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CASE REPORT

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Basilar tip fenestration giving rise to Percheron's and mesencephalic arteries

Radosław Rzepliński[1], Mikołaj Sługocki[1], Michał Tomaszewski[2], Michał Kucewicz[2], Paweł Krajewski[3], Jerzy Małachowski[2], Bogdan Ciszek[1]

[1]*Department of Descriptive and Clinical Anatomy, Medical University of Warsaw, Warszawa, Poland*
[2]*Institute of Mechanics and Computational Engineering, Faculty of Mechanical Engineering, Military University of Technology, Warszawa, Poland*
[3]*Department of Forensic Medicine, Medical University of Warsaw, Warszawa, Poland*

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The basilar bifurcation region is a common site for intracranial aneurysms, as well as it gives rise to a group of perforating arteries that supply the mesencephalon and the thalamus. Complex vascular microanatomy poses a diagnostic and therapeutic challenge for neurosurgeons, neuroradiologists and neurologists. In this paper, we present a previously unreported case of basilar tip fenestration that gave rise to five perforating arteries: the artery of Percheron and four mesencephalic arteries. Due to invaluable clinical significance, the possibility of such a variant must be considered during performing various neurovascular procedures, since e.g. embolization of the fenestration misdiagnosed as an aneurysm would inevitably lead to severe neurological complications (consciousness disturbances, quadriplegia, and sensory loss). Comprehensive knowledge of the neuroanatomy and neuroembryology is crucial to safe execution of intracranial interventions. (Folia Morphol 2024; 83, 2: 451–454)

Keywords: perforating arteries, cerebral circulation, circle of Willis, micro-CT, vascular variants, artery of Percheron

INTRODUCTION

Anatomical variants of the intracranial circulation reflect complex phylogenetic and ontogenetic development. They pose a diagnostic challenge and increase the difficulty of planning and performing intracranial procedures [18]. The distal basilar artery (BA) and proximal segments of the posterior cerebral arteries (PCA) and the superior cerebellar arteries (SCA) provide blood supply to the midbrain and posterior thalamus through perforating arteries, namely the mesencephalic and the thalamoperforating arteries [1, 11, 12]. The basilar tip is also a common site for intracranial aneurysms [9]. Therefore, the microvascular anatomy of this region is of special interest to neurosurgeons, neuroradiologists and neurologists. We would like to present a previously unreported case of basilar tip fenestration giving interesting and clinically important branches.

CASE REPORT

As a part of the project regarding the haemodynamics of the cerebral circulation, we prepared collection of specimens of the vertebrobasilar system and the perforating arteries. In one case, we discovered basilar tip fenestration (Fig. 1) — presence of a vessel connecting the precommunicating segments of the posterior cerebral arteries, which gave rise to five perforating arteries. We filled the arterial tree with

Address for correspondence: Radosław Rzepliński, Department of Descriptive and Clinical Anatomy, Medical University of Warsaw, ul. Chałubińskiego 5, 02–004 Warszawa, Poland; tel/fax: 22 629 52 83, e-mail: radoslaw.rzeplinski@wum.edu.pl

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contrast medium (as described previously [16]) and scanned the specimen with the use of Nikon Metris XT H 225 ST micro-computed tomography scanner (voxel size 0.027 mm). We analysed the results of radiological studies in Mimics 23.0 (Materialise, NV, Leuven, Belgium), created a three-dimensional reconstruction (Fig. 1B), studied the vascular territories, and measured all vessels. It turned out that the fenestration gave rise to four mesencephalic arteries and the thalamoperforating artery that provided blood supply to both thalami (the artery of Percheron, Table 1, and Fig. 2). The fenestration diameter gradually decreased from the left (1.05 mm) to the right (0.43 mm).

DISCUSSION

The superior third of the basilar artery lies in the prepontine and the interpeduncular cisterns, where it gives origin to the posterior cerebral arteries and the superior cerebellar arteries. [1] However, blood supply area is not limited to the occipital lobes, the temporal lobes (to some extend) and rostral cerebellum. Different groups of small perforating arteries branching in close proximity to the basilar tip (the pontine arteries, the thalamoperforating arteries, the posterior choroidal arteries) expand the supply area to include the upper pons, the midbrain and the posterior thalamus. It is worth noting that the superior cerebellar arteries may also be involved in the vascularization of the pons [7].

Intracranial arteries fenestrations (defined as a vessel division and fusion after some distance) [2, 19] are present in about 40% of people and the basilar artery is the second most common site (after the anterior communicating artery) [6]. However, fenestration of the basilar tip has never been described. In a recent study conducted by Krystkiewicz et at.

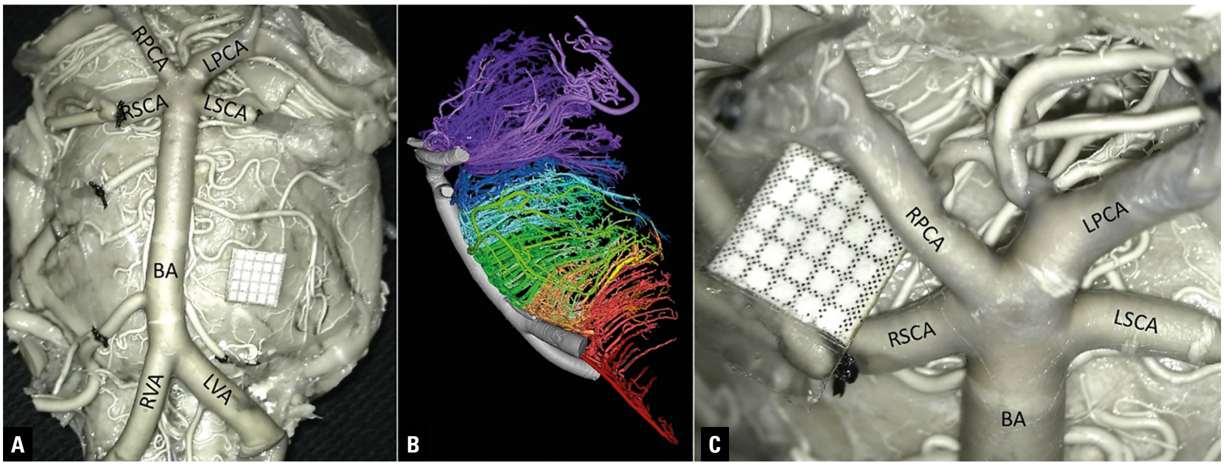

Figure 1. Anatomical specimen of the brainstem and the basilar tip fenestration (asterisk; A — front view, C — top view) and corresponding three-dimensional model (B — side view). The length of the scale bar equals to 5 mm. BA — basilar artery; LPCA — left posterior cerebral artery; RPCA — right posterior cerebral artery; LSCA — left superior cerebellar artery; RSCA — right superior cerebellar artery; LVA — left vertebral artery; RVA — right vertebral artery.

Table 1. Characteristics of the perforating arteries

Vessel number and colour on Fig. 2	Type of artery	Internal diameter [mm]	Blood supply area	Fenestration internal diameter [mm]*
1 — yellow	Mesencephalic artery	0.62	Lower left mesencephalic tegmentum and left cerebral peduncle	1.05
2 — blue	Artery of Percheron	1.01	Both paramedian thalami	0.99
3 — light orange	Mesencephalic artery	0.63	Upper mesencephalic tegmentum bilaterally	0.72
4 — dark orange	Mesencephalic artery	0.46	Lower right mesencephalic tegmentum	0.63
5 — red	Mesencephalic artery	0.56	Lower right mesencephalic tegmentum and right cerebral peduncle	0.6

*Measured on the left side of origin of the perforator

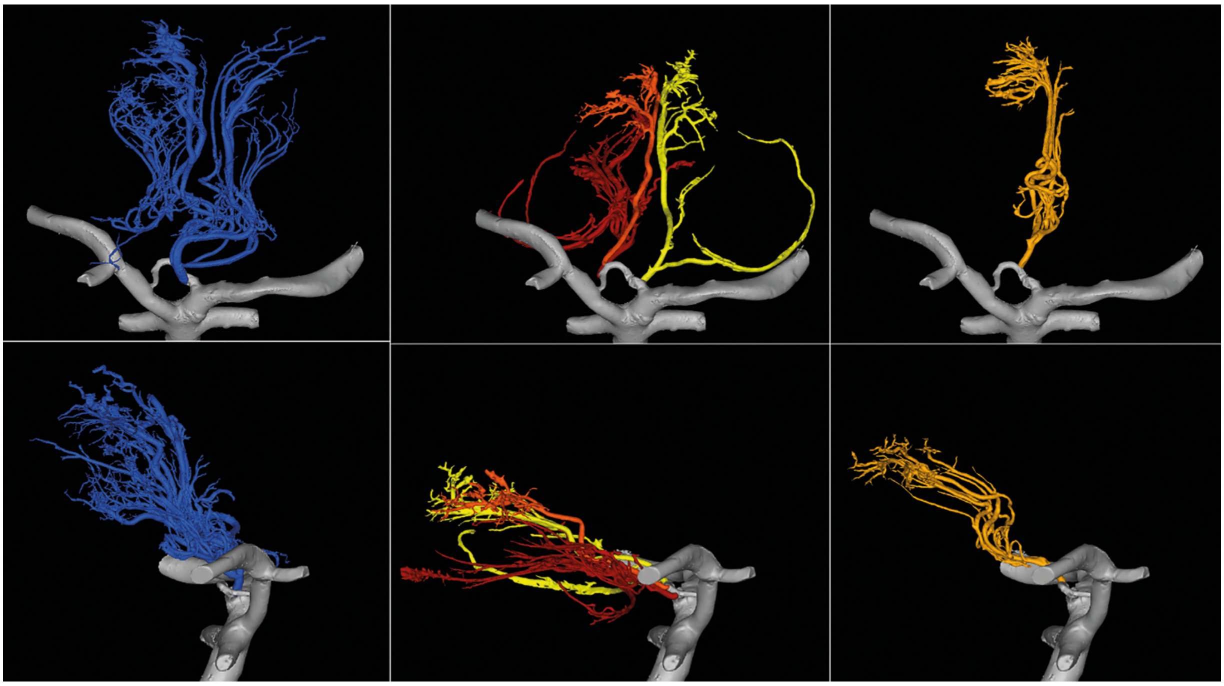

Figure 2. Vascular territories of the perforating arteries branching from the fenestration — top views (upper row) and side views (lower row). The artery of Percheron provided blood supply to the upper midbrain and the thalamus bilaterally (left column, blue artery). One of the mesencephalic arteries gave branches to the upper mesencephalic tegmentum bilaterally (right column, light orange artery). The remaining three arteries were associated with blood supply to the relevant site of the midbrain (middle column).

based on inspection of 333 human brain specimens, there were no basilar tip fenestrations reported, so the incidence can be estimated at below 0.3% [6].

The incidence of fenestrations reported by radiological and microanatomical studies differs significantly and amounts to approximately 1–30% [2, 4, 17, 13, 19] and about 40% [6], respectively. Taking into account that spatial resolution of standard imaging methods (typical voxel size of 0.25–0.3 mm) and results of our previous study, which showed that, unlike microtomography, standard tomography does not visualise the perforating arteries adequately [14, 15], we can conclude that standard clinically used radiological methods are not ideal to access presence and branches of intracranial arteries fenestrations. This is particularly important in the context of the presented case, where the fenestration gave rise to the artery of Percheron and the mesencephalic arteries. Imperfect imaging methods may falsely suggest presence of a vascular malformation (e.g. small aneurysm) and lead to unnecessary neurovascular intervention, which would result in with severe neurological complications (bilateral thalamic and mesencephalic ischemia after embolization of misdiagnosed basilar tip fenestration). Proper and uninterrupted blood supply to these regions is vital to life, as mesencephalic and thalamic ischemia leads to serious neurological complications such as coma and quadriparesis [1]. The fenestration supplied the thalamus and the cerebral peduncles bilaterally, making it of invaluable clinical significance.

Common definition of fenestration only considers the geometry of the vessel. However, according to Lasjaunias the term "fenestration" should be used to describe "a single artery with two luminal channels" [5, 8]. In the case of the distal basilar artery that develops embryologically from the caudal divisions of the internal cerebral artery, the term "segmentally unfused basilar artery" should be used [3]. Another vascular variant resulting from the development of the posterior perforating substance perforators from the embryological vascular rete is subarachnoidal anastomosis [5], present in about 60% of cases [10]. The right angle between the PCAs and the gradual decrease in the diameter of the vessel from the left to the right, which prevents recognition of two perforating arteries and their anastomosis, suggest a case of segmentally unfused basilar artery.

CONCLUSIONS

Basilar artery fenestrations can provide blood supply to vital areas of the cerebrum such as the thalamus and the mesencephalon. Neurosurgeons and neuroradiologists should be aware of presence of vascular variants of the intracranial circulation and shortcomings of classical imaging methods in terms of their visualisation. Comprehensive knowledge of neuroanatomy and neuroembryology is crucial to the safe execution of intracranial interventions.

ARTICLE INFORMATION AND DECLARATIONS

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Ethical approval

All procedures performed in the study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments. The study protocol was approved by The Ethics Committee of Medical University of Warsaw, Poland (Number 138/2020).

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Conflict of interest: The authors declare that they have no conflict of interest.

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