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A bilateral fetal origin of the posterior cerebral artery coexisting with an absent A1 segment of the anterior cerebral artery

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ABSTRACT

Background: The cerebral arterial circle variants are well-described due to their clinical significance for neurosurgeons and neuroradiologists.

Materials and methods: This magnetic resonance angiography (MRA) report describes the unusual coexistence of three cerebral variants incidentally identified in a 44-year-old female patient.

Results: The right-sided first segment (A1) of the anterior cerebral artery (ACA) was absent, and both the posterior cerebral arteries (PCAs) originated from the internal carotid arteries (ICAs). Thus, the unilateral A1 segment absence coexisted with a bilateral PCA of fetal origin. These variants' coexistence significantly disrupts the patient's primary collateral pathway.

Conclusions: The clinical significance and consequences of such variants after stroke or transient ischemic attack cannot be overstated, underscoring the importance of the current imaging findings in understanding and managing these conditions.

Keywords: cerebral arterial circle, anterior cerebral artery, posterior cerebral artery, variation, magnetic resonance angiography

INTRODUCTION

The cerebral arterial circle (of Willis) provides the brain supply. It comprises the anterior cerebral (ACA), the anterior communicating (AComA), the middle cerebral, the posterior cerebral (PCA), and the posterior communicating artery (PComA), which have been extensively studied due to their high clinical relevance. Lippert and Pabst [6] described several morphological arterial variants of the brain, such as vessel absence, hypoplasia, and accessory branches. For the anterior part of the circle, they reported a typical configuration in 60%, and the most common variants were the AComA duplication and the absence of the A1 segment (10%) [6]. The typical configuration for the posterior part of the circle occurred in 55%, while the PComA absence or hypoplasia was the most typical variant (in 10%) [6]. Different imaging techniques, such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA), offer an excellent preoperative visualization of the cerebral arterial system.

In the current MRA report, we describe the complex anatomy of the cerebral arterial system by identifying a combination of three variants, including the absence of the A1 segment, with a bilateral fetal origin of the PCA. We also discuss the ACA and PCA morphological variability, highlighting possible asymmetry and clinical consequences of such variants.

CASE REPORT

An interesting case of three cerebral arterial variants was identified during a female patient's MRA (3 Tesla) performed at the Radiological Clinic (Asklipios MEdica) for headaches investigation under the World Medical Association Bioethics Code. The investigation was conducted and documented using the Horos software (Horos Project). Evidence was obtained on multiplanar reconstruction (MPR) of the axial, coronal, and sagittal slices and their three-dimensional (3D) volume reconstruction. The head MRA of a 44-year-old female patient was further investigated due to three unique arterial variants identified in the cerebral arterial system.

On the right side of the cerebral arterial system, the origin of the A1 segment of the ACA could not be identified from the right internal carotid artery (ICA of diameter 2.5 mm);

therefore, it was absent, and the ACA distal part originated from the left ICA (diameter of 3.2 mm). The right PCA (1.2 mm diameter) emanated from the left ICA instead of the basilar artery. Contralaterally, the left-sided A1 segment was present (2.4 mm diameter) and atypically gave off both left (1.6 mm diameter) and right (1.2 mm diameter) distal ACAs. The left PCA (1.4 mm diameter) symmetrically originated from the ICA. Hence, this variant was bilaterally identified (Fig. 1). The rest of the cerebral arterial system did not exhibit any variations.

DISCUSSION

In the current case, we observed the unilateral A1 segment aplasia/absence coexisting with the PCA bilateral (fetal type) origin from the ICA. According to Padget [7], the development of the head and neck arterial system becomes noticeable when the embryo reaches a length of 16–18 mm, during the 5th developmental stage. By the 6th developmental stage, when the embryo measures 20–24 mm, the cerebral arterial system is fully formed. Padget [7] suggests that any failures or abnormalities during this intricate process — such as absent arteries or abnormal fusions — can result in morphological variants.

The ACA morphological variability has been well-described. Uchino et al. [11] analyzed the ACA anatomy in 891 patients MRAs. The most common variant was the unilateral A1 aplasia/absence, identified in 5.6%, and the rarest one was the ACA fenestration observed in 1.2% [11]. Şahin et al. [8], in a CTA study with 701 patients, observed A1 aplasia/absence in 2.53%. Contrary to the relatively high incidence of 10% provided by Lippert and Pabst [6], more recent studies indicated a relatively lower incidence of A1 segment absence (2.53–5.6%) [3, 4]. Trandafilovic et al. [9] recorded a rare case of bilateral absence of the A1 segment during dissection. Guarnizo and Muñoz [4] described the simultaneous occurrence of distal ACA triplication, left A1 segment absence, and right PCA of fetal origin.

PCA morphology has been comprehensively examined in the literature, with its variability being less common than that of ACA. Uchino et al. [12] conducted a study on the PCA anatomy using MRA in 2,350 patients, identifying PCA fenestration in 0.34% of cases, early bifurcation in a small percentage, and accessory PCA in 0.46% [12]. The PCA typically originates from the ICA and is commonly referred to as the fetal-type PCA. According to Lippert and Pabst [6], this variant can occur unilaterally or bilaterally, although such instances are rare (under 1%). However, in cadaveric studies, unilateral fetal-type PCA has been reported as a relatively common variant, occurring in approximately 20% of cases [1].

Bilateral occurrence, as seen in the current case, is infrequent, with only around 3% documented in existing studies [1]. Davidoiu et al. [2] classified the fetal-type PCA based on computed tomography angiography findings. Their study revealed that 9.35% of participants presented with the fetal-type PCA, while only 3 cases (2.15%) exhibited it bilaterally. They also highlighted the coexistence of other variants with the fetal-type PCA. In a finding similar to the current case, one male patient (0.72%) displayed unilateral A1 aplasia alongside bilateral fetal-type PCA. Additionally, Uchino and Tokushige [13] identified a typical PCA coexisting with an accessory PCA of fetal type in a 76-year-old male patient during MRA. Uchino and Irie [10] documented the coexistence of a fetal-type PCA with a hyperplastic anterior choroidal artery supplying the PCA territory (accessory PCA) during an MRA of a 71-year-old male.

The current imaging report underscores the coexistence of three cerebral variants, which have resulted in a distinctive cerebral arterial system with significant clinical implications. The unilateral absence of the A1 segment is associated with the development of AComA aneurysms. This asymmetric absence generates hemodynamic stress on the AComA, thereby contributing to the potential formation of aneurysms. Uchino et al. [10] demonstrated that in instances of A1 aplasia, the contralateral A1 segment is notably larger. As a consequence, a thrombus is more likely to travel into this hyperplastic segment compared to a typical A1 segment, which may result in an embolic infarction. In the case presented, the left ICA displayed a diameter of 3.2 mm, featuring a conventional A1 segment, while the right ICA measured 2.5 mm, with the A1 segment absent. Kruszka et al. [5] reported an increased prevalence of A1 absence among female patients with Turner Syndrome. Dharmasaroja et al. [3] indicated that fetal-type PCA is linked to inadequate collateral circulation in patients experiencing anterior ischemic strokes due to significant arterial occlusion. Intracranial collateral vessels are generally classified into primary and secondary pathways. The primary collateral pathway aligns with the anatomy of the major cerebral vessels, while the secondary pathway includes leptomeningeal vessels and the ophthalmic artery.

In the present specific case, the primary collateral pathway is entirely interrupted, leading to an isolated arterial supply to both hemispheres due to the identified variants. Therefore, collateral pathways are unlikely to develop in the event of substantial occlusion of the ICA or the vertebrobasilar system, which could result in hemodynamic insufficiency.

In conclusion, the unilateral absence of A1 and the presence of bilateral fetal-type PCA significantly disrupt the primary collateral pathways of cerebral circulation. Recent imaging studies have reported this particular combination of variants in 0.72% of cases,

indicating that the patient's cerebral arterial circle is more vulnerable to stroke and vascular insufficiency.

ARTICLE INFORMATION AND DECLARAITONS

Data availability statement

All the data are available upon request to the corresponding author.

Ethics statement

The research was conducted ethically following The Code of Ethics of the World Medical Association (Declaration of Helsinki). After informed consent, the patient agreed to the publication of the data anonymously.

Author contributions

Conceptualization: GTr, SV, MP; Data Collection: SV, PP, KV; Data Analysis: GTr, ŁO, NZ, MP; Manuscript – writing: GTr, PP, GTs, MP; Manuscript – editing: SM, ŁO, NZ, KV; Critical Revision: All authors; Approval: All authors; Supervision: MP.

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Conflict of interest

None.

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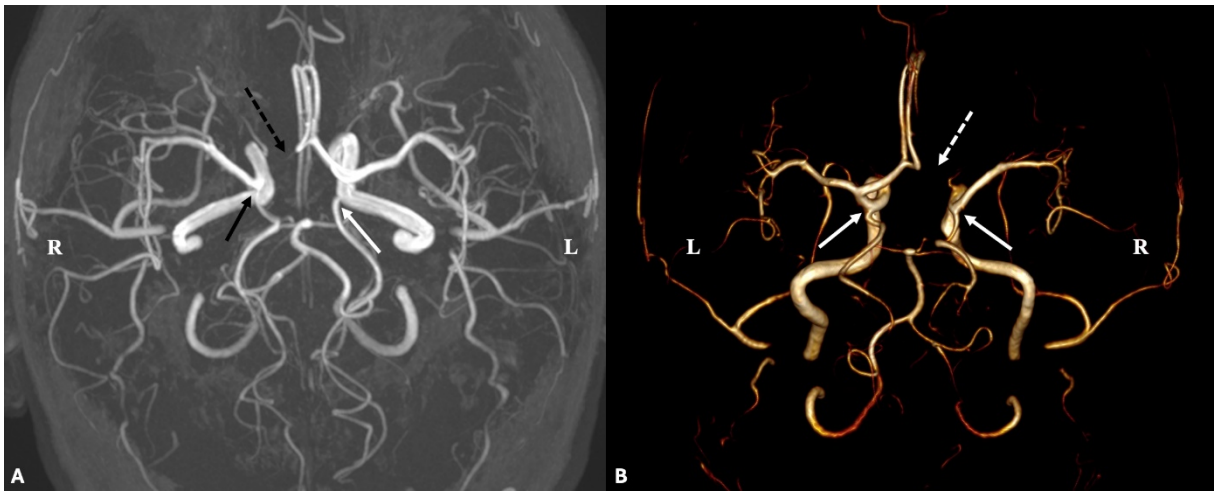

Figure 1A. MIP of the patient's cerebral arterial circle, with the right-sided A1 segment absence (dotted arrow), the right-sided PCA fetal-type origin (black arrow), and the left-sided posterior PCA fetal-origin (white arrow); **B.** The three-dimensional reconstruction (3D) of the patient's cerebral arterial circle, the bilateral PCA fetal origin (white arrows), and the right-sided A1 segment absence. L — left; MIP — maximum intensity projection; PCA — posterior cerebral artery; R — right.