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Research Article: Morphometric Evaluation of Fourth Ventricle by Using Magnetic Resonance Imaging

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Abstract

Background: The fourth ventricle is one of the components of the ventricular system in the brain , along with the lateral and third ventricles . The ventricular size is considered as a potential indicator in determination of many brain diseases. There are dimensional differences between males and females which appeared larger in males.

Aim: The aim of this study was to determine the radiological dimensions of fourth ventricle and to assess their relationship with gender and age.

Subjects and methods:
Brain Magnetic Resonance Images (MRI) of 100 patients (44 males and 56 females) were examined. The dimensions of the fourth ventricle were estimated. Additionally, the variation with sex and age were also described. After collection and checking of data, Statistical Package for Social Sciences (SPSS) was used for data entry and analysis.

Results:
The AP length of 4th ventricle of all patients ranged from 6.5-13.9 mm with mean (± SD) 10.67 ± 1.66 mm. In females, it ranged from 6.5-13.9 mm with mean (± SD) 10.48 ± 1.76 mm while in males; it ranged from 7-13.9 mm with mean (± SD) 10.92 ± 1.51 mm. The mean of 4th ventricle AP length of males were comparatively higher than females. Similarly, the 4th ventricle width of all patients ranged from 8.7-16.1 mm with mean (± SD) 12.06 ± 1.41 mm. In females, it ranged from 8.7-14.6 mm with mean (± SD) 11.85 ± 1.32 mm while in males; it ranged from 9.1-16.1 mm with mean (± SD) 12.32 ± 1.48 mm. The study showed that width of fourth ventricle was more than the AP length and both were greater in males than in females. AP length and width showed negative correlation with age.

Conclusion:
The normal reference values of ventricles obtained from MRI are necessary to form the baseline data for interpreting pathological changes, planning surgery, and determining presence and progress of some neurological diseases. Furthermore, the dimension of fourth ventricle should be taken into consideration during radiological reports and during clinical examination.

Keywords: Morphometric study, fourth ventricle, MRI.

Abbreviation: MRI : Magnetic Resonance Imaging; CT: Computed Tomography; AP-length : anterior-posterior length; CSF :cerebrospinal fluid; SPSS: Statistical Package for Social Sciences; S D: Standard Deviation.

Introduction

The ventricular system in the brain composed of CSF- filled ventricles and their connecting foraminae which originates from the central lumen of embryonic neural tube. CSF filled ventricular system is an essential part of brain. The ventricular system in the cerebral hemispheres consists of two lateral ventricles; midline third and fourth ventricles connected by inter ventricular foramen and aqueduct of Sylvius respectively.[1]
The fourth ventricle is characteristically diamond-shaped in sagittal cross-section.

The measurement of the fourth ventricle is 1.6 cm from the fastigium to the floor and 4 cm from the superior to the inferior angle [2], it is located dorsal to the pons and upper part of the medulla oblongata. The roof, located dorsally is formed by the superior medullary velum and inferior medullary velum overlying the cerebellum. The floor, located ventrally, is formed by the rhomboid fossa . The sidewalls are formed by the veli and cerebellar peduncles.It is widest at the level of the pontomedullary junction. [3,4]

It communicates superiorly with the third ventricle by means of the cerebral aqueduct, and antero-inferiorly with the central canal of the medulla oblongata. Below in the midline and laterally in the lateral recesses it communicates with the cisterna magna by the foramen of Magendie and Luschka respectively.[2]

The fourth ventricle contains choroid plexus which is one of major production of CSF and it is interconnected to cerebellopontine cistern through two lateral apertures (of Luschka) and to cistern Magna through median aperture (of Magendie). [5,6] These important openings permit the cerebrospinal fluid to flow from the ventricular system into the subarachnoid space.[7] In recent years, Computed Tomography (CT) scan and MRI have replaced the older methods of studying ventricular system.[6]

Proper knowledge and understanding about the anatomy of the brain ventricular system is helpful for clinicians, neurosurgeons, and radiologists in day-to-day clinical practice.[8-10] According to literature findings, the ventricular size is considered as an indicator in determination of many brain diseases. Additionally, the normal reference values of ventricles obtained by MRI are necessary to form the baseline data for interpreting pathological changes, planning surgery, determining presence and progress of some neurological diseases. Morphometric analysis of ventricular system is important for evaluating changes due to growth, ageing, intrinsic and extrinsic pathologies. [11,12] It helps the neurosurgeons for localization and removal of space occupying lesions around ventricular system.[13] The study of shape and size of ventricular system recently has become a main focus of interest in studies of some neuropsychiatric diseases like schizophrenia, Alzheimer's disease, and chronic alcoholism. [14-16] also familiarity about anatomy of cerebral ventricular system is important for endoscopic neurosurgery, helpful in the diagnosis and classification of hydrocephalus and follow-up of enlargement of ventricular system during therapy (ventricular shunts). [17,18]

In the last century, some researchers reported that the width of fourth ventricle to be greater than its height, and both width and height being higher in males than in females.[19-21] Relatively few authors have reported the age changes in the dimensions of fourth ventricle and its correlation to skull size. [11, 21] The greatest length and the width of the fourth ventricle are the parameters widely measured in various ventricular morphometric studies. The purpose of this study was to document the morphometric measurements of fourth ventricle and indices, and to identify sex and age related differences of our population.

Subjects and methods

Study design

A case series descriptive study using the revision of brain MRI records of patients was applied in this research.

Study setting

The place of study was Benghazi city - Libya and the department was the department of radiology where patients are referred from other health care facilities for radiological examination and diagnosis.

- Duration of study

The records of brain MRI during the period from January 2019 to March 2020 were reviewed.

- Inclusion criteria of cases

Male and female patients aged 18 years and above for whom brain MRI scan was recommended by their physicians.

- Exclusion criteria of cases

Any male and female patients aged less than 18 years, history of oncologic illnesses, hemiplegia, intracranial lesions, neurological signs, current, past psychiatric illness, alcoholism, and drug use.

- Tools

Philips; open panorama a 1.5 T MRI system). Brain MRI protocol obtained by special parameters technique such as axial T2-weighted turbo spin-echo (TR:4337.5, TE:100.0 ms; slice thickness 5.0 mm; gap 1.5 mm) was used. The measurements were performed by the brain MRI. Findings were evaluated by three observers [two radiologists and an anatomist] from digital MRI images in the hospital using the axial T2- weighted spin-echo image. The following parameters of the fourth ventricle AP length and transverse width were evaluated as illustrated by figure 1. After these measurements of the Estimations were expressed as millimeters.

- Data collection

A record sheet was used to collect data, which included: age, gender, AP length and transverse width transverse diameter.

- Administrative approval

The approval of the director of the hospital was taken before reviewing the records and collection of required data with consideration of confidentiality of the data.

- Statistical analysis

The Statistical Package for Social Sciences (SPSS); 21.0 program was used for statistical analysis of the measurement results. From these measurements, means, Standard Deviation (SD), minimum and maximum values were calculated Comparison between two groups was performed using unpaired student t-test. P value <0.05 was considered significant.

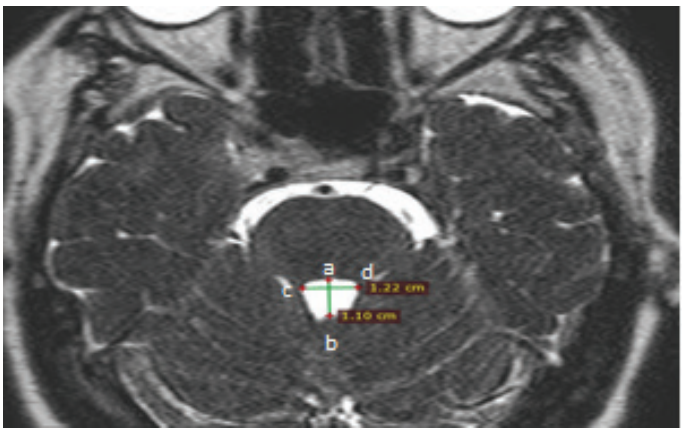

Fig 1: MRI of the brain at the level of fourth ventricle in male showing the transverse width and AP length measurement of the fourth ventricle in cm. The green lines indicate the AP length and transverse width.

Result

Brain MRI images of one hundred adult patients - (44 males &56 females) -were examined in this study as illustrated by Figure 2. The results of fourth ventricle parameters were as per Table 1 and 2.

The AP length of 4th ventricle of all patients ranged from 6.5-13.9 mm with mean (± SD) 10.67 ± 1.66 mm. In females, it ranged from 6.5-13.9 mm with mean (± SD) 10.48 ± 1.76 mm while in males; it ranged from 7-13.9 mm with mean (± SD) 10.92 ± 1.51 mm. The mean of 4th ventricle AP length of males was comparatively higher than females. Student's t test showed no significant difference in males as compared to females (10.92 ± 1.51 mm vs. 10.48 ± 1.76 mm, P= 0.19). Table 1

Similarly, the 4th ventricle width of all patients ranged from 8.7-16.1 mm with mean (± SD) 12.06 ± 1.41 mm. In females, it ranged from 8.7-14.6 mm with mean (± SD) 11.85 ± 1.32 mm while in males; it ranged from 9.1-16.1 mm with mean (± SD) 12.32 ± 1.48 mm. We found that width was higher in males than in females, but the difference was non-significant. Table 1

The study showed that the width of fourth ventricle was more than the AP length and both were greater in males than in females. Table 1

Using Pearson correlation there was a weak inverse non-significant association between AP length of fourth ventricle and age in the whole study sample and among females, while in males, the association was positive, however, very weak and non-significant. Regarding the transverse width, there was no association with the age of the subjects. Table 2

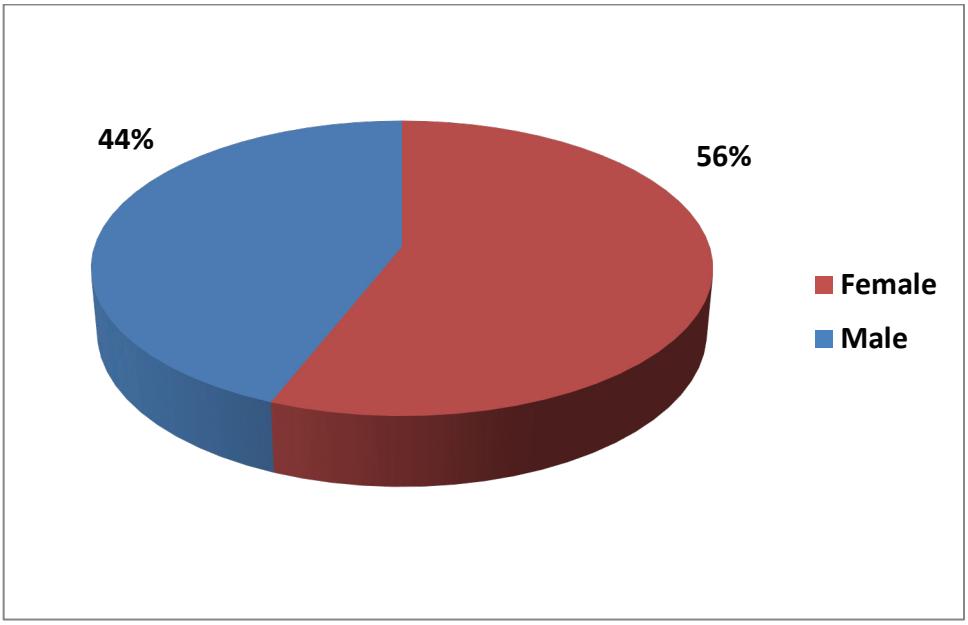

Figure 2. Distribution of patient according to sex

Table 1: Mean and standard deviation of 4th ventricle parameters of males & females

The parameters	Total (n=100)	Males (n=44)	Females (n=56)	P value
Fourth ventricle AP length in mm	10.67 ± 1.66	10.92 ± 1.51	10.48 ± 1.76	0.19
Fourth ventricle transverse width in mm	12.06 ± 1.41	12.32 ± 1.48	11.85 ± 1.32	0.10

Table 2: Correlations of brain ventricular parameters with age using Pearson correlation

The parameters	Total (n=100)	Males (n=44)	Females (n=56)
Fourth ventricle AP length in mm	-0.14	0.04	-0.22
Fourth ventricle Transverse width in mm	0.01	-0.05	0.09

Discussion

There are many causes of the fourth ventricle enlargement like brain stem tumors, blockage of foramen of luschka and Magendie, Arnold Chiari malformations, autism, etc. [22] 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. Evaluation of the normal measurements of the cerebral ventricles in the living human has great importance in the diagnosis and monitoring of several pathologies. [23,24] Through the width is always measured on axial images, there has been confusion about its length and height in previous studies.

AP Length of fourth ventricle

The present study showed that the mean AP length of fourth ventricle was 10.67 ± 1.66 mm, the maximum value being 13.9 mm and was higher in males than in females, but the difference was non-significant. These findings are in accordance with those of study by Brij Raj et al[23] [mean height: 12.18± 1.54 (males); 12.13± 1.41(females)] by CT scan and by Meshrampreeti[25] by CT scan (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. Patnaik P 2016[24] used CT and found that ; mean height 7.62 ± 2.56 mm in males, and 6.85 ± 1.66 mm in females and the mean length of fourth ventricle was higher in males than in females, but the difference was statistically non-significant.

In contrast, Gamereddin M et al[26] found slightly higher maximum height of fourth ventricle in females (9.70+/- 2.21) than in males (9.66+/-2.12) by CT scan, however the difference was non-significant. According to the opinion of Gawler (1976) [27] , the greatest height between roof and the floor of the fourth ventricle was 10.8 mm. Gawler found that the height of the 4th ventricle was higher in males as compared to females. D'souza and Natekar[28] observed that the height of the fourth ventricle was significantly larger in males (11.8 ± 2.7 mm) as compared to females (11.1 ± 2.4 mm). The width of the fourth ventricle was found to be greater than the height in both gender and was more in males (13.1 ± 2.3 mm) than in females (12.1 ± 2.4 mm) Akbari VJ et al [29] by plastination method found that the mean height of fourth ventricle was 2.29+/-0.30 cm (range 1.9 to 2.7 cm), Singh et al[30] observed that the height of the fourth ventricle was significantly higher in males (9.36 ± 1.17 mm) as compared to females (8.59 ± 1.20 mm). AP Length of fourth ventricle showed positive very weak correlation with age in males, which was statistically non-significant, and showed negative correlation with age in the whole study sample and among females. It does not depend upon age.

Transverse width of fourth ventricle

The present study showed that the mean width as 12.06 ± 1.41 mm in the studied population. The maximum value being 16.1 mm. In females, mean (± SD) 11.85 ± 1.32 mm while in males; mean (± SD) 12.32 ± 1.48 mm (p= 0.10). The width of fourth ventricle was higher than the AP length of it. Analyzing the gender variations, we found that width was higher in males than in females, but the difference was non-significant. 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,[23] 1.32+/-0.201 cm in males, higher than in females (1.19+/-0.171 cm) by MeshramPreeti[25]using CT study, the difference being non- significant. Hamidu et al. [31] reported that the mean third and fourth ventricular sizes were greater in males as compared to females, although this difference is statistically significant only for the third ventricle but no significant differences noted for the fourth ventricle. KanakarajKetal[29] also have shown significant differences between male and female in relation to the third ventricle measurement but no significant differences noted for the fourth ventricle.

The fourth ventricle width was found to be 13.0 mm and 12.0 mm in males and females, respectively [32]. The corresponding values of both Saudi Arabian males and females were; 12.54 mm and 11.60 mm with significant statistical difference (p=0.005) .[26] The value of the German healthy population was 12.5 mm.[17] In Goa population, the same dimensions were reported as 1.31 cm and 1.21 cm in males and females.[28]Among Indians, the same measurements were found as 12.16 mm and, 11.38 mm in males and females, respectively.[9] This value was higher in males than females and the highest the fourth ventricle values were in age group of 70 years in both genders. [9, 32]

In the present study the greatest AP- Length in males (10.92 ± 1.51 mm) was more than in females (10.48 ± 1.76 mm). The width of the fourth ventricle was found to be greater than the AP length in both gender and was more in males (12.32 ± 1.48 mm) than in females (11.85 ± 1.32 mm). The width of the fourth ventricle as measured in later studies by Meese et al.,[21] and D'Souza and Natekar [28] the width was found to be greater than the height in both sexes with males recording a significantly higher width (1.31cm), as compared to 1.21cm average of females.

A study conducted in Saudi Arabia to investigate the correlation of width with the age of the subjects, found that there was a moderate positive significant ($p<0.01$) correlation between fourth ventricle width and age.[26]Meshrampreeti et al reported that height and width of fourth ventricle both showed low positive correlation with age in both the sexes, which was statistically significant. [25]

Recommendation:

1- Further studies using larger population size to enable us to generalize the findings for the Libyan population.

2- Morphometric evaluation of lateral and third ventricles.

Conclusion

It is concluded that that age and gender are important and could be used as the reference values in evaluating the brain region. Additionally, revealed the importance of using MRI to evaluate both normal and pathological changes for surgeon, radiologist or neuroscientist in the ventricular region .Furthermore, we think that the normal reference values of ventricles obtained by MRI are important baseline data for interpreting pathological changes, planning surgery, and determining presence and progress of some neurological diseases.

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