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Case Report

ORIGIN OF THE LEFT VERTEBRAL ARTERY FROM IPSILATERAL COMMON CAROTID ARTERY IN A HUMAN FETUS: CASE REPORT AND BRIEF REVIEW OF THE LITERATURE

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Abstract. *Although the vertebral artery (VA) is a type of artery with a lot of variations, its origin from the common carotid artery (CCA) is one of the rarities that deserves to be presented.Microdissection of injected arteries in the thorax and neck of human fetuses under the operating microscope was used and documented in the workbook and photos. The origin of the left VA from ipsilateral CCA, and its entry into the transverse foramen of the fourth cervical vertebra (C IV), associated with the normal vascular arrangement of branches of the aortic arch were the main features of this case. Simultaneously, the right VA of normal (subclavian) origin entered the C V transverse foramen. A present case of the left VA−CCA variant is the only one discovered in human fetuses, respectively, in total it is the tenth human case in the literature. However, the future findings could show whether the right aortic arch and the carotid stenosis discovered in half of known adult cases can be possible causal and/or consequent abnormalities of the left VA−CCA variant*.

Key words: *human fetus, vertebral artery, variable origin, common carotid artery.*

Introduction

The vertebral artery (VA), a collateral branch of the ipsilateral subclavian artery (SA) may be missing on one or both sides [1,2], or can present a lot of other variations at the origin, and/or course and/or its termination [3−5].

The origin of the (right or left)VA from ipsilateral common carotid artery (CCA) or so-called VA−CCA variant was first described on the right side in 1768 by Murray [6], as cited [7], and on the left side in 1836 by Hyrtl [8], as cited [9].

It is well known that determination of anomalous VA origin is important before the performance of surgical or endovascular interventions and, besides, an appearance of atherosclerotic plaques in close proximity to the VA aberrant origin is also possible [10].

The purpose of this report was to present a unique left VA-CCA variant in the human fetus and point out the morphofunctional importance of this variant in adult life.

Materials and Methods

A very rare case was found by a retrospective analysis of the co-author's workbook and archive of slides. The present case was an incidental finding after the investigation of human fetuses at the Department of Anatomy of Faculty of Medicine in Niš during the preparation of the co-author's doctoral thesis [11]. The gestational ages of fetuses in a 50-year old anatomical collection of our department, which were estimated according to the crown-rump lengths (CRLs), as has presented in Patten's book [12], varied from the third to the eighth lunar month. The arteries were injected with Latex or Micropaque solution through the left cardiac ventricle or through the CCA and kept in 10% solution of formalin until nowadays. The arteries were dissected under the operating microscope (Olympus), while their lengths and outer diameters were measured via an installed micrometer scale. Each case was sketched in the workbook and photographed.

All fetuses were medicolegally provided from the Clinic of Gynecology and Obstetrics in Niš that as a part of our Faculty of Medicine participated as professional cooperation and internal Ethical control; the Council for Postgraduate study of our Faculty issued the main permit to the co-author for an investigation of the fetal material in the period 1983-1990.

The embryology basis of the VA−CCA variant was explained according to Padget [13], and a scheme in Lie's book [3].

Case Report

A unique case was identified in a female fetus of 220-mm CRL or 23 post-menstrual weeks. The left VA originated from the posterior wall of the ipsilateral CCA at the level of C VII vertebra. It coursed upward and out of transverse foramen of the sixth and fifth cervical (C VI and C V) vertebrae and entered the same of the C IV vertebra. Simultaneously, the right VA was of SA origin; it entered the C V transverse foramen. The outer diameter of the left VA was twice as large as on the right one. The pattern of branching of the aortic arch was as usual—the brachiocephalic trunk (BT), left CCA, and left SA (Fig. 1).

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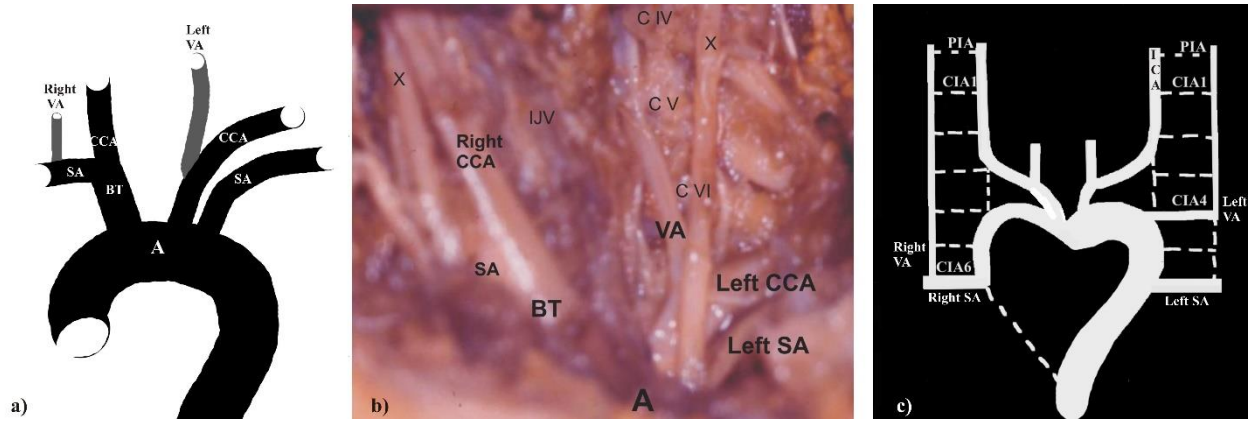

Fig. 1 Left vertebral–common carotid (VA–CCA) variant in a human fetus. **a –** scheme of variant; **b –** original picture of aortic branches and variable origin of the left VA from the ipsilateral CCA; **c –** modified diagram of embryological basis of the left VA–CCA variant according to Lie [3].
Note: We did not measure the outer diameters of arteries due to the poorly injected arteries by Micropaque.
Additional abbreviations: SA, subclavian artery; BT, brachiocephalic trunk; A, arch of the aorta (a); X, vagus nerve; IJV, internal jugular vein; C (IV, V, VI), cervical vertebra (b); PIA, proatlantal intersegmental artery; CIA, cervical intersegmental artery; ICA, internal carotid artery (c).

The recent case has been added to the list of nine published cases [8, 14–21] so far (Table 1).

Discussion

As already described, the variable origin of the left vertebral artery is relatively frequent. Its aortic arch (AA) origin was established in 2.4–5.8% of adult specimens, as cited [22], or in 23/200 fetuses [11]– as a single trunk in 19/200 or 9.5% (one case was associated with a variable origin of the right VA from the thyrocervical trunk) and as a segmentally duplicated in 4/200 or 2% of cases (one VA trunk was of the AA origin, while the other VA trunk was of SA origin); the left VA was usually localized on the AA between the left CCA and left SA and only in one case distally from the left SA [4]. The presented case was not included for consideration in the thesis due to non-injected cerebral arteries [11], but the left VA–CCA variant was noted as a rare variation. Furthermore, as cited [5], the left VA was presented as a simple or common vessel or segmentally duplicated at the level of the origin from the ipsilateral SA, or CCA, or external carotid artery (ECA), or thyrocervical trunk, or so-called left brachiocephalic artery or special left lateral SA. Additionally, there were reports about the bilateral internal carotid (ICA) origin of the VA [22] and the left ICA–VA common origin [23].

A variable left VA origin from the ipsilateral CCA was the object of this paper. The fact that in the period of 170 years, i.e. from 1844 [15] to 2013 [16] there was no published or quoted work about the left VA–CCA variant demonstrates of what arterial rarity it is.

Embryologically, the third, fourth, and sixth primitive aortic arches (PAAs) are important for the human arteries, as cited [4,5], because the first and second PAAs already disappear at day 29 of gestation, while the fifth PAA either never forms or regresses as an incomplete arch.

Padget [13] pointed out that serial cervical parts in the human embryo represent eight nerves, seven vertebrae, and six cervical intersegmental arteries (CIAs), as branches of the corresponding dorsal aorta. At the 7–12 mm (5th to 6th week), the VA is formed by an interconnection of the primitive proatlantal intersegmental artery (PIA), which is located between the occipital and cervical somites, and dorsal branches of proximal six CIAs. Bilaterally, the CIA6 also contributes to the development of the SA and a part of the definitive arch of the aorta on the left side, and a part of the SA on the right side (distal to the internal thoracic artery).

According to Patil et al. [18], the left VA–CCA variant is a result of the persistence of the left PIA continuing as the left VA with obliteration of proximal longitudinal anastomoses. We suppose that the left VA–CCA variant in our case was the consequence of the longitudinal anastomosis between the PIA and only four CIAs, associated with an involution of the anastomosis between CIA4 and CIA6, as Padget [13] and Lie [3] have proposed; simultaneously, the left CIA6 continued as the left SA. However, Inaba et al. [19] noted that it is a consequence of the persistent left CIA5 and involution of the ipsilateral middle dorsal aorta between the persistent CIA5 and CIA7, while Sharma et al. [21] described that it is caused by the persistence of any of the CIA3 to CIA6 and its migration to the level of the left CCA followed also by involution of the ipsilateral middle dorsal aorta.

Although we have found only nine published cases [8, 14–21] so far, Yuan et al. [24] evidenced two cases of the left VA–CCA variant analysing 1,231 cases of aberrant VA origin in the literature, while Sharma et al. [21] noted only 1/1,286 patients in a meta-analysis; this spe-

Table 1 Left vertebral artery (VA) origin from ipsilateral common carotid artery (CCA)

No	Age/ gender	Country	Initial symptoms or a reason of discovery	Level of VA origin	Associated variations	Associated pathology	Authors*
1							Hyrtl (1836)**
2							Hyrtl (1841)**
3							Quain (1844)**
4	76/M	USA	CTA evaluation			70% stenosis of the left CCA. Parkinson disease.	Troutman et al. [16]
5	68/M	Ireland	Headache / chest and neck pain		Right-sided aortic arch. Aberrant left SA arose from Kommerell diverticulum. Hypoplastic left VA.	>80% stenosis of both ICAs	Shaikh et al. [17]
6	64/M	India	Weakness in the right upper and lower limbs / slurred speech	C III vertebra	Trifurcation of the left CCA. Left VA entered C I transverse foramen. Absent right A1 part.	Small acute nonhemorrhagic infarct in the left thalamus. Gliotic area in the head of right caudate nucleus.	Patil et al. [18]
7	55/M	Japan	Diagnostic evaluation		Right-sided aortic arch. Aberrant left SA arose from a large Kommerell diverticulum. Left VA entered C V transverse foramen.		Inaba et al. [19]
8.	22/F	India	CTA evaluation		Right-sided aortic arch. Aberrant left SA. Origin of dilated left pulmonary a. from the ascending aorta.	Tetralogy of Fallot	Pandey et al. [20]
9.	12/U	India	CTA		Double-outlet right ventricle. A subaortic ventricular septal defect. Pulmonary stenosis. Early bifurcation of the left CCA.	Congenital heart disease	Sharma et al. [21]
10.	Fetus/F	Serbia	Incidental finding during anatomy dissection	CVII vertebra	Left and right VAs entered C IV and C V transverse foramina, respectively.		Recent case

*The authors are listed according to age-published data.
**Hyrtl, 1836; 1841 [8,14], and Quain, 1844 [15] were cited by Bernardi and Dettori [9].
M, male; CTA, computed tomography angiography; SA, subclavian artery; C (I), cervical vertebra (atlas); ICA, internal carotid artery; PIA, proatlantal intersegmental artery; A1, pre-communicating part of the anterior cerebral artery; CIA, cervical intersegmental artery; F, female; U, unknown gender.

cial incidence would range from 0.16−0.7%. In comparison to the incidence of this variant on the right side of 0.18% presented by Layton et al. [10], the left VA−CCA variant, paradoxically, could be more frequent than the right one.

We claim that case of a persistence of the left primitive PIA originating from the CCA bifurcation and its course outside of transverse foramina of all cervical vertebrae, presented by Palmer and Philips [25], should be differed from a case of the VA of the same origin and its course through the transverse foramen of the atlas showed by Patil et al. [18]. Although we described this manner of VA−CCA variant as a type 2 of the persistent PIA [1], we now think that an artery passing through the transverse foramen of one or all (seven) cervical vertebrae represents the VA rather than a PIA or its variant.

Initial symptoms or reasons of discovery of 7/10 known cases, as presented in Table 1, were unspecific (headache and chest pain or weakness of the extremities) [17,18], or incidental during diagnostic computed tomography angiography evaluations [1,19−21], or anatomy dissection in the recent case. The age of the known previous cases (4 of unknown gender, 4 of male, and 2 of female) ranged from 12−76 years.

A case of the posterior circulation infarct associated with the left VA−CCA variant induced a hypothesis

about a possible alteration of the cerebral hemodynamic in this variant [18]. It was noted that anomalous VA might be a source of aortopulmonary collaterals that may need preoperative embolization [21], e.g. in associated cyanotic congenital heart diseases [20,21]. Two cases of the left VA−CCA variant associated with stenosis of some carotid arteries could be explained as a consequence of atheromatous plaques in vessels of older patients, independent from the left VA−CCA variant [16,17].

There was an association of the left VA−CCA variant and the right aortic arch (RAA) in 3/6 known cases [17,19,20]. It would be speculative to talk about their common association, especially since the RAAs are revealed in a minor percentage (0.01% to 0.1%) in the general population [26]. Whether the genetic defects, e.g. 22q deletion that characterized the RAA [26] can lead to the discovery of the left VA−CCA variant, the future findings will show.

Conclusion

Although a fetal sample was presented, this is only the tenth case of a left VA−CCA variant discovered in the last 185 years.

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