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Normal Width of Third Ventricle in Libyan Population: Assessment By MRI

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ABSTRACT

Aim: As age advances, the human brain undergoes many gross and histopathological changes with regression of the brain tissue leading to the enlargement of the ventricles but also has been associated with many neurological disorders. Knowledge of morphometrics and the size of the normal ventricular system of the brain is important to understand these changes. This study aimed to determine the normal reference values of the width of the third ventricle in healthy subjects of the Libyan population using the magnetic resonance imaging technique (MRI) and to explore the sex and age-related differences.

Subjects and methods:

This study was carried out on one hundred patients with normal brain MRI exams who underwent non-contrast MRI brain (fifty sex females and forty-four males) aged between twelve and ninety years during the period from January 2019 and March 2020. The third ventricle width was measured and statistically analyzed.

Results:

The third ventricle width of all subjects' mean (± SD) was 3.243 ± 1.607 mm (The smallest TVW was 2.19 mm and the largest TVW was 5.84 mm). In females, the mean (± SD) was 3.08 ± 1.52 mm while in males; the mean (± SD) was 3.44 ± 1.700 mm. We found that width was higher in males than in females, but the difference was non-significant. (p value = 0.274). In our study, the youngest patient was 12 years old; whereas the oldest was 90 years. Third ventricle width (TVW) increased with advancing age and there was a steady rise across age groups until the sixth decade, after which there was a sharp rise. The small p-value ($P<0.001$) suggests that there is a statistically significant difference in third ventricle width (TVW) between the groups defined by the variable "age".

Conclusion: Understanding of ventricular system anatomy is essential for clinicians, neurosurgeons, and radiologists. The literature highlights that ventricular size is a potential indicator in diagnosing many brain-related diseases. Additionally, the normal reference values of ventricles obtained from MRI are necessary to form the baseline data for interpreting pathological changes, planning surgery, and determining the presence and progress of some neurological diseases.

KEYWORDS: Third ventricle, MRI.

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Abbreviation: MRI**:** Magnetic Resonance Imaging; CT: Computed Tomography; TVW: Third ventricle width; SPSS: Statistical Package for Social Sciences; SD: Standard Deviation

INTRODUCTION

The third ventricle of the brain is a narrow median cleft in the diencephalon between the two thalami. It communicates anteriorly to lateral ventricles through the foramen of Monro and posteriorly to the fourth ventricle through the narrow cerebral aqueduct (the cavity of the midbrain). [1, 2] The third ventricle is related to many important brain structures, including the anterior commissure, fornix, tela choroidea, pineal body, hypothalamic structures, optic chiasma, infundibulum, mammillary bodies, tegmentum of the midbrain. [3] Aging of the human brain is characterized by structural changes that are considered normal. Therefore, thorough knowledge of the age-related normal changes in the brain must be considered before any abnormal findings are analyzed. Assessing the standard measurement of the cerebral ventricles in living humans is highly significant in diagnosing and monitoring several pathologies. [4] Recently, Computed Tomography (CT) scans and Magnetic Resonance Imaging (MRI) have replaced the older methods of studying the ventricular system. [4] Accurate measurements of the ventricles provide available and safe means of aiding the diagnosis of some neurological disorders, such as early detection of hydrocephalus and cerebral atrophy, and also provide important follow-up information in affected patients. [5] As aging progresses, the human brain undergoes many gross and histopathological changes associated with the regression of the brain tissue, leading to dilatation and enlargement of the ventricles. To know these changes, the awareness of normal morphometry and the size of the normal ventricular system of the brain is essential.

The third ventricle width (TVW) is an easy way to measure brain atrophy and serves as a predictor of cognitive impairment. [6] TVW has been reported by various authors[7-11] to be from 2.29 mm to 9.2 mm, but data on gender-related differences is still scanty. [12-14] The maximum width of the ventricle has been widely used as a region of interest in various ventricular morphometric studies. The dimension of the third ventricle can vary with multiple factors such as age, gender, body mass index (BMI), and various populations. [15] Many studies conducted by different researchers have measured the width of the third ventricle among both diseased and normal individuals using different imaging modalities like ultrasound, magnetic resonance imaging (MRI), and CT scan. Turner et al. [16] measured the TVW among patients with multiple sclerosis, compared it with a control group using MRI, and reported that the width was much larger than the controls studied. According to Schochet[17], the brain undergoes many gross and histopathologic changes with advancing age and in various dementias, with regression of brain tissue leading to ballooning of the third ventricle. Studies by LeMay[18] attributed this ballooning of the third ventricle to a regression of the median nuclei of the thalami and a progressive diminution of the massa intermedia that joins them. Our study aimed to provide an average data range of third ventricle width in the normal Libyan population and evaluate the variation in size determined by age and gender.

Subjects and methods

This study was conducted on one hundred patients with normal brain MRI scans (fifty sex females and forty-four males) aged between twelve and ninety years, who underwent non-contrast MRI brain scans during the study period from January 2019 and March 2020. The third ventricle widths were measured. All the test procedures were approved by the ethics committee. The study is based on a retrospective evaluation

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of Brain MRI. The brain MRI findings were evaluated by three observers [two radiologists and an anatomist]. The participants were chosen based on their excellent health criteria. Moreover, inclusion criteria for subjects were male and female patients aged 12 years and above for whom brain MRI was recommended by their physicians. Only cases interpreted as normal were included in the study. Exclusion criteria included the presence of infarctions, intra or extra-axial hemorrhage, mass, fracture of the cranial vault, alcoholism, or drug use. MRI was performed using (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 from digital MRI images on a hospital using the axial T2-weighted spin-echo image, The widest diameter of the third ventricle was measured in millimeters (mm) on each patient as illustrated by Figure 1. The widest diameter of the third ventricle was measured in millimeters (mm) on each patient on axial images using an on-screen linear electronic caliper (Figure 1).

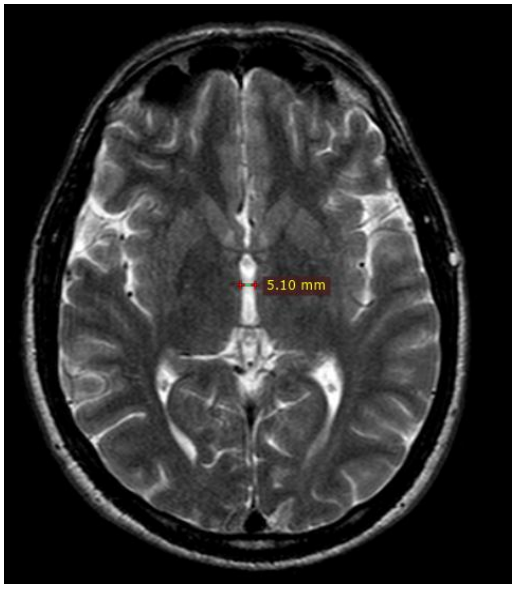

Fig. 1: MRI of the brain at the level of the third ventricle in a male showing the measurement of the third ventricle width in mm. The red line indicates the TVW.

Statistical Analysis: The SPSS 21.0 program was used for statistical analysis of the measurement results., means, SD, minimum, and maximum values were calculated from these measurements. P value <0.05 was considered significant.

Limitations: One of the biggest limitations of this study was, the inadequate sample size. Many cases had been excluded from the study due to minor pathological changes in the brain which could influence the measurement.

RESULT

Brain MRI images of one hundred participants (44 males - 56 females) were examined in this study as illustrated by Figure 1. In our study, the youngest participant was 12 years old; whereas the oldest was 90 years. 44 of the participants were male and the remaining 56 were female. The TVW of all subjects means (± SD) was 3.243 ± 1.607 mm (The smallest TVW was 1.09 mm and the largest TVW was 9.12 mm). In females, the mean (± SD) was 3.08 ± 1.52 mm while in males; the mean (± SD) was 3.44 ± 1.70 mm. We found that the third ventricle width was higher in males than in females, but the difference was non-

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significant, (P-value = 0.274). Third ventricle width (TVW) increased with advancing age and there was considerable variation in size up to the sixth decade; thereafter the size increased rapidly. the maximum width of the third ventricle had a mean of 7.24mm in males in the seventh decade. The small p-value (P<0.001) suggests that there is a statistically significant difference in TVW between the groups defined by the variable "age".

The differences in TVW between the different age groups were statistically significant, with a p-value less than 0.001 (Table 3). However, the differences in TVW among males and females of different age groups were not statistically significant (Table 2).

Table 1: Distributions of patents

AGE GROUP	TOTAL (MALE + FEMALE)	MALE	FEMALE
10-19	4	2	2
20-29	22	6	16
30-39	21	14	7
40-49	16	11	5
50-59	21	6	15
60-69	9	3	6
70-79	6	2	4
80-89	-	-	-
> 90	1	-	1
Total	100	44	56

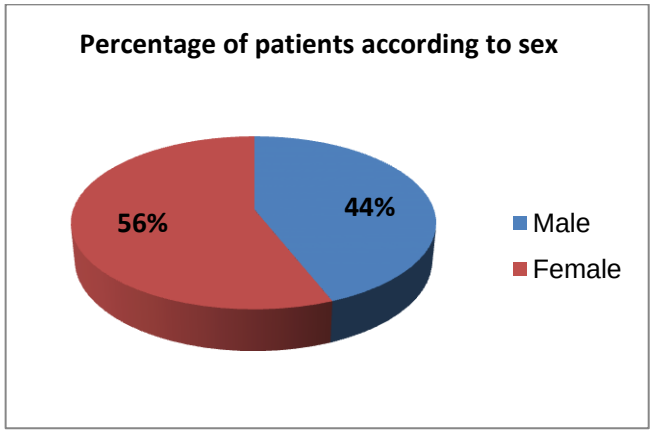

Fig. 2: Distribution of patients according to sex.

Table 2: Mean TVW distribution according to age group and gender

Age range	No. of patients	Male		Female	
		TVW	SD	TVW	SD
10-19	4	1.85	0.332	2.52	0.445
20-29	22	3.18	1.048	2.15	0.711
30-39	21	3.85	1.348	2.90	0.854
40-49	16	2.65	1.190	2.93	1.053
50-59	21	3.17	1.658	3.35	2.147

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60-69	9	3.97	1.728	3.90	0.928
70-79	6	7.24	4.058	4.67	1.343
> 90	1	-	-	5.84	-
Total	100	3.44	1.700	3.08	1.528

The higher p-value (sig. = 0.274) suggests that there is no statistically significant difference in Third ventricle width (TVW) between the groups defined by the variable "sex."

Table 3: Mean TVW distribution according to age group

Age range	Mean TVW (mm)	SD
10-19	2.19	0.502
20-29	2.43	0.917
30-39	3.53	1.269
40-49	2.74	1.121
50-59	3.30	1.981
60-69	3.92	1.134
70-79	5.52	2.477
> 90	5.84	
Total	3.24	1.607

The small p-value (P<0.001) suggests that there is a statistically significant difference in Third ventricle width (TVW) between the groups defined by the variable "age".

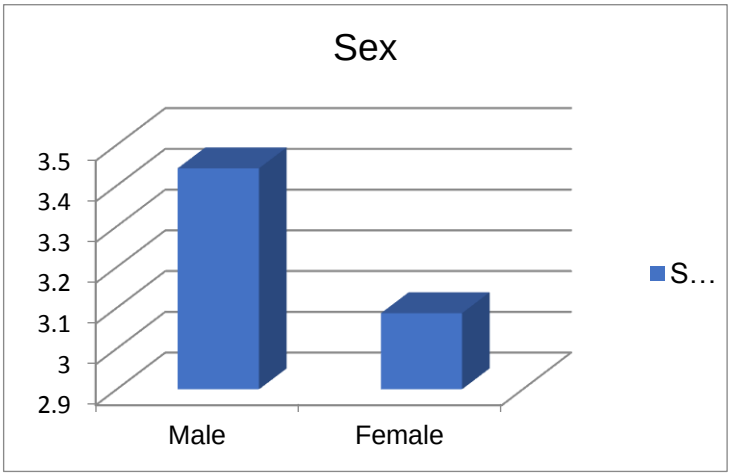

Fig. 3: Mean of 3rd ventricle width of two groups.

DISCUSSION

Various studies on different groups of people have shown varying measurements of the third ventricle width (TVW). Table 4 compares these measurements from different studies. In our study, the mean of the TVW of all subjects (± SD) was 3.243 ± 1.607 mm. In females, the mean (± SD) was 3.08 ± 1.52 mm while in males, the mean (± SD) was 3.44 ± 1.70 mm. We found that the width was higher in males than in females, but the difference was non-significant, (p-value = 0.274). The current findings were also in agreement with studies by Duffner F et al, Shrestha et al[19] & Brij et al. [14] Brij et al[14] reported that the width of the third ventricle was greater in males (3.47 ± 1.07 mm) than in females (3.31 ± 0.94 mm) and this difference was statistically insignificant (T= 1.470 p= 0.164). A study conducted in the African population

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by Hamidu AU et al[20] (in 2015, Zaria-Nigeria) reported that the mean size of the third ventricular was greater in males compared to females. Although this difference was statistically significant, the third ventricle width was found to be slightly higher in both males and females compared to our study. Interestingly, a study conducted by Zauhair et al[8] (in 2009, Iraq) showed that the third ventricle width was found to be smaller in both males and females as compared to our study. In a more recently conducted study in a similar region of the Middle East, Gameraddin M et al[11] (in 2015, Saudi Arabia) conducted a study on 152 participants, and the TVW was found to be higher in both males and females than our study. Furthermore, TVW was reported to be slightly higher in males than in females in Indian studies, (D'souza et al, Meshram et al, Brij et al). [12-14] However, Vidya K[10] (2014) in an MRI study, reported that TVW was the same in males and females.

A study in Norway found that the third ventricle width was around 3±0.9mm for young females and 4±0.9mm for young males. [21]. In Nottingham, England, another study showed that the control group's third ventricle width was approximately 5.14±1.98 mm. [16]. In a study conducted on Japanese people, the TVW was 6.39 mm in males and 5.09 mm in females. [22] and in another study, the TVW was 3.25 mm and 4.06 mm in Indian females and males. [23] In a Turkish study of TVW, the width value was reported as 3.79 ± 0.85mm in females and 4.12 ± 0.94mm in males. [24] In Germany, a study conducted on the German population reported that TVW was between 3.3 mm and 7.7 mm in the ages between 20 and 69 years old. [25] In the population of Goa, the mean of the TVW was reported as 0.45 cm and 0.39 cm in males and females respectively. [12] Gameraddin et al. [11] reported that the mean of the TVW was 5.70+1.54 mm and 5.40+1.68 in males and females of Saudi Arabia population. In this study, the mean measurements were found as 3.44+1.700 mm and 3.08+1.52 mm in males and females respectively. Results of this study showed that the small p-value ($P<0.001$) suggests that there is a statistically significant difference in TVW between the groups defined by the variable "age".

Furthermore, Skullerud[15] noted that there is a reduction in brain weight, which probably starts after the age of 55 years. This reduction in brain mass leads to an increase in ventricular sizes as a compensatory mechanism for cerebral atrophy, which occurs as a physiological process with aging. Borgersen, [26] observed a gradual widening of the third ventricle starting around the fourth decade, before then, he observed no or only a trace of the third ventricle. Haug reported similar results. [27] Both of these authors found that the mean values of the width of the third ventricle suggested a smaller ventricular system in females than in males in all ages beyond the second decade. D'Souza and Natekar[12] found a width of 0.45cm in males compared to 0.39cm in females beyond the age of sixty years.

Table 4: Third ventricle width as reported by different authors.

Author, year, area	**3rd ventricle width**	**Technology, sample size**
Gawler J et al[28] (1976) London	0.46 cm	CT, 78
Soininen H et al[29] (1982) Finland	0.92 cm	CT, 85
Duffner F et al[30] (2003) Germany	0.33	MRI, 30
Hernández NL[7] (2007)	3.9 ± 2.5 mm	-
Zauhair A.[8] (2009)	Male 2.39±0.649 mm; Female 2.16±0.578 mm	112

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Wollenweber[9] (2011)	3.6 ±1.8 mm	-
Vidya K. Satapara[10] (2014),Gujrat India	0.52 cm,	MRI, 83
D'souza e DMC & Natekar PE[12] (2007) Goa, India	Male 0.45cm, Female 0.39 cm	CT, 1000
Meshram P & Hattangdi S[13] (2012) Mumbai India	Male 0.77; Female 0.67	CT, 200
Brij et al[14] (2014)	Males 3.47 ± 1.07mm; females 3.31 ± 0.94	CT, 358
Gameraddin M et al[11] (2015) Saudi Arabia	Males 5.70 ± 1.54 mm ; females 5.40 ± 1.68	CT, 152
Patnaik P et al[31] (2015) , India	Males 7.47+/-2.81mm; females 6.39+/-2.6	CT, 59,
Shrestha et al[19] (2015) , Nepal	Males 4.64mm; females 4.22	CT, 200
Hamidu et al[20] (2015) , Nigeria	Males 4.23 ± 1.25; females 3.81 ± 0.87	CT, 488
Present study, 2023, Libya	Males 3.44 ± 1.70 mm; females 3.08 ± 1.52 mm	MRI, 100

CONCLUSION

In conclusion, the observations presented in this study have defined anatomical parameters that need to be taken into consideration for evaluating ventricular size relative to brain volume changes and guidelines for determining the reference values. Also, this paper offers crucial information that is essential for the safe and accurate diagnosis of many neurological disorders and to evaluation of both normal and pathological changes making that valuable for surgeons, radiologists, or neuroscientists who use MRI to evaluate pathological changes in the ventricular region. furthermore, the significance of studies that consider age and gender is increasingly recognized as crucial in improving our understanding of these issues.

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