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A rare case of the dual origin of the right vertebral artery with an aortic arch origin of the left vertebral artery

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SUMMARY

In clinical practice, rare structural vascular variations pose important risks for clinical procedures such as diagnostic vascular interventions or surgical treatment. The authors herein describe a rare case of an unusual origin of both vertebral arteries in a singular adult male cadaver. The two right vertebral arteries independently originated from the right subclavian artery, while the left vertebral artery took origin from the aortic arch. The left vertebral artery entered the 5th transverse foramen while the two right vertebral arteries entered the 4th and 6th transverse foramen, respectively.

Key words: Embryological development – Vertebral artery – Origin variation – Anatomical variations

INTRODUCTION

The vertebral artery is an important conduit for blood supply to the brain. Therefore, it is very important to accurately understand its anatomy and variations for clinical imaging diagnosis, surgical planning of the thorax/neck, and endovascular treatment in conditions such as arteriovenous malformations or cerebral aneurysms, thrombosis, occlusion, arterial dissection and atherosclerosis (Komiyana, et al., 2001; Satti et al., 2007; Sawant and Rizvi, 2017; Dodevski and Tosovska-Lazarova, 2012).

Generally, the vertebral arteries bilaterally originate from the supero-posterior aspect of the proximal parts of the subclavian arteries; they run upwards and backward in the scaleno-vertebral triangle formed by the scalenus anterior and longus colli muscles. They pass through the sixth to first cervical transverse foramina and finally enter into the cranial cavity via the foramen magnum (Matula et al., 1997). Vertebral artery variations are quite rare but not uncommon. They include origin, course, diameter and number variations (Dong and Li, 2009). The artery variability is more common on the left vertebral artery than it is on the right (Quain, 1844; Jiyeon et al., 2016; Lazaridis et al., 2018). In his classical studies, Quain (1844) noted the variations in which the vertebral arteries, usually given from the subclavian, take origin directly from the aorta or exist as double on one side. However, it appears that the reported origins of the left subclavian artery from the arch of the aorta or double right vertebral artery did not occur at the same time in one specimen. Many studies later found the incidence of the variations in vertebral artery origin and course to be between 1-10% (Watanabe et al., 2016; Yuan et al., 2016; Kim, 2018; Lazaridis et al., 2018). While the discovery of arterial variability is often incidental, some anatomical variations are suspected to cause a headache, dizziness and other symptoms that require careful diagnosis (Satti et al., 2007). We report here, in detail, the unique morphological characteristics of these variations, their possible embryonic

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etiology, and their clinical implications.

CASE REPORT

The case that we are reporting was found during a routine medical students' dissection of a formalin -fixed adult male cadaver aged 78 in the Department of Human Anatomy, Sun Yat-sen School of Medicine. The body was in supine position, keeping the head and neck straight allowing dissection of the anterolateral neck area and the chest, thus permitting access to the vertebral arteries. The length of both vertebral arteries was measured from the point of origin up to the point of entry into the respective transverse foramina with a thread and Vernier calipers (in mm). Arteries' outer diameters were also determined at the points of origin and at entry into transverse foramina with the aid of a calibrated sliding Vernier calipers (accuracy of 0.02 mm). The course of the vertebral arteries was traced through the cervical region into the foramen magnum. The intracranial branches were examined for arterial fenestrations after dissection.

(A) The left vertebral artery (Fig. 1)

The left vertebral artery originated directly from the aortic arch, i.e. from the interval between the left common carotid artery (Fig. 1, labelled 3) and the left subclavian artery (Fig. 1, labelled 1). It ascended to the fifth cervical vertebra where it entered its transverse foramen. Its outer diameter at the point of origin was 6.28 mm. The left vertebral artery origin was situated 8.60 mm to the right-hand side of the left common carotid artery root. The left subclavian artery arose at the distance of 8.00 mm further to the left of the left vertebral artery. The outer diameter of the left vertebral artery before entering the transverse foramen of the fifth cervical vertebra was 4.85 mm. Its overall length measured from the point of origin up to the point of entry into the fifth transverse foramina was found to be 97.06 mm. The artery was unusually larger in diameter throughout its course (Fig. 2). There were no variations noted from its course through the transverse foramina, entry into cranium or merging with the right vertebral artery.

B) The right vertebral artery (Fig. 2)

Two vertebral arteries were found on the right side:

The first right vertebral artery originated from the right subclavian artery, 3.56 mm to the right-hand side of the right common carotid artery origin. Its outer diameter at the point of origin was 2.49 mm and it tapered to an outer diameter of 1.66 mm

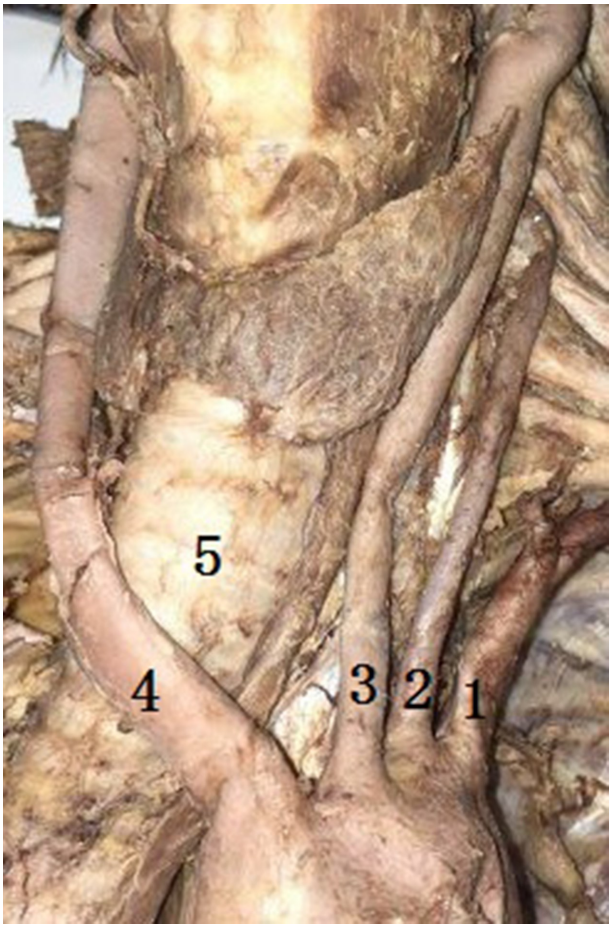

Fig 1. Left vertebral artery arising directly from the aortic arch. 1=left subclavian artery; 2=left vertebral artery; 3=left common carotid artery; 4 = brachiocephalic trunk; 5=trachea.

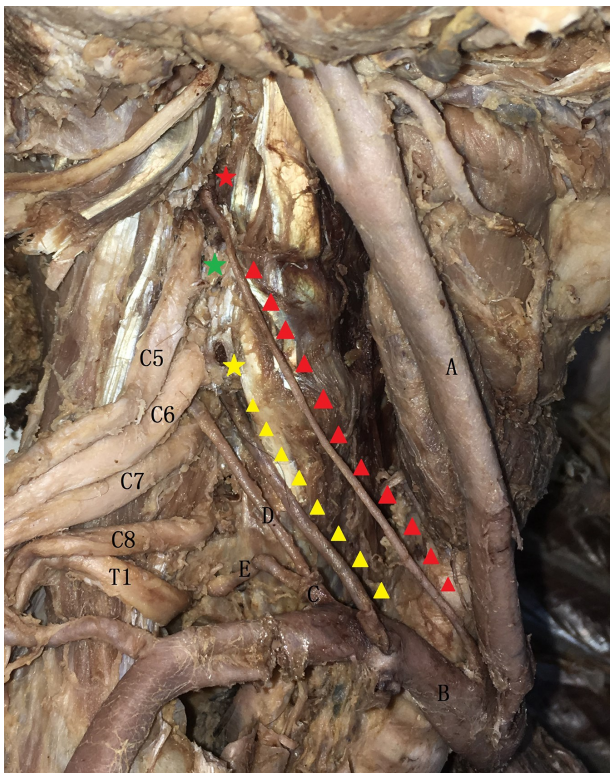

Fig 2. On the right, two vertebral arteries are present. The first right vertebral artery of proximal right subclavian artery origin (red); the second right vertebral artery of right subclavian artery origin (yellow); the fourth transverse foramen (red star); the sixth transverse foramen (yellow star); A= right common carotid artery; B= right subclavian artery; C= costocervical trunk; D= deep cervical artery.

prior to its entry into the transverse foramen of the fourth cervical vertebra (C4). This course of the first right vertebral artery had a total length of 84.36 mm. The artery was unusually smaller in diameter compared to that of the left (Fig. 2).

The second vertebral artery originated from the right subclavian artery (Fig. 2, yellow arrowheads). The distance between this artery's point of origin, from that of the first right vertebral artery, was 11.70 mm. Its outer diameter at origin was 2.73 mm. It spanned a relatively shorter distance to the sixth cervical vertebra. The artery entered the transverse foramen at this level (Fig. 2, yellow star) and had an outer diameter of 2.30 mm while its total length was 52.00 mm. The artery was also of unusually smaller diameter compared to that of the left. The two arteries merged into one at the level of the fourth cervical vertebra to take a course up through the remaining transverse foramina. There was no evidence of fenestrations on the vertebral and cranial arteries.

COMMENTS

Embryology

The vertebral artery arises as a secondary development, bilaterally, from a series of dorsal rami of dorsal intersegmental arteries belonging to the neck (Barry, 1951). Any abnormal development of these processes undoubtedly accounts for the aberrant origin and course of the vertebral arteries. In the present case study, the left vertebral artery takes origin directly from the arch of the aorta between the left common carotid and left subclavian arteries. This appears to be the most common vertebral artery variation (Satti et al., 2007; Yuan et al., 2016). This variation possibly arose as a result of persistence of dorsal intersegmental arteries cranial to the seventh, especially from first to fourth left aortic arch (Koenigsberg et al., 2003; Satti et al., 2007; Lazaridis et al., 2018).

Incidence

According to the results reported in the literature, the dual origin variation of the vertebral artery in China has rarely been found since the report of Zhou et al. (2008). According to earlier domestic data (Chinese Anatomy Society Physical Survey Commission, 2002), autopsy findings had showed that the incidence of an accessory vertebral artery in the Chinese population was 1.36% (1.36 ± 0.48), left: 0.85 ± 0.38 (%), right 0.51 ± 0.2 (%). Yuan et al. (2016), in a review of 1286 variations, involving 955 patients and 331 cadavers reported that most of the vertebral artery variability appeared on one side and often on the left. There were only 2 cases that had the variability of the right vertebral artery originating from the aortic arch. Our single case is very unique in that it exhibited bilateral variability: stemming from the aortic on the left and having a double right vertebral artery. Such findings on one subject have not been reported widely in the literature. In fact, the findings of a review by Lazaridis et al. (2018) noted its uncommon occurrence. Motomura et al. (2018) recently reported a case of duplicated right vertebral artery found in the neck of a 91-year-old female cadaver. The proximal leg of the arteries arose from the area between the right subclavian artery and the right common carotid artery that diverged from the brachiocephalic artery. On the contrary, in their case, the two arteries merged into one and entered the fourth transverse foramen. Earlier on, Watanabe et al. (2016) also encountered two vertebral arteries on the left side on a formalin-fixed cadaver. One arose from the aortic arch between the origin of the left common carotid artery and the left subclavian artery, entered the transverse foramen of the 4th cervical vertebra and the other arose from the left subclavian artery as expected, but divided into two branches anterior to the cervical vertebrae, and entered the transverse foramina of the 6th and 7th cervical vertebrae. Unlike our current observations, Watanabe and colleagues noted existence of 3 arterial fenestrations in the cranial arteries. Earlier on, Anderson (1880) had reported a case of left vertebral artery arising from the arch of the aorta, as observed in our case, but in his case it then divided into two branches that run together and reunited leading to a transverse foramen entry at 5th cervical vertebra. In another study by Lemke et al. (1999), a preoperative digital subtraction angiography revealed a right vertebral artery arising from the descending aorta after the left vertebral artery instead of the usual right subclavian artery. Furthermore, Kim (2018) recently found that ten of the 3386 patients (0.295%) who received CT angiography had a dual origin of the vertebral artery. Seven patients had a right dual origin of the vertebral artery from the right subclavian artery, and three patients had a left dual origin from the left subclavian artery and aortic arch. All these previous findings, although unique, are different from our present case, which is bilateral on one specimen. It is unfortunate that we are not able to relate our unique finding to the cause of death or any clinical data that would possibly be as a consequence of such an occurrence.

Transverse foramen entry level

Vertebral artery entry into the sixth cervical transverse foramen is the normal occurrence in the majority of human patients ever examined. For example, in a study comprising 70 anatomic preparations in different forms, 181 patients, 95 angiographies of the aortic arch, and 86 color-coded Doppler sonographies, Matula et al. (1997), found that the level of entry of the vertebral artery into the C6 transverse foramen happened in 91% of their cases. Similarly, Hong et al. (2008) found that in 94.9% (n=350 CT scans) of all specimens under study, the vertebral artery entered the transverse foramen of C6 vertebrae. This means that the remainder of cases represent the uncommon occurrences in which the vertebral artery enters other transverse foramina on its way up to the posterior circulation (Matula et al., 1997). It has been reported in the literature, for instance, that only one pa-

tient (n=2287) in whom the right vertebral artery entered the third transverse foramen, 1% entered the fourth, 5% the fifth; and about 1% entered the seventh transverse foramina (Hasebe, 1928). In our present case, the two right vertebral arteries separately entered the fourth and sixth transverse foramina (concordant with Motomura et al., 2018, single cadaver finding), respectively, while on the left side the vertebral artery which directly originated from the aorta entered the fifth transverse foramen. The advent of variation of vertebral artery entry into the cervical transverse foramina presents a case of vascular bending that will have a certain impact on hemodynamics. This is especially so with advancing age, arterial elasticity reduction, cervical spondylosis or vertebral artery atherosclerosis which will subsequently reduce blood flow to the brain to produce clinical symptoms (Zhou et al., 2008). Therefore, it is important to pay attention to such variations during the anterior or lateral approach to the cervical spine so as to prevent inadvertent injury and potentially serious complications (Bruneau et al., 2006).

Clinical Significance

Although most of the vertebral artery anomalies have no clinical symptoms, most scholars believe that such variations are likely to be risk factors for cerebrovascular diseases such as intracranial aneurysms and arteriovenous malformations (Satti et al., 2007; Lazaridis et al., 2018). The abnormal origin of the vertebral artery and its tortuous course could also easily lead to hemodynamic changes. In addition, rare structural variations such as those described above pose important risks for clinical procedures such as vascular interventions in the chest and neck. In our present case study, the prevertebral left vertebral artery was longer than its counterpart although the tortuosity was not apparent upon dissection and examination. It was also nearly twice as large as the counterparts on the left. In this case, the right accessory vertebral artery is prone to be mistaken for other blood vessels in neck surgery or vascular interventions and could be easily damaged by ligation or embolization. The left vertebral artery which is seen originating from the aortic arch may compound results of cerebral angiography resulting in false negatives. Therefore, early detection of such vascular changes will certainly help to prevent the occurrence of related diseases. However, due to lack of large sample data in our case report, it is still difficult to make a definitive conclusion regarding vertebral artery variability and its associated clinical sequelae.

CONCLUSION

The origination variation of both vertebral arteries is rare but can be well explained by embryonic development. Therefore, we should find out more about the regularity of variation through the analysis of large data samples. We should also use modern technologies such as selective angiography to find out the variation of blood vessels in advance and to make accurate clinical diagnoses so as to avoid the occurrence of unexpected events at the clinic. The teaching of anatomy should also reflect the possibility of such variations.

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