was less than in females (3.28±1.40, 95% CI 2.88-3.67). There was no significant difference found regarding mean CMI among males and females [Table/Fig-3].

Parameters		Males (n=24)	Females (n=26)	p-value
Transverse inner diameter of skull [mm]	Range	64.6-139.6	86-128.5	0.789
	Mean	112.5±18.5	111.3±11.6	
Maximum width of cella media [mm]	Range	22-77.2	14.6-69.7	0.038
	Mean	43.6±15	38.5±16.8	
Cella media index	Mean	2.74±0.93	3.28±1.4	0.1
	95% CI	2.66-3.14	2.88-3.37	

[Table/Fig-3]: Measurements of cella media index in hydrocephalic children according to gender (N=50).
T-test; p-value <0.05 was statistically significant

The mean cella media index in children below three years (2.81±1.36, 95% CI 2.49-3.12) was less than in children above three years (3.43±0.87, 95% CI 3.09-3.76). There was a statistically significant difference was found in two groups in terms of mean [Table/Fig-4].

Parameters		Below 3 years (n=31)	Above 3 years (n=19)	p-value
Transverse inner diameter of skull [mm]	Range	64.6-136.4	109.2-139.6	0.045
	Mean	107.8±16.4	119.1±7.3	
Maximum width of cella media [mm]	Range	14.6-77.2	23.2-65.4	0.067
	Mean	43.6±17.1	38.1±10.8	
Cella media index	Mean	2.81±1.36	3.43±0.87	0.049
	95% CI	2.66-3.12	3.09-3.37	

[Table/Fig-4]: Measurements of cella media index in hydrocephalic children according to age.
ANOVA; p-value <0.05 was statistically significant

Mean CMI in all the age groups was more in females as compared to males. Least CMI was found in males of 4-6 years age group and maximum was found in females in the age group 7-9 years [Table/Fig-5].

Age (years)	Male (n=24)	Female (n=26)	Cella media index Mean±SD	
			Male	Female
0-3	17	14	2.71±1.13	3.21±1.84
4-6	2	9	2.03±0.49	3.10±0.57
7-9	4	3	3.84±0.42	4.16±1.2
10-12	1	-	3.97	-

[Table/Fig-5]: Distribution cella media index in the hydrocephalic children according to age and gender (N=50).

DISCUSSION

Cella Media Index (CMI) is most commonly used parameter for evaluation of ventricular dilatation. Meese et al., gave a proposal for grading of ventricular dilatation in hydrocephalic children. According to them CMI >4.0 was considered as normal, the range between 3.6-4.0 was slight dilatation, 3.0-3.5 was moderate dilatation and <3.0 was extreme dilatation [13]. Swati G et al., graded mild hydrocephalus as 3.5-2.3, moderate as 2.4-1.6, and severe hydrocephalus as 1.9-1.2 [11].

Haug G, in his study found CMI as 0.295 and stated that CMI increases with age and is maximum transverse inner diameter of the skull divided by maximum width of the cella media [14]. Pedersen H et al., in a study including 155 normal children below age of 15 years found that the CMI (7.4) was higher in older children (>3 years) than (6.1) in a younger age group (<3 years) [15]. Patnaik P et al., in their study on lateral ventricle ratios among 60 normal CT scans observed CMI as 0.22 and stated that CMI/CMR depends upon cerebrum size [12]. Swati G et al., in their study on mild to severe hydrocephalic children under 10 years found CMI ranging from 3.5-1.2 and stated that CT is a valuable tool in differentiating communicating and non communicating hydrocephalus and helps in determining the etiology of hydrocephalus in children [11].

Kolsur N et al., in their study on 300 normal CT scans found CMI as 0.227 and stated its usefulness in diagnosis and treatment of obstructive hydrocephalus [4]. Mondal M et al., in their study on 126 brain scans observed the CMI as 0.186 which was more in males and showed linear increase with age [3]. In the present study, the entire study population was divided into two groups according to age, gender and cases and controls and the mean CMI was calculated and was found to be 3.02 which was in consistent with the findings of Swati G et al., and were graded as mild hydrocephalic cases based on the grading given by Swati G et al., [11].

Mean of CMI in cases (3.02±1.24, 95% CI 2.66-3.37) is less than in controls (11.9±2.87, 95% CI 11.1-12.7) with p-value <0.001 shows significant difference. The mean CMI of males (2.74±0.93, 95% CI 2.66-3.14) is less than in females (3.28±1.4, 95% CI 2.88-3.37) with p-value=0.1. Among the hydrocephalic children there is no significant difference of mean of CMI between males and females which was in consistent with the findings of Kolsur N et al., [4].

The mean CMI in children below three years (2.81±1.36, 95% CI 2.79-3.12) is less than in children above three years (3.43±0.87, 95% CI 3.09-3.26) with p-value=0.049. Among the hydrocephalic children the difference of mean of CMI in 0-3 years age group was found to be (2.71±1.13) in males and (3.21±1.84) in females and the mean CMI in 7-9 years age group was found to be (3.84±0.42) in males and (4.16±1.2) in females.

The mean CMI observed was more in hydrocephalic children with more than three years of age and was increasing with age which was in consistent with the findings of Kolsur N et al., [4], Mondal M et al., and Haug G et al., as he stated that CMI increases gradually with age [3,14]. Thus CMI is very useful in grading of hydrocephalus, and allows the neurosurgeons to take early decisions on interventions, if required.

The comparison of previous studies with present study is shown in [Table/Fig-6] [3,4,11,12].

S. No.	Study	Place and year of the study	Sample size and population (children/adult)	CMI
1	Patnaik P et al., [12]	New Delhi, India 2014	60 adults	0.22
2	Swati G et al., [11]	Gwalior, India 2017	53 children	3.5-1.2
3	Kolsur N et al., [4]	Karnataka, India 2018	300 adults	0.227
4	Mondal M et al., [3]	Kolkata, India 2019	126 adults	0.186
5	Present Study	Telangana, India 2023	100 children	3.02

[Table/Fig-6]: Comparison of Cella Media Index in the present study with previous studies [3,4,11,12].

Limitation(s)

The study was conducted in a limited sample. The size of the sample could be increased to get more relevant data in future for proper understanding of hydrocephalus in children.

CONCLUSION(S)

In present study, CMI was significantly decreased among cases as compared to controls. Among the hydrocephalic children there was no significant difference of CMI between males and females but significant difference was seen between the two age groups. Thus CMI could be used for early diagnosis and grading of ventricular enlargement by radiologists and for early intervention for shunt procedures by neurosurgeons. Thus, measurement of CMI was found to be reliable to measure the dilatation of ventricular system and a helpful parameter for early identification and surgical intervention by neurosurgeons.

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