BJCR
Brazilian Journal of Case Reports

PCAA
Publicações Científicas de Acesso Aberto

Case Report

Anatomical Variations of Bilateral Posterior Circulation and Anterior Cerebral Artery: Case Report and Literature Review

Jonnathan Vianna [1,*], **Franklin de Freitas Tertulino** [1], **Eduardo Martiniano de Lima** [1]

[1] Federal Rural University of the Semi-Arid Region, Mossoró, Rio Grande do Norte, Brazil.

* Correspondence: jonnathanvianna@gmail.com.

Abstract: It is not uncommon to find anatomical variations in the Circle of Willis in healthy individuals. These variations are typically singular or, more rarely, dual, and by definition, would not cause symptoms in the patient. However, reports in the literature suggest that these so-called "arterial variations" may be associated with the development of aneurysms, hemorrhages, and cerebral abnormalities, as well as increasing the risk of vascular insufficiency and severe brain damage during thromboembolic events. We present the case of a 64-year-old woman with complaints of refractory headache, whose magnetic resonance angiography demonstrated the association of three anatomical variations: azygos anterior cerebral artery, true fetal origin posterior cerebral artery, and complete fetal origin posterior cerebral artery.

Keywords: Magnetic Resonance Angiography; Anatomical Variation; Cerebral Arteries.

Citation: Vianna J, Tertulino FF, Lima EM. Anatomical Variations of Bilateral Posterior Circulation and Anterior Cerebral Artery: Case Report and Literature Review. Brazilian Journal of Case Reports. 2025 Jan-Dec;05 (1):bjcr51.

https://doi.org/10.52600/2763-583X.bjcr.2025.5.1.bjcr51

Received: 13 November 2024
Accepted: 4 January 2025
Published: 6 January 2025

1. Introduction

Anatomical variations are congenital morphological differences observed across various organ systems, typically without functional impairment [1]. Vascular anatomical variations are asymptomatic but can elevate the risk of aneurysms, hemorrhages, and cerebral malformations. At the base of the brain, the Circle of Willis (or anterior cerebral circulation) is a critical vascular structure comprising the posterior cerebral arteries, posterior communicating arteries, middle cerebral arteries, anterior cerebral arteries, and anterior communicating artery. However, as this case demonstrates, anatomical variations in this structure, while asymptomatic by definition, can alter symptomatology in the presence of certain cerebrovascular pathologies, such as stroke.

In this study, magnetic resonance angiography (MRA) using the "3D-TOF" (Time-of-Flight) technique was employed. This method provides contrast between vascular structures with flow and stationary tissue in a single acquisition [2]. TOF is the gold-standard technique for evaluating cerebral arterial vascularization for anatomical variants and vascular malformations [3]. It offers advantages over other imaging modalities, such as digital angiography, being non-invasive, free from ionizing radiation, and avoiding iodinated contrast. While TOF can also assess intracranial venous structures, gadolinium contrast is required for this purpose [2].

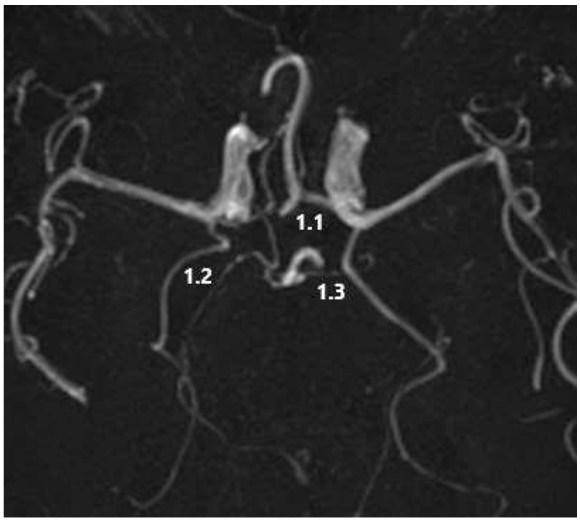
We report a case of a 64-year-old woman presenting with an alteration in anterior cerebral circulation and two variations in posterior cerebral circulation, potentially ex-

plaining her clinical presentation. This case is particularly significant as alterations in posterior circulation drainage patterns can lead to venous congestion, increased local pressure, and heightened risk of ischemic or hemorrhagic events. Furthermore, posterior circulation alterations may result in hypoperfusion in critical areas such as the cerebellum and brainstem, increasing the risk of focal neurological deficits, particularly in cases of venous thrombosis or stenosis. Notably, this article reports a novel association of anatomical variations in the scientific literature, contributing to a broader understanding of these malformations and aiding in the development of clinical guidelines for managing anatomical variations, thereby avoiding unnecessary interventions.

2. Case Report

A 64-year-old female patient, conscious and oriented in time and space (Glasgow Coma Scale score of 15), presented with complaints of severe headache and dizziness, both refractory to clinical treatment. To further investigate, a cranial magnetic resonance angiography (MRA) using the "3D-TOF" (Time-of-Flight) technique with flow-sensitive sequences was performed. The study included three-dimensional reconstruction using maximum intensity projection (MIP) techniques. The examination revealed variations in the Circle of Willis and the posterior cerebral artery (PCA), including: a segment of the anterior cerebral artery indicative of an azygos artery ("common A2 segment") (Figure 1); duplication of the posterior cerebral artery in the right hemisphere, with the presence of a true fetal-type artery, and a complete fetal-type posterior cerebral artery in the left hemisphere (Figure 2).

Figure 1. Magnetic resonance angiography using the 3D-TOF technique, transverse view (axial cut) of the Circle of Willis. 1.1) Formation of an azygos anterior cerebral artery. 1.2) Duplication of the right posterior circulation. 1.3) Left posterior circulation via the posterior communicating artery.



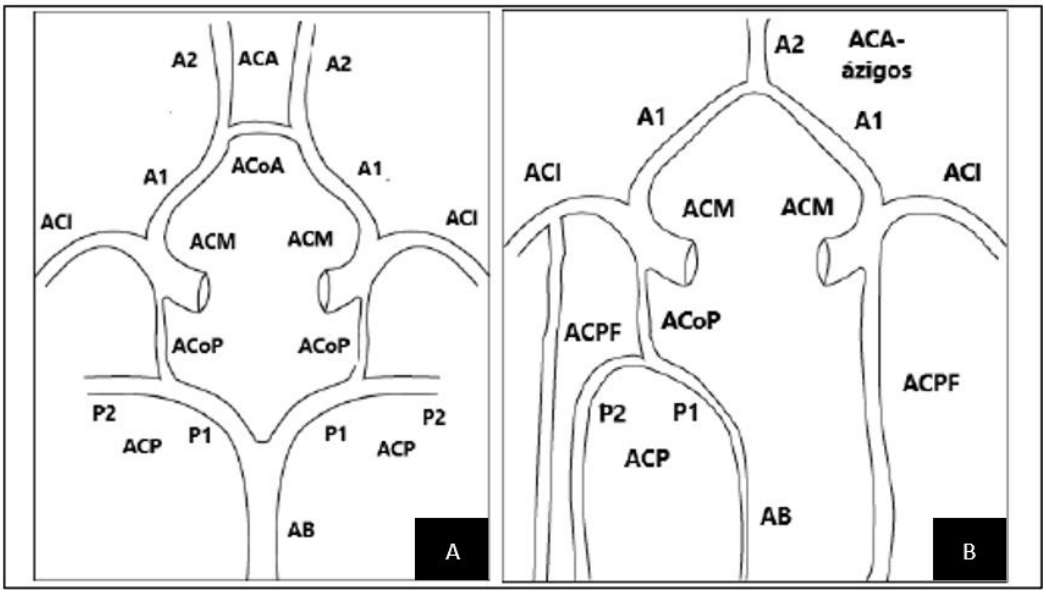
3. Discussion

3.1 Anatomy

The vertebral arteries and internal carotid arteries (ICA) are responsible for brain vascularization [4]. These arteries branch out until they reach the base of the brain, forming a complex anastomosis called the Circle of Willis [5]. The ICA primarily supplies blood to the brain [4], traveling unbranched through the carotid canal in the petrous portion of the temporal bone, then passing through the cavernous sinus [4]. Beyond this, the cerebral portion of the ICA diversifies into several branches, the most relevant to this case being the posterior communicating artery (PCoA), middle cerebral artery (MCA), and anterior

cerebral artery (ACA). The MCA and ACA connect to form the Circle of Willis (or Arterial Circle of the Brain) [4-6].

Figure 2. Schematic diagram comparing the most common Circle of Willis with the one presented by the patient, including all three anatomical variants. In Figure 2A, the most frequent Circle of Willis configuration in the general population is shown. Conversely, in Figure 2B, the patient's presentation is illustrated, highlighting the anatomical variations. A1: A1 segment of the ACA; A2: A2 segment of the ACA; AB: Basilar Artery; ACA: Anterior Cerebral Artery; ACA-azygos: Azygos Anterior Cerebral Artery; ICA: Internal Carotid Artery; MCA: Middle Cerebral Artery; ACoA: Anterior Communicating Artery; PCoA: Posterior Communicating Artery; PCA: Posterior Cerebral Artery; FOPCA: Fetal-Origin Posterior Cerebral Artery; P1: P1 segment of the PCA; P2: P2 segment of the PCA.



After the ICA bifurcates, the first segment of the ACA, known as the proximal segment or A1, connects to the anterior communicating artery (ACoA). The ACA then continues as the distal segment or A2. The largest branch is the medial striate artery (or recurrent artery of Heubner), which supplies the head of the caudate nucleus. Cortical branches further supply the medial and orbital surfaces of the frontal lobe [5, 7]. In summary, the ACA irrigates the frontal pole and superior and medial surfaces of the brain. The MCA, a direct branch of the ICA, supplies the temporal pole and lateral surface of the brain, while the PCA supplies the occipital pole and inferior surface of the brain. Additionally, PCoA supplies the optic tract, internal capsule, thalamus, and cerebral peduncle; the basilar artery supplies the brainstem and cerebellum; and the vertebral artery supplies the meninges and cerebellum [7]. Understanding the vascularization of the brain and identifying corresponding irrigation areas are crucial, as symptoms depend on the degree and location of the lesion or variation.

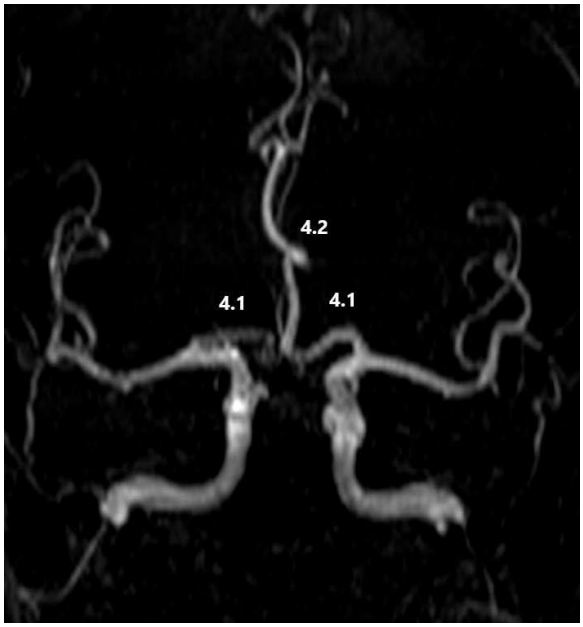
3.2 Azygos Anterior Cerebral Artery

The azygos anterior cerebral artery (ACA-azygos) is a rare anatomical variation of the Circle of Willis, with an incidence of approximately 0.3% to 5% [8, 9]. This variation involves the fusion of the A1 segments, forming a single A2 segment, which increases the potential for damage in cases of ischemia. Furthermore, it can predispose patients to alterations in vasomotor regulation, frequently associated with headaches. Embryologically, the ICA divides into two trunks: the rostral and caudal. Around day 40 of embryogenesis, the rostral portion subdivides into the medial and lateral olfactory arteries, with the medial olfactory artery developing into the ACA (Figure 3). Variations in the ACA

originate during this embryonic stage. The lateral olfactory artery gradually develops into the MCA, recurrent artery of Heubner, anterior choroidal artery, and lateral striate artery [8, 10].

In this patient, the presence of a single A2 artery may result in increased hemodynamic stress, leading to a higher risk of arterial rupture and a predisposition to aneurysm formation [11], particularly at the bifurcation area, due to doubled hemodynamic pressure [12]. Saccular aneurysms have an incidence of approximately 13-71% in cases of ACA-azygos [9, 12]. This variation is also associated with several cerebral abnormalities, including hydranencephaly, agenesis of the corpus callosum, prosencephalic cysts, and optic nerve dysplasia [9, 13]. The ACA typically emits branches that supply parts of the caudate nucleus, internal capsule, putamen, and globus pallidus [14]. Additionally, leptomeningeal branches of the ACA supply the anterior frontal lobe, part of the corpus callosum, and the medial surface of the hemispheres, extending from the superior frontal sulcus to the parieto-occipital sulcus [14].

Figure 3. Magnetic resonance angiography using the 3D-TOF technique, transverse view (axial cut) of the patient, showing the A1 segments of the ACAs (4.1) merging into a single A2 segment (ACA-azygos, 4.2).



3.3 Posterior Cerebral Artery of Fetal Origin

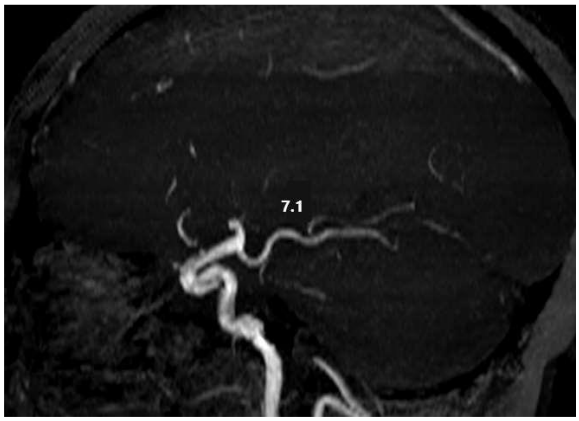
The term "Posterior Cerebral Artery of Fetal Origin" (PCAF) encompasses various vascular variations involving the posterior cerebral artery (PCA) and distal branches of the internal carotid artery (ICA) [16]. Typically, these structures are connected via the posterior communicating artery (PCoA) to vascularize the occipital lobe, inferomedial temporal lobe, and part of the inferior posterior parietal lobe [17]. However, in this variation, which occurs in 11% to 46% of adults [17], the PCA territory is predominantly perfused by ICA branches. Literature describes multiple types of PCAF, differentiated by the absence or caliber of the P1 segment of the PCA and the PCoA [18]. The presence of PCAF increases the risk of vascular insufficiency [18] and severe brain damage during thromboembolic events [17], potentially explaining ischemia in specific brain areas, as seen in the refractory pain experienced by the patient in this case.

The formation of this variation occurs during the fifth week of gestation, during the choroidal stage of embryogenesis, when the caudal branch of the internal carotid artery

(cICA) fails to regress as it typically would. Instead, it persists, forming a branch that contributes to posterior circulation. This branch can become a major or sole component of the PCoA or serve as a complementary component of the circulation (true fetal origin) [16].

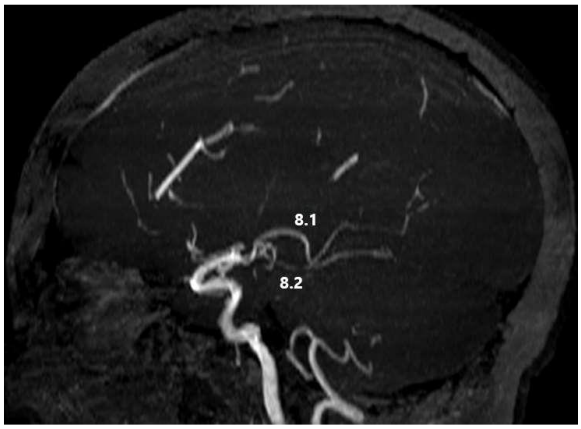
In the left hemisphere, the formation of a "full" (complete) PCAF is observed, where the P1 segment of the PCA is absent. As a result, posterior circulation in the left hemisphere is entirely supplied by the ICA branch (Figures 1, 2, and 4). This finding supports the hypothesis that such vascular alterations predispose the patient to ischemic regions. Furthermore, a thromboembolic event affecting the ICA would impact both the MCA and the posterior and inferomedial portions of the left hemisphere.

Figure 4. Magnetic resonance angiography using the 3D-TOF technique, parasagittal view of the left hemisphere of the patient, showing the PCoA (white arrow), which originates from the ICA.



In the right hemisphere, the formation of a true PCAF is observed (Figure 2), which creates two posterior cerebral arteries (PCA): one resulting from the persistence of the anterior choroidal artery (AChA) and the other from the P1 and P2 segments of the PCA [16]. This results in a duplication of the posterior circulation in the right hemisphere (Figures 1, 2, and 5). This case is one of only three described in the literature where two anatomical variations of the PCA are present in the same patient [19, 20]. Such a fetal variant of the PCA significantly alters cerebral hemodynamics, emerging as a risk factor for ischemia and potentially explaining the patient's refractory headache.

Figure 5. Magnetic resonance angiography using the 3D-TOF technique, parasagittal view of the left hemisphere of the patient, showing the PCoA (white arrow), which originates from the ICA.



4. Conclusion

This is the first reported case of two anatomical variations in the PCA combined with an anatomical variation in the anterior circulation in the same patient. Understanding similar cases is crucial to encouraging the scientific community to further investigate such malformations, particularly in clinical scenarios and during embolization or stenting procedures, due to the complex morphology of these vessels. It is also noteworthy that, in the event of vascular involvement of the MCA, ICA, or PCA, there will be distinct clinical manifestations compared to an aneurysm or thromboembolism in a Circle of Willis without variations. The rarity of this case and the potential studies it may inspire are crucial for advancing medical education, particularly for neurologists, neurointensivists, emergency physicians, and neurosurgeons.

Funding: Not applicable.

Research Ethics Committee Approval: We declare that the patient approved the study by signing an informed consent form and the study followed the ethical guidelines established by the Declaration of Helsinki.

Acknowledgments: None.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Freixinet JL, Caminero JA, Marchena J, Rodríguez PM, Casimiro JA, Hussein M. Spontaneous pneumothorax and tuberculosis: long-term follow-up. Eur Respir J. 2011;38(1):126-131. doi:10.1183/09031936.00128910. PMID: 20947681. Available from: https://pubmed.ncbi.nlm.nih.gov/20947681/
2. Ruiz CR, Nascimento SRR, Vidsiunas AK, Andrades L, Souza CC. Dupla variação anatômica vascular em um único indivíduo: estudo morfométrico. ABCS Health Sciences. 2017 Dec 11;42(3). doi: 10.7322/abcshs.v42i3.919.
3. Leite CC. Angiorressonância magnética intracraniana 3D "time-of-flight" (TOF). Radiologia Brasileira. 2024 Aug 01;37(3).
4. Valentim M. Angiografia por ressonância magnética: técnicas e práticas na rotina radiológica. Salutis Scientia. 2012 Jul 31;4.
5. Moore AFD. Anatomia Orientada Para a Clínica. 7th ed. Rio de Janeiro: Guanabara Koogan; 2014.
6. Vogl AW, Mitchel AWM, Drake RL. Gray's Anatomy for Students. 40th ed. Elsevier; 2009.
7. Paulsen F, Waschke J. Atlas de Anatomia Humana. 23rd ed. Rio de Janeiro: Gen Guanabara Koogan; 2012.
8. Louis ED, Mayer SA, Rowland LP. Merritt's Neurology. 12th ed. Rio de Janeiro: Guanabara Koogan; 2011.
9. Singh H, Dhandapani S, Mathuriya SN. Types of azygos distal anterior cerebral artery branching patterns: Relevance in aneurysmal surgery. Cureus. 2016 Jul 07. doi: 10.7759/cureus.681.
10. Makowicz G, Poniatowska R, Lusawa M. Variants of cerebral arteries - Anterior circulation. Pol J Radiol. 2013 Jul 07;78. doi: 10.12659/PJR.889403.
11. Tahir RA, Haider S, Kole M. Anterior cerebral artery: Variant anatomy and pathology. J Vasc Interv Neurol. 2019 May 05;10.
12. Baldawa S, Katikar D, Marda S. Giant saccular distal azygos artery aneurysm: Report of a case and review of literature. Asian J Neurosurg. 2011 Apr 04;11. doi: 10.4103/1793-5482.175621.
13. Chowdhury D. Azygos anterior cerebral artery aneurysm with subarachnoid hemorrhage. Neuroimmunology and Neuroinflammation. 2018;5(9):39.
14. Kesanakurthy MVSN, Ghanta Rk. Azygos anterior cerebral artery aneurysm with subarachnoid hemorrhage. Asian J Neurosurg. 2016 Jul 07;11.
15. Tatu L, Moulin T, Bogousslavsky J. Arterial territories of the human brain cerebral hemispheres. Neurol Neurosci Frontal. 2012 Feb 14. doi: 10.1159/000333602.
16. Baptista AG. Studies on the arteries of the brain: II. The anterior cerebral artery: Some anatomic features and their clinical implications. Neurology. 1963 Oct 01. doi: 10.1212/wnl.13.10.825.
17. Coulier B. Duplication of the posterior cerebral artery (PCA) or "True Fetal PCA": An extremely rare variant. J Belg Soc Radiol. 2018 Jan 01;102.
18. Lambert SL, Williams FJ, Oganisyan ZZ. Fetal-type variants of the posterior cerebral artery and concurrent infarction in the major arterial territories of the cerebral hemisphere. J Investig Med High Impact Case Rep. 2016 Sep 13. doi: 10.1177/2324709616665409.
19. Raamt AFV, Mali WPTM. The fetal variant of the circle of Willis and its influence on the cerebral collateral circulation. Cerebrovasc Dis. 2006 Jun 20. doi: 10.1159/000094007.
20. Masoud H, Nguyen TN, Thatcher J. Duplication of the posterior cerebral artery and the "true fetal" variant. Interv Neurol. 2015 Oct 01. doi: 10.1159/000437310.

21. Bulsara KR, Zomorodi A, Provenzale JM. Anatomic variant of the posterior cerebral artery. AJR Am J Roentgenol. 2007 Apr 01. doi: 10.2214/AJR.06.0991.
22. Netter FH. Atlas of human anatomy. 6th ed. Elsevier Health Sciences; 2014.