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Morphometric assessment of the external anatomy of fourth ventricle & dorsal brainstem in South Indian population

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***Abstract*---**Background: Morphometric analysis of ventricular system is helpful in the diagnosis and classification of hydrocephalus and in the assessment and follow-up of enlargement of ventricular system during therapy (ventricular shunts). Present study was aimed to study morphometric assessment of the external anatomy of fourth ventricle & dorsal brainstem. Material and Methods: Present study was descriptive, observational study, conducted in apparently normal brain specimens from human cadavers with known age and sex. The brainstem was separated and the measurements of fourth ventricle & cadaver brainstem were made using millimeter rulers. Results: In present study among 60 fresh adult human cadavers, height & width of fourth ventricle was comparable among male & females, difference was not significant statistically. Various brainstem measurements were comparable among male & females, difference was not significant statistically. Conclusion: Baseline anatomical baseline data helps in

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interpreting pathological changes, planning surgery, and determining presence and progress of some neurological diseases.

***Keywords*---**dorsal brainstem, fourth ventricle tumors, anatomical data, morphometric assessment.

Introduction

Understanding the anatomy of the central nervous system is a fundamental part of neurosurgical training. The development of new techniques and the optimization of existing ones largely depend on the topographic study of cadaveric specimens.[1] Both anatomical structure and physiological functions of the brain are complex but essential to sustain life. Starting from planning and initiation, voluntary movements, behaviour, memory, sensory and motor functions, hearing and vision, regulation of all visceral functions are directly or indirectly controlled by the brain.[2] Objective and morphometric studies of human brain ventricles is under limelight, recently due to it is relation with several pathologies evidences such as schizophrenia, hydrocephalus, tumors, Trauma and as well as gender and aging which could lead to dementia.[3] Morphometric analysis of ventricular system is also helpful in the diagnosis and classification of hydrocephalus and in the assessment and follow-up of enlargement of ventricular system during therapy (ventricular shunts).[4] Present study was aimed to study morphometric assessment of the external anatomy of fourth ventricle & dorsal brainstem.

Material and Methods

Present study was single institute based, descriptive study, conducted in Department of Anatomy, at Kanachur Institute of Medical Sciences, Mangalore, Our friends from Raja muthiah Medical College, Annamalai university, SRM Medical College Hospital and Research Centre, Trichy were the main think tank behind the project. And since we wanted the study in from different regions of South India we made it a multiple institute study. Study duration was of 2 years (January 2020 to December 2021).

Inclusion criteria

Apparently normal brain specimens from human cadavers with known age and sex were studied.

Exclusion criteria

Any diseases that may have altered the size of the brain tissue (trauma-related parenchymal injuries, non-traumatic intracranial hemorrhages, ischemic systemic diseases, and intracranial tumors).

Among 60 fresh adult cadavers, we performed our measurements by two independent investigators, and mean was calculated. Two calvarias were opened in those cases without histopathological evaluation sampling, and they were cut using tentorium scissors. The brainstem was removed from the foramen magnum, and then the whole brain was removed. The brainstem was separated and the measurements of fourth ventricle & cadaver brainstem were made using millimeter rulers. Data was collected and compiled using Microsoft Excel, analysed using SPSS 23.0 version. Frequency, percentage, means and standard deviations (SD) was calculated for the continuous variables. Difference of proportions between qualitative variables were tested using chi- square test or Fisher exact test as applicable. P value less than 0.5 was considered as statistically significant.

Results

In present study among 60 fresh adult human cadavers, height & width of fourth ventricle was comparable among male & females, difference was not significant statistically.

Table 1
Measurement of fourth Ventricles (in mm)

Parameters	Male (in mm)	Female	P value
Height of fourth ventricle	26.6 ± 4.4	25.8 ± 4.5	0.63
Width of fourth ventricle	27.8 ± 4.2	27.1 ± 4.6	0.75

Various brainstem 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	57.5 ± 4.29	54.16 ± 2.47	0.28
Aqueduct Obex (mm)	41.51 ± 4.88	40.38 ± 2.08	0.86
Lateral Recess Length (mm)	17.39 ± 3.06	16.92 ± 2.21	0.15
Facial Colliculus - Obex	24.74 ± 2.31	22.44 ± 1.86	0.86
Aqueduct – Facial Colliculus	23.31 ± 3.65	24.1 ± 2.88	0.42
Mesencephalon	15.67 ± 1.30	16.05 ± 1.16	0.55
Pons	31.45 ± 3.39	32.83 ± 2.86	0.69
Medulla Oblongata	16.51 ± 1.86	16.28 ± 2.07	0.42
Foramen Luschka (Distance between Right and left)	23.39 ± 2.67	24.72 ± 2.05	0.79
Distance between Median and Sulcus Limitans	6.57 ± 0.98	6.42 ± 0.72	0.75
Distance between the 5^{th} cisterns	36.82 ± 2.64	37.61 ± 1.98	0.46
Distance Between the midlines of Superior and Inferior Colliculus	8.31 ± 0.91	7.80 ± 0.82	0.52

Discussion

The fourth ventricle (V4) is an expansion of the ependymal canal located between the medulla oblongata and the pons forward, and the cerebellum located behind. This rhombencephalic cavity (medulla oblongata and pons) is covered by the cerebellum of metencephalic origin and communicates above with the midbrain aqueduct and then below with cisterns, including the cerebellar-spinal cistern, through the tela choroidea of the V4. This anatomical disposition of embryological origin helps to explain the approach of V4 via a sub-tonsillar procedure or telovelar approach, respecting the integrity of the cerebellum. Fourth ventricle may be obstructed by congenital causes like Dandy Walker malformation, Arnold Chiari malformation Type II with myelomeningocele and tumours such as medulloblastoma, ependymoma and astrocytoma leading to hydrocephalus.[5] Ventricular size measurement is necessary for determination and follow-up many neurological illness, and pathologies. Ventricular enlargement is an indicator of brain parenchyma loss.[6]

Furthermore, ventricular size measurements are used in studies hydrocephalus, schizophrenia, tumors, trauma, Alzheimer's disease, Parkinson's disease, gender, aging, and athropy which is associated with many neurological diseases such as stroke and dementia, Huntington's disease and provides useful indices of cerebral asymmetry and atrophy.[7,8] Tumors and vascular malformations located in the brainstem were considered unresectable for a long time due to the high risk of complications.[9] In the past few decades, the advances in neuroimaging and neurophysiological monitoring corroborated with anatomical knowledge and the experience of neurosurgeons have led to the refining of the surgical approaches to lesions located in or around the brainstem.[10,11] In study by Shahin S et al.,[12] noted that that the lateral ventricles vary in size within certain limit according to age, sex and laterality. All the parameters of lateral ventricles (lengths of frontal horn, length of ventricular body) were significantly larger in males than those in females. While the length of frontal horn of the lateral ventricles (of both sides) increases in size up to the age of 40 years and thereafter regresses, the length of ventricular body bears a linear relationship with age throughout life-span.

Antar V et al.,[13] studied 42 fresh cadavers with a mean age of 45.38 ± 16.41 years old were included in this research. We found no statistically significant difference between measurements and BMIs. Facial colliculus was visualized in 92.9% (n=39), but it could not visualized in 7.1% (n=3) of the subjects. When the right side of the stria medullaris was examined, one bundle was seen in 59.5% (n=25) of the subjects, two bundles were seen in 31% (n=13) of the subjects, and 3 bundles were seen in 9.5% (n=4) of the subjects. When the left side of the stria medullaris was examined, one bundle was seen in 57.1% (n=24) of the subjects, two bundles were seen in 33.3% (n=14) of the subjects, and three bundles were seen in 9.5% (n=4) of the subjects.

Patnaik P et al.,[14] noted that mean AP-4 was 7.24 +/- 2.18 mm with 95% CI being 6.81 to 7.67 mm. Mean W-4 was 13.70+/- 2.26 mm with 95% CI being 13.25 to 15.15 mm. Length showed non-significant correlation with AP (r=0.087, p=0.54) and with TD (R=0.18, P=0.21). Width showed negative correlation with anteroposterior diameter (r= -0.08, p=0.54) but positive correlation with transverse diameter of cerebrum (r=0.25, p= 0.08). Length showed almost nil correlation with age whereas width showed negative correlation with age (t stat = -1.68, p = 0.09). Conclusion: Diameters of cerebrum and 4th ventricle width were significantly higher in males. 4th ventricle width showed maximum correlation with transverse diameter of cerebrum. 4th ventricle length does not depend upon age but width decreases with age.

In study by Polat S et al.,[15] mean values of brain ventricles and indices were observed; frontal horn width (FHW) (33.14 mm); third (3rd) ventricle width (TVW) (3.37 mm); fourth ventricle anteroposterior width (FVWAP) (9.93 mm); fourth ventricle transverse width (FVWT) (12.40 mm); and the maximum transverse inner diameter of the skull (TIDS) (128.75 mm) in females. The same dimensions were 34.85 mm, 3.91 mm, 10.26 mm, 12.81 mm, and 134.68 mm in males, respectively. There were statistically significantly differences in the frontal horn width, third (3rd) ventricle width, and the maximum transverse inner diameter of the skull values in between sexes. The mean values of Evans' index which obtanied with maximum width between the frontal horns of the lateral ventricles divided by the maximum transverse inner diameter of the skull were found as 0.280 ±0.172 in females; whereas the same dimensions were calculated 0.276±0.161 in males. These values were lower in healthy male subjects than females, however; there were no found significantly difference between groups.

Conclusion

The morphology of the dorsal brainstem is important in surgical approaches for the fourth ventricle tumors. Baseline anatomical baseline data helps in interpreting pathological changes, planning surgery, and determining presence and progress of some neurological diseases.

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