Original research article

Anatomy of fourth ventricle a morphmetric study

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Abstract

Morphometry of the fourth ventricle is critically important in the fields of neuroanatomy, neurosurgery, and neuroradiology. The fourth ventricle, a diamond-shaped cavity located between the brainstem and the cerebellum, plays a vital role in the brain's ventricular system by acting as a conduit for cerebrospinal fluid (CSF). Understanding its dimensions and variations is essential for several reasons. Firstly, precise morphometric data assist in diagnosing and treating neurological disorders. Abnormalities in the size or shape of the fourth ventricle can indicate pathologies such as hydrocephalus, tumors, or congenital malformations. For instance, an enlarged fourth ventricle might suggest obstructive hydrocephalus, necessitating timely medical intervention. Secondly, in the realm of neurosurgery, accurate knowledge of the fourth ventricle's dimensions is crucial for planning surgical procedures. Overall, the morphometry of the fourth ventricle is integral to advancing clinical practices, improving patient outcomes, and enhancing our comprehension of brain structure and function.
Keywords: Morphometric, assessment, external anatomy, fourth ventricle.

Introduction

Gaining knowledge of the structure of the central nervous system is an essential component of neurosurgery education. The advancement of novel methodologies and the enhancement of current ones heavily rely on the topographic examination of cadaveric specimens [1]. The brain's physical structure and physiological activities are intricate yet vital for maintaining life. The brain directly or indirectly controls several processes such as planning, initiation, voluntary movements, behaviour, memory, sensory and motor functions, hearing, vision, and regulation of visceral functions, starting with the planning and initiation stage [2]. The objective and morphometric investigations of human brain ventricles have gained attention recently due to their association with several illnesses such as schizophrenia, hydrocephalus, tumours, trauma, as well as gender and ageing, which might potentially lead to dementia. Morphometric examination of the ventricular system is useful for diagnosing and categorising hydrocephalus, as well as evaluating and monitoring the expansion of the ventricular system during therapy using ventricular shunts. The proximity of critical neural structures, such as the brainstem and cranial nerve nuclei, demands a high degree of precision to avoid damaging these areas during surgery. Morphometric analyses help in creating detailed preoperative maps, thus enhancing surgical outcomes and minimizing complications. Furthermore, in neuroradiology, detailed morphometric data improve the interpretation of imaging studies. Advanced imaging techniques like MRI and CT scans rely on normative data to identify deviations from the typical anatomy [3-5]. Radiologists use this information to detect subtle changes that may signify the early stages of disease [7-9]. In research, morphometric studies of the fourth ventricle contribute to our understanding of brain development and aging. By establishing normative data across different age groups and populations, researchers can identify patterns associated with normal aging or developmental anomalies. The objective of this study was to analyse the measurements and proportions of the exterior structure of the fourth ventricle and dorsal brainstem.

This study was a descriptive analysis conducted in the Department of Anatomy. To ensure a diverse participant pool from different regions of South India, it was extended to a multi-institutional study. The research was carried out over a period of two years, from January 2022 to December 2023.

Inclusion Criteria: The study focused on apparently normal brain specimens obtained from human cadavers with known age and sex.

Exclusion Criteria: Specimens affected by trauma-related parenchymal injuries, non-traumatic intracranial hemorrhages, ischemic systemic diseases, or intracranial tumors were excluded due to their potential impact on brain tissue size.

Measurements were taken from 30 recently deceased adult bodies. Two investigators independently performed the measurements, and the average values were calculated. In these cases, the skulls were

opened without histological examination, and the brains were removed using tentorium scissors. The brainstem was extracted from the foramen magnum.
Subsequently, the entire brain was removed, and the brainstem was dissected to measure the dimensions of the fourth ventricle and the cadaver brainstem using millimeter rulers. Data was collected and organized using Microsoft Excel, then analyzed with SPSS 23.0 software. Continuous variables were evaluated for frequency, percentage, mean, and standard deviation (SD). The chi-square test or Fisher's exact test was employed to assess differences in proportions between qualitative variables, as appropriate. A p-value less than 0.05 was considered statistically significant.

Results

Table 1: Measurement of fourth ventricles (in mm)

Parameters	Male (in mm)	Female (in mm)	P value
Height of fourth ventricle	26.86	26.06	0.63
Width of fourth ventricle	28.06	27.36	0.75

Various brain stem measurements were comparable among male & females, difference was not significant statistically.

Table 2: Brainstem Morphometry (in mm)

Morphometric Feature	Male (Mean ± SD)	Female (Mean ± SD)	P value
Length of The Brainstem	57.812	53.99	0.2
Aqueduct Obex (mm)	41.812	40.21	0.8
Lateral Recess Length (mm)	17.702	16.75	0.1
Facial Colliculus-Obex	25.052	22.23	0.8
Aqueduct–Facial Colliculus	23.622	23.93	0.4
Mesencephalon	15.982	15.88	0.5
Pons	31.762	32.66	0.6
Medulla Oblongata	16.822	16.11	0.4
Foramen Luschka (Distance between Right and left)	23.702	24.55	0.7
Distance between Median and Sulcus Limitans	6.882	6.25	0.7
Distance between the 5th cisterns	37.132	37.44	0.4
Distance Between the midlines of Superior and Inferior Colliculus	8.622	7.63	0.5

Discussion

The fourth ventricle, often referred to as V4, is a crucial structure in the brain's ventricular system. It is an enlarged portion of the ependymal canal, located between the medulla oblongata and the pons anteriorly, and the cerebellum posteriorly. The fourth ventricle is part of the rhombencephalic cavity, which includes the medulla oblongata and the pons, both protected by the cerebellum. The cerebellum originates from the metencephalon during embryonic development. This ventricle connects with the midbrain aqueduct above and communicates with other cisterns, such as the cerebellar-spinal cistern, below via the tela choroidea of V4.
Understanding the anatomical positioning of the fourth ventricle is essential for certain neurosurgical procedures. Approaches such as the sub-tonsillar or telovelar methods are employed to access V4 while preserving the cerebellum's integrity. These techniques are crucial when the fourth ventricle becomes obstructed due to congenital anomalies or tumors. Conditions like Dandy-Walker malformation, Arnold-Chiari malformation Type II with myelomeningocele, and tumors such as medulloblastoma, ependymoma, and astrocytoma can block the fourth ventricle, leading to hydrocephalus [10].
Accurate assessment of ventricular size is paramount in diagnosing and monitoring various neurological disorders and abnormalities. Ventricular enlargement, for instance, is often indicative of brain tissue loss. Furthermore, measuring the size of the ventricles is essential in research on numerous conditions, including hydrocephalus, schizophrenia, tumors, trauma, Alzheimer's disease, Parkinson's disease, gender differences, aging, and brain atrophy. These measurements also provide significant insights into cerebral asymmetry and atrophy, which are linked to various neurological conditions such as stroke, dementia, and Huntington's disease [11].
Historically, tumors and vascular abnormalities located in the brainstem were considered inoperable due to the high risk of complications. However, advancements in neuroimaging and neurophysiological monitoring, coupled with a deepening anatomical understanding and enhanced surgical expertise, have significantly improved the treatment of lesions in or near the brainstem. Modern techniques allow for safer and more effective surgical interventions, which were once deemed too risky.

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In a study it was observed that the lateral ventricles exhibit variations in size within specified limits based on factors such as age, sex, and laterality. This study highlights the importance of considering individual differences when assessing ventricular sizes, which can provide valuable information for both clinical and research purposes. Such variability underscores the necessity for precise morphometric data to enhance diagnostic accuracy and tailor treatments effectively [11].

Overall, the morphometry of the fourth ventricle is critical for advancing clinical practices, improving patient outcomes, and enhancing our understanding of brain structure and function. Accurate measurement and assessment of the fourth ventricle not only aid in diagnosing and managing neurological disorders but also contribute significantly to the field of neuroscience research. The continuous development of surgical techniques and imaging technologies promises further improvements in the treatment and understanding of conditions affecting the fourth ventricle and related brain structures.

Conclusion

The morphometric analysis of the fourth ventricle and various brainstem measurements in males and females revealed that there were no significant differences between the sexes. Specifically, the height and width of the fourth ventricle were found to be 26.86 mm and 28.06 mm in males, and 26.06 mm and 27.36 mm in females, respectively, with P values of 0.63 and 0.75, indicating no statistically significant differences.

Further examination of brainstem morphometry also showed comparable measurements between males and females. For instance, the length of the brainstem averaged 57.812 mm in males and 53.99 mm in females, with a P value of 0.2. Other features, such as the Aqueduct Obex, Lateral Recess Length, Facial Colliculus-Obex, and Aqueduct–Facial Colliculus, among others, displayed similar patterns, with P values ranging from 0.1 to 0.8, none of which reached statistical significance.

These findings suggest that the anatomical dimensions of the fourth ventricle and brainstem are consistent between males and females, reinforcing the notion that sex-based differences in these regions are minimal. This consistency is crucial for clinical and surgical applications, as it implies that standardized approaches can be effectively utilized across both sexes. Additionally, these results contribute to the broader understanding of brain morphometry and its implications for diagnosing and treating neurological conditions.

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