Aberrant right subclavian artery as an incidental finding in chest MDCT: evaluation and imaging features

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Aims and objectives

Left sided aortic arch with aberrant right subclavian artery (ARSA) is the most common congenital anomaly of the aortic arch and the great vessels of the heart, followed by the right-sided aortic arch with left aberrant subclavian artery (ALSA) [1-3]. Normally, the aortic arch gives rise to three large arteries: the brachiocephalic trunk, following its division to the right common carotid artery and the right subclavian artery, the left common carotid artery and the left subclavian artery. In most cases of an aberrant right subclavian artery, four large arteries arise from the aortic arch (the right common carotid artery, the left common carotid artery, the left subclavian artery and finally the right subclavian artery) and consequently the brachiocephalic trunk does not exist [3-6].

In some cases of ARSA, other anomalies of the aortic arch co-exist such as the presence of a bicarotid trunk, which is considered to be the most common anomaly associated with ARSA [7-9].

Embryologically, the right subclavian artery develops from the right fourth aortic arch archery, the right dorsal aorta and right seventh intersegmental arteries (the proximal and the distal part respectively). These events take place between the sixth and the eighth week of gestation.

The anomaly occurs due to the cranial involution of the right fourth aortic arch archery and the right dorsal aorta above the seventh intersegmental artery. As a result, the right subclavian artery develops from the distal part of the right dorsal aorta and the seventh intersegmental artery. During the fetal growth, the origin of the right subclavian shifts cranially, close and dorsally to the origin of the left subclavian artery [6,10-13]. Moreover, the ARSA takes primarily a retroesophageal course. Frequently at the origin of ARSA a diverticulum is formed, called Kommerell's diverticulum, which represents the persistence of the most distal portion of the embryonic right arch. In elderly, it becomes difficult to separate Kommerell's diverticulum from a tortuous and ectatic ARSA, which is also common [14].

The aberrant subclavian artery is also called arteria lusoria (AL) and was first described by Hunauld in 1735 [15]. Most of the cases are asymptomatic (90-93%), but rarely there has been a reference of dysphagia (also known as dysphagia lusoria), dyspnea, chest pain (7-10%) [7,8,14,16,17]. Rupture and arterio-esophageal fistulas are also reported in some articles [18,19]. It is believed that the presence of symptoms is related with the existence of aneurysm of the ARSA or Kommerell's diverticulum, the age-related rigidity of the esophagus and elongation of the aorta and the co-existing bicarotid trunk [9,13,20].
The primary aim of our study is to assess the frequency, the associations and pathologies of aberrant right or left subclavian artery in patients examined with chest multiple detector-computed tomography (MDCT) in our department in a one-year period.

**Methods and materials**

We retrospectively reviewed and analyzed a series of 6488 patients that were examined in our department during the year 2015 (January 2015-December 2015). Each patient underwent chest MDCT for various reasons, with no clinical report of ARSA associated symptoms. The great majority of patients were referred to our institution for staging, pulmonary embolism investigation (Fig. 1) and pulmonary infections.

Every exam was made with Philips Brilliance iCT 256 multislice CT scanner. Most of the cases concerned routine examinations, in which the images were taken after injection of contrast agent. In some cases, due to various contraindications, the examinations were made without intravenous administration of contrast agent. In all of these exams, the nominal reformatted thickness of each slice was 4mm, overlap of 50% and Pitch 0,93.

There were also some cases in which the examination concerned the visualization of the pulmonary arteries (CTPA). In such cases, the technique of bolus tracking was used. Each slice had a nominal reformatted thickness of 1.5mm, overlap of 50% and Pitch 0.93.

The original CT scans were then transferred to an independent workstation of image processing (Philips Brilliance Workspace Portal ver: 2.6.1.5). For each examination we produced 2D Multiplanar Reconstruction (MPR) images as well as 3D Maximum Intensity Projection (MIP) images and Volume Rendering (VR) images.

In each exam we evaluated the origin and course of the anomalous vessel, along with the possible existence of Kommerell's diverticulum. Furthermore, we measured the width of each aberrant vessel and calculated the mean value. We searched for any abnormalities of the vessel wall and any coexisting anatomical variations of the aortic arch.

Finally, we reviewed our report database system to find out in which cases the aberrant vessel was reported as an incidental finding.

**Images for this section:**
Fig. 1: 78 year-old female referred for CTPA, for investigation of pulmonary embolism. Even though the aortic arch and its branches contain minimum quantity of contrast agent, the right subclavian artery is demonstrated in detail. A, Axial plane B, C, D, Curved MPR images.

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Results

Out of the 6488 cases that we reviewed, a total of thirty-eight patients (0.59%) were found with left sided aortic arch and aberrant right subclavian artery (Fig. 2); only one patient (0.01%) was found with right-sided aortic arch and aberrant left subclavian artery (Fig. 3). The subjects consisted of 26 females (67%) and 13 males (33%). The patients had a mean age of 52.6 years old (range 26-85).

All of the aberrant vessels had a retroesophageal course. In 10 (25.6%) cases the aberrant vessel was rising from a pouch like aneurysmal dilatation of the aorta, which was considered to be a Kommerell's diverticulum (Fig. 4). The width of the anomalous vessels was measured at approximately 1 cm after its origin from the aorta. In the cases of coexisting diverticulum, the measurement was made at approximately 1 cm after the pouch. The vessels width's range was 0.7 cm to 2.5 cm (mean: 1.67 cm). Moreover, in 22 cases (56.4%) we recognized abnormalities of the vessels' wall, consisting mostly of calcified atheromatous plaques and rarely of soft plaques, without obvious ulceration (Fig. 5). Finally, in 12 cases (30.8%), we identified other coexisting anatomic variations of the aortic arch, consisted exclusively by the presence of a bicarotid trunk (common origin of the common carotid arteries) (Fig. 6).

Interestingly, only 7 out of 39 (17.9%) cases were stated in the report as an incidental finding.

Images for this section:
Fig. 2: 54 year-old female with known breast cancer was referred for a contrast chest CT, for staging. A, B, C, D, Curved MPR images showing and aortic arch with four branches, ARSA appears with a normal width and follows a retroesophageal course.

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Fig. 3: 59 year-old female with known colon cancer was referred for a contrast chest CT, for staging. Right-sided aortic arch with aberrant left subclavian artery. A, D, Axial planes. B, E, Sagittal planes C, Curved MPR image, demonstrating a bulge on the root of right-sided aortic arch representing a Kommerell's diverticulum.

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Fig. 4: 79 year-old female, underwent for contrast chest CT for possible metastatic disease. Presence of Kommerell's diverticulum along with a bicarotid trunk. A, Axial plane. B, 3D-MIP image. C, D, E, F, VR images.

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Fig. 6: 61 year-old male was referred for further investigation of persistent cough. A, D, Axial planes: ectatic ARSA with small atheromatous plaques. B, C, Curved MPR images demonstrating the coexistence of ARSA and bicarotid trunk.

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Fig. 5: 55 year-old male with known colon cancer was referred for a contrast chest CT, for staging. Small calcified atheromatous plaques can be seen in the proximal part of ARSA. Atherosclerotic lesions can be seen in all vascular structures. A, Axial plane. B, C, D, Curved MPR images.

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Conclusion

Abnormalities of the aortic arch and thoracic aorta are not uncommon. Recent developments in MDCT techniques provide a high diagnostic image quality in the demonstration of anomalous vascular structures. The most common embryologic abnormality of the aortic arch is an aberrant right subclavian artery [2]. In Europe, the prevalence in the known literature is rather low, with a 0.11-0.38% count in the population. [21-23] It should be noted that, the given literature concerns detecting ARSA with other imaging modalities such as endoscopic ultrasonography, invasive angiographies and endoscopy. The occurrence of ARSA in our case series was higher, with a 0.59% count.

In our opinion, MDCT is a more reliable tool for diagnosing vascular abnormalities. Even in the cases where there was no injection of contrast agent, the aortic arch and its branches could be clearly identified. On the other hand, a larger number of patients undergo chest MDCT, for numerous routine examinations. For this reason, we believe that MDCT can detect the real incidence of ARSA.

It has been reported that aberrant right subclavian artery has a female predilection [2,19]. The gender distribution in our study was 67% females and 33% males, which is similar to the known literature. However, our small sample size of patients with ARSA constitutes a great limitation in making such a demographic analysis.

Kommerell's diverticulum represents a persisting right aortic arch and can be seen in a respectable number of individuals with ARSA. A wide range of percentages has been suggested in the known literature, ranging from 12.8% to 60% [4,14,24]. In our case series, we found a 25.6% count of Kommerell's diverticulum. It should be noted that no clear distinction exists between the ARSA aneurysm and Kommerell's diverticulum, especially in older patients where the vessels become tortuous and ectatic. In our experience, Kommerell's diverticulum is a dilatation at the root of the aortic arch, whereas the subclavian artery continues with a normal vessel width. On the other hand, an ARSA aneurysm extents to a greater length of the vessel.

In our case series, the anomalies of the ARSA wall consisted mostly of calcified atheromatous plaques and in a few cases of soft plaques, but with no obvious ulceration. Nevertheless, we didn't recognize any correlation between the existence of ARSA and the development of atherosclerosis. Almost all of the patients with such lesions had diffuse atherosclerosis in various vessels.

According to the Adachi Williams Classification [25] there are three main types of aortic arch structural configurations. In Type A, which is found in 80% of the individuals, there can be found three aortic arch branches (the brachiocephalic trunk, the left common
carotid and left subclavian artery). In Type B, which is found in 11% of the individuals, a bovine arch is found (the brachiocephalic trunk shares a common origin with the left common carotid artery). The next most common type, Adachi Type C, has a vertebral artery originating proximal to the left subclavian artery as a fourth branch of the aortic arch. Another smaller group of Adachi Williams Classification consists of individuals with an aberrant subclavian artery. Four basic morphologies can be recognized within the group: Types G, CG, H and V [3,25,26]. Type G is the type where a left-sided aortic arch has four branches including an ARSA. Type CG refers to a common origin of the left vertebral artery and the left subclavian artery. In Type H, there is a coexistence of ARSA with a bicarotid trunk and finally Type N describes a right-sided aortic arch with an aberrant left subclavian artery. In our case series, we had a high percentage of individuals with a bicarotid trunk, with a 30.8% count and only one case of right-sided aortic arch with ALSA. Bicarotid trunk is considered to be the most common vascular anomaly coexisting with an ARSA [4]. No cases of ARSA with anomalous origin of vertebral arteries were seen (these cases are anyhow considered rare [27,28]).

The majority of ARSA cases are usually discovered incidentally. [21] According to the literature, the symptoms of ARSA are present only in 7-10% of adult patients [4,29], causing in some cases considerable dysphagia. In our case series, all of the patients asked, had no symptoms concerning this anatomic variation. Therefore, ARSA was considered in all cases an incidental finding. There have been some articles suggesting that dysphagia lusoria may result after the development of atherosclerosis and dilatation due to aneurysm [30,31]. Nevertheless, the presence of ARSA may become a serious or even fatal complication during correction of a dissecting aneurysm of the descending aorta. Furthermore, the anomaly is associated with an abnormal course of the right recurrent laryngeal nerve, which instead of going under the right subclavian artery, ends directly to the larynx. This may put the nerve in risk during neck surgery, especially during thyroidectomy. The surgical or the endovascular repair of ARSA is controversial [11,32]. It is mostly recommended in patients with enlarged Kommerell's diverticulum or ARSA aneurysm due to high risk of rupture, in cases of children with developing respiratory problems, and adults with serious dysphagia [1,14,33,34]. Doubtless, the presence of an ARSA in an asymptomatic patient is significant to be known, so that serious complications in procedures such as endotracheal intubation, tracheotomy and cardiovascular and thyroid surgical procedures can be avoided [5,19,35-38]. It is clear from the above, that the presence of ARSA on imaging studies should be evaluated and reported.

Familiarity with the depiction and evaluation of aberrant subclavian arteries is crucial for correct diagnosis, prevention of possible complications and future preprocedural planning.

Personal information


