

AORTIC ARCH ARTERIES IN MAN AND DOMESTIC ANIMALS: A COMPARATIVE STUDY

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ABSTRACT

Background: The arch of aorta in man has three main branches that supply the region of head and neck and upper limbs. The aorta beginning at the base of left ventricle, curves to the right and ascends upto the level of upper border of second right sternocostal joint. In animals the aorta is the main systemic arterial trunk and ascends to curve sharply backwards forming the arch to reach the eighth or ninth thoracic vertebra. The branches arising from the arch of aorta in man supply the head and neck. This study was undertaken to compare the arrangement of branches arising from the aorta considering the differences in posture and locomotion between the animals and man.

Materials and Methods: The specimens of the human heart were obtained from the regular dissection done on the cadavers for teaching purpose in the department of Anatomy, P.E.S Institute of medical sciences and research. The heart specimens of the domestic animals were obtained from the local butcher who had legal permission to sacrifice the animals for sale. The heart was removed carefully along with the arch and its branches. 10% formalin was used to transport and preserve the specimens in glass jars.

Results: Only one large vessel was seen arising from the convexity of the arch called the Common brachiocephalic trunk (CBCT) in domestic animals. The brachiocephalic trunk arises from the aortic arch and branches cranially. It provides the blood supply for the thoracic limbs, the neck, the head, and the ventral portion of the thorax. The brachiocephalic trunk gave both subclavian arteries and continued as the bicarotid trunk. The bicarotid trunk bifurcates in to left and right common carotid arteries. The left subclavian artery was found to lie at a lower level than the right in the animals in this study.

Conclusion: The arrangement of branches of aorta in man and animals is certainly different and this could be due to postural adaptations and haemodynamics specific to the species. This area has potential for research in trying to understand the evolution of cerebro-vascular flow and dominance.

KEY WORDS: Bovine Aortic Arch, Anterior Aorta, Posterior Aorta, Bicarotid Trunk, Human Aortic Arch, Common Brachiocephalic Trunk.

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BACKGROUND

The ascending aorta is 5 cm long and begins at the base of the left ventricle. It begins at the level of the lower border of the 3rd left costal cartilage. It ascends obliquely, curving to the right, behind the left of the sternum, to the level of upper border of the second left costal cartilage. Anterior to the ascending aorta in its lower part is the infundibulum and initial segment of the pulmonary trunk and posterior to it lie the right pulmonary artery, left atrium and principal bronchus.

The arch of aorta arises at the level of the upper border of second right sternocostal joint. It ends level with the sternal end of the second left costal cartilage. The summit of the arch is 2.5 cm below the superiosternal border. The arch of aorta gives three branches in humans, they are Brachiocephalic trunk, left Common Carotid, left Subclavian artery.

In the domestic mammals the aorta is the main systemic arterial trunk. It begins at the base of the left ventricle and is almost median at its origin.

Its first part, the ascending aorta (aorta ascends) passes upwards and forwards between the pulmonary artery on the left and right atrium on the right. It then curves sharply backward and dorsally inclines somewhat to the left, forming the arch of aorta (arcus aortae) and reaches the ventral surface of the spine at the eighth or ninth thoracic vertebrae. After passing backward along the ventral aspect of the bodies of the vertebrae and between the lungs, it traverses the hiatus aorticus and enters the abdominal cavity.

The branches arising from the arch of aorta in man supply the head and neck. Man's erect posture has a bearing on the number of branches and the direction of blood flow towards the structures in the head and neck. Whereas in animals with a posture that varies with their locomotion and feeding habits like reaching out to branches of trees or bowing low to feed from the ground or ruminating with head upwards the blood flow should definitely have a distinct arrangement of vessels that arise from the heart. Therefore the study was undertaken to observe and compare the differences in the branching pattern of the arch of aorta in man and other

domestic mammals. Only one large vessel arises from the convexity of the arch called the Common brachiocephalic trunk (CBCT). (fig 1,2,3)

The brachiocephalic trunk arises from the aortic arch and branches cranially. It provides the blood supply for the thoracic limbs, the neck, the head, and the ventral portion of the thorax.

The brachiocephalic trunk gives the left subclavian (left axillary) artery and the right subclavian (right axillary) artery and continues as bicarotid trunk. The bicarotid trunk bifurcates into left and right common carotid arteries. Thus it was observed that the common brachiocephalic trunk gives origin to the left subclavian artery (a.subclaviasinistra), Right subclavian artery (a.subclaviadextra), and the Bicarotid trunk (truncusbicaroticus).

The bicarotid trunk is a short common trunk, which arises from the common brachiocephalic trunk, extends cranially and branches into the left and right common carotid arteries. The results might help us understand the functions of the great vessels of the heart and their arrangement in relation to the evolutionary postural changes and adaptations to the environment.

MATERIALS AND METHODS

The specimens of the human heart were obtained from the regular dissection done on the cadavers for teaching purpose in the department of Anatomy, P.E.S Institute of medical sciences and research.

The heart specimens of the domestic animals were obtained from the local butcher who had legal permission to sacrifice the animals for sale.

The heart was removed carefully along with the arch and its branches.

10% formalin was used to transport and preserve the specimens in glass jars.

RESULTS

Arch Of Aorta In Domestic Mammals (Cow, Goat & Sheep): The aorta is the main systemic arterial trunk. (fig-1,2,3) In the cow there were two main divisions from the arch, which was very short. First part, the ascending aorta (aorta ascends) passes upwards and forwards between the pulmonary artery on the left and right atrium

on the right. It then curves sharply backward and dorsally inclines somewhat to the left, forming the arch of aorta (arcus aortae) and reaches the ventral surface of the spine at the eight or ninth thoracic vertebrae. After passing backward along the ventral aspect of the bodies of the vertebrae and between the lungs, it traverses the hiatus aorticus and enters the abdominal cavity.

Branches Of The Aortic Arch (Cow, Goat & Sheep): Only one large vessel arises from the convexity of the arch called the Common brachiocephalic trunk (CBCT). (fig 1,2,3)

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Fig. 1: Arch of aorta in the cow.

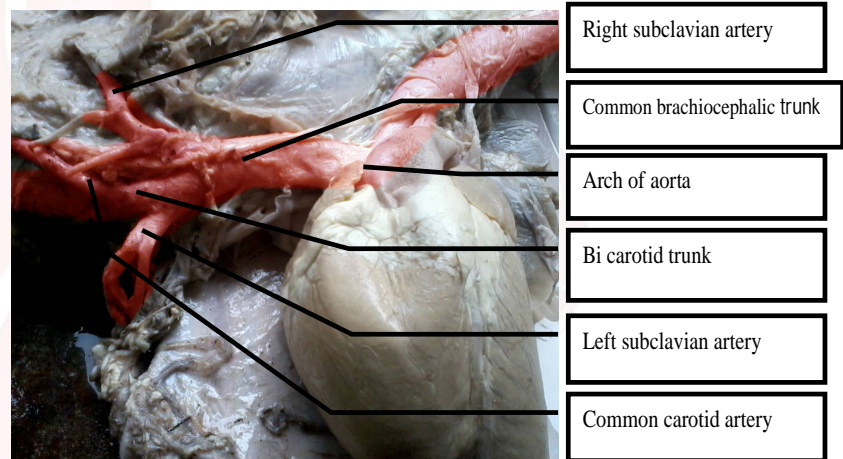


Fig. 2: Arch of aorta in goat.

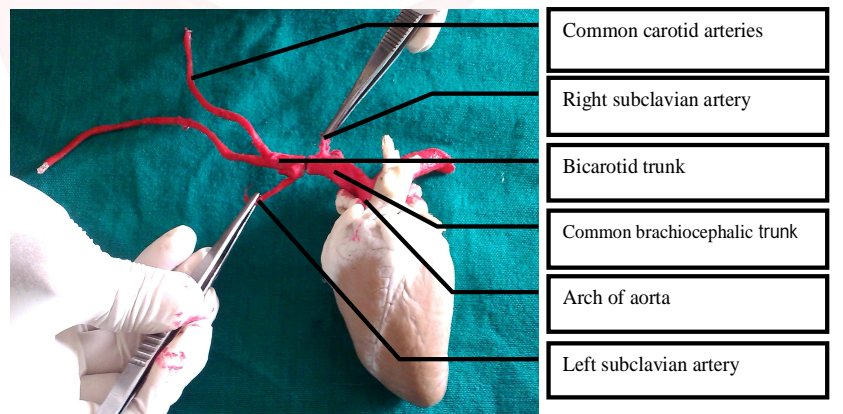
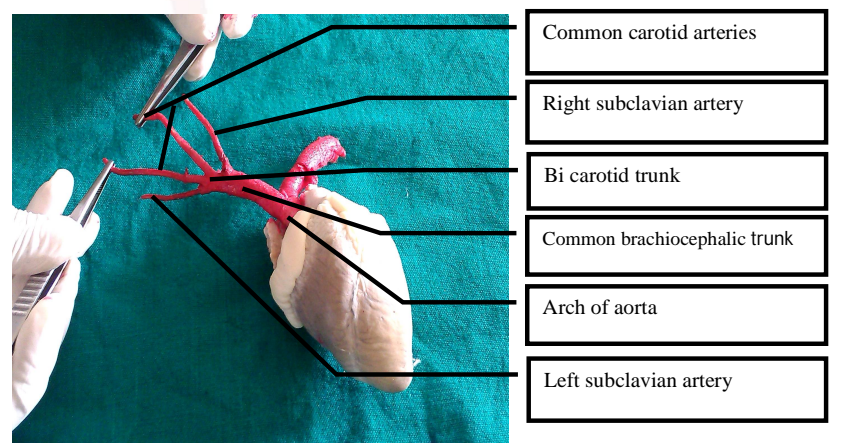


Fig. 3: Arch of aorta in sheep.



DISCUSSION

The aortic arch in man continues from the ascending aorta, the arch first ascends diagonally back and to the left over the anterior surface of the trachea, then back across its left side and finally descends to the left of the fourth thoracic vertebral body, continuing as the descending thoracic aorta [1].

The arch begins posterior to the right half of the sternal angle, it passes posteriorly with a slight inclination and convexity to the left, while arching through the lower half of the superior Mediastinum [2].

Septimussiession et al [3] in his book "The anatomy of domestic animals" 4th edition described that the aorta begins at the base of left ventricle, median in its origin. It passes between pulmonary artery on the left and right atrium on the right. It curves backwards and dorsally inclining to the left to form the arch of aorta and reaches the ventral surface of the spine at the eighth or ninth thoracic vertebra [3].

Ranjithkumarghosh et al [4] in the text book of primary veterinary anatomy, 2nd edition, the ascending aorta (aorta ascends) inclines backwards after forming a sharp curve, the aortic arch (arcus aortae). From the arch the vessel continues caudally along the dorsal aspect of the thoracic abdominal and pelvic cavities as descending aorta. At the level of the 4th rib it gives off a very large vessel called the brachiocephalic trunk. It is almost like a bifurcation from the main aorta and is referred to as the anterior aorta. It gives off the left axillary (subclavian) artery at the level of the 2nd intercostal space and the right axillary artery at the level of the first rib. It continues as the bicarotid trunk. This trunk gives off the right and left carotid arteries.

August Schummer et al [5,6] described the circulatory system of the domestic mammals. They have described that the aorta ascendens rises craniodorsally on the right side of the pulmonary trunk and continues into the arcus aortae. The arch reaches the vertebral column to the left of the midline at the level of the 5th, 6th, or 7th thoracic vertebra.

Dayce et al [7] in the text book of veterinary anatomy third edition, described that the first

part of aorta gives origin to the paired subclavian and paired common carotid arteries. These vessels take origin from a short, cranially directed brachiocephalic trunk in the larger species. In the dog and pig, the left subclavian artery remains distinct and takes a separate, more distal origin.

Alur Raghavan et al [8] has described the arterial system of animals in the angiology chapter of his book. The primary trunk of the arterial system has been called the aortic trunk or the common aorta. It divides after about 35 to 60 mm into two branches of unequal size, the anterior and posterior aortae. These are the terminal branches of the common aorta. The larger and posterior of the two is called the posterior aorta. The posterior aorta is divided into the thoracic and abdominal parts. The anterior aorta is the common brachiocephalic trunk.

K.F. Layton [9] argues that the use of the term bovine aortic arch is a misnomer and further clarifies that the aortic arch in ruminants does not resemble the arch in humans. In his study he has cited Shaw JA et al [10] who has described Carotid stenting in such a variant. According to the author when the left common carotid artery has a common origin with the origin of innominate artery it is described as a bovine aortic arch. A true bovine arch is one in which a single vessel originates from the aortic arch giving rise to right and left subclavian arteries and a common carotid trunk for the right and left carotid arteries. The author has cited Habel RE, Budras KD [11] in his study for describing the true bovine arch.

In a study on the patterns of aortic arch in American white and Negro stocks by De Garis CF et al [12] 25% of blacks were found to have a common origin for innominate artery and left common carotid artery. The author has also reported an incidence of 10% in blacks where the left common carotid artery arises from the Innominate artery. In all the specimens of the domestic animals like cow, goat, sheep it was observed that the arch was not as prominent as that in man. The arch was short and continuous with the vessel that was destined to supply the thorax and abdomen and was designated as the posterior aorta. The vessel to supply the head, neck, and limbs bifurcated from the aorta, and

turned cranially to reach the various structures. What is notable here is that unlike in man where we have three different branches, in the animals we have one large trunk which gives off branches to the head and neck. This common trunk has been named by some authors the anterior aorta. Another feature to note is that the subclavian arteries are given off by the brachiocephalic trunk to the right and left limbs. In man only the right subclavian artery arises from the brachiocephalic trunk and the left subclavian artery arises directly from the arch of aorta. Both the carotids have again a common trunk in animals.

In a study by Christophe C et al [13] thoracic aorta and its branches were studied in mice they explained that the geometry of the branches of the murine aortic arch was similar to that of men and both these species had a sigmoidal curve of the first part of aorta comprising of ascending aorta, aortic arch and superior part of descending aorta. In both the ascending and descending aorta do not lie in a single vertical plane. Such an arrangement describes a non-planar aortic geometry. They concluded that this arrangement is in contrast to the planar aortic pattern in domestic mammals where the ascending and descending aorta lie in a single vertical plane.

CONCLUSION

The observation in this study shows the remarkable branching of arteries from the aorta according to the needs of the species. The presence of so many arteries serves the survival functions of the animals like searching for prey and feeding and later ruminating in leisure. In man the sharing of a common trunk to give away the subclavian and carotid on the right side can be given a second thought. The development of carotids is from the 3rd arch arteries. The left subclavian artery is not a pharyngeal arch artery. It forms from the left seventh intersegmental artery. It shifts its origin close to the left common carotid artery due to differential growth. The left subclavian artery was found to lie at a lower level than the right in the animals in this study. This point can be further studied on the basis of cerebral dominance in man. Is the right subclavian artery supplying the right upper limb

sharing the trunk with right common carotid for any reason still unknown? Does this kind of arrangement of vessels have any bearing of significance to determine cerebral dominance in humans? If the individual has a variation in the branches of the arches, might there be any variation in his brain dominance? Can it be correlated? This observation has potential for research in this area.

Conflicts of Interests: None

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