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Arterial Abnormalities and Associated Variations of the Vertebrobasilar System on the Brain Base: Apropos of a Rare Case

Anomalías Arteriales y Variaciones Asociadas del Sistema Vertebrobasilar en la Base del Cerebro: Un Caso Raro

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SUMMARY: The presented case characterizes an association of primitive and definitive arteries with variations on the cadaveric brain base of a very old man. This case is found by the retrospective review of the data archive obtained during many years of cooperation of the author and co-authors. Fenestration of the (ectatic) basilar artery, partial and total duplication of some cerebellar arteries was associated with other variations of the vertebrobasilar and carotid systems. Although this is a case autopsied because of the myocardial infarction, the peculiarity of the case lies in the absence of the aneurysm based on the fenestration or dissection of one of the cerebral arteries.

KEY WORDS: Human cadaver; Brain base; Vertebrobasilar system; Arterial variations.

INTRODUCTION

Morphologically well-known facts relate to the vertebrobasilar system (VBS) that includes paired vertebral (VA) and unpaired basilar (BA) arteries with branches.

The precursors of the VA, as cited by Uchino *et al*. (2015), are six primitive cervical arteries (CIAs) and one of the primitive carotid-vertebrobasilar anastomoses, called proatlantal intersegmental artery (PIA) existing at 5(6)- to 12 mm embryo. The precursors of the BA, appearing at 4 mm embryo, as cited by Vasovic *et al*. (2009), are paired longitudinal neural arteries (LNAs) that connect with caudal ends of paired primitive internal carotid arteries (ICAs), rostrally, and with cerebral VAs, i.e. PIAs, caudally. The LNA is actually in the form of bilateral plexus simplifying in the BA, usually at 7- to 12 mm embryo.

Intracranially, the definitive VA distributes, as cited in *Terminologia Anatomica* (Federative International Programme for Anatomical Terminology, 2019), the medial medullary and lateral medullary and meningeal branches, and unpaired anterior spinal branch and posterior inferior cerebellar artery (PICA). The BA distributes, as also cited in *Terminologia Anatomica* (Federative International Programme for Anatomical Terminology, 2019), the anterior inferior cerebellar (AICA) and superior cerebellar (SCA) arteries, pontine and mesencephalic branches on the anterior side of the pons.

Special morphological features of the VBS relate to the convergent union of paired VAs at the level medullopontine sulcus in the single BA, and bilateralism of BA side- and terminal branches during a rectilinear course along the basilar sulcus of the pons. However, the variations of the origin (Vasovic *et al*., 2012; Stojanovic *et al*., 2017; Hori *et al*., 2020), and/or course (Vasovic *et al*., 2012), and/or termination of the BA and/or its branches (Songur *et al*.,

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2008; Dodevski *et al*., 2015; Porzionato *et al*., 2016), are not rare. On the other side, some BA abnormalities are more frequent, some are very rare. One of the BA more common abnormalities, such as fenestration, as cited by Dimmick & Faulder (2009) has been found in 0.6 % of angiographic images and about 5 % of autopsies. The pathoanatomical significance is in the appearance of an aneurysm on a base of the BA fenestration, whose incidence was 35.5 % within a series of 59 VBU aneurysms (Campos *et al*., 1987). Another arterial abnormality, such as partial (segmental) duplication of the PICA beginning (Uchino *et al*., 2015) was a rare finding and without pathoanatomical changes of the same artery.

The purpose of this report is to present the previously mention abnormalities of the BA associated with some variations of BA and other arteries of the VBS and carotid system (CS) on the brain base in a cadaveric specimen.

CASE REPORT

An unusual case was discovered by the retrospective analysis of data archive (descriptions and schemes of main variations and/or (ab)normalities documented by photos) of 388 adult cadavers of both sexes and different age and cause of death. The research of cerebral arteries at the Department of Forensic Medicine was performed by the author and co-author (MT and BS); the approvals were obtained by the Council on Graduate Study and Research Ethics Committee of the Faculty of Medicine (Nos. 01-9068-4 and 12-2307-2/6).

The values of outer diameters (ODs) of the arteries necessary for the mark of normal or hypoplastic cerebral artery (Vasovic *et al*., 2013a), or ectatic artery (Vasovic *et al*., 2012), as well as a classification of the cerebral arterial circle (CAC) on the brain base (Vasovic *et al*., 2013b), are applied.

Associated abnormalities and variations including atheromatous changes of the arterial walls on the brain base characterize the case of a 76-year-old male cadaver (Fig. 1), autopsied because of the myocardial infarction. The ODs of selected arteries on the brain base was calculated at the corresponding digital image by the co-author (MD), using the ImageJ processing program (http://rsb.info.nih.gov/ij/index.html).

Arterial abnormalities (A-1 and A-2) were as follow:

A-1. Fenestration of the BA was in the form of 10.36 mm long slit in a distal BA half; caudal and rostral limits of the fenestration are two transverse lines; the first is at the trigeminal (V) portion level (caudally) and the second one is at the beginning of the left SCA (more distal from the present two SCAs). Both side LNAs limiting fenestration, like "bypass" vessels, were of different ODs (1.07 mm of the right vessel and 2.14 mm of the left vessel).

A-2. There was a segmentally duplicated beginning of the right PICA, wherein the initial arteries of different sizes (ODs =1.55 mm and 0.59 mm, respectively) originated from the ipsilateral intracranial (V4) part of the VA.

Arterial variations of the VB (B-1 to B-5) and CS (C-1 to C-3) were as follow:

B-1. The vertebrobasilar union (VBU) of both V4 parts was dislocated at the level of the upper edge of the left olive on the anterior side of the myelencephalon.

B-2. The anterior spinal artery originated only from the intracranial (V4) part of the left VA.

B-3. There were ectatic proximal and terminal BA parts (OD=4.52 mm), i.e. anterior and posterior to the fenestration.

B-4. There were double left SCAs (ODs=1.15 mm and 1.41 mm, respectively).

B-5. BA bifurcation was located in the interpeduncular fossa at the half of its length; its terminal branches—paired posterior cerebral arteries (PCAs) are larger (2.47 mm and 2.30 mm) than the posterior communicating arteries (PCoAs) that are branches of the internal carotid arteries (ICAs).

C-1. The cerebral arterial circle (CAC) belongs to the literature type XVIII—hypoplastic both PCoAs (0.76 mm on the left and 0.83 mm on the right side) and the left A1 part (1.75 mm). There was no overall view to the left A1 because its most part is sheltered by the ipsilateral optic nerve.

C-2. There was a presence of a variable median callosal artery (MdCA), as the third post-communicating (A2) part, with a beginning from the single anterior communicating artery (ACoA).

C-3. The OD of the left (3.82 mm) or right (3.41 mm) ICA was smaller than the same of the BA (4.52 mm).

The atheromatous plaques were insular in the walls of VBS and CS arteries; however, we did not see these in each of the three A2 parts, right LNA, right V4 part, and cerebellar arteries.

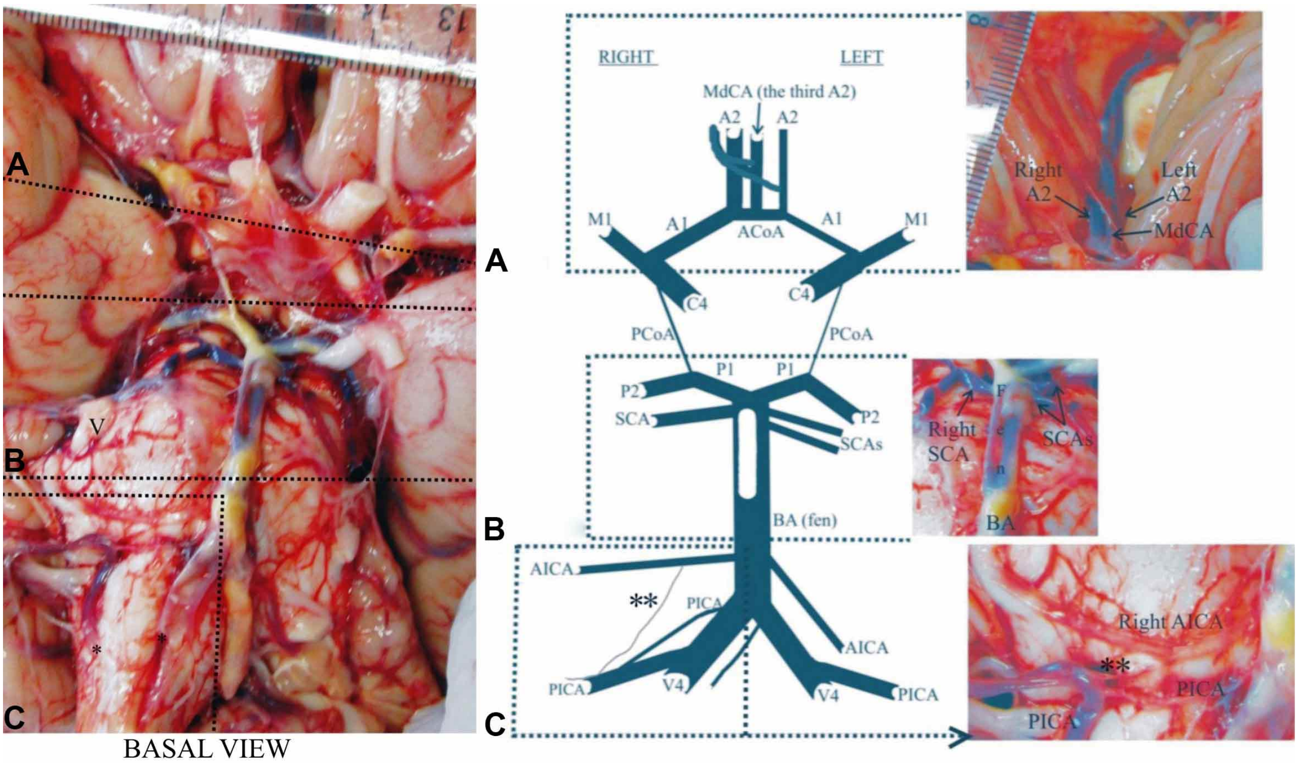

Fig. 1. (Basal view) Cerebral angioarchitecture on a part of the brain base in a human cadaver. The site of artificial break of the caudal right posterior inferior cerebellar artery (PICA) from the ipsilateral intracranial (V4) part of the vertebral artery is marked (*). (A-C) Composite of schematized angioarchitecture and corresponding insets. (Inset "A") Three post-communicating (A2) parts—the left and right A2 parts of the anterior cerebral artery (ACA) and the median callosal artery (MdCA) originating from the anterior communicating artery (ACoA) were particularly shown. (Inset "B") Fenestration of the basilar artery (BA) and double left superior cerebellar arteries (SCAs) are in the focus. (Inset "C") Hypoplastic (rostral) PICA starts from the V4 part on the right side. There was a pseudoduplication of the right caudal PICA caused by one twig (**) branched from the ipsilateral anterior inferior cerebellar artery (AICA). Additional abbreviations: A1, pre-communicating part of the ACA; M1, sphenoidal part of the middle cerebral artery; C4, cerebral part of the internal carotid artery; PCoA, posterior communicating artery; P1, pre-communicating part of the posterior cerebral artery (PCA); P2, post-communicating part of the PCA.

DISCUSSION

Arterial abnormalities and variations on the brain base in a human cadaver that were no bases of aneurysm's development or cause of death are presented.

A fenestration of an artery should be differing from a partial (segmental) duplication of the beginning of an artery, especially having in mind its definition. Namely, fenestration of the artery (herein BA) implies a morphological status which is characterized by the doubling of the artery on one part of the course, but after its beginning by a single trunk; the double parts of the artery have their own vessel's tunicae (Vasovic´ *et al*., 2013a). Although the BA fenestrations are most commonly located close to the VBU (Dimmick & Faulder, 2009), reflecting the craniocaudal direction of longitudinal fusion of primitive LNAs (Hoh *et al*., 2004), presented fenestration was located at the distal BA part. Hypothetically, the existence of BA fenestration in a distal part may indicate the possibility of a fusion of primitive LNAs of the opposite (caudocranial) direction, especially if the axial fusion of LNAs and caudal ends of primitive ICAs precedes it. An extreme size of BA fenestration described by Uchino *et al*. (2002), or herein presented case is probably developed in this manner. We discovered BA fenestrations in 3.87 % of cases (5/120 fetuses, including one case of multiple fenestrations, and 4/112 adult cadavers) in an early study (Vasovic *et al*., 2013a). One of the previous findings was the fetal case including BA fenestration and persistence of the (fenestrated) MdCA, as in this adult case, but without MdCA fenestration.

Although the SCA is the almost constant bilateral BA branch (Porzionato *et al*., 2016), or the PICA as an intracranial VA branch on both sides, the presented case characterized the presence of total duplicated SCA on the left and segmentally duplicated PICA beginning on the right side. A similar incidental finding of double SCAs on the right side was found in a 45-year-old cadaver but associated with BA aneurysm (Vasovic *et al*., 2013a), as well as in an 84-year-old woman on the left side associated with the hemorrhagic infarction of the corresponding cerebellar territory (Porzionato *et al*., 2016). In terms of frequency, Dodevski *et al*. (2015) found double SCAs in 1.83 % of cases during the investigation of CT angiograms of 105 patients, while Songur *et al*. (2008), have cited higher incidence (14 %). Uchino *et al*. (2015), described two female patients with segmentally duplicated (left and right) PICA beginning associated with the right ICA-PCoA aneurysm in both cases, while Stojanovic *et al*. (2017), showed segmental duplication of the left AICA origin and variations of other VBS arteries. Segmental duplication of the PICA beginning result, as cited by Porzionato *et al*. (2016), from the persistence of anastomosis of caudal PICA with the lateral spinal artery, while rostral vessel develops from a hypertrophied radiculopial artery.

An inclination of VBU and domination of the right VA, in this case, differ from the findings published by Hori *et al*. (2020), which revealed a higher prevalence of the same among the patients with VA dissection.

Although other authors (Campos *et al*., 1987) pointed out more common aneurysm development on the BA fenestration, the question is why there was no aneurysm in this case? Perhaps the morphofunctional interaction between the abnormality (fenestration) and the variation (ectasia) during life stopped hemodynamic forces on the fenestrated BA wall in this case. A similar case of "asymptomatic" ectatic BA and fenestration, but with a length of 7-8 mm at proximal BA part was presented in a 59-year-old female patient (Zdjelar *et al*., 2018).

The atheromatous plaques in the VBS, although expected pathoanatomical changes in the cadaver of old age (Songur *et al*., 2008), previously a man in the eighth decade of life, in this case, were with a selective location. Namely, these were visible in the wall of the left VA, not in the right VA, then in the left LNA, but not in the right LNA of BA fenestration.

In conclusion, presented case of associated arterial abnormalities and variations on the brain base indicates a possibility of the partial persistence of developmental precursors of definitive arteries in old age without their severe pathoanatomical changes, such as a dissection or aneurysm, or cerebral infarction.

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STOJANOVIC, B.; VASOVIC, L.; TRANDAFILOVIC, M.; VLAJKOVIC, S. & DREVENSEK, M. Anomalías arteriales y variaciones asociadas del sistema vertebrobasilar en la base del cerebro: Un caso raro. *Int. J. Morphol., 40(3)*:750-754, 2022.

RESUMEN: El caso presentado caracteriza una asociación de arterias primitivas y definitivas con variaciones sobre la base cerebral cadavérica de un anciano. Este caso se encuentra mediante la revisión retrospectiva de datos obtenidos durante muchos años de un trabajo de cooperación del autor y coautores. La fenestración de la arteria basilar (ectásica), la duplicación parcial y total de algunas arterias cerebelosas se asoció con otras variaciones de los sistemas vertebrobasilar y carotídeo. Si bien se trata de un caso de autopsia a causa de un infarto del miocardio, la peculiaridad del caso radica en la ausencia del aneurisma en base a la fenestración o disección de una de las arterias cerebrales.

PALABRAS CLAVE: Cadáver humano; Base del cerebro; Sistema vertebrobasilar; Variaciones arteriales.

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