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VARIATIONS OF AORTIC ARCH BRANCHES IN FULL TERM FOETUSES

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ABSTRACT

The aortic arch is a challenging site for endovascular repair. The relationship of the arch of the aorta and its branches are embryologically determined and are found to be highly variable. This makes the arch of the aorta more vulnerable to injury during the surgical manipulation of the heart, lungs and the great vessels. The arch anomalies produce tracheo-oesophageal constriction, which accounts for 1%-2% of all congenital heart defects. This study would provide an anatomical basis to assist surgeons in performing safe vascular surgery involving the aortic arch, and its branches in cases in which stenting is used as an adjunct to balloon angioplasty for the treatment of both stenotic and occlusive lesions of the supra aortic trunks.

Key words: aortic arch, brachiocephalic trunk, right subclavian artery, left common carotid artery, left subclavian artery, vertebral artery.

INTRODUCTION

The standard type of branching of the arch of aorta from right to left is brachiocephalic trunk (with right common carotid and right subclavian as its branches), left common carotid (LCC) artery and left subclavian artery. There are plenty of variations in the origin and number of branches from the aortic arch. Most of the anomalies of the aortic arch and its branches arise as a result of altered development of primitive aortic arch associated with "migration" and "merging" of the branch arches during the early gestation period. The variations of branches arising from aortic arches have been documented by several authors in different races.[1-10]

A common trunk between the brachiocephalic trunk and left common carotid artery, a variant termed as "bovine aortic arch" has been described in literature.[11,12] It has been hypothesized that anomalous origins and the distribution of the large aortic arch vessels can cause changes in cerebral hemodynamics that may lead to cerebral abnormalities.[13] The true value of detecting anomalous origins is the diagnostic gain prior to the surgery of supra aortic arteries. For cases in which the vertebral artery originates from the carotid artery or its branches, the ligation of the common carotid artery may cause a compromise of the posterior cranial fossa blood supply. [14] If the detection of a vertebral artery in the normal position is not possible, the presence of such a variant must be taken into consideration. If a right retro esophageal subclavian artery is diagnosed during aortic arch repair, corrective surgery should be considered. Otherwise the anomalous right subclavian artery may become tortuous resulting in esophageal or tracheal compression causing dysphagia lusoria. Intensive care patients should be screened before long-term placement of nasogastric tube, in order to avoid fistulization and fatal hemorrhage. Aortic arch anomalies have been described as being associated with chromosome 22q11 deletion.[15] While performing endovascular surgery, the femoral artery is punctured and a catheter is advanced towards the aortic arch as well as the major branches originating from the aortic arch through the abdominal aorta. In the presence of anomalous arch vessels, it is difficult to perform the procedure. Hence, a detailed knowledge of anomalous origin of supra aortic arteries will assist surgeons in performing safe and effective endovascular surgeries.

MATERIALS AND METHODS

This study was performed on one hundred and thirty human foetuses. They were obtained from the Department of Anatomy, MIMS and local hospitals of Vizianagaram.

In each foetus, the thoracic cavity was opened, the pericardium was removed, the left brachiocephalic vein was cut and the aortic arch and its branches were traced to find out whether the branching pattern was normal or abnormal.

OBSERVATIONS

In the present study, the aorta commenced at the upper

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part of the left ventricle. After ascending for a short distance, it arched backwards and to the left, over the root of the left lung. Then, it descended on the left side of the thoracic part of the vertebral column. Most of the aortic arches showed the classical branching pattern of brachiocephalic trunk, left common carotid and left subclavian arteries (Illustration 1).

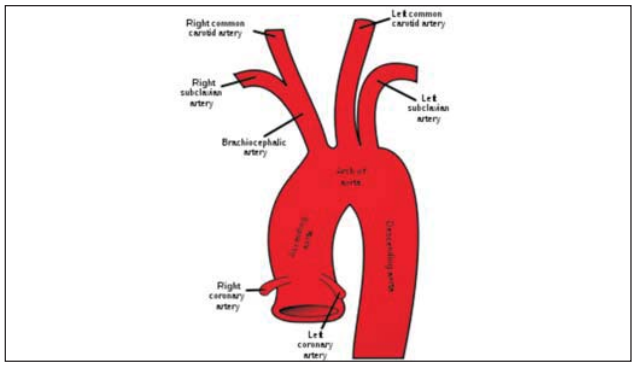
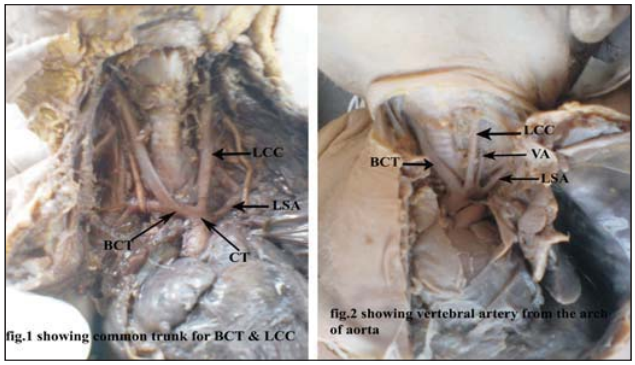


Illustration 1. Classical branching pattern of aortic arch.

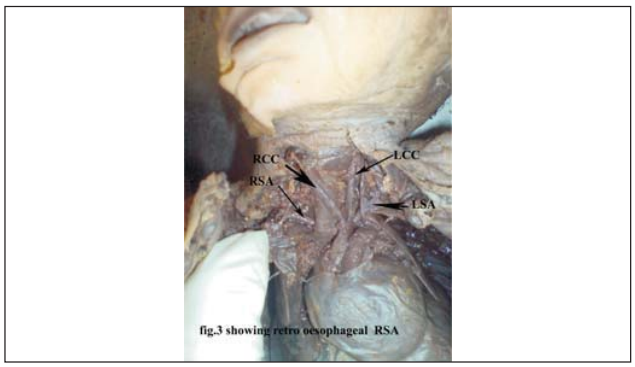
However, ten foetuses showed different arterial patterns.

Aortic arch in two specimens showed only two branches. First was common origin for brachiocephalic trunk and left common carotid artery, second was origin of left subclavian artery distal to the common trunk (fig.1).

In six specimens, there were four branches from the upper convex surface of arch of aorta. Left vertebral artery arose directly from the arch. This additional branch was located between the origins of left common carotid and left subclavian artery (fig.2).



In two specimens, the anomalous right subclavian artery was the last branch of the left aortic arch from the posterior aspect. It reached the right upper limb by crossing obliquely behind the oesophagus (fig.3) .



DISCUSSION

Detection of anomalous origin of the branches of the arch of aorta is of diagnostic value before vascular surgeries of supraaortic arteries, as they are likely to occur as a result of variations in the extent of the fusion and absorption of some of the aortic arches into the aortic sac during the embryonic period. Based on a study of 1000 cadavers Liechty et al described 15 types of variant aortic arches[16] (Illustration. 2).

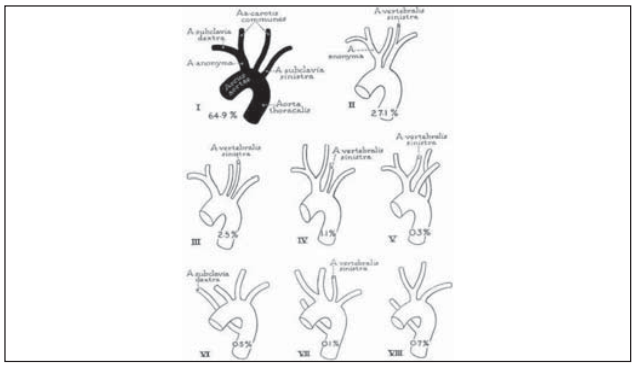


Illustration. 2. Different types of variant aortic arches.

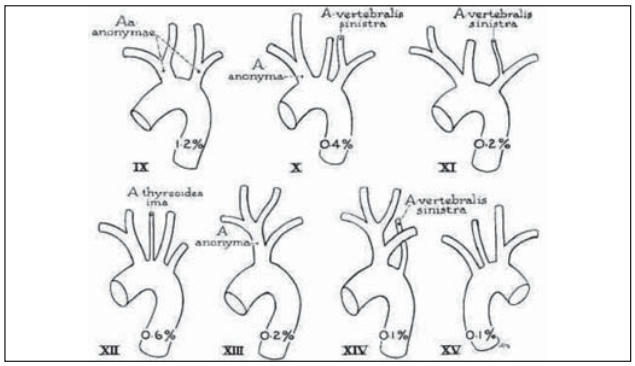


Illustration. 2. Different types of variant aortic arches.

According to Adachi William's Classification , in about 80% of individuals, three branches arise from the aortic arch: the brachiocephalic trunk, the left subclavian artery, and the left common carotid artery, described as Type A[17,18].

11% of individuals have an Adachi type B pattern, which consists of a common trunk for the left common carotid and the brachiocephalic artery and therefore has only two aortic arch branches.

The next most common type, Adachi type C, has a vertebral artery originating proximal to the left subclavian artery as a 4th branch of the aortic arch.

The origin of the retro esophageal right subclavian artery as the last branch occurs in 0.4 - 2% of individuals.

The right aberrant subclavian artery, the arteria lusoria, arises on the left side of the midline as the last branch of the left aortic arch and crosses the mediastinum obliquely from left to right, indenting the esophagus posteriorly. This pattern corresponds to type G of the Adachi-Wiliams-Nakagawa-Takemura classification of aortic arch branching. Its mirror image is the left aberrant subclavian artery, which was reported by Adachi as a type M anomaly, originating on the right side as the last branch of the arch[18].

The Adachi and Williams Classification recognize four basic morphologies within this group: Types G, CG, H, and N (Illustration 3).

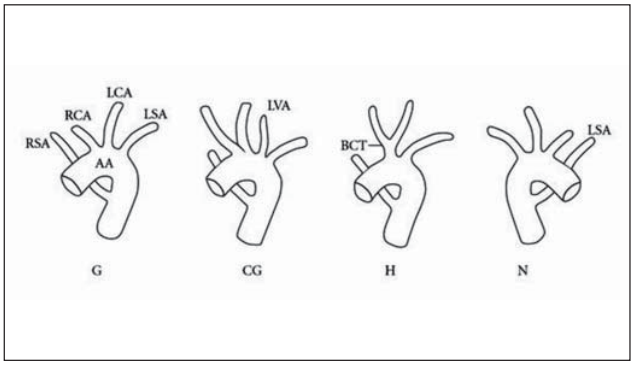


Illustration 3: Retro esophageal subclavian anomalies. Note the rare Type H, with the bicarotid trunk.

In the present study, 92% of the specimens showed the three branches from the arch as in Adachi type A classification as compared with 64.9% as reported by Liechty et al., 65% by Anson , 86% by Wright, and 94.3% by Martia L.Nelson et al.[16, 19, 20, 21]

Liechty et al. and Anson M., reported the common origin for brachiocephalic trunk and left common carotid in 27% of specimens ; Wright recorded the same in 7% of specimens and Martia L.Nelson et al observed this type of variation in 1.03% of specimens [16,19,21,22] but in our study it was observed in 1.5% of specimen.

Hollinshead stated that in 5% of the specimens the left vertebral artery arose directly from the aortic arch [22] while Moss and Adams stated that the incidence of this variation is 10%[23]. In a recent analysis on 1000 aortic arches 2.5% of the specimens had this variation[24]. In the present study it is reported as 4.6%.

Bergman et.al stated that right subclavian may arise directly from the arch of aorta as the first, second, third, fourth or fifth branch[11]. Holzapfel studied 133 autopsy cases of anomalous right subclavian artery arising as the last branch of the aortic arch and he reported that, in 80% of cases the right subclavian artery passes behind the oesophagus , in 15% of cases between the trachea and oesophagus and in front of trachea in 5% of cases[25].

Liechty et.al reported this variant artery in 0.5% of specimens[16]. Moss and Adams reported an incidence of 0.9%[23], McDonald and Anson reported anomalous right subclavian artery with retroesophageal course in 2.5% cases[26], and in the present study it is 1.5% .

Embryological basis of variations of aortic arch

The variations in the arch of aorta are due to unusual absorptions of arterial arches.[27]

In the common trunk variety, proximal part of the third aortic arch normally gets extended and absorbed into the left horn of aortic sac. If it gets absorbed into the right horn of the aortic sac, the branching pattern of the brachiocephalic trunk is abnormal.

The left subclavian artery normally develops from left seventh intersegmental artery and the first part of the vertebral artery develops from the dorsal ramus of the seventh intersegmental artery (proximal to post costal anastomosis). In the present case the vertebral artery developed from the persistent sixth cervical intersegmental artery.

The proximal part of right subclavian artery originates from the right 4th aortic arch artery, and the distal part from the right dorsal and right seventh intersegmental arteries.

In the present study, the right 4th aortic arch artery and/or the right dorsal aorta have involuted cranial to the seventh intersegmental artery; the connection between the aortic sac and the right subclavian artery has disappeared. The right subclavian artery has developed from the right 7th intersegmental artery and the distal segment of the right dorsal aorta. Differential growth has shifted the origin cranially and so that it lies close to the origin of the left subclavian artery. Since it has originated dorsally it has a retro oesophageal course.

CONCLUSION

Awareness of vascular variations of aortic arch is very important to surgeons for appropriate invasive techniques in order to achieve desired objectives and to avoid major complications during vascular surgery. The anatomic and morphologic variation of the arch of aorta and its branches is imperative in diagnostic and surgical procedures in the thorax and neck.

ABBREVIATIONS

AA	-	AORTIC ARCH
BCT	-	BRACHIOCEPHALIC TRUNK
LCC	-	LEFT COMMON CAROTID
LSA	-	LEFT SUBCLAVIAN ARTERY
RCC	-	RIGHT COMMON CAROTID
RSA	-	RIGHT SUBCLAVIAN ARTERY
VA	-	VERTEBRAL ARTERY

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