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Anatomical Variation in Arch of Aorta: A Case Report

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ABSTRACT

Background: *The aortic arch lies wholly in the superior mediastinum. It begins when the ascending aorta emerges from the pericardial sac at the upper border of second right sternocostal joint and ends at vertebral level T IV/V continuing as the descending thoracic aorta. Three branches arise from the convex side of the arch. However variation in the branching pattern occurs due to developmental changes in the pharyngeal arch system during embryonic period. The knowledge of these variations is important for radiological diagnosis and cardio-thoracic surgeries in this region.*

Methods: *A variation in the aortic arch was noticed during routine undergraduate dissection. The cadaver was a female aged 70 yrs donated by next of kin after her natural death due to cardiac arrest.*

Results: *The arch showed 3 branches from left to right, first a common trunk (CT) giving rise to brachiocephalic trunk (BT) and left common carotid artery (LCCA), second branch of left vertebral artery (LVA) and third branch of left subclavian artery (LSA). The brachiocephalic trunk was also observed to be on left of midline and crossing the trachea from left to right.*

Discussion: *This variation must have resulted from failure of bifurcation of aortic sac leading to LCCA joining the aortic sac resulting in common trunk giving rise to BT and LCCA. The shift of the BT to the left of midline may be a compensatory mechanism to balance the abnormal origin. There could have been increased absorption of embryonic tissue between origin of LSA from aortic arch and origin of LVA resulting in LVA arising directly from the arch.*

Conclusion: *These variation patterns must be known to surgeon to avoid complications during aortic instrumentation and minimizing risks due to iatrogenic damages during cardiothoracic surgeries.*

Keywords: *Aortic arch, Brachiocephalic trunk, Left common carotid artery, Left vertebral artery, Left subclavian artery*

Introduction

The cardiovascular system is the first system to function in the embryo. The primordial heart and the vascular system appear as early as middle of the third week of embryogenesis. The arch of aorta develops from pharyngeal arch arteries in close relationship with the aortic sac. Since many changes are involved in transformation of embryonic pharyngeal arch arterial system into the adult pattern many variants occur either due to persistence or absorption of parts of this pharyngeal arch arterial system.[1]

The aortic arch is a superior mediastinum structure that continues from the ascending aorta beyond the pericardial sac at the level of upper border of second right sternocostal joint. It runs upwards, backwards and then to the left and ends by continuing as the descending aorta at vertebral level T IV/V.[2] The aortic arch curves around the hilum of the left lung and its shadow is identified as the "aortic knuckle" in Postero-Anterior view of chest radiograph. Three branches arise from the superior aspect of the arch all crossed by the left brachiocephalic vein anteriorly. From right to left they are brachiocephalic trunk (BT), left common carotid artery (LCCA) and left subclavian artery (LSA). The brachiocephalic trunk is the largest of the three branches and divides into right common carotid artery (RCCA) and right subclavian artery (RSA). This classical branching pattern is however seen only in 65% of the population as indicated by previous studies in this region while 35% show variations in the branching pattern and coarctation of aorta.[3] These variations may range from differences in the distance between the origins of the branches to the number of branches. They result due to developmental changes in the pharyngeal arch system during embryonic period either by persistence of parts of the pharyngeal arch arteries that should disappear or by absorption and disappearance of parts that should normally persist.

The aortic arch variations has been associated with chromosome 22q11 deletion along with other congenital cardiac anomalies like Tetralogy of Fallot, Conoventricular VSDs and interrupted aortic arch.[4,5] The aortic arch variations attribute to less than 1% of congenital cardiovascular defects but the information on the wide spectrum of anatomic variants of arch of aorta is vital for cardiothoracic surgeons, radiologists and vascular interventionists to minimize iatrogenic risks while performing on arteries in this region. We report a variant aortic arch branching pattern in a cadaver showing origin of 3 branches from aortic arch in right to left sequence of a common trunk giving rise to Brachiocephalic artery and Left common carotid artery, followed by origin of Left Vertebral artery and Left subclavian artery respectively.

Case Report

During routine undergraduate dissection of the thoracic region a variation was noticed in the aortic arch of a 70 yrs old female cadaver. The branching pattern of the aortic arch showed 3 branches from right to left, first a common trunk (CT) giving rise to brachiocephalic trunk (BT) and left common carotid artery (LCCA), second was the origin of left vertebral artery (LVA) and third in sequence was origin of left subclavian artery (LSA). The brachiocephalic trunk was also observed to be on left of midline and crossing the trachea from left to right (Fig 1).

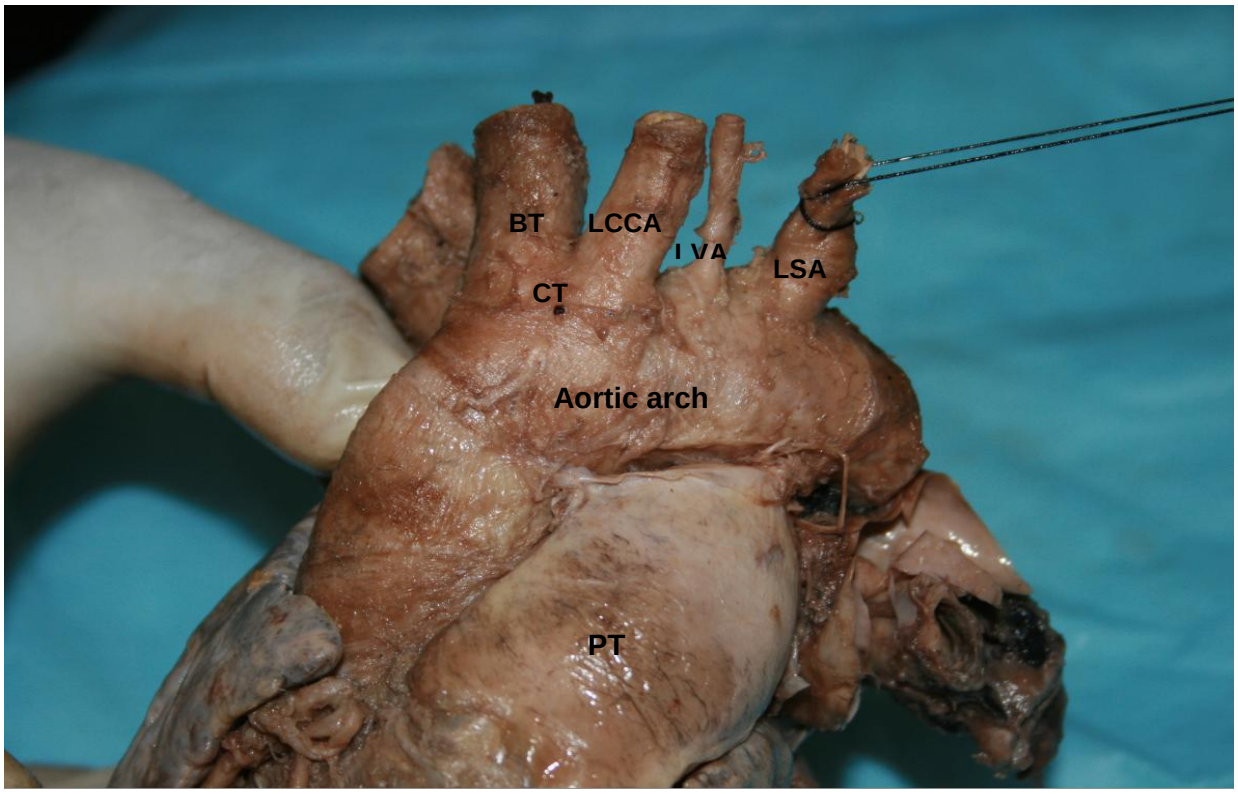

FIG 1: Aortic arch gives 3 branches from right to left: common trunk (CT), left vertebral artery (LVA) and left subclavian artery (LSA). The common trunk branches into brachiocephalic trunk (BT) and Left common carotid artery **(**LCCA**)** PT: Pulmonary Trunk

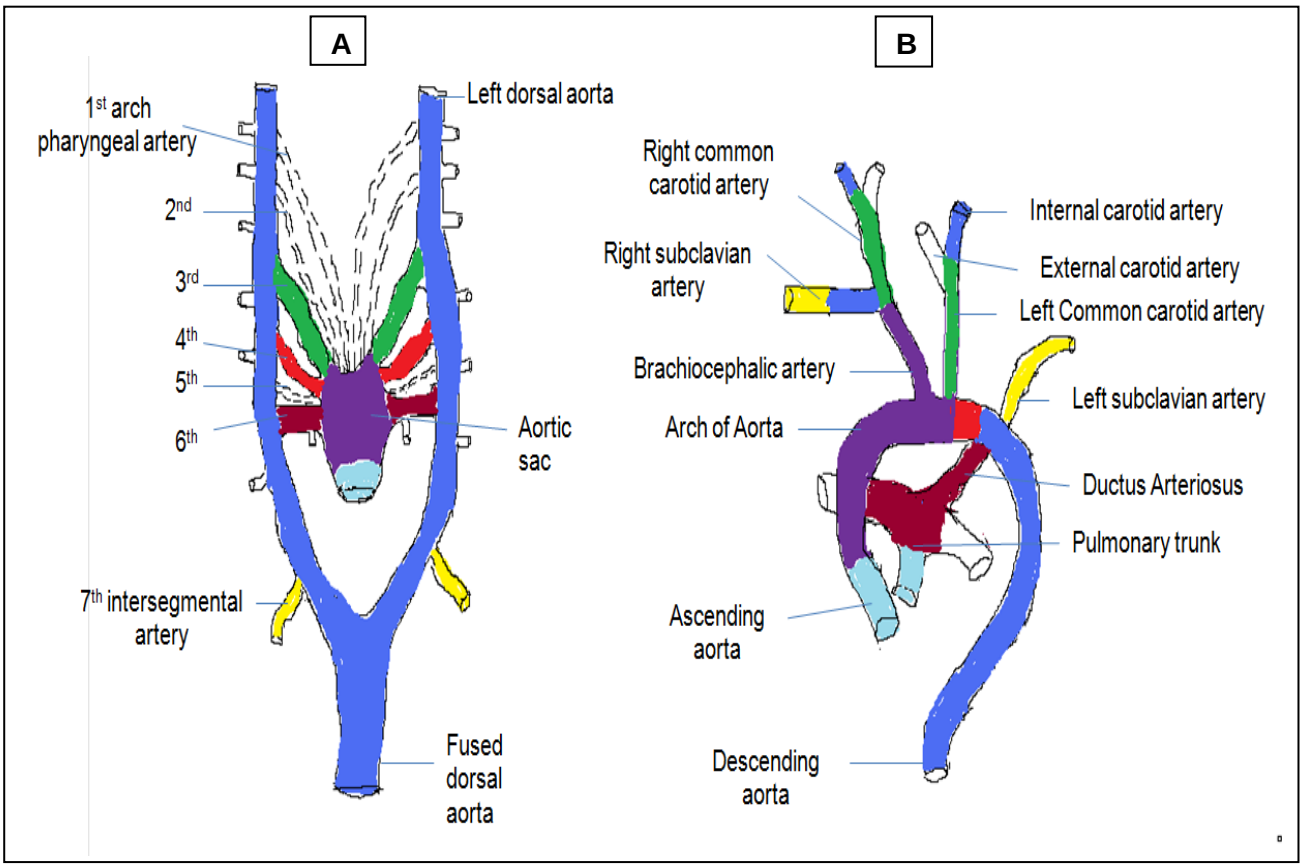

FIG 2: A. Pharyngeal arch arteries at 6 wks of development

B. Derivatives of Pharyngeal arch arteries at 8 weeks of development

Discussion

Right and left primitive aorta are the first arteries to appear in the embryo and are continuous with the two endocardial heart tubes. Each primitive aorta consists of a portion lying ventral to the foregut called Ventral Aorta in the first pharyngeal arch and a dorsal portion lying dorsal to the gut called Dorsal Aorta. After the fusion of the two endocardial tubes the two ventral aorta partially fuse to form the Aortic Sac and the unused part remain as right and left horns of the sac. Successive arterial arches appear in the second to sixth pharyngeal arches each being connected ventrally to the right and left horn of aortic sac and dorsally to the dorsal aorta. Though six pairs of pharyngeal arch arteries develop they are not present at the same time; by the time sixth pair develops the first two pairs disappear.[1]

The arch of aorta is formed from left fourth pharyngeal arch artery with contribution from aortic sac in its proximal part and from dorsal aorta in its distal part. The classical pattern of aortic arch branches from right to left form a sequence of brachiocephalic artery, left common carotid and left subclavian artery. The right horn of the aortic sac forms the brachiocephalic artery, the proximal part of third left pharyngeal arch artery forms the left common carotid artery and the left 7th intersegmental artery forms the left subclavian artery (Fig 2).[6]

In our case the first branch in right to left sequence was a common trunk giving rise to brachiocephalic artery and left common carotid artery. When the aortic sac fails to bifurcate into right and left horns, then the left common carotid artery will arise directly from aortic sac resulting in a common trunk from the aortic arch giving rise to brachiocephalic artery and left common carotid artery. This is one of the most common variation of the aortic arch with an incidence of 4.8% in Indian population.[7] Previous studies have suggested a higher incidence in black population. It is also called the bovine aortic arch however it is a misnomer as this pattern bears no resemblance to aortic arch branching seen in cattle where a single great vessel originates from the aortic arch. This large brachiocephalic trunk gives rise to both subclavian and carotid arteries.[8] Individuals are generally asymptomatic with this variation and it seldom adds to iatrogenic risk while operating in this area however stenosis or occlusion of the common trunk may have severe ischemic consequences.[9]

Variant origin of the left vertebral artery is not unusual and has been seen to originate from aortic arch in 2.4-5.8% of the cases.[10] The most frequent location is between the left common carotid and left subclavian artery. The possible cause for the origin of the left vertebral artery from the aortic arch is the persistence of the dorsal intersegmental arteries cranial to the 7th intersegmental artery, which is the typical site of anastomosis.[11] In the present study the left sixth segmental artery might have persisted as the first part of the left vertebral artery and segment of dorsal aorta must have failed to disappear resulting in direct origin of the LVA from aortic arch. Anomalous origin of vertebral artery causes alteration of cerebral hemodynamic.[12] The vertebral artery of aortic arch origin may show higher stress possibly due to direct arterial pulsatile flow in comparison to origin from subclavian artery where the direct flow gets dampened. Komiyama et al noted a higher incidence of arterial dissection in individuals with left vertebral artery of aortic origin.[13] They attributed the pathology to enhanced hemodynamic stress to vertebral artery from pulsations of the aorta.

Conclusion

Anatomic variations in the branching pattern of aortic arch are quite common. Although the individuals are asymptomatic vertebral artery originating directly from arch of aorta may be prone to dissecting aneurysm. These variation patterns must be known to surgeon to avoid complications during aortic instrumentation and minimizing risks due to iatrogenic damages during cardiothoracic surgeries. This case study will

provide additional data on incidence of aortic arch variations.

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