

# Basilar artery fenestration

A. Dodevski<sup>1</sup>, M. Lazareska<sup>2</sup>, D. Tosovska-Lazarova<sup>1</sup>, J. Zhivadinovik<sup>1</sup>, A. Stojkoski<sup>2</sup>

<sup>1</sup>Institute of Anatomy, Medical Faculty, "Ss. Cyril and Methodius University", Skopje, R. Macedonia

<sup>2</sup>University Institute of Radiology, "Ss. Cyril and Methodius University", Skopje, R. Macedonia

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*The posterior circulation of the brain constitutes the vertebrobasilar system and its branches, which are responsible for about 30% of the brain's blood supply. The aim of this study was to describe the anomalies of the basilar artery, especially fenestrations. For that purpose, we examined 50 patients with computed tomography (CT) angiography during an 8-month period. In the CT reports of 2 (4%) patients of the 50 analysed, fenestration was found at the proximal basilar trunk. The two fenestrations in our series were not associated with aneurysms. No collateral branches originated from the two limbs of the fenestration. In conclusion, basilar artery fenestrations are a rare finding. The data derived from this study are useful teaching material for anatomists, and for the radiologists and neurosurgeons they are important for diagnostic and intervention procedures such as CT, magnetic resonance imaging, angiography, and surgical and endovascular procedures. (Folia Morphol 2011; 70, 2: 80–83)*

**Key words:** basilar artery, fenestration, aneurysm

## INTRODUCTION

The posterior circulation of the brain constitutes the vertebrobasilar system and its branches. The basilar artery, so named because of its position at the base of the skull, is a single trunk formed by the junction of the two vertebral arteries. It extends from the lower to the upper border of the pons, lying in its median groove, under cover of the arachnoid. It ends by dividing into the two posterior cerebral arteries [4].

The basilar artery, which supplies the brainstem and posterior part of the human brain, arises from the junction of the two vertebral arteries. Unlike most systemic arteries, which have a tree-like branching pattern, the basilar artery is an artery in which two arterial flows merge [6].

According to Wollschlaeger [8], the basilar artery diameter ranges from 2.70–4.28 mm and its length from 24.80–38.50 mm. The length of the basilar artery depends on the site of origin and termination of the vessel.

Variations of the basilar artery are rare in comparison to those of the other intracranial arteries constituting the circle of Willis [14]. The aim of this study was to describe the variations of the basilar artery, especially fenestrations.

## MATERIAL AND METHODS

During an 8-month period, from February 1<sup>st</sup> 2010 to September 30<sup>th</sup> 2010, 50 patients from the University Institute for Radiology in Skopje, R. Macedonia were examined. This was an anatomical analysis of computed tomography angiography (CTA) images carried out for a medically justified goal with the approval of the Macedonian Ethical Committee. The study included 25 females and 25 males, ranging in age from 19 to 75 years, mean age 57.8 ± 13.02 years. Patients underwent CTA, which is a relatively new imaging method in the study of anatomy, with characteristics of practical handling and accurate orientation. In previous years CTA was con-

Address for correspondence: A. Dodevski, MD, Institute of Anatomy, Medical Faculty, "Ss. Cyril and Methodius University", 50 Divizija, bb, 1000 Skopje, R. Macedonia, tel/fax: +389 2 31 25 304, e-mail: acedod@hotmail.com

sidered to be a relatively safe, fast, and minimally invasive procedure, which was a reliable tool for the investigation of vessels. CTA was undertaken for a variety of clinical reasons, including symptoms of cerebral ischaemia (17 cases), subarachnoid haemorrhage (19 cases), headache (8 cases), dizziness (5 cases), and neoplasm (1 case). CTA was performed with a CT scanner Somatom, Volume Zoom, Simens, multislice 4. Contrast material was injected by using intravenous catheter placed in the peripheral vein (a total of 100 mL) at a rate of 3 mL/s with a pressure injector. After the contrast medium was injected, by use of bolus tracking software, scanning was carried out automatically. The data were transferred to a workstation for post-processing. Reconstruction included the following: maximum intensity projection (MIP); four-dimensional CTA with volume rendering; and reformatted multiplanar reformation (MPR) performed through the basilar artery. The basilar artery was clearly and directly shown in the high quality images, and satisfied the requirements of our study. In all of the 50 patients the course of the basilar artery extending from its origin to its end was clearly observed. The CTA reports were analysed for fenestration of the basilar artery.

## RESULTS

In two of the 50 analysed CT reports (4% of patients), fenestrations were found. The first patient was a 74 year-old man admitted to our hospital with symptoms of subarachnoid haemorrhage. The basilar artery had a straight course and at its proximal part there was a fenestration, the window of which was 8 mm long. The left limb of the fenestration had a transverse diameter of 4 mm. The right limb had a lesser transverse diameter of 1.5 mm. No collateral branches originated from the two limbs of the fenestration (Fig. 1).

The second patient, a 74 year-old woman, was admitted to the hospital with a headache and recurrent vomiting. CTA was performed and depicted a fenestration of the proximal segment of the basilar artery. The fenestration window was 3.68 mm long, a medium fenestration according to its length. The right limb of the fenestration was larger than the left (Fig. 2).

None of the two proximal fenestrations in our series was associated with an aneurysm.

## DISCUSSION

Basilar artery variations are rare and most commonly include fenestration or duplication and rare-

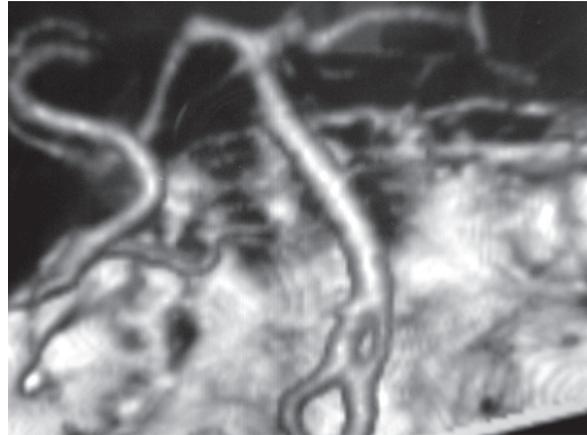


Figure 1. Large fenestration at proximal basilar artery.

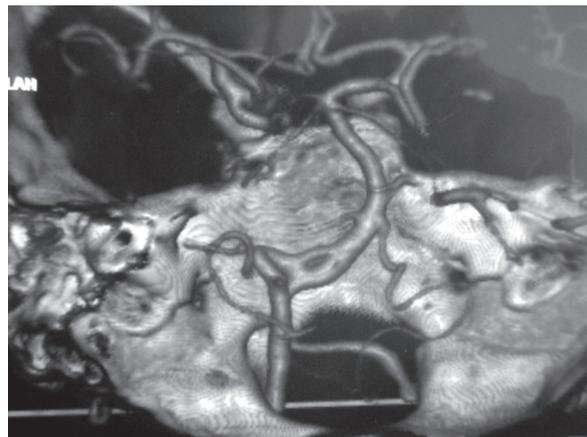


Figure 2. Medium fenestration at proximal basilar artery.

ly hypoplasia, segmental aplasia, plexiform appearance, etc. [14]. The best way to understand congenital anomalies of the head and neck vasculatures is by analysing the embryonic development of aortic and supra-aortic vessels.

The basilar artery is formed by the fusion of two primitive longitudinal neural arteries during the second to fourth stages of embryonic development. The fusion usually occurs during the fifth week of foetal life when the two primitive arteries of the ventral side of the neural tube are approximately 5–6 mm long. In the early stages of fusion these arteries are connected by several bridging areas; further fusion occurs to form the basilar artery. If these areas of irregularity persist, they result in fenestration or, if fusion fails to occur, duplication of the basilar artery [3].

A fenestration is defined as a single artery with two luminal channels, which may or may not share

their adventitial layer [2]. There is a spectrum of appearances, from a tiny island of tissue separating the two channels to actual duplication of a long segment of the involved artery [10].

Fenestration of the intracranial artery is a rare occurrence. Basilar artery fenestrations are the most frequently observed fenestrations of the cerebral arteries, with the vertebral and middle cerebral artery fenestrations being the next most frequent [11]. The true frequency of fenestration of the basilar artery is difficult to ascertain, and the data vary according to the type of series. The incidence of fenestration of the basilar artery is reported to be 0.02% to 0.6% in angiographic series, 2.0% on magnetic resonance angiography (MRA), and from 1.3% up to 6.0% in autopsy series. The discrepancy between the autopsy incidence and angiographic incidence of basilar artery fenestrations can be explained by the fact that in some fenestrations the divider is very thin and in most projections is angiographically occult. Additionally, the aneurysm itself may obscure the fenestration, preventing angiographic recognition [2]. Fenestration can occur anywhere along the course of the basilar artery, but the most frequent site of basilar artery fenestration is in the proximal portion of the basilar trunk, close to the junction of the vertebral arteries. However, the middle or distal portion of the basilar artery is rarely affected. Fenestrations of the basilar artery are classified according to their length as small (0–3 mm), medium (3.1–5 mm), or large (> 5.1 mm) [12].

Islak et al. [7], in a retrospective review of 2000 angiograms, found 26 (1.3%) intracranial artery fenestrations. Of the 26 arterial fenestrations, 20 (77%) were located at the basilar artery, three (12%) at the vertebral artery, and three (12%) at the middle cerebral artery.

Ahn et al. [1], in their study, found that the retrospective incidence of basilar artery fenestrations was 0.62% (5/803) in conventional cerebral angiography and 1.14% (10/880) in an MRA study group. Twelve fenestrations were located in the proximal portion of the basilar artery and one was in the mid-portion of the basilar artery [1].

Sanders et al. [10], in their retrospective review of 5190 cerebral angiograms, reported 37 patients with 38 fenestrated arteries: 16 basilar, 10 vertebral, 9 middle cerebral, and 3 anterior cerebral arteries. The angiographic incidence of basilar artery fenestration was 0.3%. In 5 cases fenestration was

at the proximal basilar artery, in 7 cases in the mid-basilar artery, and in 4 cases in the distal part of the basilar artery.

A fenestration or a segmental duplication of the basilar artery, previously reported exclusively as an anatomic variation, owes its clinical interest to the possible association with aneurysms localised in the fenestrated segments. Fenestration has been shown to be associated with defects in the wall at its proximal and distal margins. The lateral walls of the fenestrated artery have a normal intrinsic architecture. However, the medial walls show septation dividing the vascular channel into two distinct channels. The medial walls of the fenestration have focal defects at both ends of the fenestration. The media are absent locally with discontinuity of elastin at the proximal end of the fenestration. The subendothelium is thickened distally and thinned proximally. These structural changes at the proximal end of the fenestration are similar to those seen in cerebral artery bifurcations. The changes in the subendothelial structures are consistent with those produced by haemodynamic stress. The anatomic, structural, and haemodynamic changes that occur at the proximal end of the fenestration are consistent with the theory of the cause of intracranial aneurysms [5]. Sanders et al. [10] found that the incidence of aneurysm in 16 basilar artery fenestration sites was 1 in 16 (7%). Considering all intracranial fenestrations, the incidence of aneurysms at the fenestration site was 1 in 38 (3%). However, some very interesting data about the association between aneurysms and fenestration has been presented by Campos et al. [3]. Of 59 cases with vertebro-basilar junction aneurysms diagnosed and treated, 21 (35.5%) aneurysms arose in a fenestration of the proximal basilar artery. In 6 cases the length of the fenestration measured less than 5 mm, in 14 cases it measured 6–10 mm, and in 1 case it was 15 mm. Twenty cases showed the fenestration just above the vertebro-basilar junction, and one case had the fenestration in the mid-basilar artery. All aneurysms arose from the proximal juncture of the fenestration [3]. Tasker and Byrne [12], in their series of 103 patients, found 9 patients to have a fenestration of the basilar artery, all associated with aneurysms of the basilar artery. In 6 (66%), the aneurysm arose at the site of the fenestration. In 4 cases the fenestrations were in the mid- or mid/distal portion of the basilar artery. There were 5 patients with proximal fenestration.

trations near the vertebro-basilar junction [12]. Therefore, when a vertebro-basilar junction aneurysm is present, an associated fenestration should be strongly suspected. In the series with increased incidence of association between aneurysm and fenestration, like those of Campos et al. [3], Tasker and Byrne [12] and Peluso et al. [9], etc., selected patients with known aneurysms were evaluated for the presence of fenestration. In our series as well as in Sanders' series, patients with fenestrations were evaluated for the presence of an aneurysm. In our study, basilar artery fenestrations were found in 2 (4%) patients in the CTA. In both patients there were no aneurysms at the fenestration site or at the site of posterior circulation. Our series was small; perhaps a greater number of cases with basilar artery fenestrations would reveal aneurysms.

The clinical significance is controversial, but a basilar artery fenestration might be misinterpreted as an arterial dissection or thrombosis, especially in patients with stroke, thereby leading to an incorrect decision regarding further diagnostic approaches or therapies [11]. There has been speculation about associations between vertebro-basilar artery fenestrations and brainstem ischaemia, or infarctions, although their relationships are controversial [13]. Collateral branches can originate from the two limbs of the fenestration. Clearly, it is important to investigate these data and to identify the fenestration separately from the aneurysm before surgery in order to prevent inadvertent clipping of a limb of the fenestration, including these important branches [3].

## CONCLUSIONS

In conclusion, basilar artery fenestrations are a rare finding. We found two (4%) fenestrations at the proximal basilar trunk. According to their length, one fenestration was medium in size and the other was large. Our data show that there was no association between the fenestrations and aneurysms at the basilar artery. The information derived from this study present valuable teaching material for students and postgraduates. The applicative value for radiologists and neurosurgeons is in the diagnostic and intervention procedures such as CT, magnetic resonance imaging, angiography, and surgical and endovascular procedures.

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