ORIGINAL ARTICLE

Correlation of the inclination of the tentorium cerebellum and the volume of the posterior cranial fossa

Redžib Direković[1,2], Hakija Bečulić[1,3], Zdenka Krivokuća[4]

[1]Department of Anatomy, School of Medicine, University of Zenica, [2]Department of Anaesthesiology and Intensive Care Unit, Cantonal Hospital Zenica, [3]Department of Neurosurgery, Cantonal Hospital Zenica; Zenica, [4]Department of Anatomy, School of Medicine, University of Banja Luka, Banja Luka; Bosnia and Herzegovina

ABSTRACT

Aim To investigate the influence of the inclination and insertion of the cerebellar tentorium on the posterior cranial fossa (PCF) volume.

Methods A retrospective, non-randomized study including 174 patients (117 females and 57 males) who underwent magnetic resonance imaging in the period from 31 December 2020 to 1 June 2021 under the indication (mostly headache) set by a competent ordinary. Acute or chronic intracranial events were not verified in the patients.

Results The average value of the PCF volume was 138.93 cm^3 and the slope of the tentorium was 44.15°. Comparing the volume of the PCF and the slope of the tentorium in males and females no significant difference was found. A correlation was found in the females age groups 18-24 and 45-54 years.

Conclusion Understanding dimensions of the posterior cranial fossa morphometry has clear implications for reducing morbidity and mortality in surgery, especially in the case of applying lateral approaches and their variations.

Key words: cerebellar malformation, posterior fossa capacity, tentorial position

Corresponding author:
Redžib Direković
Department of Anaesthesiology and Intensive Care Unit,
Cantonal Hospital Zenica
Crkvice 67, 72 000 Zenica,
Bosnia and Herzegovina
Phone: +387 32 405 133;
Fax: +387 32 405 534;
E-mail: redzo.direkovic@gmail.com
ORCID ID: https://orcid.org/0000-0003-4997-6402

Original submission:
10 December 2022;
Revised submission:
08 March 2023;
Accepted:
29 June 2023
doi: 10.17392/1568-23

Med Glas (Zenica) 2023; 20(2):112-116

INTRODUCTION

The posterior cranial fossa (*fossa cranii posterior)* is defined as the prominent anatomical space which situates some major structures of the central nervous system (1). The majority of PCF occupies the *cerebellum* with its two hemispheres. Other structures are *medulla oblongata*, *pons* and *mesencephalon,* neural and vascular elements. Only the first two cranial nerves are not completely or partially situated in the PCF. After leaving the brainstem, cranial nerves III to XII pass through the PCF and use communicating channels to exit the fossa (2-4).

Because of the structures that can be found in the PCF, and because of the important communications the PCF has, its volume is highly important, hence knowing the factors that can affect its volume is crucial. One of the factors than can affect the volume, in context of its inclination which is the focus of the study, is *tentorium cerebelli* (3,5). Tentorium forms superior, dural wall of the PCF and represents the demarcation point between occipital lobes of the *cerebrum* and lobes of the *cerebellum.* It also divides the intracranial space on supratentorial and infratentorial spaces (3,5).

The tentorial notch represents the communication between supratentorial and infratentorial spaces and it can be divided into an anterior and a posterior part. The anterior part is occupied by midbrain which ascends superiorly into diencephalon (5,6). The posterior part or half of the notch is occupied by *vermis cerebelli* or *splenium corporis callosi.* A number of malformations can affect the shape, dimensions and volume of the PCF including Chiari malformations, Dandy Walker malformations and malformations of the craniovertebral junction (7,8).

Even though there are many studies of the PCF and its morphometric analysis (9), there is no particular study in the Western Balkan countries.

The aim of this study was to investigate morphometric data of the posterior cranial fossa and to consider an influence of the low tentorium insertion on the volume of the posterior cranial fossa.

PATIENTS AND METHODS

Patients and study design

The study is designed as a retrospective, non-randomized control study which included 174 (117 female and 57 male) patients with different age and gender who underwent magnetic resonance imaging (MRI) in the period from 31 December 2020 to 1 June 2021, usually prediagnosed with headache by their family doctors.

Exclusion criteria were acute or chronic intracranial incidents such as intracranial bleeding (epidural, subdural, subarachnoid or intracerebral), tumour-like or ischemic lesions, and hydrocephalus.

The study was performed with a consent of the Ethical Committee of the Cantonal Hospital Zenica, Bosnia and Herzegovina (B&H).

Methods

Obtained scans were performed in a lying position, T1 and T2 sequences in axial, coronal and sagittal planes, using MRI (Siemens Magnetom Avanto 1.5 T, Erlangen, Germany). After obtaining the scans, they were imported to IMPAX system (Alpha Healthcare Impax 6.5.3.2525), which enables a direct and detailed analysis. The analysis of each scan was performed under the supervision of a neurosurgeon. Measured parameters of the PCF were as follows:

length – measured in T1 sequence and mediosagittal plane from the apex of clivus to internal occipital protuberance; the length of imaginary line matches Twining's line (Figure 1A) (7,9);

Twining's line – the imaginary line which connects torcula (internal occipital protuberance) with the *dorsum sellae turcicae* in the mediosagittal plane, visualising the midline intracranial structures (*corpus callosum, ventriculus tertius, ventriculus quartus, arbor vitae cerebelli* et cetera) (Figure 1A) (7,10);

McRae's line – the imaginary line which extends from basion to opisthion in mediosagittal plane, T1 sequence (Figure 1A) (7,10);

height – measured in T1 sequence, sagittal plane, as a distance between the Twining's and McRae's line, from the middle of first line to the middle of the second one (Figure 1B) (7,10);

width – measured in T1 sequence in axial plane from the beginning of the sigmoid sinus on the left and right sides (at the level of the junction between the superior border of petrous pyramid and squamous part of occipital bone) (Figure 1C) (7,10), and

tentorial inclination (TI) – determined by measuring the angle between the Twining's line and the tentorium in T1 sequence, mediosagittal plane (Figure 1D) (7, 10).

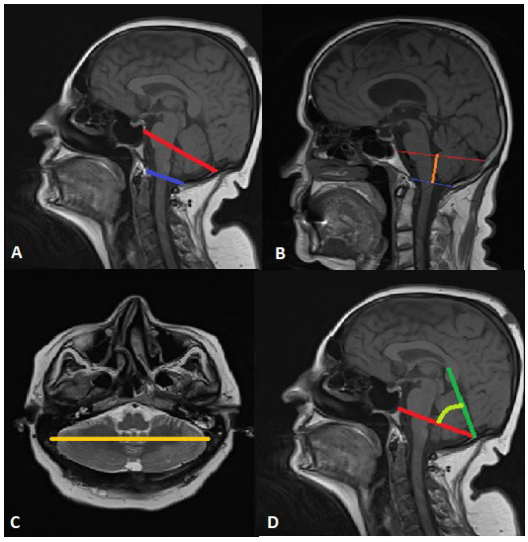

Figure 1. Measured parameters of the posterior cranial fossa (PCF). A) red line - Twing's line, blue line – McRee line; B) orange line- heigh of PCF, C) yellow line - width of PCF; D) tentorial inclination (Cantonal Hospital Zenica, 2021)

After measuring parameters of the PCF and the tentorium, the volume of the PCF (V(PCF)) was calculated using the following formula:

V (PCF) = 4/3 x π x (a/2 x b/2 x c/2)

a – length of PCF; b – width of PCF; c – height of PCF (10).

Statistical analysis

A statistical analysis was performed using the t-test, regression and correlative functions within the data analysis option. It was compared the regression function, as well as a correlation between the V(PCF) and TI in all specimens (generalised). Afterwards, the regression and corelation function analyses were made in separate groups of males and females. Using the t-test, male and female groups were compared in order to evaluate potential difference between V(PCF) and TI. The male and female patients were divided in the groups according to their age, in order to evaluate the correlation between the V(PCF) and the age of patients, and also the correlation between the TI and the age of patients. A verification of the correlations (r) and regression functions was performed using ANOVA analysis. The statistical significance was set at $p \leq 0.05$.

RESULTS

The overall PCF volume (174 patients) of 138.93 cm^3 (range 10.82 - 256.46) and the tentorium inclination of 44.15° (range 27.20° - 58.80°) were found.

Using the t-test we compared V(PCF) and TI in males and females. The calculated t value was 1.17 (t=1.17) for V(PCF), which is less than a critical t value for double-sided t-test (t=1.98). Thus, we conclude there was no significant difference in V(PCF) in males and females. The determined value of TI was 1.7 (t=1.7), which is less than double-sided t-test (t=1.98). There is no significant difference in the tentorial slope in males and females.

Among 117 female patients 132.59 cm^3 (range 10.82 - 256.46) for volume of the PCF and 44.15° (27.20° - 55.50°) for TI were found. The regression analysis showed no significant correlation between V(PCF) and TI.

Among 57 male patients V(PCF) of 152.054 cm^3 (102.33 - 246.36) and T1 of 44.16° (range 29.6° - 58.80°) were found. The regression analysis showed no significant correlation between V(PCF) and TI.

Comparing the patients age and V(PCF) a significant correlation was found in the female age group 18-24 and 45-54. In the male group, no found significant correlation between the age and V(PCF) was found in any age group (Table 1 and 2).

Table 1. Correlation between the females age and volume of the posterior cranial fossa (PCF)

Age group	Correlation (r)	p
18 – 24	0.89	0.003
25 – 34	0.16	0.54
35 – 44	-0.39	0.06
45 – 54	-0.38	0.049
55 – 74	0	1

Table 2. Correlation between the males age and the tentorial inclination

Age groups	Correlation (r)	p
18 – 24	-0.22	0.78
25 – 34	-0.39	0.38
35 – 44	0.17	0.57
45 – 54	0.13	0.62
55 – 74	-0.38	0.27

The correlation between the age and V(PCF) volume found in the females age group 18-24 showed an increase in the volume of the posterior cranial fossa (Figure 2). The correlation between the age and V(PCF) found in the females age

group 45-54 showed a decrease in the volume of the posterior cranial fossa (Figure 3).

No significant deviations in V(PCF) and TI values in males were noticed.

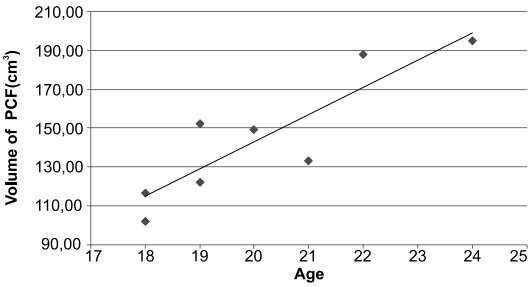

Figure 2. Correlation between the age and volume of the posterior cranial fossa (PCF) for females in the age group 18-24

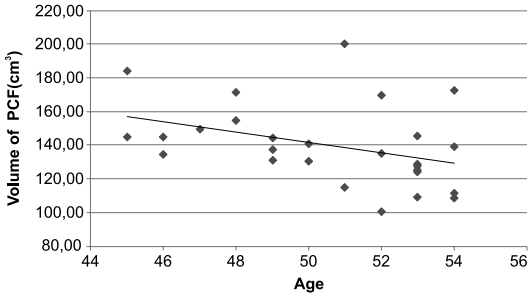

Figure 3. Correlation between the age and volume of the posterior cranial fossa (PCF) for females in the age group 45-54

DISCUSSION

The importance of determining the V(PCF) lies in the fact that it is a relatively small space with a low level of adaptability to volume changes, which accommodates some of the major anatomical structures (11). The PCF is a very important area in anatomy and surgery. It is the common place for tumorous, vascular and degenerative lesions (9). Surgeries in craniovertebral region demand special attention in the context of morphological and morphometric parameters of this area (9).

There are many anatomical variations of the posterior cranial fossa according to gender, age, and race (11). Even though there are many studies of the PCF and its morphometric analysis (7,9), no study has been conducted in the Western Balkan countries. The comparison of the values of the PCF volume and tentorial inclination in our study showed no significant difference between the genders. A correlation was found in the females age groups 18-24 and 45-54. Also, no significant deviations in the value of the tentorial inclination according to the age was found. No significant deviations in V(PCF) and TI values in males were noticed. The results obtained in this study can be used for the purpose of the diagnosis and treatment of lesions of the posterior cranial fossa. Similar results can be found in a study performed by Dagtekin et al. (1) and their results showing that measured parameters solidify the presumption that abnormality of the occipital bone can be a cause of the Chiary malformation type 1. Bothelo et al. (12) found no difference in cerebellum and brainstem sizes in patients with the Chiary malformation and control group, although, lower morphometric parameters of clivus and the PCF were found in certain specimens.

Badie et al. (13) found that the ratio between the V(PCF) and supratentorial volume was lesser in patients with the Chiary malformation type 1, and it can be the main causative factor of tonsillar herniation. Patients with the Chiary malformation type 1 that have the lesser V(PCF) and supratentorial space ratio (PFR) develop symptoms earlier and have tendency of a better response to sub occipital decompression. Sgouros et al. (14) informed that the kids with the Chiary malformation type 1 did not have V (PCF) lesser than normal, whereas children with the Chiary malformation type 1 and syringomyelia had significantly lesser V(PCF) than normal. Goel et al. (15) came to the fact that the lower V(PCF) value was associated with the Chiari malformation, and propose decompression of the foramen magnum in lesser V(PCF). Trigylidas et al. (16) detect that the average mean posterior fossa volume and intracranial volume proportion for all Chiary malformation type 1 patients were measurably smaller than those of the control patients. Tubbs et al. (17) who conducted volumetric examination in a family of the Chiary malformation type 1 reported in four generations concluded that it was not essential for patients with the Chiary malformation type 1 to have a smaller PCF.

Understanding the morphometric dimensions of the posterior cranial fossa has implications on lowering the morbidity and mortality of the PCF and craniovertebral junction surgeries, mostly using the lateral approach and their variations, as well as in a possible injury, inhibition or even destruction of structures that are situated in this

area. Clear understanding of the relationship between the lesions and their impact on the parameters of the PCF and surrounding neurovascular structures is important for exact surgical dismemberment.

FUNDING

No specific funding was received for this study.

TRANSPARENCY DECLARATIONS

Competing interest: None to declare.

REFERENCES

1. Dagtekina A, Avci E, Kara E, Uzmansel D, Dagtekind O, Koseoglua A, Talas D, Bagda-toglua C. Posterior cranial fossa morphometry in symptomatic adult Chiari I malformation patients: Comparative clinical and anatomical study. Clin Neurol Neurosurg 2011; 113:399-403.
2. Şeker A, Rhoton AL. The Anatomy of the Posterior Cranial Fossa. In: Özek M, Cinalli G, Maixner W, Sainte-Rose C. (Eds). Posterior Fossa Tumors in Children. Cham, Germany: Springer, 2015.
3. Shukla V, Hayman LA, Ly C, Fuller G, Taber KH. Adult cranial dura I: intrinsic vessels. J Compu Assist Tomo 2002; 26:1069-74.
4. Carlos AFF, Luiz RMS, Andreza NS, Augusto BAN, Lenine GB. Anatomical study of jugular foramen in the neck. Braz J Otorhinolaryngol 2020; 86:44-8.
5. Adeeb N, Mortazavi MM, Tubbs RS, Cohen-Gadol AA. The cranial dura mater: a review of its history, embryology, and anatomy. Child Nerv Syst 2012; 28:827-37.
6. Klintworth GK: The comparative anatomy and phylogeny of the tentorium cerebelli. Anat Rec 1968; 160:635-41.
7. Kanodia G, Parihar V, Yadav RY, Bhatele PR , Sharma D. Morphometric analysis of posterior fossa and foramen magnum. J Neurosci Rural Pract 2012; 3:261-6
8. Vurdem UE, Acer N, Ertekin T, Savranlar A, Inci MF. Analysis of the volumes of the posterior cranial fossa, cerebellum, and herniated tonsils using the stereological methods in patients with Chiari Type I malformation. ScientificWorld Journal 2012; 2012:616934
9. Basaran R, Efendioglu M, Senol M, Ozdogan S, Isik N. Morphometric analysis of posterior fossa and craniovertebral junction in subtypes of Chiari malformation. Clin Neurol Neurosurg 2018; 169:1–11.
10. Öksuzler M. Polat S. Ipek CE, Goker P. The relationship of the posterior cranial fossa with age and sex. Int J Morphol 2021; 39:1371-82.
11. Botelho RV, Heringer LC, Botelho PB, Lopes RA, Waisberg J. Posterior fossa dimensions of Chiari malformation patients compared with normal subjects: systematic review and metanalysis. World Neurosurgery 2020; 138:521-29.
12. Badie B, Mendoza D, Batzdorf U. Posterior fossa volume and response to suboccipital decompression in patients with Chiari I malformation. Neurosurgery 1995; 37:214-8
13. Sgouros S, Kountouri M, Natarajan K. Posterior fossa volume in children with Chiari malformation Type I. J Neurosurg 2006; 105:101-6. Comment in J Neurosurg 2007; 106:329.
14. Goel A, Bhatjiwale M, Desai K. Basilar invagination: A study based on 190 surgically treated patients. J Neurosurg 1998; 88:962-8.
15. Trigylidas T, Baronia B, Vassilyadi M, Ventureyra EC. Posterior fossa dimension and volume estimates in pediatric patients with Chiari I malformations. Childs Nerv Syst 2008; 24:329-36.
16. Tubbs RS, Hill M, Loukas M, Shoja MM, Oakes WJ. Volumetric analysis of the posterior cranial fossa in a family with four generations of the Chiari malformation Type I. J Neurosurg Pediatr 2008; 1:21-4.