Int. J. Morphol.,
43(5):1580-1583, 2025.

Morphological Features of the Vertebral Artery Canal

Características Morfológicas del Canal de la Arteria Vertebral

Huseynova Gulgiz & Efendiyeva Narmin

GULGIZ, H. & NARMIN, E. Morphological features of the vertebral artery canal. *Int. J. Morphol., 43(5)*:1580-1583, 2025.

SUMMARY: At present, new examination methods used to determine the cause of cerebrovascular accidents require obtaining new anatomical facts about the morphology of the vertebral arterial canal (VAC) and the transverse processes foramens (TF) that form it. For this reason, this study is devoted to the investigation of the morphometric parameters of the vertebral artery canal at the level of the transverse process part, i.e. the bone segment, in adults. For this purpose, a 168 cervical vertebrae (CV) taken from the bone collection of the Museum of Anatomy, located at the Department of Human Anatomy and Medical Terminology of the Azerbaijan Medical University, was used. Statistical analysis was performed using SPSS software version 16. The TF of the CV have different shapes. Among them, elliptical TF predominate. Usually, the TF of the CV, is larger on the left than on the right. The TF of the upper CV (C2-3) are narrower than the lower ones and are located in an oblique plane facing outward. The relative sizes of the TF of the lower CV (C5-6) increase. In this case, the exception is the last and first CV. At the level of the last CV (C7), the TF is either absent or of the smallest size. In rare cases, the 7th vertebra has a large transverse foramen.

KEY WORDS: Cervical vertebra; Vertebral artery canal ; Foramen transversarium; Morphometry.

INTRODUCTION

Currently, among neurological and neurosurgical diseases, pathologies associated with impaired nutrition of the brain in the vertebrobasilar basin are widespread (Murai, 1998; Mitchell, 2005). However, in recent years, opinions on the causes of cerebral stroke have also varied (Fazan *et al*., 2004; Jayanthi *et al*., 2010). Thus, if the occurrence of stroke was previously explained only by age-related changes in the vessels of the brain (especially arteries), currently in most cases it is explained by pathology of the main arteries of the brain - the internal carotid and vertebral arteries. Based on the above, to clarify the concept of transient cerebral ischemia, new research in this area, new knowledge and data on the morphology and topography of the vertebral and internal carotid arteries are needed (Markelova *et al*., 2008; Kars, 2018; Stojanovic *et al*., 2024). It is known that in the extracranial part, the vertebral artery, passing through the scalenovertebral triangle (the first is the prevertebral part of the vertebral artery) and the TF of the C2-6 (sometimes C7) cervical vertebrae (the second is the transverse process part of the vertebral artery), is located on the groove of the same name of the posterior arch of the atlas (the third is the atlantic part of the artery of the vertebral artery). A review of the literature showed that in the cervical spine, classical knowledge about the morphological and topographic-anatomical changes of the vertebral artery requires updating (Kars, 2018; Sanchis-Gimeno *et al*., 2018; Chaiyamoon *et al*., 2021; Siedlecki *et al*., 2021). Since, at present, complex examination methods used to determine the cause of cerebrovascular accidents (angiography, CT, MRI, etc.) allow us to obtain new anatomical data and facts regarding age, individual and genital characteristics of the VAC and TF, which can serve as an anatomical basis for determining the etiology of cerebrovascular accidents (Yi *et al*., 2022; Tuncer & Alkan, 2023). Furthermore, the above-mentioned confirm the relevance of the study.

MATERIAL AND METHOD

The research work was devoted to the study of the morphological features of the bone segment of the vertebral artery canal in adults. For this purpose, a 168 cervical vertebrae from the bone collection of the Museum of Anatomy, located at the Department of Human Anatomy and Medical Terminology of the Azerbaijan Medical University, were used. Measurements were taken using a digital caliper with an accuracy of 0.01 mm.

Azerbaijan Medical University, Department of Human Anatomy and Medical Terminology, Baku, Azerbaijan.

Received: 2025-06-17 Accepted: 2025-07-21

Sagittal (anteroposterior) and frontal (transverse) dimensions of the TF were measured in mm on both sides with a digital stainless steel vernier caliper with 0.01 mm accuracy. After measuring the frontal and sagittal dimensions of the TF, their area was calculated using the formula $S = \pi * A * B/4$ ($\pi = 3.14$; A – the transversal dimensions; B – the sagittal dimensions). Statistical analysis was performed using SPSS software version 16. Variables were presented as mean ± SD (mean ± standard deviation of the mean). Comparisons were made between their different parameters on the right and left sides using Student's t-test and p-value. Significance was considered according to the significance level of the p-value as follows: $P \angle 0.05$ is not significant, $P \leq 0.05$ is significant, $P \leq 0.01$ is highly significant.

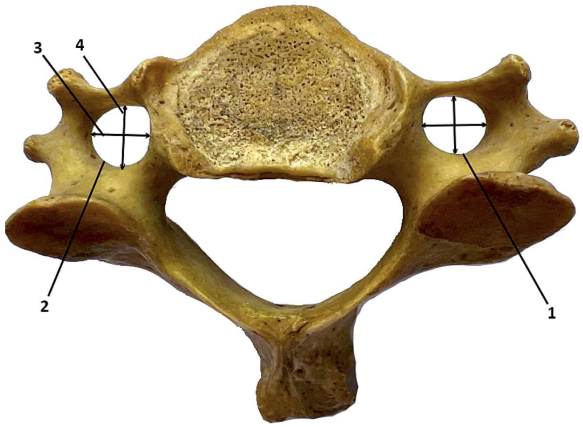

Fig 1. Cervical vertebra of adult: 1. Right transverse foramen; 2. Left transverse foramen; 3. Transverse dimension; 4.Sagittal dimension.

RESULTS

The bone segment of the VAC is formed by the TF of the 2-7th cervical vertebrae and is limited in front by the costal part of the transverse process, behind by the transverse process itself, from the outside by the bone protrusion of the transverse process remaining between these two parts from the inside by the body of the vertebra (Figs. 1 and 2). The types of the TF of a CV found in the Azerbaijan population are classified as follows: elliptical, round, rarely triangular and irregular types. Elliptical forms of the TF are more common than round ones. The TF with elliptical forms are found in the following types: elliptical in sagittal dimension, elliptical in transverse dimension, elliptical with right inclination and elliptical with left inclination.

Table I. The area of the transverse foramens of the cervical vertebres.

Number	The area of the TF (S; M±s)	
	Left side	Right side
C_1	35,94±9,16	33,62±9,14
C_2	31,57±7,98	30,47±9,65
C_3	27,43±6,72	27,17±6,16
C_4	27,64±7,14	26,87±7,18
C_5	28,32±7,07	28,02±8,43
C_6	33,07±9,51	31,92±9,50
C_7	17,38±10,28	16,87±11,95

Note: TF - transverse foramen. S – the area of the transverse process foramens – mm^2; M+s – average price.

According to the obtained data, the area of the TF of the CV is: C1– 34.78 mm^2; C2 – 31.02 mm^2; C3 – 27.31 mm^2; C4 – 27.26 mm^2; C5 – 27.67 mm^2; C6 – 32.50 mm^2; C7 – 17.12 mm^2 (Table I). During the research, transverse processes foramens of different, mostly oval shapes were found in the cervical vertebrae, and their area was largest (34.78+2,4 mm^2) at the 1st cervical vertebra and smallest (17.12+1,4 mm^2) at the 7th cervical vertebra. In rare cases, the 7th vertebra had a large transverse foramen.The transverse process foramens with the largest area is typical for the 1st and 6th cervical vertebrae. This indicator is characterized by asymmetry. Usually, the area of this foramen on the left side is larger than on the right.

Fig. 2. 3rd (Fig. 2A), 4th (Fig. 2B), 5th (Fig. 2C) and 6th (Fig. 2D) cervical vertebrae in adult. 1. Left transverse foramen; Right transverse foramen.

DISCUSSION

The spinal arteries and veins are responsible for the formation of the TF, and changes in these vessels during their development will be reflected in changes in the structure, shape, and size of the TF (Samrid, 2023). Therefore, the study of morphological changes in this foramen has an important clinical role, since it directly affects the function of the vessels that pass through it (Ellis, 2006; Murugan & Verma, 2014; Ramachandran *et al*., 2014; Molinet *et al*., 2017; Moreira & Herrero, 2020; El-Dwairi *et al*., 2021). Thus, the differences in TF sizes of the cervical vertebrae correspond to the correlation-adaptation property of the organ formation process. Since the spinal artery changes its position at the beginning and end of the bone segment of the canal - it forms pronounced natural bends - "upper and lower siphons". Based on this, the size of the TF of a C1-2 and C6 vertebtes creates an additional periarterial zone and prevents the disruption of blood flow during movements of the head and neck in different directions (Markelova *et al*., 2008; Bhabhor *et al*., 2024). Based on theoretical knowledge about the formation of the TF of the CV for the passage of the vertebral artery and vein, it can be concluded that the large size of this foramen in the first cervical vertebra is associated with the transition of the vertebral artery, from a vertical to a horizontal position (formation of the superior siphon) or hemodynamic variability (Murai, 1998). Because it is in this part that the vertebral artery is subjected to the greatest shock wave of blood flow. After this, the arterial pressure drops again towards the junction with the vessels of the internal carotid artery at the base of the brain. The increase in the area of the TF of the lower CV can also be explained by a similar hemodynamic law. Since in most cases the artery, entering the transverse foramens C6-5 from the front and at different angles, forms the lower siphon and passes into a vertical position in the second part (Jayanthi *et al*., 2010).

Furthermore, if we analyze the mean values of TF size in studies of Turkish (Tuncer & Alkan, 2023), Jordanian (El-Dwairi *et al*., 2021), Latin American (Moreira & Herrero, 2020), Thai (Chaiyamoon *et al*., 2021) and Indian (Bhabhor *et al*., 2024) populations, we will see that different results are obtained. For the Azerbaijani population, the left-sided morphometric preference in area of the TF is more characteristic. According to our results, the mean value of the TF area is larger on the left side. According to Ouies (2018), on Egiptian population, no significant differences between the right and left side TF size as regard the antroposterior and transverse dimensions were found.

The fact that the TF of the cervical vertebrae on the left are larger than on the right can be explained by the fact that, according to literature, in 70 % of cases the left vertebral artery has a diameter 1.5–2 times larger than the right (Markelova *et al*., 2008).

CONCLUSION

The TF of the CV have different shapes (elliptical, round, triangular, irregular). Among them, elliptical TF predominate. Usually, the TF, of the CV, is larger on the left than on the right.

The TF of the upper (C2-3) cervical vertebrae are narrower than the lower ones and are located in an oblique plane facing outward.The relative sizes of the TF of the lower CV (C5-6) increase. In this case, the exception is the last and first CV. At the level of the last CV (C7), the TF is either absent or of the smallest size.

GULGIZ, H. & NARMIN, E. Características morfológicas del canal de la arteria vertebral. *Int. J. Morphol., 43(5)*:1580-1583, 2025.

RESUMEN: Actualmente, los nuevos métodos para examinar y determinar la causa de los accidentes cerebrovasculares requieren la obtención de nuevos datos anatómicos sobre la morfología del canal arterial vertebral y los forámenes de los procesos transversos que lo conforman. Por esta razón, en este estudio se investigó los parámetros morfométricos del canal de la arteria vertebral a nivel del proceso transverso, es decir, el segmento óseo, en adultos. Para ello, se utilizaron 168 vértebras cervicales (VC) extraídas de la colección ósea del Museo de Anatomía, ubicado en el Departamento de Anatomía Humana y Terminología Médica de la Universidad Médica de Azerbaiyán. El análisis estadístico se realizó con el programa SPSS versión 16. Los forámenes de los procesos transversos (FT) de las VC presentaban diferentes formas, predominando los FT elípticos. Generalmente, el FT de la VC es mayor en el lado izquierdo que en el derecho. Los FT de la VC superiores (C2-3) son más estrechos que los inferiores y se ubican en un plano oblicuo hacia afuera. El tamaño relativo del FT de las VC inferiores (C5-6) aumenta. En este caso, la excepción es la última y la primera VC. A la altura de la última VC (C7), el FT está ausente o es de menor tamaño. En casos excepcionales, la séptima vértebra presenta un foramen transverso de mayor tamaño.

PALABRAS CLAVE: Vértebra cervical; Canal de la arteria vertebral; Foramen transverso; Morfometría.

REFERENCES

Bhabhor, P.; Kumar, R.; Shinde, D. & Chaudhari, G. Variations in transverse foramina of cervical vertebrae: morphology and clinical importance. *Int. J. Acad. Med. Pharm., 6(4)*:368-71, 2024.

Chaiyamoon, A.; Yannasithinon, S.; Sae-Jung, S.; Samrid, R.; Thongbuakaew, T. & Iamsaard, S. Anatomical variation andmorphometric study on foramen transversarium of the upper cervical vertebrae in the Thai population. *Asian Spine J., 15(5)*:557-65, 2021.

El-Dwairi, Q. A.; Abu Ghaida, J. H.; Isa, H. M.; Al-Mousa, A. A.; Marashdeh, W.& Al-Muqbel, K. M. Morphometric study of foramina transversaria in Jordanian population using cross-sectional computed tomography. *Anat. Sci. Int., 96(1)*:70-8, 2021.

Ellis, H. *Foramen Transversarium*. In: Ellis, H. (Eds.). Clinical Anatomy. 11th ed. Malden (MA), Blackwell Publishing, 2006. pp.325-8.

Fazan, V. P. S.; Caetano, A. G. & Filho, O. A. R. Anomalous origin and cervical course of the vertebral artery in the presence of a retroesophageal right subclavian artery. *Clin. Anat., 17(4)*:354-7, 2004.

Jayanthi, V.; Prakash; Devi, M. N.; Geethanjali, B. S. & Rajini, T. Anomalous origin of the left vertebral artery from the arch of the aorta: review of the literature and a case report. *Folia Morphol. (Warsz.), 69(4)*:258-60, 2010.

Mitchell, J. The vertebral artery: a review of anatomical, histopathological and functional factors influencing blood flow to the hindbrain. P*hysiother. Theory Pract., 21(1)*:23-36, 2005.

Molinet, G. M.; Robles, F. P.; & Roa, I. Anatomical variations of the foramen transversarium in cervical vertebrae. *Int. J. Morphol., 35(2)*:719-22, 2017.

Moreira, J. J. M. & Herrero, C. F. P. S. Anatomical variations and morphometric features of the foramen transversarium in the cervical vertebrae of a Latin American population: a Brazilian study. W*orld Neurosurg., 137*:e18-e26, 2020.

Murai, T. Hemodynamics of a simulation of the vertebrobasilar system using silicone tube. *Acta Otolaryngol. Suppl, 118(5339)*:30-5, 1998.

Murugan, M. & Verma, S. A study on variations of foramen transversarium of cervical vertebrae. *Natl. J. Clin. Anat., 3(1)*:4-7, 2014.

Ouies, S. M. A morphologic and morphometric study of the foramen transversarium of the cervical vertebrae: an osteological study in upper *Egypt. J. Am. Sci., 14(6)*:25-9, 2018.

Ramachandran, K.; Ravikumar, P. C. & Manavalan, M. S. A study on the foramen transversarium in cervical vertebrae. *Int. J. Health Sci. Res., 4(12)*:178-83, 2014.

Samrid, R.; Iamsaard, S.; Kasai, Y.; Poodendan, C.; Yannasithinon, S.; Sae-Jung, S. & Chaiyamoon, A. Morphometric study and anatomical variation with its incidence of foramina transversaria on the lower cervical vertebrae. *Int. J. Morphol., 41(1)*:111-7, 2023.

Sanchis-Gimeno, J. A.; Blanco-Perez, E.; Llido, S.; Perez-Bermejo, M.; Nalla, S. & Mata-Escolano, F. Can the transverse foramen/vertebral artery ratio of double transverse foramen subjects be a risk for vertebrobasilar transient ischemic attacks? *J. Anat., 233(3)*:341-6, 2018.

Siedlecki, Z.; Szostak, M.; Nowak, K. & Sniegocki, M. Atypical course of vertebral artery outside the cervical spine: case report and review of the literature. *World Neurosurg., 145*:405-8, 2021.

Stojanovic, V.; Trandafilovic, M.; Pavlovic, M.; Ugrenovic, S.; Kundalic, B. & Cukuranovic, K. Variations in foramen transversarium in typical cervical vertebra. *Int. J. Morphol., 42(4)*:945-9, 2024.

Tuncer, I. & Alkan, E. Morphometric study of cervical spinal canal and transverse foramen diameter using computed tomography: sex difference and relationship to age in Turkish population. *Medicine (Baltimore), 102(49)*:e36155, 2023.

Yi, X.; Xie, P.; Zhang, L.; Lu, F.; Chen, H. & Liu, K. Entrance and origin of the extracranial vertebral artery found on computed tomography angiography. *Sci. Rep., 12(1)*:15274, 2022.

Corresponding author:
Professor Huseynova Gulgiz
Azerbaijan Medical University
Department of Human Anatomy and Medical Terminology
Baku
AZERBAIJAN

E-mail: gulqiz65@mail.ru

https://orcid.org/0009-0006-2411-9518

Corresponding author:
Efendiyeba Narmin
Azerbaijan Medical University
Department of Human Anatomy and Medical Terminology
Baku
AZERBAIJAN

E-mail dr.nafandiyeva@gmail.ru

https://orcid.org/0009-0007-3294-9818