Forensic consequences of anatomical variants in cerebral vascularization -
the case of bihemispheric posterior inferior cerebellar artery

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Abstract: The anatomy of the posterior inferior cerebellar artery (PICA) has a wider variability compared to the superior cerebellar artery (SCA) or the anterior inferior cerebellar artery (AICA). The PICA with bihemispheric distribution (bPICA) can be found in less than 0.1% of cases. We report here a rare such case, documented by anatomical microdissection. A true right bPICA was found emerging the origin of the basilar artery. From its lateral medullary segment the equivalent of the rostral trunk of an AICA was leaving, and from the tonsillomedullary segment of the bPICA emerged a trunk distributed in the territory of the caudal branch of the AICA. The telovelotonsilar segment of that bPICA was further sending off the PICAs proper, ipsilateral and contralateral. Each of these was supplying equally the vermis and the cerebellar hemisphere. The contralateral PICA proper was also distributed in the territory of the caudal trunk of the AICA, while the rostral trunk of the absent AICA was supplied by the SCA. Radiologists and surgeons should be aware of this variant, to diagnose it accurately, avoid pitfalls in diagnosis of bilateral cerebellar infarcts, and to avoid its damage during the microsurgical exposures.

Key Words: cerebellum, cerebellar artery, cerebellar infarct, arterial anatomic variant, PICA.

Radiologists, neurosurgeons and forensic pathologist must be aware of radiologic features and geographic territories of cerebellar arteries [1], as even minor variants may have important clinical and forensic consequences.

The posteroinferior cerebellar artery (PICA) has the most complex, tortuous, and variable course and area of supply of the cerebellar arteries [2; 3]. The PICA is defined as the artery that supplies the posterior inferior surface of the cerebellum [4], or as the cerebellar artery arising from the vertebral artery (VA) [2]. It usually originates from the VA, but it may also originate from the basilar artery (BA) [2; 5], independently or through a common trunk with the anteroinferior cerebellar artery (AICA) [4]. Usually, if one PICA is absent, its territory is supplied either by the AICA, or by the superior cerebellar artery (SCA) [4]. The AICA arising as a single trunk usually bifurcates into a rostral and a caudal trunk [2].

The PICA is divided into five segments: 1) anterior medullary, 2) lateral medullary, 3) tonsillomedullary 4) telovelotonsillar, and 5) cortical [2; 6].

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Bilateral cerebellar infarction has been attributed to bihemispheric supply of a PICA in numerous clinical cases [7]. The bihemispheric variant of PICA (bPICA) remains however a rare anatomical variant in which a single artery may supply both PICAs [4]. There were not found in the literature any anatomical dissections proofing the bihemispheric PICA.

CASE REPORT

Brainstem and cerebellum in a 56 years old male cadaver were dissected and removed of the posterior fossa during the autopsy. Following microdissections that were performed by use of 4.5x surgical magnifying glasses the anatomy of a bPICA was documented (figures 1, 2). That anatomical piece belonged to a 20 specimens lot on which the microanatomy of the cerebellar arteries was studied by microdissection.

The right PICA left the BA origin, immediately after the left and right VAs joined into the BA. It then coursed on the anterior medullary surface, to continue on the right lateral surface of medulla oblongata. From the lateral medullary segment of the bPICA emerged a trunk supplying the territory of the rostral branch of the AICA (Figure 1). From the tonsillomedullary segment of the bPICA emerged a trunk distributed in the territory of the caudal branch of the AICA. Distally, the telovelotonsilar segment of bPICA divided into two cortical trunks supplying both cerebellar arteries, as PICAs proper (each with vermian and hemispheric distribution); the contralateral one had an initial course over the cerebellar vermis (Figure 2).

The contralateral AICA was also absent; the territory of its rostral trunk was supplied by the ipsilateral SCA, and the territory of its caudal trunk was supplied by the left PICA proper emerged from the right bPICA.

DISCUSSION

Basal brain arteries are known to be easily ruptured secondary to relatively minor blunt trauma[8], through to strain mechanisms [9], sometimes associated with alcohol abuse [10]. For example Mant described
a series of eight lethal traumatic subarachnoid hemorrhages secondary to apparently minor trauma to the head or neck [9]. Bostrom et al. described two cases of PICA ruptures both determined by fights with two men, associated with alcohol consumption [8].

Dolma described two cases of PICA rupture, both associated with blunt head trauma [11], etc. Usually the cause of PICA rupture is a blow at the skull base or the upper posterior cervical area, leading to immediate loss of consciousness and death, through central respiratory arrest [8] by one or more of the following mechanisms: (1) ischemic lesions in areas vascularized by the ruptured vessel, (2) direct compressive effects of the blood on the brainstem, (3) stretch of the nervous tissue caused by the production of a local hematoma, (4) direct effect of the trauma on the brainstem [12; 8].

A longer survival may be associated with brainstem infarctions, intimal fibrosis, necrosis and fragmentation of the arterial wall [11], etc. As the blow can be minor adjacent lesions can be minor (small hemorrhages in the adjacent muscles, small hematomas), or even absent[12; 13]. The possible absence of traumatic lesions, associated with the fact that PICA ruptures may lead, in longer survivals with the development of a local aneurism [14-16], may cause difficulties for the forensic pathologist to determine whether the cause of death is violent or not.

The incidence of the bPICA is unknown, but most likely is less than 0.1% (at least 4/5000); several reports have identified bilateral cerebellar infarcts associated with a bilateral PICA supply [4]. A high percentage of variations can be seen even in a small number of cases [17].

In embryos of 22.5 and 23 mm crown-rump length the PICA is not yet defined due to the persistence of a plexus located on the lateral aspect of the myelencephalon, indicating that its origin and course are established at the end of the embryonic period [3]. It is likely that in synchrony with the progressive descent of the cerebellum, the branches of that myelencephalic plexus have a rostrocaudal progression in feeding the cerebellum and the morphogenesis of the PICA results from the selection of portions of this plexus [3]. An asymmetrical evolution of the myelencephalic plexus could lead so to a bPICA.

There are two subtypes of bPICA: the true bPICA, which supplies both cerebellar hemispheres from a single trunk, and the vermian variant in which a single PICA only provides bilateral vermian supply while the contralateral cerebellar hemisphere is vascularized either by the AICA or the SCA [7].

There is reported here a rare vascular variant, of a true bPICA distributed to both cerebellar arteries. Supplemental variation is represented by the distribution of the bPICA in the territory of the ipsilateral AICA by two distinctive collateral branches, proximal and distal, supplying, respectively, the rostral and caudal trunks of the normal AICA.

Therefore bPICA was completely distributed ipsilaterally to the lower cerebelum, and contralaterally only to the posero-inferior part of the cerebellar hemisphere, and can be viewed as a common right inferior cerebellar artery further sending off a contralateral PICA. As a clinical consequence a proximal occlusion of the bPICA, or a stenotic lesion of the BA origin, may lead to a bilateral cerebellar infarct, with an increased severity ipsilaterally.

The diagnosis of cerebellar infarction can be missed due to various pitfalls [18]; failure to accurately diagnose a bPICA territory could lead to important errors. A differential diagnosis should be made between a cerebellar infarction due to a bPICA occlusion and a basilar occlusion with a bilateral PICA/AICA complex, or bilateral distal vertebral occlusion [7]. A diagnostic clue may be the presence of an unilateral supply of the AICA territory throughout the bPICA.

In cases of true bPICA, as the one presented in our report, the chances of developing acute ischemic lesions in the neural structures of the posterior cerebral fossa are significantly increased, as a single trunk vascularizes both cerebellar hemispheres, causing most likely a supraaacute evolution. Therefore, if such an anatomic variant is identified, more aggressive treatment options must be used to limit the chances of a lethal outcome. Also, in cases with bPICA microsurgical approaches of the cerebellomedullary fissure [19] must be performed with extreme caution, as a damage to the bPICA may impair bilaterally the cerebellar blood supply.

**ACKNOWLEDGEMENTS**

This paper is partly supported by the Sectorial Operational Program Human Resources Development (SOPHRD), financed from the European Social Fund and by the Romanian Government under the contract number POSDRU 64153 (author #1).