Review of the normal anatomy and congenital anomalies of the aortic arch in a 64-row MDTC

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Learning objectives

A comprehensive knowledge of the normal anatomy, anatomic variations and congenital anomalies of the aortic arch is important because they are very common in the general population.

The purpose of this pictorial essay is the description of the normal anatomy, variations and anomalies of the aortic arch in a multidetector 64 row CT.
Background

Congenital anomalies and anatomical variants of the aortic arch can be incidentally detected in adults from imaging studies performed for other indications. Congenital anomalies of the aortic arch have clinical importance as they may be associated with vascular rings or other congenital cardiovascular diseases. Variations can be of relevance when performing angiography or endovascular interventions.

Multidetector computed tomography (MDCT) angiography plays an important role in the noninvasive assessment of these anomalies because it is able to display the detailed anatomy of vascular structures and the spatial relationships with adjacent organs. This is the greatest advantage of the use of MDCT angiography in comparison to other imaging modalities.

To evaluate all possible anatomical variants and anomalies of the aortic arch we performed a retrospective analysis of 500 patients who underwent a MDCT thoracic angiography in our hospital between January and December 2010 without previous knowledge of the patient history. Anatomical variants were found in 99 patients (20%) and congenital anomalies in 21 patients (4%).

In this pictorial essay we illustrate 64-slice MDCT angiography appearances of the normal, anatomical variants and congenital anomalies of the aortic arch.
1. Normal anatomy

The most common aortic arch branching pattern consists of three great vessels originating from the aortic arch (Fig. 1):

- The first branch is the innominate artery that gives rise to the right subclavian and right carotid arteries.
- The second branch is the left common carotid artery.
- The last branch is the left subclavian artery.

2. Anatomical variants

- **Bovine aortic arch**: it's the most common variant which is seen in 25-30% of the population. It occurs when the left common carotid artery has a common origin with the innominate artery (Fig. 2). We found this anatomical variant in 52 patients (10%).

- **Origin of the left common carotid artery from the innominate artery**: this variant is similar to the bovine arch, except that the left common carotid artery originates from the innominate artery more distally rather than as a common trunk (Fig. 3) and occurs in about 7% of the general population. We found this variant in 18 patients (3.6%).

- **Aberrant left vertebral artery**: although the left vertebral artery originates from the subclavian artery in most patients, it arises directly from the aortic arch in 5-6% of the population, this can be an important variant in patients undergoing cerebral angiography. There are four vessels that originate from the arch (Fig. 4). We found a left aberrant vertebral artery in 29 patients (5.7%).

3. Congenital anomalies

Persistence of a segment of arch that should have regressed or regression of a segment that should have normally persisted explains the development of most arch anomalies. Congenital anomalies of the aorta and its branch vessels are found in 0.5% to 3% of the population.
**Left aortic arch with aberrant right subclavian artery**: this is the most common congenital abnormality of the aortic arch vessels occurring in 0.5%-2% of the general population. The anomalous subclavian artery is the last main branch artery of the aortic arch, crossing the mediastinum obliquely behind the trachea and esophagus to reach the right arm (Fig. 5). Often, there is dilatation of the origin of the aberrant vessel, termed a diverticulum of Kommerell. This type of anomaly is usually asymptomatic and is found incidentally on imaging examinations, we found it in 18 patients (3.6%).

**Right aortic arch anomalies**: a right aortic arch occurs in approximately 0.05% to 0.2% of the population. There are two main types of right arch: the right arch with aberrant left subclavian artery and the right arch with mirror image branching.

- **Right arch with aberrant subclavian artery**: the branching sequence is left common carotid, right common carotid, right subclavian and anomalous left subclavian arteries. The aberrant subclavian artery often arises from an associated diverticulum of Kommerell (Fig. 6), representing the distal remnant of the left arch. The descending aorta is more commonly right-sided. Approximately 10% of patients have associated heart disease. We found it in one patient.

- **Right arch with mirror imaging**: is the mirror image of the normal left aortic arch. The great arteries originate from the right arch in the following order: left innominate, right carotid and right subclavian arteries (Fig. 7). The descending aorta usually descends on the right. We found it in one patient.

**Double aortic arch**: a double arch occurs in 0.05% to 3% of the population and it is characterized by the presence of two aortic arches arising from a single ascending aorta. Each arch gives rise to its own subclavian and carotid arteries before uniting to form a single descending aorta, which is usually left-sided. It is the most common cause of a symptomatic vascular ring; the trachea and esophagus are encircled and compressed by the two arches.

Most patients are asymptomatic, and the diagnosis is an incidental finding on imaging examinations. Clinical symptoms include dysphagia from the retroesophageal course of the aorta or from a vascular ring and a pulsatile neck mass.

In some cases, segmental atresia of one arch, usually the left, occurs with fibrous continuity of the interrupted segment. In this type, an aortic diverticulum may be present at upper descending aorta which is more often right-sided.

We found a double aortic arch in one patient.
Fig. 1a sagittal and 1b axial MPR image shows the normal aortic arch and supra-aortic vessels: innominate artery (1), left common carotid artery (2), and left subclavian artery (3) consecutively.

Fig. 1

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Fig. 2

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Origin of the left common carotid artery from the innominate artery

Fig. 3: 3D volume-rendered MDCT shows the left common carotid artery that originates from the innominate artery.

Fig. 3

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Fig. 4a: 3D volume-rendered MDCT shows the aortic arch and supra-aortic vessels: brachiocephalic artery (1), left common carotid artery (2), aberrant left vertebral artery (3) and left subclavian artery (4) consecutively.

Fig. 4b: Axial MIP CT cranial to aortic arch shows the four vessels that arise from the aortic arch.

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Fig. 5a: axial MIP MDCT image shows left aortic arch with an aberrant right subclavian artery coursing posterior to the esophagus and trachea.

Fig. 5b: coronal MIP MDCT shows the origin of the aberrant right subclavian artery arising from the posterior arch.
Right aortic arch with aberrant subclavian artery

Fig. 6a axial MIP and 6b coronal MIP thick slab showing right aortic arch with aberrant left subclavian artery arising from an associated diverticulum of Kommerell (arrow) crossing the mediastinum posterior to the trachea.
Fig. 7a and 7b axial MIP MDCT showing right aortic arch and supra-aortic vessels: left innominate artery (1), right common carotid artery (2) and right subclavian artery (3).
Conclusion

Variations of the aortic arch and its branching are frequently found, mostly as an incidental finding during routine diagnostic scanning.

MDCT angiography is a good method to study the aortic arch and its associated branching pattern.
References


