

Aberrant right subclavian artery: its clinical importance in thoracic surgery

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SUMMARY

Anomalies of the aortic arch include various variations. Aberrant right subclavian artery (ARSA) is one of the most common variations in this region, with an incidence of approximately 1% of all population. For this reason, ARSA is accidentally encountered during clinical settings. In 2019, we encountered a case of ARSA during a human cadaver dissection course for medical students at Teikyo University. This cadaver did not have a Kommerell's diverticulum, which is often accompanied in ARSA. While the present case is a vascular anomaly, it has a clinical relevance because of its topographical nature juxtaposed to the trachea and esophagus.

Key words: Anatomy – Cardiovascular system – Blood vessels – Arteries – Subclavian artery

ABBREVIATIONS

6w (6 weeks)

Aberrant right subclavian artery (ARSA)

Aortic arch (AA)

Aortic sac (AS)

Ascending aorta + Aortic arch + Descending aorta (ACA + AA + DCA)

Brachiocephalic artery (BCA)

Bronchi (B)

Common carotid trunk (CCT)

Common carotid artery + External carotid artery + Internal carotid artery (CCA + ECA + ICA)

Dorsal aorta (DA)

Esophagus (E)

Kommerell's diverticulum (KD)

Left and right internal thoracic arteries (LIT and RIT)

Left subclavian artery (LSA)

Non-recurrent laryngeal nerve (NRLN)

Pulmonary artery + Ductus arteriosus (PA + DA)

Right subclavian artery (RSA)

Right and left common carotid arteries (RCCA and LCCA)

Subclavian artery (SCA)

Trachea (T)

INTRODUCTION

The aortic arch and its branches begin to form during the early developmental stages through highly dynamic remodeling of anlagen (Sadler, 2023). Therefore, anomalies affecting the aortic arch are well-known and reported relatively frequently (Stojanovska et al., 2012).

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To date, there are at least 10 major patterns of anomalies in terms of aortic arch branches (Williams et al., 1932). Among them, there are two subtypes showing an aberrant position of the right subclavian artery (ARSA). In ARSA, the right subclavian artery (RSA) is the last branch from the aortic arch, and it runs behind the esophagus to direct towards the right upper extremity. The major difference between the two types lies in the absence (type G) and presence (type H) of the common carotid trunk (CCT).

ARSA occasionally accompanies a unique combined sequela called the Kommerell's diverticulum (KD). It is an aneurysm-like dilatation at the origin of the ARSA, and is assumed to be a persistent dorsal aorta from the embryonic period (Kommerell, 1936). Considering this, KD may become a toehold for delineating the developmental sequence that leads to ARSA. In addition, while

it is very rare, ARSA tends to accompany the so-called "non-recurrent laryngeal nerve (NRLN)" compared with normal individuals (Stewart et al., 1972). It will increase the risk of complications during surgery of head and neck.

In this report, we present a case of type H ARSA without KD and discuss its clinical importance in terms of thoracic surgical intervention.

CASE REPORT

During a dissection course for medical students in 2019, we encountered a 95-year-old female cadaver with an ARSA. The patient had died from heart failure. The cadaver was fixed with 3% formalin solution. During the dissection of the thoracic region, an ARSA was found, while the surrounding structures such as the recurrent laryngeal nerves were partially eliminated.

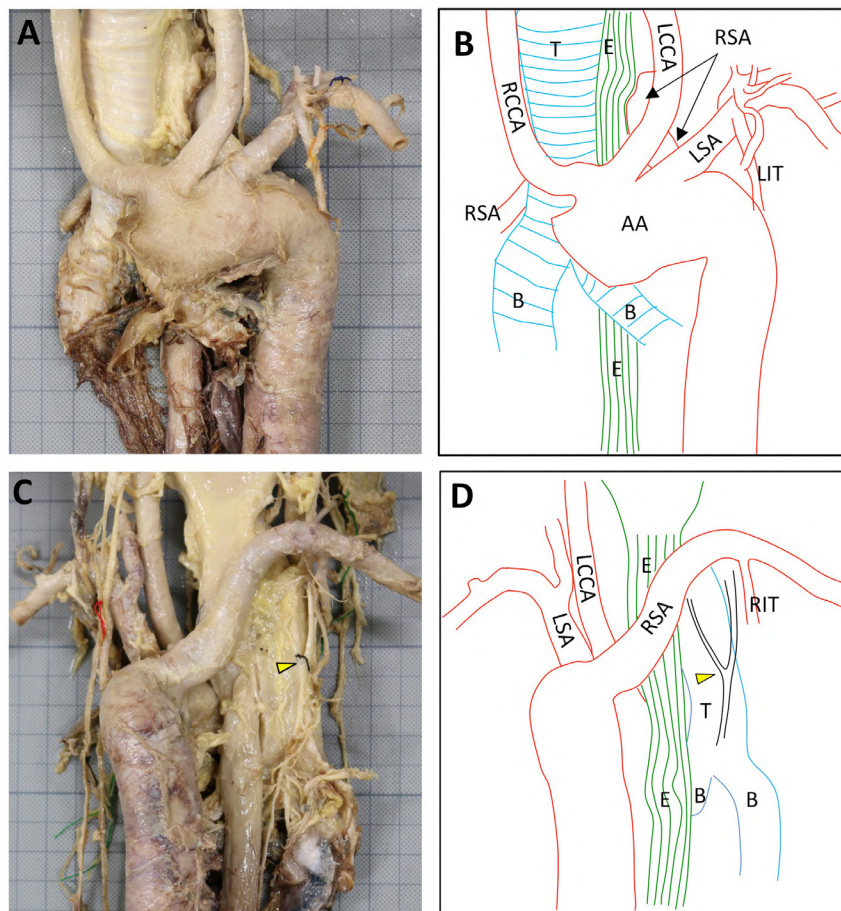


Fig. 1.- Photographs and schematic diagrams of eviscerated arterial system and the trachea and esophagus from the cadaver. **A** and **B**: Ventral views. The common carotid trunk is the first branch of the aortic arch (AA). The common trunk was immediately divided into the right and left common carotid arteries (RCCA and LCCA). The left subclavian artery (LSA) is the second branch. The third branch, which is the right subclavian artery (RSA), is not clearly visible on the ventral side. **C** and **D** show the dorsal views. The RSA runs dorsally to the esophagus (E), trachea (T), and bronchi (B). The left and right internal thoracic arteries (LIT and RIT) originated from the subclavian arteries as usual.

At first glance, the shape and route of the aortic arch appeared normal; however, considerable deviations in branching patterns were noted. The common carotid trunk appeared at the superior edge of the aortic arch, followed by the left subclavian artery. As the last branch, the right subclavian artery passed through the dorsal side of the aortic arch and branched off to the right (Fig. 1A, B). Then, the right subclavian artery ran obliquely between the esophagus and the vertebral column toward the right axilla (Fig. 1C, D). No KD was noted.

The CCT was very short and appeared stunted, with an outer diameter of 18 mm. The CCT gave rise to the left and right common carotid arteries with similar outer diameters, both of which directed the head forward. The outer diameters of the right and left common carotid arteries were respectively 13 mm and 11 mm. The left subclavian artery emerged immediately next to the CCT

and was clearly demarcated by a steep incisure. After leaving the aortic arch, it ran obliquely upward towards the left, leaving the vertebral artery. Therefore, this is identified as the left subclavian artery. The peripheral branching pattern of the left subclavian artery was normal. Morphometry on the arterial outer diameter is summarized in Table 1.

Table 1. Morphometry on the diameter of observed arteries.

	Outer diameter(mm)
Ascending aorta	30
Descending aorta	25
Common carotid trunk	18
Right common carotid artery	13
Left common carotid artery	11
Right subclavian artery	14
Left subclavian artery	10

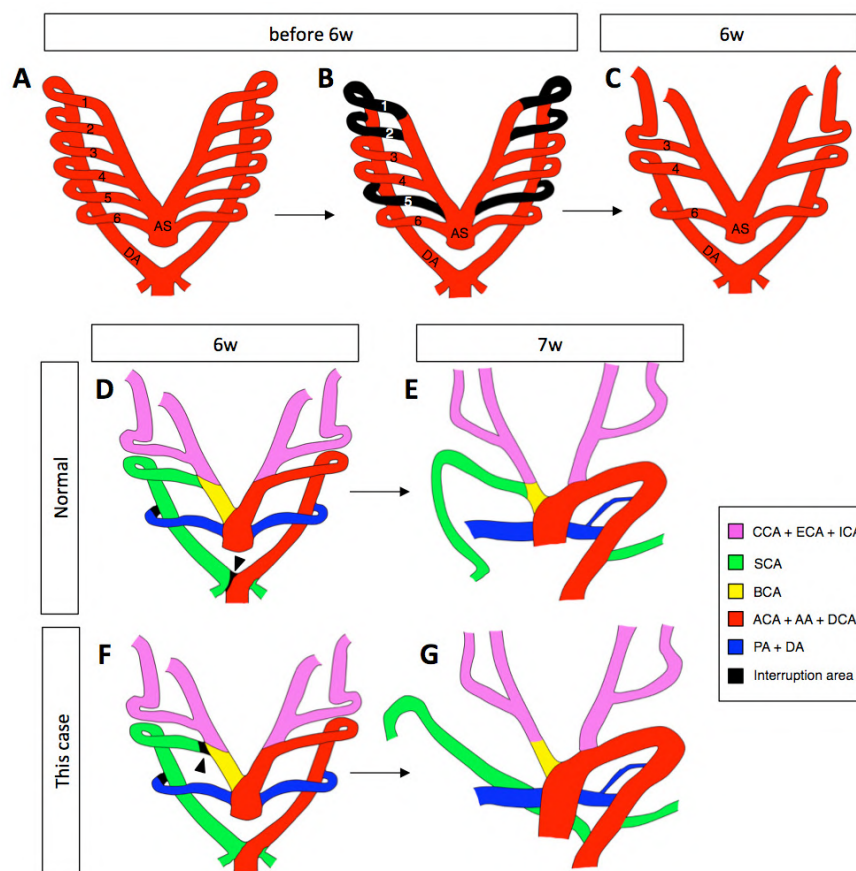


Fig. 2.- Schematic diagram comparing the normal development of the aorta and its branches (A-E) with the present case (F-G). **A)** Six-paired primitive aortic arch before the sixth week of gestation. **B)** The same period as the schematic in **A**, showing future regression of the arterial areas in black areas. **C)** The arterial arch at the sixth week of gestation after regression of the black area in **B**. **D** and **F** show the schematic in **C** with future arterial areas color-coded, and regressing areas were indicated with black areas and arrowheads. **E** and **G** show the separation of the right subclavian artery from the arterial arch, as black areas in **D** and **F** degenerate. The normal right subclavian artery separates from the future descending aorta. However, in the present case, it separates from the future brachiocephalic artery.

There are no apparent branches in the ventral view. Nevertheless, when we examined the dorsal side of the aortic arch, a relatively large artery with an outer diameter of 14 mm arose from the most caudal region of the aortic arch. This large, aberrant right subclavian artery ran towards the right with a slight elevation to the head, followed by a steep turn that formed an S-shape. Finally, the aberrant right subclavian artery directed towards the right axilla and passed behind the esophagus.

With respect to the recurrent laryngeal nerve, the left trunk followed a normal pathway, turning around the aortic arch to climb the trachea. The right trunk, which normally turns around the right subclavian artery, was lost at the time we found the ARSA. However, a branch emerging directly from the right vagal nerve was identified, which ran cranially between the trachea and esophagus and finally innervated the right larynx. Therefore, the present cadaver did not appear to have NRLN. No significant abnormalities were observed in the venous network.

COMMENTS

Developmental sequelae that cause ARSA are relatively well-assumed (Fig. 2), but no direct evidence has been obtained experimentally. Briefly, three of six pairs of primitive aortic arches connect to the AS regress to form an anlage of the definitive aortic arch around the sixth gestational week (Sadler, 2023). Stojanovska et al. (2012) assumed that the fifth dorsal right arterial arch located behind the origin of the right subclavian artery regresses, giving rise to anlagen of the brachiocephalic, common carotid, and subclavian arteries. Therefore, the right fourth aortic arch and right dorsal aorta, located behind the esophagus, were forced to remain in contact. The retro-esophageal arch becomes the last branch of the aortic arch, which further differentiates into the right subclavian artery.

In contrast, ARSA adopts different segregation trajectories. In this case, the junction between the AS and fourth right aortic arch regressed, resulting in detachment of the prospective brachiocephalic artery from the definitive aortic arch. To maintain the bloodstream in the right

upper limb, the right dorsal aorta does not lose its connection with the dorsal aortic trunk, originally called the AS.

From a clinical standpoint, Polgaj (2014) reported that 126 of 141 cases were discovered during routine radiological examinations, whereas only 15 were noticed and recorded during dissection-related activities. While Polgaj focused on ARSA in childhood, ARSA is often accidentally discovered in middle age. In such cases, care should be taken in the thoracic part of the digestive system and respiratory system during surgical interventions.

Demographically, 30% of all cases were found in Caucasian population, while Japanese cases account for 6-7%. However, according to Iimura (2017), the incidence of type G and H is estimated to be between 0.2-1.6% in the Japanese population, suggesting that this anomaly is rather frequent in the Japanese population, especially in female.

Although KD is present in 60% of ARSA (Epstein et al. 2002), it was not in our case. Japanese population revealed KD in 38 (59%) of 69 cases, the results is consistent with Epstein's report.

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Ethical considerations

This study was conducted in compliance with the principles set forth in the Declaration of Helsinki and the guidelines for research involving cadavers established by the Japanese Association of Anatomists. We collected and preserved self-signed consent forms for body donation in accordance with international and university standards. Consent was obtained from the bereaved family before the dissection.

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