

# ANATOMICAL AND MORPHOLOGICAL VARIATIONS OF THE BASILAR ARTERY ASSOCIATED WITH CEREBRAL CIRCULATION CHANGES

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**Abstract:** The basilar artery (BA) is one of the main vessels that supplies oxygen rich blood to the brain and it plays a very important role in cerebral circulation. It is formed by the union of the left and right vertebral arteries at the junction between the medulla oblongata and the pons, near the abducens nerve (CN VI)

The vertebrobasilar system is a major blood supply route to the posterior part of the brain, and variations in the basilar artery (BA) may affect blood flow and contribute to neurological symptoms or ischemic events.

**Aim:** This study aimed to assess how often anatomical variations of the BA occur according to sex and age, to measure BA diameter, and to evaluate their possible clinical relevance in patients with different neurological and traumatic conditions.

**Materials and Methods:** A retrospective study was conducted on 60 patients (25 women, 41.67% and 35 men, 58.33%) with a mean age of  $45.0 \pm 12.0$  years. Patients were examined at the Clinical Hospital Tetovo over a one-year period. CT, MRA, and Doppler ultrasound were used to evaluate the basilar artery. Measurements were taken and classified as normal, hypoplasia (<2 mm), or dolichoectasia (>4 mm). Data were analyzed using SPSS v26.

**Results:** Normal BA morphology was the most common finding in both sexes, especially in males (74.3%) compared to females (64%). Hypoplasia was more frequent in females (32%) than males (17.1%), while dolichoectasia was slightly more common in males (8.6%) than females (4%). In hypoplastic arteries, diameters ranged from 1.80 to 1.95 mm, while in dolichoectasia they exceeded 4.0 mm. Overall, the findings showed noticeable sex-related differences and were in line with previous studies.

**Conclusion:** Anatomical variations of the basilar artery are relatively common and may influence blood flow in the posterior circulation. Recognizing these changes early through modern imaging techniques is important for better diagnosis, risk evaluation, and clinical decision-making

**Keywords:** *Basilar artery, anatomical variations, cerebral circulation, vertebrobasilar system, posterior circulation infarction.*

**Field:** Medical Sciences and Health

## 1. INTRODUCTION

The vertebrobasilar system (VBS) is one of the main blood supply systems of the brain, providing oxygen-rich blood to the brainstem, cerebellum, thalamus, and occipital lobe. The basilar artery (BA) is formed by the joining of the left and right vertebral arteries and it represents the main artery of the posterior circulation [9,10]. Although its anatomy is usually described in a standard way, in real life there are often small natural variations.

These variations, such as hypoplasia, asymmetry, or dolichoectasia, are clinically important because they can change normal blood flow in the brain. Some people may never notice them, while in others they can lead to symptoms like dizziness, visual problems, imbalance, or even stroke. Hypoplasia means a smaller artery (usually <2 mm), while dolichoectasia refers to an enlarged and elongated artery (>4 mm). The basilar artery can also show different branching patterns, such as fenestration or unusual origins of cerebellar arteries. Even though these differences may seem small, they can affect blood flow and increase the risk of vascular complications in the posterior circulation. Because of this, recognizing these variations is very important in clinical practice. Modern imaging techniques like MRA and CTA help doctors detect them early and better understand patient risk.

The aim of this study was to analyze the frequency of anatomical variations of the basilar artery (BA) in relation to sex and age. In addition, the study sought to evaluate the diameter of the basilar artery and its potential influence on cerebral circulation, particularly in patients presenting with different clinical manifestations. Furthermore, the study aimed to compare the obtained findings with existing data from international literature in order to identify similarities, differences, and possible clinical implications.

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## 2. MATERIALS AND METHODS

In this retrospective observational study, 60 patients were analyzed, including 25 women (41.67%) and 35 men (58.33%), with a mean age of  $45.00 \pm 12.00$  years. Of the total number of patients ( $n = 60$ ), 33.3% were younger than 45 years, whereas 67.7% were older than 45 years. The patients were examined and hospitalized in the Department of Traumatology and Neurosurgery at the Clinical Hospital Tetovo during a one-year period. They were admitted for various conditions, including head injuries, neck injuries, traffic accidents, vertigo, and other neurological complaints, and were grouped according to sex and age. The patients underwent evaluation using Computed Tomography (CT), Magnetic Resonance Angiography (MRA), and color Doppler sonography. The analysis included measurement of the basilar artery diameter, as well as assessment for the presence of hypoplasia, dolichoectasia, and normal anatomical morphology. Our results were compared with data reported in internationally.

## 3. RESULTS

Descriptive statistical methods were used, including the arithmetic mean and standard deviation ( $X \pm SD$ ). Comparative statistics of lipid parameters between groups were analyzed using Student's t-test for independent and dependent samples, as well as non-parametric tests according to the Mann-Whitney U test. The results were processed using SPSS software version 26.

Table 1: Number of patients by gender and mean age  $\pm$  SD

Total number of patients	60 (100 %)	mean age $\pm$ SD
<b>Male</b>	<b>35 (58.33 %)</b>	<b>45.00<math>\pm</math>12.00 years</b>
<b>Females</b>	<b>25 (41.67 %)</b>	<b>45.00<math>\pm</math>12.00 years</b>

**Source:** The material presented in tables 1,2,3,4 and 5 was obtained from the records in the patient examination logbook in symptoms in the Departments of Traumatology and Neurology during the period from 11/2024 to 11/2025. The patients were diagnosed using CTM and Magnetic Resonance Angiography (MRA) in the Radiodiagnostics Department at the Clinical Hospital of Tetovo.

Table 2. Distribution of patients by age

Age	Men (n=35)	Wome(n=25)
<45 years	14 (40%)	10 (40%)
>45 year	21 (60%)	15 (60 %)

Table 3: Distribution of patients by symptoms and clinical picture

Symptoms	Number of patients (60-100%)
<b>Vertigo syndrome with cervical spondylosis</b>	<b>30 (50 %)</b>
<b>Essential hypertension</b>	<b>12 (20 %)</b>
<b>Vertebrobasilar ischemia</b>	<b>10 ((16.7 %)</b>
<b>TIA (Transient Ischemic Attack)</b>	<b>8 (13.3 %)</b>

The female population, normal morphology of the basilar artery was observed in 64% of patients, hypoplasia in 32%, and dolichoectasia in 4%. In the male population, normal morphology was present in 74.3% of cases, hypoplasia in 17.1%, and dolichoectasia in 8.6%. The mean arterial diameter in patients with hypoplasia ranged from 1.80 mm to 1.95 mm, while in the case of dolichoectasia it was 4.0 mm.

Table 4: Distribution of anatomical variations Basilar Artery in women

Anatomical Variations Female	Women	%
<b>Normal morphological anatomy</b>	<b>16</b>	<b>64.0</b>
<b>Hypoplasia</b>	<b>8</b>	<b>32.0</b>
<b>Dolichoectasia</b>	<b>1</b>	<b>4.0</b>
<b>Total</b>	<b>25</b>	<b>100</b>

Table 5: Distribution of anatomical variations in men

<b>Anatomical variations</b>	<b>Men (n)</b>	<b>%</b>
<b>Anatomical variations</b>	<b>26</b>	<b>74.00</b>
<b>Hypoplasia</b>	<b>6</b>	<b>17.10</b>
<b>Dolichoectasia</b>	<b>3</b>	<b>8.60</b>
<b>Total</b>	<b>35</b>	<b>100</b>

In the male sex, normal anatomical morphology was present in 26 patients (74.0%), hypoplasia in 6 patients (17.10%), and dolichoectasia in 3 patients (8.6%). In patients with hypoplasia, the diameter ranged between 1.80 mm and 1.95 mm, while in dolichoectasia it was over 4.0 mm.

#### 4. DISCUSSIONS

In our study, we found noticeable anatomical variations of the basilar artery (BA), with hypoplasia being the most common finding, especially in female patients. It was present in 32% of females compared to 17.1% in males, while dolichoectasia was more frequently observed in males (8.6%). These results are generally in line with published international studies, which suggest that variations in the vertebrobasilar system can influence blood flow in the posterior circulation and may be linked with ischemic changes. Even small differences in vessel shape and size can affect how blood moves through the brain and may contribute to reduced perfusion or vascular changes over time. In our study, we defined hypoplasia as a vessel diameter below 2 mm, and dolichoectasia as a diameter greater than 4 mm. who showed that dolichoectasia of the basilar artery increases the risk of posterior circulation stroke, especially in older patients, most likely due to disturbed and turbulent blood flow. Catalano et al. also pointed out that both congenital and acquired variations of the BA can be clinically important, as they are associated with conditions such as transient ischemic attacks, vertebrobasilar insufficiency, and ischemic stroke. In our sample, patients with hypoplasia had BA diameters between 1.80 mm and 1.95 mm, which is consistent with Chuang et al., who considered diameters below 2 mm as a relevant risk factor for posterior circulation events. Additionally, Hsu et al. reported an association between vertebral artery hypoplasia and acute ischemic stroke affecting the posterior circulation, while Dong et al. demonstrated through hemodynamic studies that structural variations of the basilar artery can significantly alter cerebral blood flow. Because our study did not include a control group, we compared our results with existing international literature in neuroangiography and radiology, and overall, modern imaging methods such as MRA and CTA remain essential tools for early detection and clinical evaluation of these vascular variations.

#### 5. CONCLUSIONS

Anatomical variations of the basilar artery (BA) are quite common and they can play an important role in how blood circulates in the brain, sometimes leading to disturbances in cerebral circulation. In many cases these variations may not cause any symptoms, but in others they can be associated with different neurological problems ranging from mild complaints to more serious deficits. Because of this, early detection is very important, and modern imaging techniques such as MRA and CTA have made it much easier to identify these vascular differences in routine clinical practice. Recognizing them in time helps clinicians better understand a patient's symptoms and reduces the risk of future cerebrovascular complications. Overall, variations of the BA and the vertebrobasilar system are not just anatomical findings, but clinically meaningful features that are important for diagnosis, prevention, and planning of both surgical and interventional treatment, as well as for predicting patient outcomes.

#### REFERENCES

- Byrne, J. (2012). Cranial arterial anatomy. In *Tutorials in endovascular neurosurgery and interventional neuroradiology* (pp. 37–38). Springer.
- Cao, S., Zhai, M., He, J., et al. (2023). Basilar artery curvature increases the risk of posterior circulation infarction occurrence in patients without vertebrobasilar stenosis. *Neurological Sciences*, 44, 1273–1280.
- Catalano, M., Crimi, L., Belfiore, G., et al. (2024). Congenital and acquired anomalies of the basilar artery: A pictorial essay. *Neuroradiology Journal*, 37(6), 661–677.
- Chen, J., & Chen, D. (2010). A case report of intracranial vertebral-basilar artery hypoplasia presenting with episodic dizziness. *Ghana Medical Journal*, 44(3), 123–125.
- Chuang, Y. M., Chan, L., Wu, H. M., et al. (2022). Association of vertebral artery hypoplasia and vertebrobasilar cerebrovascular accident. *Medicina*, 58(9), 1189.
- Dong, J., Mei, Y., Bai, X., et al. (2022). Hemodynamic differences between basilar artery fenestration and normal vertebrobasilar

- artery: A pilot study. *Frontiers in Neurology*, 12, 766174.
- Gray, H., & Standring, S. (2016). *Gray's anatomy*. Elsevier.
- Henry Knipe. (2025, August 15). Basilar artery. *Radiopaedia*. <https://radiopaedia.org/articles/basilar-artery>
- Hsu, C. F., Chen, K. W., Su, C. H., et al. (2021). Bilateral vertebral artery hypoplasia and fetal-type variants of the posterior cerebral artery in acute ischemic stroke. *Frontiers in Neurology*, 12, 582149.
- Jayapala, D., & Mathangasinghe, Y. (2024). The prevalence of termination variations of the basilar artery: A systematic review and meta-analysis. *Anatomy & Cell Biology*, 57(Suppl. 3), S267–S268.
- Kuybu, O., Tadi, P., & Dossani, R. H. (2023). Posterior cerebral artery stroke. StatPearls Publishing.
- Litschel, R., Kühnel, T. S., & Weber, R. (2015). Frontobasal fractures. *Facial Plastic Surgery*, 31(4), 332–344.
- McElroy, K., & Brinjikji, W. (2020). Junctional dilatation of the basilar tip: A normal anatomical variant with a benign natural history. *Journal of the Neurological Sciences*, 419, 117161.
- Olindo, S., Khaddam, S., Bocquet, J., et al. (2010). Association between basilar artery hypoplasia and undetermined or lacunar posterior circulation ischemic stroke. *Stroke*, 41(10), 2371–2374.
- Passero, S. G., & Rossi, S. (2008). Natural history of vertebrobasilar dolichoectasia. *Neurology*, 70, 66–72.
- Radiopaedia. (2022). Basilar artery. <https://radiopaedia.org/articles/basilar-artery>
- Savitz, S. I., & Caplan, L. R. (2005). Vertebrobasilar disease. *New England Journal of Medicine*, 352(25), 2618–2626.
- Schomer, D. F., Marks, M. P., et al. (1994). The anatomy of the posterior communicating artery as a risk factor for ischemic cerebral infarction. *New England Journal of Medicine*, 330, 1565–1570.
- Smoker, W. R., Corbett, J. J., Gentry, L. R., et al. (1986). High-resolution computed tomography of the basilar artery: Vertebrobasilar dolichoectasia. *AJNR American Journal of Neuroradiology*, 7(1), 61–72.
- Snell, R. S. (2010). *Clinical neuroanatomy* (7th ed.). Lippincott Williams & Wilkins.
- Standring, S. (2016). A brief history of topographical anatomy. *Journal of Anatomy*, 229(1), 32–62.
- Triantafyllou, G., Paschopoulos, I., Papadopoulos-Manolarakis, P., et al. (2026). Prevalence of basilar artery variants: A systematic review with meta-analysis of radiological studies. *Neuroradiology*.
- Uchino, A., Saito, N., Takahashi, M., et al. (2012). Neuroradiological analysis of basilar artery fenestration based on MR angiographies. *Surgical and Radiologic Anatomy*, 34(5), 421–428.
- Zhang, Z., Liu, Z., Tian, Z., et al. (2014). Association between basilar artery hypoplasia and posterior circulation infarction. *Semantic Scholar*, 94(47), 3721–3725.
- Zheng, J., Sun, B., Lin, R., et al. (2021). Association between the vertebrobasilar artery geometry and basilar artery plaques determined by high-resolution magnetic resonance imaging. *BMC Neuroscience*, 22, 20.