Surgical and Radiologic Anatomy (2022) 44:419–421
https://doi.org/10.1007/s00276-022-02896-w

ANATOMIC VARIATIONS

Type 2 left proatlantal artery with normal left vertebral artery and association with an aberrant right subclavian artery and a bi-carotid trunk

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Received: 29 September 2021 / Accepted: 24 January 2022 / Published online: 10 February 2022
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Abstract
Type 2 proatlantal artery (PA) is a rare type of the carotid-vertebrobasilar anastomosis that arises from the external carotid artery and enters the posterior fossa via the foramen magnum (FM). The type 2 PA is usually large and takes a similar course to the occipital artery (OA). The peripheral branch of the OA arises from the distal segment, just proximal to the FM. The ipsilateral vertebral artery (VA) is usually aplastic or hypo-plastic. We diagnosed a case of relatively small type 2 left PA in a patient with a normally developed ipsilateral VA. Furthermore, the patient had an aberrant right subclavian artery associated with a bi-carotid trunk. The combination of these extracranial arterial variations has not been reported in the relevant English language literature.

Keywords Aberrant right subclavian artery · Cerebral arterial variation · Computed tomography angiography · Occipital artery · Type 2 proatlantal artery

Introduction

Several types of carotid-vertebrobasilar anastomosis have been reported [8]. The most caudally located type of anastomosis is persistent second cervical intersegmental artery [10], followed by persistent first cervical intersegmental artery, which has been named type 2 proatlantal artery (PA) [4]. The type 2 PA arises from the proximal external carotid artery (ECA) and runs posteriorly, similarly to the course of the occipital artery (OA). Finally, it enters the posterior fossa via the foramen magnum and continues to the V4 segment of the vertebral artery (VA). Because the proximal segment of the ipsilateral VA is usually aplastic or hypo-plastic, the type 2 PA is large. We herein report a case involving a relatively small type 2 PA with a normally developed ipsilateral VA. The patient also had an aberrant right subclavian artery (SA) associated with a bi-carotid trunk [3, 11].

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Case report

An 81-year-old man with cerebral infarction in the right basal ganglia underwent cranio-cervical CT angiography for the evaluation of arterial lesions. A 64-slice CT machine was used (SOMATOM Definition Flash, Siemens Healthineers, Erlangen, Germany).

There were no significant steno-occlusive lesions in the intracranial arteries. CT angiography of the neck region showed the right SA arising from the aortic arch (AA), distal to the origin of the left SA, which was indicative of an aberrant right SA. The left common carotid artery (CCA) arose from the right CCA, forming a bi-carotid trunk (Fig. 1). There was an anastomotic artery between the left OA and left VA at the level of the foramen magnum (FM), indicative of type 2 PA (Fig. 2). The left VA was normally sized and no stenotic lesions were observed from its origin to the anastomotic point. The right VA was relatively small. No carotid-vertebrobasilar anastomosis was observed on the right side. Schematic illustrations are presented in Figs. 3 and 4.

The patient was treated conservatively and showed a good clinical course.

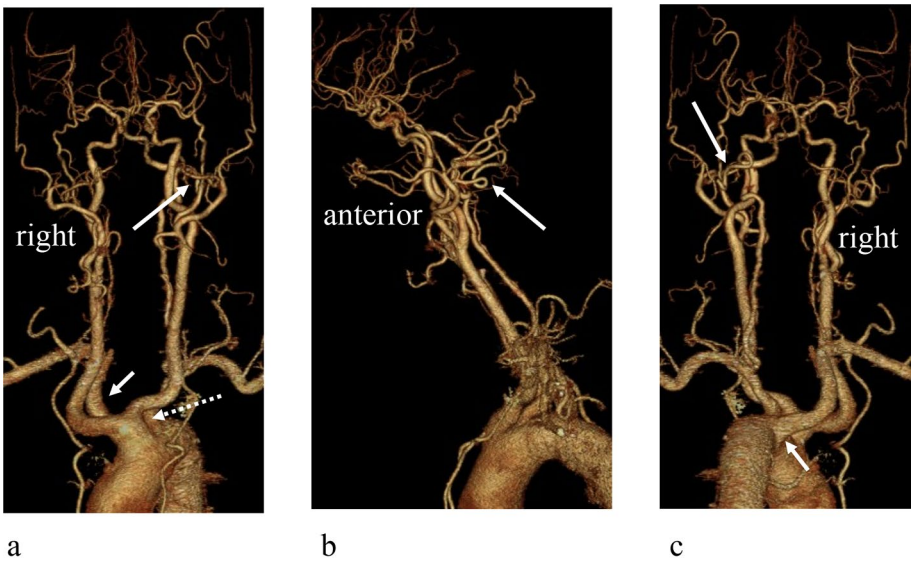

Fig. 1 AP (**a**), left lateral (**b**), and PA (**c**) projections of CT angiography show an anastomotic artery between the left external carotid artery and left vertebral artery (VA) (long arrows). An aberrant right subclavian artery (short arrows) and bi-carotid trunk (dotted arrow) are observed. A normally developed left VA and slightly hypo-plastic right VA are observed. The left VA has no stenotic lesion from its origin to the anastomotic point

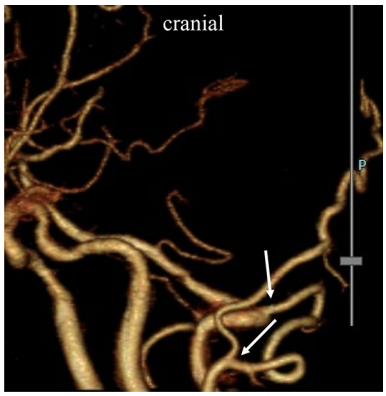

Fig. 2 Slightly left anterior oblique projection of CT angiography shows the anastomotic artery arising from the proximal segment of the left occipital artery and fusing with the VA at the level of the foramen magnum, indicative of type 2 proatlantal artery (arrows)

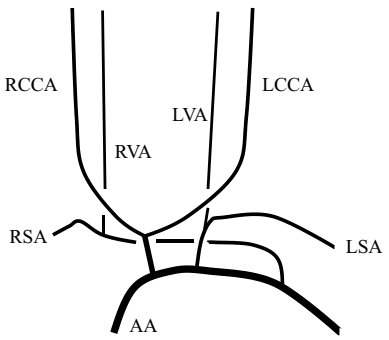

Fig. 3 A schematic illustration of branching variations of this patient in AP projection. *AA* aortic arch, *LCCA* left common carotid artery, *LSA* left subclavian artery, *LVA* left vertebral artery, *RCCA* right common carotid artery, *RSA* right subclavian artery, *RVA* right vertebral artery

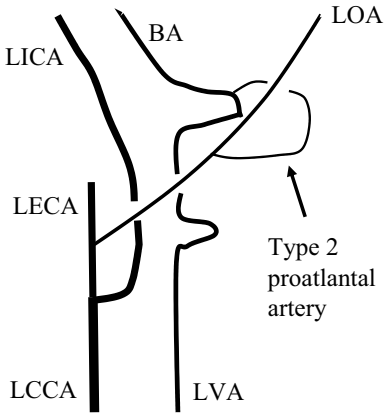

Fig. 4 A schematic illustration of the left carotid and vertebrobasilar system of this patient in the left lateral projection. *BA* basilar artery, *LCCA* left common carotid artery, *LECA* left external carotid artery, *LICA* left internal carotid artery, *LOA* left occipital artery, *LVA* left vertebral artery

Discussion

Extremely rarely, a large artery arises from the proximal ECA, takes a similar course to the OA, and fuses with the VA at the level of FM. Just before entering the posterior cranial fossa via the FM, the distal occipital artery arises. This type of carotid-vertebrobasilar anastomosis is considered a persistent first cervical intersegmental artery and is termed type 2 PA [4]. In contrast, the type 1 proatlantal artery arises from the cervical ICA and fuses with the VA at the level of FM, and this type of carotid-vertebrobasilar anastomosis is considered to be a persistent proatlantal artery [4]. Usually, ipsilateral or bilateral proximal VA is aplastic or hypo-plastic [2]. Thus, type 2 PA is an important collateral pathway from the ECA to the VA. Normally,

small anastomoses are found between the OA and VA. If a pressure gradient occurs between the OA and VA, these anastomoses subsequently dilate. These postnatal collateral vessels should not be confused with this rare variation [7]. In our patient, there is normally developed left VA without a stenotic lesion at the proximal segment, suggesting that there was no pressure gradient between the OA and VA. Therefore, in our patient, the anastomotic lesion is considered to have a congenital origin.

Boukobza et al. [1] reported a case of left type 2 PA that was associated with a common origin of the brachiocephalic trunk and left CCA. Our patient also had an aberrant right SA with a bi-carotid trunk. The association of type 2 PA and persistent trigeminal artery has also been reported [9]. Extremely rarely, congenital anastomosis between the proximal segment of the ECA and the proximal V3 segment of the VA is found. The OA can be seen separately. Thus, this is not type 2 PA (persistent first cervical intersegmental artery) and is instead regarded as persistent second cervical intersegmental artery [10].

An aberrant right SA forms when an abnormal regression of the right aortic arch at the segment between the primitive right CCA and right SA occurs. Based on CT angiography [11], it was reported that approximately 0.5% of the general population has an aberrant right SA. According to a cadaver study [5], its prevalence is 2.2%, which is much higher than the rate detected by CT angiography. This discrepancy may be caused by the limited number of cases in the cadaver study. Because an aberrant right SA is seldom overlooked on CT angiography due to its typical appearance, most examples of this variation in the adult population are found incidentally. However, because this artery crosses the midline via the retro-esophageal space, and may cause esophageal dysfunction, especially in children. Moreover, because neither a right trans-radial nor a trans-brachial approach can be successfully applied in for cranio-cervical intervention, this common variation should be recognized before the procedure. Similar to our patient, a bi-carotid trunk, which is observed in cases where the bilateral CCAs have a common trunk, is seen in approximately 1/3 of cases of an aberrant right SA [11]. The reason for this highly frequent association is unknown. Recently, a patient with multiple cerebral arterial variations has been reported [6].

The clinical significance of these arterial variations is limited; however, to avoid complications, it is important to recognize the presence of type 2 PA before performing cranio-vertebral junction surgery and trans-catheter intervention in the ECA territory. Recognition of an aberrant right SA before the procedure is also important for reducing both the examination time and the rate examination failure during catheterization of the cervical arteries.

Conclusion

We encountered an extremely rare case of type 2 left PA with a normally developed left VA. Because the pressure gradient between OA and VA seems to absent, the anastomotic artery was considered to have a congenital origin. The patient also had an aberrant right SA with a bi-carotid trunk, which is a relatively common variation. Recognition of these variations is important before surgery and catheterization.

Author contributions AU carried out the study design and drafted the manuscript. All authors reviewed the manuscript critically, and have read and approved the final manuscript.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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