MORPHOLOGICAL AND ANATOMICAL VARIATIONS OF THE BASILAR ARTERY AND THEIR INFLUENCE ON CEREBRAL CIRCULATION

Gazmend ZYLBEARI[1,2], Zamira BEXHETI[3], Elita MASHA[1], Milka ZDRAVKOVSKA[1] , Art ZYLBEARI1[1,2], Sadi BEXHETI[2] , Светлана JOBEBCKA[1], Tose KRSTEV[1]

1. Faculty of Medical Sciences, Goce Delcev University, Stip, North Macedonia
2. Department of General Medicine, Faculty of Medical Sciences,University of Tetova, Rep. of North Macedonia
3.South East European University - Tetova, Rep. of North Macedonia
Corresponding author e-mail: gazmend.zulbeari7@gmail.com

Abstract

The basilar artery (Basilar artery BA) is one of the arteries that supplies the brain with oxygen-rich blood. 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 nerves (CN VI) [1,2].The basilar artery represents the principal vessel of the posterior cerebral circulation and plays a major role in the vascularization of the brainstem, cerebellum, and occipital regions. ogether with the two vertebral arteries, it forms the vertebrobasilar system (VBS), which supplies blood to the posterior part of the Circle of Willis and connects with the blood supply of the anterior part of the circle provided by the internal carotid arteries [3,4,5].Anatomical variations of the BA, such as hypoplasia, dolichoectasia, tortuosity, and others, may contribute to disturbances in cerebral circulation, including hypoperfusion of the brainstem and cerebellum, as well as the development of neurological deficits. These may manifest clinically as headache, vertigo, ataxia, visual disturbances,transient ischemic attacks, and other symptoms [6,7,8].

Keywords: Morphological variations of the basilar artery (BA), cerebral circulation

Introduction

The vertebrobasilar system (VBS) is one of the most important vascular systems of the brain and is responsible for supplying blood to the brainstem, cerebellum, thalamus, and occipital lobe. The BA as a component of the VBS, is formed by the fusion of the left and right vertebral arteries and represents the main arterial vessel of the posterior cerebral circulation [9,10].Anatomical variations of the BA, such as hypoplasia, asymmetry, and dolichoectasia, have considerable clinical significance because they may lead to hemodynamic disturbances, transient ischemic attacks, and cerebrovascular stroke [11]. Hypoplasia is most commonly defined as an arterial diameter of less than 2 mm, whereas dolichoectasia is characterized by dilation and elongation of the artery with a diameter greater than 4 mm (Bruneau et al., 2006).Clinical pathological disorders involving the BA may manifest as cranial nerve deficits, cerebellar dysfunction, motor and sensory impairment, altered consciousness, vertigo, and clinical syndromes such as the “top-of-the-basilar syndrome” and the „locked-in syndrome” [12,13,14].Several anatomical variations in the distribution of the BA artery have been documented. The posterior inferior cerebellar artery, which usually arises from the vertebral artery, may originate from the BA in approximately 10% of cases. The most common variation is basilar artery fenestration, resulting from incomplete embryological fusion of the primitive longitudinal arteries. Another relatively frequent variation is the aberrant origin of cerebellar branches,including trifurcation and quadrifurcation, which together account for more than 10% of cases.Variations in arterial diameter may also be observed, such as hypoplasia and vertebrobasilar dolichoectasia, which are characterized by elongation, tortuosity, and dilatation of the basilar trunk. These morphological features are of clinical importance because they may affect the hemodynamics of the posterior circulation and may be associated with an increased risk of neurovascular compression or ischemic events in the posterior cerebral circulation

[15,16,17, 18].Anatomical variations of the BA, including fenestration, hypoplasia, dolichoectasia, atypical branching patterns,and others, are clinically important because they may alter cerebral hemodynamics, thereby increasing the risk of posterior circulation stroke, aneurysm formation, and vertebrobasilar insufficiency (VBI) [19,20].Modern radiological techniques, such as Magnetic Resonance Angiography(MRA),Computed Tomo-graphy Angiography(CTA), and color Doppler sonography, enable precise visualization and analysis of anatomical variations in cerebral blood vessels.

Purposse of the work

The aim of this study was to analyze the frequency of anatomical variations of the BA according to sex and age, to assess the measurements of the basilar artery diameter and their influence on cerebral circulation in patients with different clinical manifestations, and to compare the obtained results with data reported in international studies.

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 ± 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.

Statistical Analysis

Descriptive statistical methods were used, including the arithmetic mean and standard deviation (X ± 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 number 1: number of patients by gender and mean age ± SD

Total number of patients	60 (100 %)	mean age ± SD
Male	35 (58.33 %)	45.00±12.00 years
Females	25 (41.67 %)	45.00±12.00 years

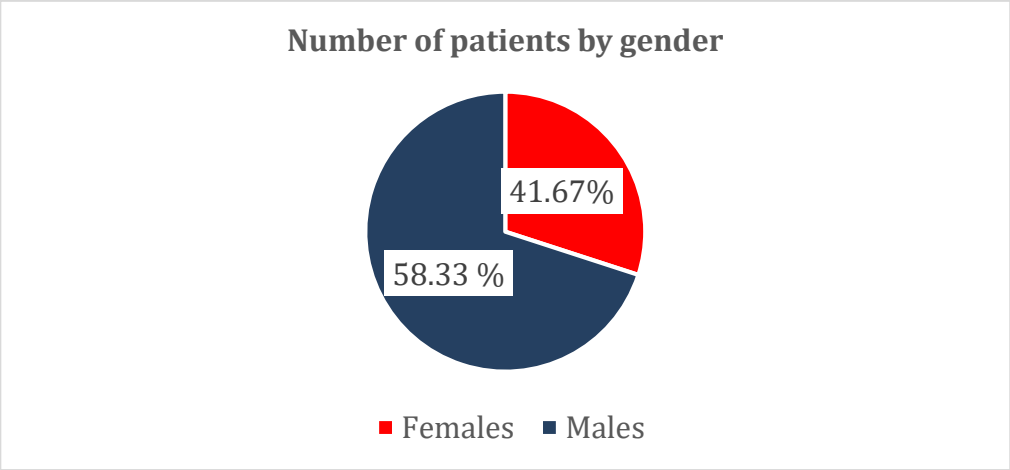


Table 2. Distribution of patients by age

Age	Men (n=350	Wome(n=25)
<45 years	14 (40%)	10 (40%)
>45 year	21 (60%)	15 (60 %)

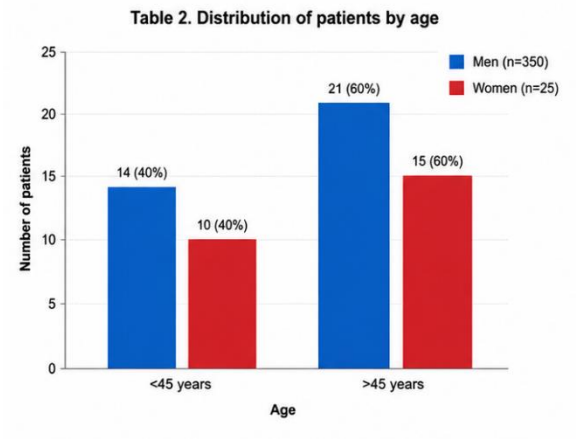
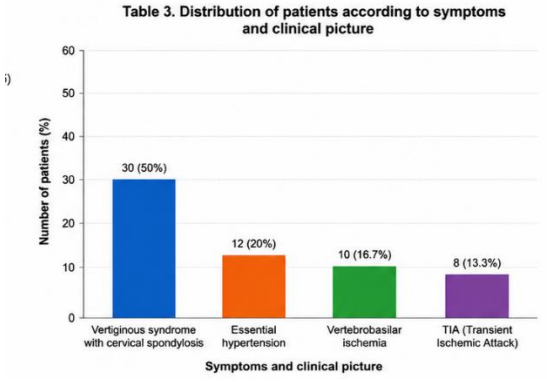


Table 3: Distribution of patients by symptoms and clinical picture

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



Results

In 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	%
Normal morphological anatomy	16	64.0
Hypoplasia	8	32.0
Dolichoectasia	1	4.0
Total	25	100

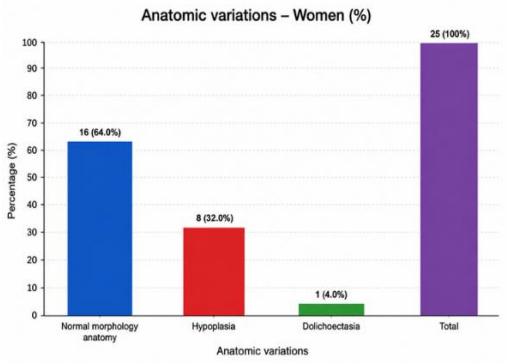
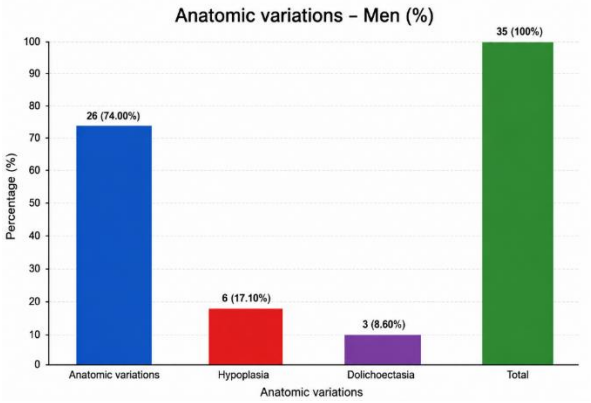


Table 5. Distribution of anatomical variations in men

Anatomical variations	Men	%
Anatomical variations	26	74.00
Hypoplasia	6	17.10
Dolichoectasia	3	8.60
Total	35	100



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.

Discussion

In our study, significant anatomical variations of the basilar artery (BA) were identified, with hypoplasia being the most frequent variation, particularly in the female population. In females, hypoplasia was registered in 32% of patients, while in males it was present in 17.1%. On the other hand, dolichoectasia was more common in males (8.6%).Our findings are consistent with recent international studies indicating that anatomical variations of the vertebrobasilar system significantly influence cerebral hemodynamics and are associated with ischemic disturbances in the posterior cerebral circulation [21]. It has been shown that the geometry and morphological variations of the vertebrobasilar system (VBS) are directly related to the formation of atheromatous plaques and reduced flow in the basilar artery.Hypoplasia was defined as a vessel diameter of less than 2 mm, according to the criteria described by Smoker et al.-1986 [22,23], while dolichoectasia was defined as arterial dilatation with a diameter greater than 4 mm (Passero & Rossi, 2008[30].In the study by Cao S, Zhai M, et al. [24], it was demonstrated that dolichoectasia of the basilar artery significantly increases the risk of infarction in the posterior circulation, especially in patients older than 60 years. The authors emphasized that such anatomical changes lead to turbulent flow and hemodynamic instability.Similar findings were reported by Catalano et al. [25], who highlighted that both congenital and acquired variations of the BA play an important role in the development of neurological symptoms,transient ischemic attacks(TIA), vertebrobasilar insufficiency, and ischemic stroke.In our study, patients with hypoplasia had BA diameters ranging from 1.80 mm to 1.95 mm. These values are comparable with the results of Chuang et al. [26], who demonstrated that hypoplastic arteries with a diameter of less than 2 mm represent a risk factor for vertebrobasilar cerebrovascular events.Hsu et al. [27] also showed that bilateral vertebral artery hypoplasia is associated with acute ischemic stroke and impaired posterior circulation. Dong et al. [28], through hemodynamic analysis, found that variations of the basilar artery cause changes in cerebral blood flow, further confirming the importance of these anatomical variations in the pathophysiology of cerebral ischemia.Due to the absence of a control group in our study, the obtained results were comparatively analyzed with data from international studies and publications in the fields of neuroangiography and radiology [29].Modern imaging techniques, especially MRA and CTA, enable early and precise detection of such anatomical variations. According to current neuroradiological recommendations, these methods play an important role in assessing the risk of cerebrovascular diseases and planning further treatment.

Conclusion

Anatomical variations of the BA are relatively common and represent an important factor in the disturbance of cerebral circulation. They may be associated with neurological deficits and a wide spectrum of neurological symptoms.Early detection of these variations using modern radiological methods is of great importance for the prevention of cerebrovascular complications and timely patient management.In conclusion, we can state that anatomical variations of the BA, as well as the VBS, are key elements in the diagnosis, prevention, and management of vertebrobasilar disorders and symptoms, and have significant clinical importance in predicting surgical and interventional outcomes.

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