

Case Report

APROPOS OF THE SIMULTANEOUS ABSENCE OF SOME EMBRYOLOGICAL VASCULAR FORERUNNERS AND PERSISTENCE OF OTHER ONES ON THE BRAIN BASE IN LATE ADULTHOOD

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Abstract. *Associated arterial abnormalities and variations on the brain base were discovered in a cadaveric specimen of the male gender of older life age. This case was found by a retrospective analysis of 388 forensic cases in a common data archive of the authors of this report. Arterial abnormalities were related to the aplasia of (intracranial part) of the right vertebral artery and (large) fenestration of the pre-communicating part of the right posterior cerebral artery. Arterial variations included different morphological statuses such as those of a special origin, double vessels, and small or oversized caliber. The brain angioarchitecture in the present case was not the base for the aneurysm's development, probably because of the lesser influence of hemodynamic factors on the walls of persistent primitive and definitive arteries, as well as due to good collateral circulation till to the end of the sixth decade of life.*

Key words: *Human cadaver, brain base, arteries, postnatal status, associated variations and abnormalities.*

Introduction

The specific angioarchitecture on the brain base is conditioned by the anastomoses of branches of the vertebrobasilar (VBS) and carotid (CS) systems. As well known, some cerebral arteries of these systems are usually paired, such as vertebral (VA) and internal carotid (ICA) arteries, while some arteries are unpaired, such as basilar (BA) and anterior communicating artery (ACoA).

Arterial variations within VBS and CS, such as a variable origin [1–3], unusual course and/or termination [2, 4], hypoplasia [2, 4, 5], or (dolicho)ectasia [1], or duplication [2, 3, 6, 7], or accessory vessels [7] can relate to the single or more vessels [8].

Arterial abnormalities, such as (total or segmental) aplasia [2–4, 9], or fenestration [2, 5, 7, 10, 11] can be associated with some of the previously mentioned variations. However, both states of arteries could be with [10], or with no cerebral pathology [7, 11].

One of the cases of associated arterial variations and abnormalities of the VBS and CS arteries on the brain base with no cerebral aneurysm or other cerebral pathology will be here presented.

Materials and Methods

The research of 388 brains was performed during the author's graduate and postgraduate studies in the period 2006–2016, as well as the co-authors' (BS and MM-T) graduate study at the Faculty of Medicine in Niš in the

period 2011–2015, under the mentorship of the professor (LV) of Anatomy; the approvals were obtained from the Council of Graduate Studies of Faculty of Medicine and the Head of the Institute of Forensic Medicine, as well as the Research Ethics Committee (No. 01-9068-4 and No. 12-2307-2/6, respectively). All noted cases are a part of a common (co)author's archive.

Each single brain base with blood vessels and a ruler placed next to them in all cases was recorded on the photo film and schematically presented in the workbook. The morphological status of arteries on the brain base was inspected macroscopically and by a magnifying glass; their eventual abnormal status as a guide for more detailed observation on other hemispheric surfaces.

The outer diameters (ODs) of the cerebral arteries were calculated using the digital images by the co-author (DĐ), via the ImageJ processing program (<http://rsb.info.nih.gov/ij/index.html>).

A differentiation of (arterial) variation from the (arterial) abnormality was made personally, as well as according to the online available definitions of these arterial statuses in the two dictionaries [12, 13].

The value of the normal or hypoplastic OD of the corresponding cerebral artery within the cerebral arterial circle is defined according to the same value presented in the two articles, respectively [14, 15]. An extreme arterial OD or ectasia of the main arteries of the vertebrobasilar system is marked according to the presented values in the other two articles, respectively [1, 16].

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Concomitant arterial variations and abnormalities on the brain base existed in the case (a 61-year-old man) with the lethal upshot because of the recurrent myocardial infarction. Associated morphological specificities of cerebral arteries were found by the retrospective research of a common data archive. This case was one among 388 cadaveric specimens in the common (co)author's archive of forensic cases.

Figure 1 (a, b) shows associated abnormalities and variations of arteries of the VBS and CS on the brain base.

Arterial abnormalities (A) were as follows:

A-1. The pre-communicating (P1) part (OD=3.51 mm) of the right posterior cerebral artery (PCA) was fenestrated at almost whole length; the arteries that shaped the P1 fenestration were of normal ODs (2.16 mm

and 2.32 mm). Simultaneously, the left PCA had a singular trunk (OD=2.56 mm).

A-2. The right VA at its intracranial part (V4) was absent.

A-3. The atheromatous plaques in the walls of cerebral arteries were present but scarce.

Arterial variations (V) were as follows:

V-1. There was (mild) hypoplasia of the cerebral (C4) part of both ICAs (OD=2.68 and 2.62 mm, respectively).

V-2. The sphenoidal (M1) part of the left middle cerebral artery (MCA) and pre-communicating (A1) part of the right anterior cerebral artery (ACA) were also (mildly) hypoplastic (OD=1.84 and 1.78 mm, respectively), while these arteries on the opposing side were of normal ODs (2.50 mm and 2.08 mm, respectively).

V-3. The ACoA interconnecting both ACAs was in the form of double vessels (additionally seen in B-inset),

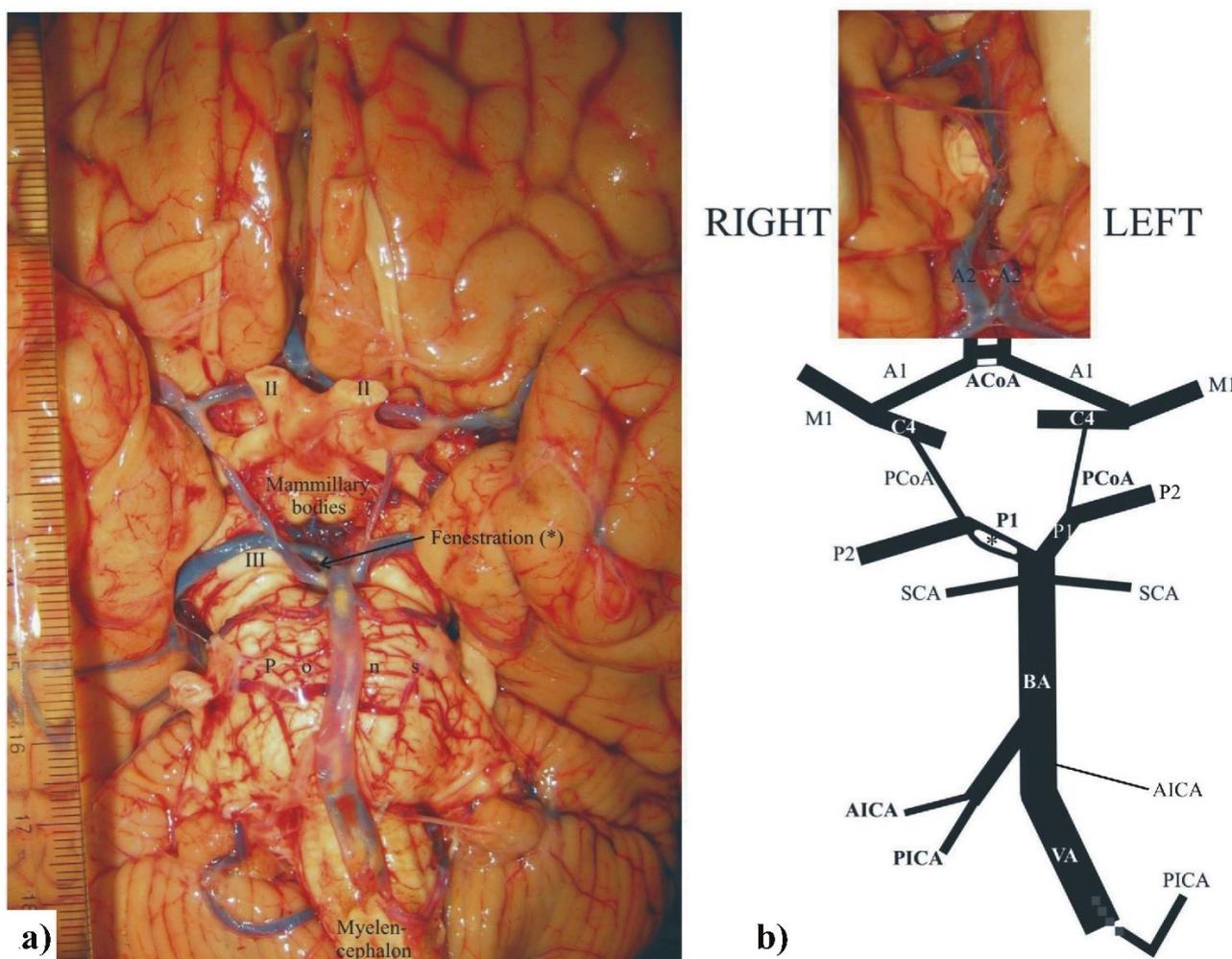


Fig 1 a, b A case of associated arterial variations and abnormalities on the brain base. **a)** Original view of cadaveric arteries. II, optic nerve (on both sides); III, oculomotor nerve (visible on the right side). **b)** Scheme of main arteries on the brain base and inset of a part of the anterior cerebral circulation corresponding to the original picture.

b-inset: A2, post-communicating part of the anterior cerebral artery (ACA).

b-schema: ACoA, anterior communicating artery; A1, pre-communicating part of 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); fenestration of the right P1 part was marked by star; P2, post-communicating part of PCA; SCA, superior cerebellar artery; BA, basilar artery; AICA, anterior inferior cerebellar artery; PICA, posterior inferior cerebellar artery; VA, vertebral artery on the left side.

Table 1. Comparison of main morphological abnormalities and variations of cerebral arteries between the recent and similar* literature cases

Cases	Age in years /gender	Morphological abnormalities**	Morphological variations***					Associated pathology	References	
			Fenestra Aplasia	Hypoplasia	Ectasia	Double cerebral arteries	Variable origin of cerebellar arteries			Other
Recent	61/M	Right V4 part P1 part	Both ICAs	Left M1 part	Left PCoA	Left VA	AcoA	Common origin of the right AICA and PICA from the BA	Cadaver	Present
Literature	56/M	Right P1 part						Right MCA aneurysm		[10]
	79/M	Right V4 part						Termination of the right VA in the right PSA	No	[4]
	62/F		Both ICAs			Both VAs and BA			Hypertension, type 2 diabetes and silent myocardial ischemia	[17]
	76/M			Left MCA				Anomalous left AChA branch	Aneurysm of a collateral extending from the proximal A2 part to the M1 part. Anamnestic myocardial infarction.	[18]
	U (MRA)	Right P1 part						Fetal-type of posterior cerebral circulation	No data	[19]
	U (MRA)			Hypoplasia of the left A1 part	Left PCoA				No data	[20]
	60/M					Left VA and BA		Dolicho trunks of BA and left VA	Obstructive hydrocephalus	[21]
	44/F						AcoA	A2 triplication	AcoA aneurysm	[22]
	U (dissected brain block)							Common origin of the right AICA and PICA from the BA	Cadaver	[23]

*Each of the arterial abnormalities and variations in the recent case was a key point during the selection of literature cases

**Abnormality [13]

***Variation [12]

M, male; P1 part, pre-communicating part of the posterior cerebral artery; V4 part, intracranial part of the vertebral artery; ICA, internal carotid artery; M1 part, sphenoidal part of the middle cerebral artery; A1 part, pre-communicating part of the anterior cerebral artery; PCoA, posterior communicating artery; VA, vertebral artery; AcoA, anterior communicating artery; AICA, anterior inferior cerebellar artery; PICA, posterior inferior cerebellar artery; BA, basilar artery; MCA, middle cerebral artery; PSA, posterior spinal artery; F, female; AChA, anterior choroidal artery; A2 part, post-communicating part of the anterior cerebral artery; MRA, magnetic resonance angiography; ACA, anterior cerebral artery.

wherein a rostral one was of larger OD (1.81 mm vs. 0.25 mm).

V-4. The posterior communicating artery (PCoA) was hypoplastic on the left side (0.92 mm) and of normal OD on the right side (1.53 mm).

V-5. There was a common trunk of the right anterior inferior cerebellar (AICA) and posterior inferior cerebellar (PICA) arteries that branched off ipsilaterally from the proximal BA third.

V-6. The left AICA was hypoplastic; it began from the BA and was more caudal concerning the level of the right AICA–PICA trunk origin.

V-7. The BA was in a continuation of the large left VA (OD=4.04 mm).

V-8. The left PICA originated from the posterior side of the left V4 at the level of the anterior median fissure, i.e. at the midpoint between the pyramids of the myelencephalon.

Secondary finding

The left oculomotor (III) nerve was invisible (see Figure 1, a); it was absent or artificially broken.

Comparison of present and similar cases

Table 1 shows the age and gender of other cases [4, 10, 17–23] in whom all or some of the morphological variations and/or abnormalities as in the here presented case.

Discussion

The formation of six pairs of primitive branchial or aortic arch arteries (PAAs), at the 1.3 mm human embryo stage, is the first indication of the circulatory system. Bilateral ICA appears at 3 mm embryo (24 days) by development from the PAA3 and the distal segment of the dorsal aorta. The BA is formed at 5 to 8-mm embryo by the coalescence of their forerunners—paired plexiform longitudinal neural arteries on the anterior side of the hindbrain [24, 25]. The VA on both sides develops by the transverse anastomoses of six cervical intersegmental arteries (CIAs) and primitive proatlantal intersegmental artery (PPIA) [26] at 7 to 12 mm of the embryo [24]. Complete development of cerebral arteries with possible variations and/or abnormalities was finished at the 40 mm of the embryonic stage, i.e. in the 52-day-old embryo [25].

We differentiated between arterial variations and abnormalities. In the first case (variation), there was a mild shape of dysmorphology, while in the second case, there was a heavier shape of dysmorphology. Although there were examples of a single appearance some of these variations or abnormalities, we described an association between the four shapes of arterial variations (hypoplasia, ectasia, double vessels, and variable origin) and two arterial abnormalities (aplasia and fenestration), without atheromatosis.

Here presented ICA hypoplasia (ICAH) on both sides is marked according to the ODs that were smaller than 3 mm, as proposed by Omarjee et al. [15]. The ICAH, as cited [15], is the result of a developmental failure of the primitive dorsal aorta on day 24 of gestation, while the PAA3 is normal on both sides. The reason for the side diameter discrepancy of the ACA and MCA, in this case, could be

explained by the delayed unilateral simplification of the plexiform precursors of the corresponding artery in the embryo from the 35th to the 52nd day of gestation [24, 25].

Double ACoAs were more likely a consequence of a reorganization of the plexiform ACoA in two vessels at 40 mm of embryonic stage [25] and upkeep of this doubling in the postnatal period. We claim that these are solely vessels, with no ACoA fenestration as López-Sala et al. [8] have described. Otherwise, double ACoAs were found in 23/266 cadavers or 8.64% [6] and 0.9% of cases among 426 CT angiograms [8].

The OD of the left VA (4.04 mm) in this case was defined as ectatic according to the statement by Passero and Rossi [1]. The previously mentioned authors pointed out that a progression of VA-BA dolichoectasia exposes patients to a high risk of stroke, whilst recurrent heart attack was the cause of death in the presented case. Other authors named the artery with an extreme OD hyperplastic [7].

Dellion et al. [3] found one common AICA-PICA trunk during the anatomy dissection of 25 formalin-fixed human heads but in the presence of both VAs. This AICA-PICA trunk, although herein was an incidental finding, can be a "usual" finding in the case of the absence of one VA.

The absence of the VA, here "invisible" right V4 part, was a consequence of stopped transverse anastomoses between the six CIAs and PPIA before 7 mm of embryonic stage [24, 25]. In the previous review, 50-year-old data (1967–2016) on the higher frequency of left VA absence in comparison to the right VA have been pointed out [9]. We here presented the absence of the (right) V4 part, because we had no data about the status of other topographical (prevertebral, cervical, and atlantic) parts of the right VA. That's right, Blackburn et al. [4] described the absence of the right V4 part in a 79-year-old man, while the hypoplastic right VA has finished as the right posterior spinal artery.

Arterial fenestration is defined according to the doubling of a single original trunk and the reunion of these two vessels after some path; double vessels have special tunica intima and media and, sometimes tunica adventitia [6]. Fenestration of the PCA, as cited [11], may result from the incomplete fusion of the network of vessels (caudal end of the primitive ICA) which serves as the precursor of a definitive PCA in 4 to 6 mm embryos. Generally, the clinical importance of a fenestration relates to the appearance of the aneurysm on itself, as cited [5, 6, 11], but there were opposite cases. One of these was a case of the right P1 fenestration in a 56-year-old man, associated with an aneurysm of the right middle cerebral artery [10]. Vlajković et al. [11] discovered 0.85% of PCA fenestrations among 468 (200 fetal and 268 adults) cadaveric specimens, while Gunnal et al. [2] recorded 1.17% of PCA fenestrations among 170 adult cadavers; there were no aneurysms in adult cases in both studies.

As seen in Table 1, there were descriptions [4, 10, 17–23] of mostly singular arterial variation or abnormality but no similar combination of these on the brain base as in the presented case. Contrary to the absence of cerebral

pathology in this case, the same was discovered in other cases. These examples were as follows: the right PCA fenestration was associated with MCA aneurysm in the case of a 56-year-old man [10], or the left MCA hypoplasia was associated with an aneurysm of post-communicating ACA part–M1 collateral in a 76-year-old man [18], or double ACoA was the basis of the aneurysm on itself artery in a 44-year-old woman [22] or dolichoectasia of the VA and BA was followed by obstructive hydrocephalus in a 60-year-old man [21].

Conclusion

There is an association of arterial variations and abnormalities on the brain base as morphological entities, while the absence of a cerebral aneurysm can indirectly indicate a

greater influence of genetic factors compared to hemodynamic factors in the presented case.

Ethical considerations. The protocol was approved by the Council on Graduate Study and Research Ethics Committee (Nos. 01-9068-4 and 12-2307-2/6) of our Faculty of Medicine. There were no financial or commercial gains and the authors declare that they have no conflicts of interest.

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