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Anatomy

Morphometric MRI Study of Third Ventricle of Brain among Bangladeshi Adults

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Abstract **Original Research Article**

Background*:** The third ventricle of the brain is a small median cleft located in the diencephalon between right and left thalamus; anteriorly it communicates to the lateral ventricles by foramen of Monro, posteriorly connects to the fourth ventricle through the cerebral aqueduct. Morphometry and accurate measurements of the brain ventricles have clinical importance because various diseases affect the size and morphology of the ventricles. ***Objective: This study was aimed to determine the morphometry of third ventricle of brain by magnetic resonance imaging (MRI) scan. ***Methods*:** This cross-sectional study was conducted at Department of Anatomy, Dhaka Medical College, Dhaka, Bangladesh from January 2020 to December 2020. Patients referred by Department of Medicine, Dhaka Medical College Hospital (DMCH) for MRI were enrolled as study subjects. Total 100 adult Bangladeshi subjects (50 male and 50 female) were selected following selection criteria. Their MRI of brain was done by MAGNETOM VIDA (3T Tesla) SIEMENS MRI machine following standard procedure. The MRI scans were evaluated by registered radiologists. All parameters were measured from the soft copy of MRI scans using RadiAnt DICOM Viewer. ***Results*:** The mean (±SD) maximum height of the third ventricle was 23.69 ± 1.13 mm in male and 22.38 ± 0.72 mm in female, that was significantly larger in male ($p<0.001$). The mean (±SD) anterior-posterior length of third ventricle was 27.17 ± 0.67 mm and 26.16 ± 0.58 mm in male and female respectively, which was significantly higher in male than female ($p<0.001$). However, no significant difference was observed in mean (±SD) anterior-posterior commissural distance between male and female (26.47 ± 1.6 mm and 26.06 ± 1.00 mm, $p= 0.129$). The mean (±SD) maximum width of third ventricle was found significantly higher in male than female (4.33 ± 0.41 mm versus 3.68 ± 0.68 mm, $p<0.001$). ***Conclusion*:** The maximum height, anterior to posterior length and maximum width of third ventricle are significantly higher in male than female, but there is no significant difference in anterior to posterior commissure distance of third ventricle between male and female in Bangladeshi adults.

Keywords: Bangladeshi Adults, Morphometry, Magnetic Resonance Imaging (MRI), Third Ventricle.

1. INTRODUCTION

The brain ventricles are cerebrospinal fluid (CSF) filled cavities and these are two lateral ventricles, third ventricle, aqueduct of Sylvius and fourth ventricle [1]. The third ventricle is a slit like cleft between the two thalami which possesses two lateral walls, a roof, a floor, an anterior and a posterior wall [2]. The third ventricle lies below the fornix and the corpus callosum of brain [2]. The lamina terminalis lies anteriorly and mammillary body lies in the floor of third ventricle [3]. Lesion of third ventricle can have variety of clinical manifestations such as dysfunction of hypothalamic pituitary gland axis, hydrocephalus, congenital cyst such as cavum veli interpositi (CVI) cyst [4]. The surgical management of tumours within the third ventricle remains as a distinct challenge for neurosurgeons due to deep locations of tumours and involvement of neurovascular structures. Appropriate knowledge of normal morphometry of the third ventricle is essential to approach the third ventricle for removal of any pathological lesion [5]. The knowledge of normal and abnormal ventricular system is essential for clinicians,

neurosurgeons and radiologists [6]. Pneumoencephalography and ventriculography were the older methods which were used previously to observed the ventricular system by injecting air by lumbar puncture under local anaesthesia [6]. In recent years, Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) scan have replaced the older approaches used to study the ventricular system [7]. CT scan causes oncogenic and teratogenic effect due to exposure of conventional X-ray radiation [8]. Magnetic Resonance of Imaging (MRI) is an investigative tool that has been gaining popularity for its non-invasive approach [9]. In MRI scan intensity differences are used to differentiate gray matter, white matter and CSF [10]. So, magnetic resonance imaging (MRI) is safe for patients. There are many computer-based software programmers such as the XoranCat, RadiAnt DICOM Viewer and Versalius which are used in measurement of MRI scan of brain. Compared with physical and linear measurements the RadiAnt DICOM Viewer software is most accurate and precise for measurements of MRI scan of brain [11]. Ventricular size measurements show differences in population to population and vary in sexes [12-15]. Mathew, *et al*., studied the morphometric parameters of the third ventricle by MRI scan and showed that the anterior-posterior length and height are greater in male than female in Punjab (India) population [14]. In another study it was reported that, the mean width of third ventricle was higher in male than female [15]. However, study conducted in Gujarat, Western India reported that the mean width of third ventricle is same among male and female in MRI study [16]. Therefore, ventricular size measurement is necessary for determination and follow up of many neurological illness and pathologies [17]. In this background, the present study was aimed to determine the normal morphometric values of third ventricle of brain using MRI scan. The study can reveal whether there is any gender related difference between adult Bangladeshi male and female regarding the different parameters of third ventricle, on MRI scan of brain.

2. METHODOLOGY

2.1. Study Design

This cross-sectional study was conducted at Department of Anatomy, Dhaka Medical College, Dhaka, Bangladesh from January 2020 to December 2020. The study was carried out after approval of the Research Review Committee of Dhaka Medical College, Dhaka, Bangladesh.

2.2. Study Participants

All patients referred by Department of Medicine, Dhaka Medical College Hospital (DMCH) for MRI were enrolled as study subjects. A total of 100 adult Bangladeshi subjects (50 male and 50 female) age ranged between 25-64 years were selected following selection criteria. Age 25 years was selected because the development and maturation of prefrontal cortex of the brain was fully accomplished at the age of 25 years [18], and age 64 years was selected because physiological ventricular dilatation due to irreversible loss of brain substances occur at the age of 65 years or above [19]. Individuals having any history of epilepsy, stroke, head injury, brain surgery, brain tumor or any other intracranial lesions were excluded from this study.

2.3. Study Procedure

After selection, the objective, procedure and benefit of the study were explained to all study subjects and informed written consent was taken from them. A detailed clinical history was taken and relevant physical examination were done accordingly. Then the MRI scan of brain of each study subject was done by MAGNETOM VIDA (3T Tesla) SIEMENS MRI machine, following standard procedure. The MRI scans were evaluated by a registered radiologist. The soft copy of MRI scan was displayed on computer screen. All parameters were measured from the soft copy of MRI scan by making two points and joining them with a straight line, using RadiAnt DICOM Viewer [11]. The study parameters were- maximum height, anterior-posterior length, maximum width and anterior-posterior commissural distance (AC-PC distance) of the third ventricle.

2.4. Operational Definitions

T1 (Transmission System) Image of MRI:

In T1 weighted images tissues comprising water and fluid appear to be dark (black) and the tissues containing fat appear bright (white) in color [20].

T2 (Transmission system) Image of MRI:

In T2 weighted images tissues filled with water and fluids appear to be bright (white) and tissues with fat appear to be dark (black) in color [20].

Anterior-Posterior Commissural Distance (AC-PC Distance):

The line which passes from the posterior portion of the anterior commissure (AC) to anterior part of the posterior commissure (PC) [13].

2.5. Methods of Measurement of Different Parameters of Third Ventricle

The soft copies of MRI scans of the brain were taken and their images were transferred to CD or DVD and different dimensions of third ventricle were measured with the help of the computer image measuring software (RadiAnt Dicom Viewer). T1 weighted (T1W) scan, T2 weighted (T2W) scan were used in sagittal, coronal, axial/transverse planes for the measurements of variables.

Procedure of Measurement of Maximum Height of the Third Ventricle [14]

The maximum height was measured from the upper part of mammillary body to highest curvature of the lower border of the fornix in midsagittal T1 MRI scan

of the brain by measuring software 'RadiAnt DICOM Viewer' in millimetres (Image- 1).

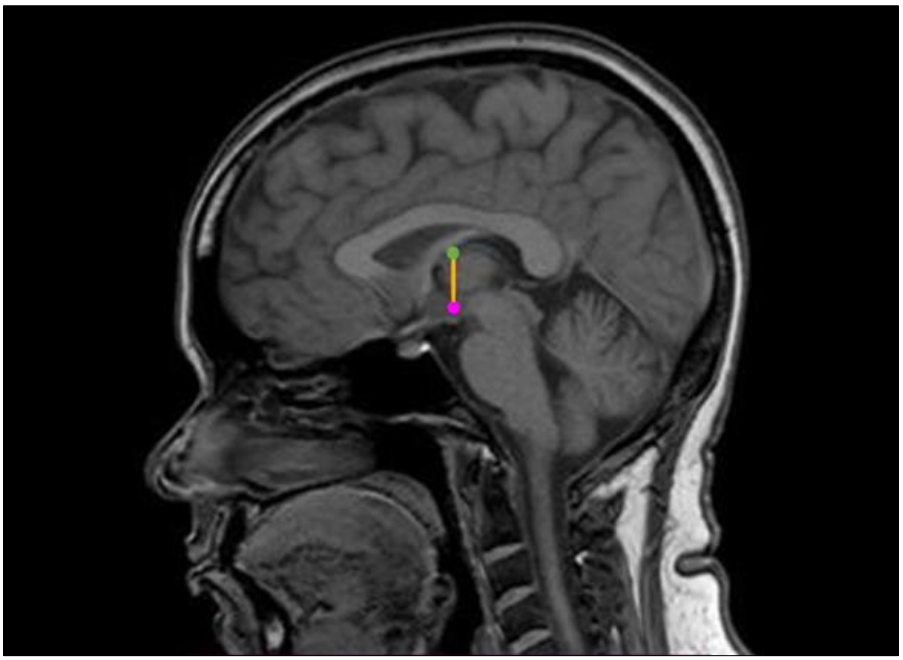

Image 1: Midsagittal T1 MRI scan of the brain showing measurement of maximum height of the third ventricle as orange line, **Pink dot**: Upper part of mammillary body, **Green dot**: The highest curvature of the lower border of fornix, **Orange line:** Maximum height of the third ventricle.

Procedure of Measurement of Anterior - Posterior Length of the Third Ventricle [14]

The length was measured by a horizontal line from posterior commissure to lamina terminalis in midsagittal T1 MRI scan of the brain by measuring software 'RadiAnt DICOM Viewer' in millimetres (Image- 2).

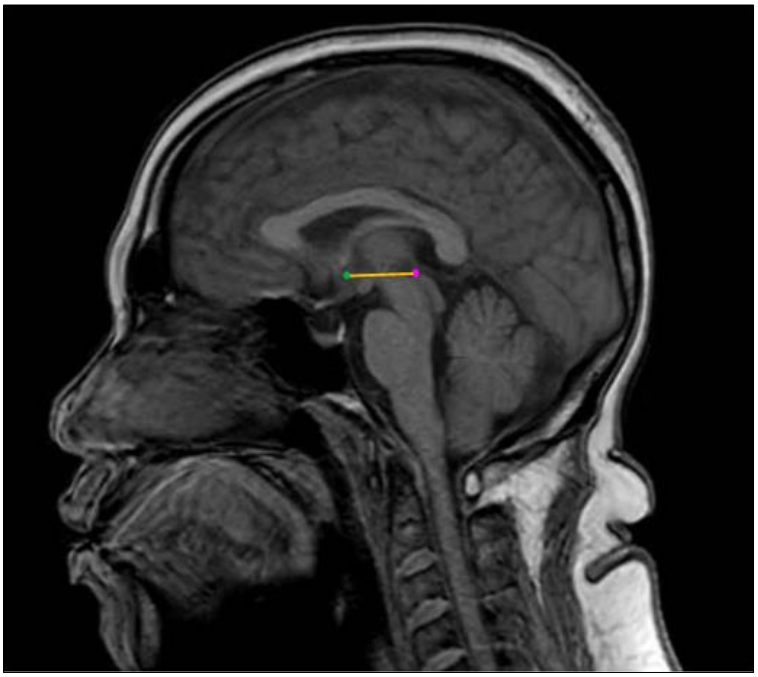

Image 2: Midsagittal T1 MRI scan of the brain showing measurement of anterior-posterior length of the third ventricle as orange line, **Pink dot:** The posterior commissure, **Green dot:** The lamina terminalis, **Orange line:** Anterior to posterior length of the third ventricle.

Procedure of Measurement of Anterior-Posterior Commissural Distance [13]

The distance was measured from the posterior part of the anterior commissure to anterior part of the posterior commissure in midsagittal T1 MRI scan of the brain by measuring software 'RadiAnt DICOM Viewer' in millimetres (Image- 3).

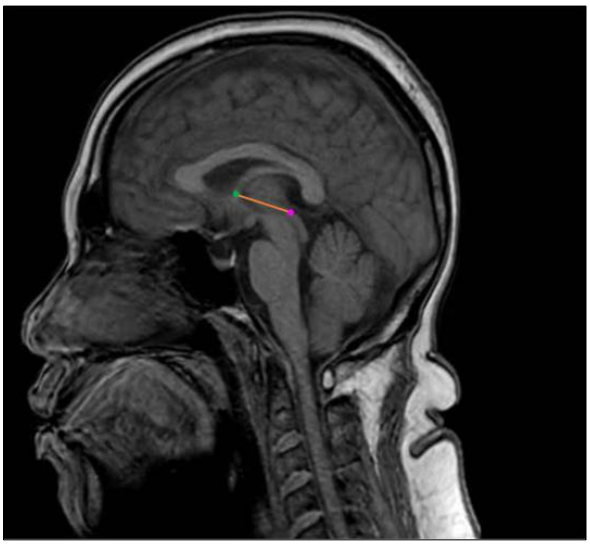

Image 3: Midsagittal T1 MRI scan of the brain showing the measurement of anterior - posterior commissural distance as orange line, **Green dot:** Posterior portion of the anterior commissure, **Pink dot:** Anterior portion of the posterior commissure, **Orange line:** Anterior - posterior commissural distance.

Procedure of Measurement of Maximum Width of the Third Ventricle [21]

Maximum width of the third ventricle was measured between the right and left lateral wall of the third ventricle in coronal T2 MRI scan of the brain by measuring software 'RadiAnt DICOM Viewer' in millimetres (Image- 4).

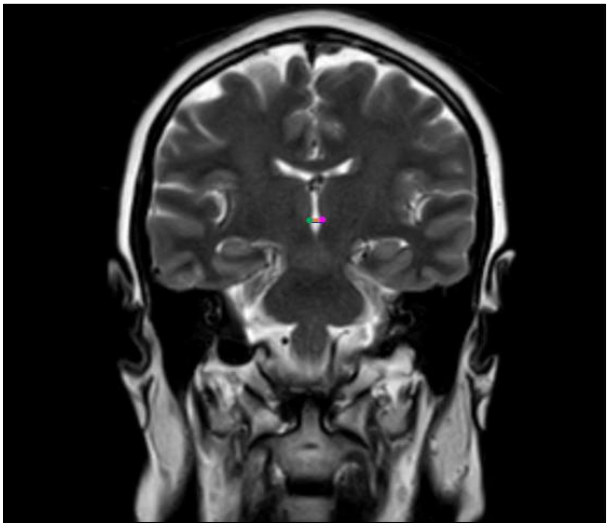

Image 4: Coronal T2 MRI scan of the brain showing the measurement of maximum width of the third ventricle as orange line, **Green dot:** Left lateral wall of the third ventricle, **Pink dot:** Right lateral wall of the third ventricle, **Orange line:** Maximum width of the third ventricle.

2.5. Statistical Analysis of Data

The statistical analysis was done by unpaired Students 't' test for comparison between male and female participants by using Statistical Package for Social Science (SPSS) version 22.0. Statistical analysis was accepted as significant at p-value less than 0.05 ($p<0.05$).

3. RESULTS

The present study was conducted on one hundred (100) MRI scans of brain among healthy Bangladeshi adults in both genders. Out of 100 MRI scans of brain, fifty (50) were of male and fifty (50) were of female.

3.1. Maximum Height and Anterior-Posterior Length of Third Ventricle of Male and Female in Midsagittal T1 View of MRI Scan of Brain

Maximum Height of Third Ventricle

In male, the height of third ventricle (mean ± SD) was 23.69 ± 1.13 mm and the range was 20.40 mm to 25.20 mm. In female, the height of third ventricle (mean ± SD) was 22.38 ± 0.72 mm and the range was from 21.00 mm to 23.70 mm. The mean maximum height was found larger in male than female and the difference was statistically significant (p<0.001) (Table- 1).

Anterior-Posterior Length of Third Ventricle

The mean (±SD) anterior-posterior length of third ventricle was 27.17 ± 0.67 mm and 26.16 ± 0.58 mm in male and female respectively. The range of anterior-posterior length of third ventricle was 25.20 mm to 28.50 mm and 25.30 mm to 27.40 mm in male and female respectively. Significant difference was observed in mean anterior-posterior length of male and female (p<0.001), anterior-posterior length of third ventricle was higher in male than female (Table- 1).

Table 1: Maximum height and anterior-posterior length of third ventricle of male and female in midsagittal T1 view of MRI scan of brain (N= 100)

Variables	Male (n=50) Mean ± SD	Female(n=50) Mean ± SD	p-value
Maximum height of third ventricle (Measurements in mm)	23.69 ± 1.13 (20.40 – 25.20)	22.38 ± 0.72 (21.00 – 23.70)	<0.001*
Anterior-posterior length of third ventricle (Measurements in mm)	27.17 ± 0.67 (25.20 – 28.50)	26.16 ± 0.58 (25.30 – 27.40)	<0.001*

Figures in parentheses indicate range, SD = Standard deviation, Comparison of values between male and female was done by Unpaired Student's 't' test, * = Significant, N= Total number of sample n= Sample size in each group

3.2. Anterior-Posterior Commissural Distance of Male and Female in Midsagittal T1 View of MRI Scan of Brain

The anterior-posterior commissural distance (mean ± SD) was 26.47 ± 1.6 mm and 26.06 ± 1.00 mm in male and female respectively. The range of anterior-posterior commissural distance was 24.30 mm to 36.50 mm in male and that was 23.80 mm to 27.50 mm in female. There was no significant difference in mean anterior-posterior commissural distance between male and female (p = 0.129) (Table- 2).

Table 2: Anterior–posterior commissural distance of male and female in midsagittal T1 view of MRI scan of brain (N=100)

Variable (Measurements in mm)	Male (n=50) Mean ± SD	Female (n=50) Mean ± SD	p-value
Anterior -posterior commissural distance (AC-PC)	26.47 ± 1.6 (24.30-36.50)	26.06 ± 1.00 (23.80 – 27.50)	0.129 ns

Figures in parentheses indicate range, SD = Standard deviation, Comparison of values between male and female was done by Unpaired Student's 't' test, ns= Not significant, N= Total number of samples, n= Sample size in each group

3.3. Maximum Width of Third Ventricle (In Coronal T2 View) Of Male and Female of MRI Scan of Brain

The maximum width of third ventricle (mean ± SD) was 4.33 ± 0.41 mm and 3.68 ± 0.68 mm in male and female respectively. The range of maximum width of third ventricle was 3.80 mm to 5.30 mm in male and that was 1.15 mm to 4.64 mm in female. Significant difference was found between male and female in maximum width of third ventricle (p<0.001). Where male had a significant higher value than female (Table-3).

Table- 3: Maximum width of third ventricle (in coronal T2 view) of male and female of MRI scan of brain (N=100)

Variable (Measurements in mm)	Male (n=50) Mean ± SD	Female (n=50) Mean ± SD	p-value
Maximum width of the third ventricle	4.33 ± 0.41 (3.80 – 5.30)	3.68 ± 0.68 (1.15 – 4.64)	<0.001*

Figures in parentheses indicate range, SD = Standard deviation, Comparison of values between male and female was done by Unpaired Student's 't' test. * = Significant, N= Total number of samples, n= Sample size in each group.

4. DISCUSSION

The brain ventricular system is filled with cerebrospinal fluid. The third ventricle is a narrow, funnel shaped structure, located in the centre of the brain between the right and left thalamus. It anteriorly communicates to the lateral ventricles by foramen of Monro. The third ventricle posteriorly connected to the fourth ventricle via aqueduct of Sylvius. There are many pathological conditions which are associated with the third ventricle. These are may be congenital or acquired in origin. Third ventricular size measurement is

necessary for determination and follow-up many neurological illness and pathologies [6]. During recent years majority of the morphometric studies on the impact of gender on the cerebral ventricles were performed among Caucasians in western countries, but very small number of morphometric studies were conducted in Asian populations [22, 23]. Of those, gender variations in this measure have not been extensively studied. Magnetic resonance imaging (MRI) allows acquisition of 3-D volume data and measurement of linear distances in any chosen image plane, using recent software [24]. The present study was aimed to measure different morphometric parameters of the third ventricle among adult Bangladeshi male and female using MRI scan.

In this present study, the mean height of third ventricle was significantly higher in male than female ($p<0.001$). Same finding was observed among the population of India [14], in the population of Germany [24], and in American population [25], where the values were significantly greater in male than female. In this present study, a significant gender difference was observed in the mean anterior-posterior length of third ventricle ($p<0.001$), male had higher values than female. In accordance a couple of related studies were reported significant difference between male and female in mean anterior-posterior length of third ventricle and male had greater value than female [14-26].

Regarding the mean anterior-posterior commissural distance, it was found that there was no significant difference in anterior-posterior commissural distance between male and female in this current study ($p>0.05$). In this context, one previous study showed no significant difference for anterior-posterior commissural distance among male and female [27].

The present study observed a significant gender difference for the mean maximum width of third ventricle ($p<0.001$). This finding was similar to those of population in Nepal [21], American people [25], and people of Turkey [17], where the maximum width of third ventricle was significantly greater in male than female.

Measurements taken from MRI scans on different parameters of third ventricle of brain have shown higher mean values for male compared to female. Therefore, it revealed important information about morphometric variations in male and female among Bangladeshi adults.

5. CONCLUSION

This morphometric study was an attempt to construct data on measurements of different variables of third ventricle of brain among adult Bangladeshi people by MRI scan. This current study demonstrated that; height, anterior to posterior length, maximum width of third ventricle were significantly higher in male than female, but no significant difference was found in anterior-posterior commissure distance of third ventricle between male and female among Bangladeshi adults. The present study found that the morphometric variables of the third ventricle had significant variations among adult Bangladeshi male and female. This may contribute to the understanding of the relative status of the present study sample in context of the morphometric variations of the different populations around the world.

Limitations

The current study had several limitations. First, the sample size was relatively small. Secondly, it was a single centre study. So, the results of the study could not be the full representation of the whole community of Bangladesh. Third, during selection of study subjects the assessment of the exclusion criteria was based totally on the information gathered through verbal enquiry and on visual impression. Moreover, the results of the present study could not be compared with other similar MRI scan based Bangladeshi studies due to lack of previous study.

Recommendations

Further studies with larger sample size are recommended to get more precise picture in order to produce a more comprehensive data of morphometry on measurements of third ventricle of brain. To represent the actual picture of Bangladeshi population, separate studies on people of different geographical regions of Bangladesh can be done. Studies can be done on different age groups to find out age related changes on different dimensions of third ventricle of brain among Bangladeshi people.

Conflicts of Interest: All authors stated that they have nothing to disclose.

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