Variation in the morphology and branching pattern of the aortic arch: A case report

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Abstract

Introduction
The arch of the aorta is situated in the superior mediastinum and it normally branches into three: the brachiocephalic trunk, left common carotid artery, and the left subclavian artery. Variations in its morphology and branching pattern are mainly due to the errors in its embryologic development. Here, we report concurrent variation in the morphology and branching pattern of the aortic arch.

Case report
The first branch of the aortic arch was a common trunk which divided into the brachiocephalic trunk and the left common carotid artery. There was a constriction in the aortic arch immediately to the left of this common trunk. The left vertebral artery arose from the aortic arch, dorsolateral to the origin of the left subclavian artery. At the root of the neck, the left vertebral artery passed behind the first thoracic and inferior cervical sympathetic ganglia.

Conclusion
Knowledge of these variations may be very useful to surgeons involved in the cervical and thoracic sympathectomies, vascular surgeries, and cardiac catheterization procedures.

Introduction
The arch of the aorta is the continuation of the ascending aorta. It is situated in the superior mediastinum and usually branches into three: the brachiocephalic trunk, left common carotid, and left subclavian arteries. This branching pattern is found in 65%–80% of population. Variation in the aortic arch branches occurs mainly due to the abnormal fusion or disappearance of aortic arch arteries during the embryonic period. Variations, such as its coarctation, might result in decreased blood flow to certain regions of the body depending on where the coarctation is situated. Variations in the branching pattern may result in iatrogenic injuries of the variant branches; their compression by adjacent structures or problems in the catheterization procedures. Knowledge of these concurrent vascular variations in the superior mediastinum may be very important to various medical disciplines and we discuss the clinical importance of these variations in this article.

Case report
During routine dissection classes for medical undergraduates, we observed the following variations in the morphology and branching pattern of the arch of the aorta. The aortic arch was situated in the superior mediastinum, behind the manubrium sterni. Its first branch was a common trunk for the brachiocephalic trunk

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Figure 1: Dissection of the major vessels in the superior mediastinum. (AA – aortic arch; CT – common trunk; C – constriction/coarctation of the aorta; SVC – superior vena cava; BCT – brachiocephalic trunk; LCC – left common carotid artery; LS – left subclavian artery; LV – left vagus nerve; RS – right subclavian artery; RCC – right common carotid artery; TRC – trachea; THR – thyroid gland; LVA – left vertebral artery).

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and left common carotid artery. This common trunk appeared to be in line with the ascending aorta and was the direct continuation of the same (Figure 1). The common trunk was about 2 cm broad and 2 cm long. It divided into left common carotid artery and brachiocephalic trunk in front of the trachea. Immediately to the left of the origin of the common trunk, the aortic arch had a slight constriction/coarctation (Figures 1 and 2). The left subclavian artery took its origin from the aortic arch immediately to the left of the constriction. Further, the left vertebral artery arose from the arch of aorta, dorsolateral to the origin of the left subclavian artery (Figures 2 and 3). This artery coursed upwards in the superior mediastinum behind the left subclavian artery and on the left side of the oesophagus. At the root of the neck, it passed behind the first thoracic and the inferior cervical sympathetic ganglia (Figure 3). Further course and branching of the left vertebral artery were normal. These variations were observed in an adult male cadaver aged about 60 years.

**Discussion**

The aortic arch and its branches develop from six pairs of aortic arch arteries during the embryonic development. Variation in the morphology and branching pattern of the aortic arch is attributed to the deviation from the normal pattern of development. Previous studies have reported various branching patterns of the arch of the aorta. In an extensive angiographic and multi-slice computerized tomography image study, conducted by Vucurevic et al., 74.72% of the patients had a normal branching pattern of the aortic arch, which they named as type I. The abnormal patterns were named, from type II to VIII. Type II (2.84%) had a common origin of the left common carotid and subclavian arteries. Type III (15.56%) had an origin of the left subclavian artery from the brachiocephalic trunk. Type IV (0.55%) had the aortic origin of both common carotid and subclavian arteries, with the right subclavian artery having a retrooesophageal course. Type V (0.24%) also had four supra-aortic branches as in type IV; however, they arose from a double- or a right-sided aortic arch. Type VI (3.63%) comprised the aortic origin of the left vertebral artery. Type VII (0.24%) had the origin of the right vertebral artery directly from the aortic arch. And, type VIII (2.22%) had the aortic origin of the thyroidea ima artery. With reference to the origin of left vertebral artery, the current case belongs to type VI of the above classification. However, it differs from the above study in having a common origin of the brachioccephalic trunk and left common carotid arteries. Another computed tomographic angiography study reports the coexistence of the common trunk for brachioccephalic and left common carotid artery and direct origin of left vertebral artery from aortic arch in only 1.2% cases. However, these cases were not accompanied by the coarctation of the aortic arch as reported in the current case. Uchino et al. conducted a CT angiography study on 2,357 patients. They did not find a variation similar to the current case in their study. However, in their study, the left common carotid artery arose from brachioccephalic trunk in 6% of the patients.

Direct origin of the left vertebral artery from the aortic arch has been documented in 1%–3% of cases. A very recent imaging study, reports its direct origin from the aortic arch in 3.7% cases. Lippert and Pabst have classified the variant origin of the left vertebral artery from the aortic arch into the following eight types. In type 1, it arises from the aortic arch between the left common carotid and

![Figure 2: Dissection of the major vessels in the superior mediastinum. The left subclavian artery has been pulled to the right to expose the left vertebral artery. (CT – common trunk; C – constriction/coarctation of the aorta; SVC – superior vena cava; BCT – brachiocephalic trunk; LCC – left common carotid artery; LS – left subclavian artery; LV – left vagus nerve; TRC – trachea; LVA – left vertebral artery).](image-url)
left subclavian arteries; in type 2, it takes origin between a common trunk formed by the left common carotid and brachiocephalic trunk and left subclavian artery; in type 3, it arises to the left of the left subclavian artery; in type 4, it arises to the left of the left subclavian artery and coursed behind it; in type 5, it originates as a second branch next to the common trunk; in type 6, it is the same as type 1 but the right subclavian artery arises from descending aorta; in type 7, it arises as a penultimate branch; and in type 8, it is duplicated and both branches arise from the aortic arch. In the current case, the origin was similar to type 4. But it originated from the dorsolateral aspect of the arch of the aorta.

Coexistence of three variations observed in the current case is unique and a similar case has not been reported earlier. Knowledge of possibility of these variations is of importance to many medical disciplines. Despite accurate preoperative assessment and adequate preparations, unexpected and unsuccessful situations may occur during vascular surgery. Complication of open surgery of the aortic arch includes ischemic problems, which can be caused by unrecognized variation of vascular anatomy. Some anomalous branches of the aortic arch may be overlapped by other vessels and are not visible radiographically. They are usually identified only intra-operatively. The left vertebral artery in the current case arose from the aorta dorsolateral to the left subclavian artery and coursed behind it throughout the superior mediastinum. Hence, this variation cannot be recognized in radiographs.

**Case report**

**Conclusion**

The coarctation observed in the current case might result in decreased blood flow to the distal part of the aortic arch in a long run and might be the point of atherosclerotic changes. The course of the left vertebral artery behind the left subclavian artery in the superior mediastinum and posterior to the two sympathetic ganglia at the root of the neck predisposes it to iatrogenic injuries during sympathectomy procedures. Knowledge of these variations may be very useful to the surgeons involved in the cervical and thoracic sympathectomies, vascular surgeries, and cardiac catheterization procedures.

**References**

Case report
