Study on the variation of branching pattern of arch of aorta in Nepalese

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ABSTRACT

The variations of vessels arising from the aortic arch are numerous. The purpose of this study is the description of the variations on the branching pattern of arch of aorta, in order to offer useful data to anatomists, radiologists, vascular surgeons, neck and thorax surgeons in Nepalese subjects, and relating it with embryological basis. In this investigation, branching patterns of arch of aorta were studied in 85 cases of Nepali origin. Variations in the anatomical arrangements of the branches of arch of aorta in the Nepali population were as par with other populations of the world. Variations on the branching pattern of the arch of aorta were found in 17 cadavers (20.0%) of elderly Nepalese. The accurate information on this is vital for vascular surgery in the thorax, head and neck regions. Although, the variations are usually asymptomatic, they may cause dyspnea, dysphagia, intermittent claudication, misinterpretation of radiological examinations and complications during neck and thorax surgery. These observations are precious while invading the arch of aorta and its branches by instruments, as all areas are susceptible to surgical attack.

Keywords: Arch of aorta, branches, variations, radiological examination, vascular surgery.

INTRODUCTION

The variations of the branches of the arch of aorta are usually associated with abnormalities of the heart. Many variations are due to different modes of transformation of the primary vessels of the branchial arches, especially the fourth. Since part of aorta and pulmonary trunk develop from common truncus arteriosus, irregular and imperfect development of the septum between them may produce variations.[1] In about 80.0% of individuals, three branches arise from the arch of aorta: the brachiocephalic trunk, left common carotid artery, and left subclavian artery. Adachi first classified this branching pattern as Type A. Another 11% have a common trunk incorporating the left common carotid artery and the brachiocephalic trunk leaving only two branches originating from the arch of aorta, Adachi's Type B. The pattern, Type C, has the left vertebral artery, a fourth branch of the arch of aorta, originating proximal to the left subclavian artery.[2] Numerous other variations of the branching pattern of the arch of aorta are found in less than 1.0% of cases.[1] In all reported cases, however, the most distal branch arising from the arch, or the descending thoracic aorta, was either a subclavian or thyroid ima artery.[3-5] We are reporting here the different modes of variations in Nepalese population.

MATERIALS AND METHODS

The study was carried out in 85 cadavers as well as specimens of both sexes, approximately aged between 35 to 65 years of Nepali origin, at Manipal College of Medical Sciences, Pokhara, Nepal over a period of three years. The mediastina were opened and the branching patterns of the arch of aorta were observed.

RESULTS

The commonest pattern of branches originating from the arch of the aorta- brachiocephalic trunk, left common carotid artery, and left subclavian artery- were observed in 68 cases (80.0%). Variations from the common pattern of branches of the arch of aorta were found in 17 cases (20.0%). The following two categories of variations on the branching pattern of the arch of aorta were found:

I. Common origin of the brachiocephalic trunk and the left common carotid artery: In 11 cases (12.9%), arch of aorta had only two branches, these were- first was common origin of the brachiocephalic trunk and the left common carotid artery and second was origin of the left subclavian artery distal to the origin of the common trunk of brachiocephalic and left common carotid arteries. Both the branches were originated from the convex surface of the arch of aorta. The brachiocephalic trunk showed further bifurcation into right subclavian and right common carotid arteries as in the usual branching pattern (Fig. 1). II. Direct origin of the left vertebral artery from the arch of the aorta: In 6 cases (7.0%), arch of the aorta had four branches arising from its convex surface. In addition to the three common branches- brachiocephalic trunk, left common carotid artery and left subclavian

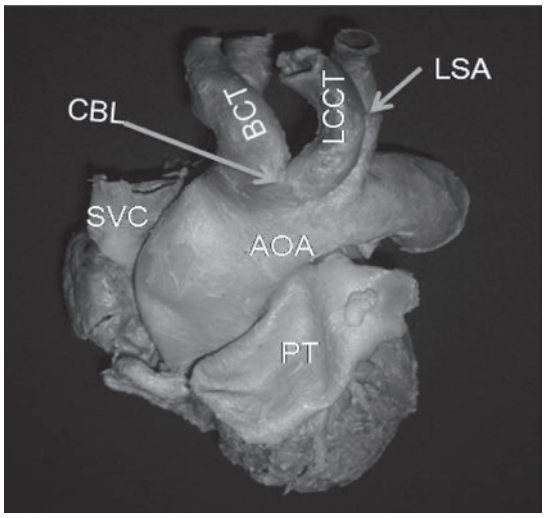

Fig. 1. Common origin of brachiocephalic trunk and left common carotid artery from arch of aorta

BCT=Brachiocephalic Trunk, LCCT=Left Common Carotid Artery, LSA=Left Subclavian Artery, AOA= Arch of Aorta, PT=Pulmonary Trunk, CBL=Common Origin of Brachiocephalic Trunk & Left Common Carotid Artery,

SVC=Superior Venacava.

artery, the convex surface of the arch of aorta was given origin to the left vertebral artery, located between the origins of the left common carotid and the left subclavian arteries (Fig. 2), ascended upward and backward lying behind the left vagus, left brachiocephalic vein and left common carotid artery.

No other noticeable variations on the branching pattern of the great blood vessels were found. There were no noticeable differences in the heart too.

DISCUSSION

The true value of detecting anomalous origins of the branches of the arch of aorta is the diagnostic gain before vascular surgeries of supraaortic arteries, as variations on the branching pattern of the arch of aorta are likely to occur as a result of the altered development of certain branchial arch arteries during the embryonic period of gestation.[6]

In about 80.0% of Nepali individuals, following three branches arise from the arch of aorta- brachiocephalic trunk, left common carotid artery, and left subclavian artery as in Adachi's type A classification. The approximation of the left common carotid artery to the brachiocephalic trunk, as in Adachi's type B classification, present study variation category I, is in 12.9% of Nepali individuals. The direct origin of the left vertebral artery from the upper convex surface of the arch of aorta, as in Adachi's type C classification, present study variation category II, is in 7.0% of Nepali individuals. These observations are very important while invading the arch of aorta and its branches with instruments, since these are susceptible to surgical attack.[6,7] Non-recognition of the critical variable branches of the arch of aorta at surgery may cause fatal consequences.[8] The angiographic detection of common origin of brachiocephalic trunk and left common carotid artery may be a marker for the presence of accompanying congenital cardiac defects and coronary arterial abnormalities. Understanding the pathophysiological effects of such a defect is important when planning the palliative or corrective procedures, and when assessing the potential benefit of the surgical repair over the long term.[9] Vascular remodeling within the aorta results in a loss of structural integrity with consequent aneurysm formation.[10]

Developmentally, the variations on the branching pattern of the arch of aorta may be explained as follows- Left limb of aortic sac normally forms the part of the arch of aorta that intervenes between the origins of the brachiocephalic trunk and the left common carotid artery. If the aortic sac fails to bifurcate into right and left limbs, then the variations on the branching pattern of arch of aorta may occur as observed in present study. The 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, also results the variable branching pattern.[11,12,13] Direct origin of the left vertebral artery from the upper convex surface of the arch of aorta between the origins of the left common carotid and left subclavian arteries may be explained as increased absorption of embryonic tissue

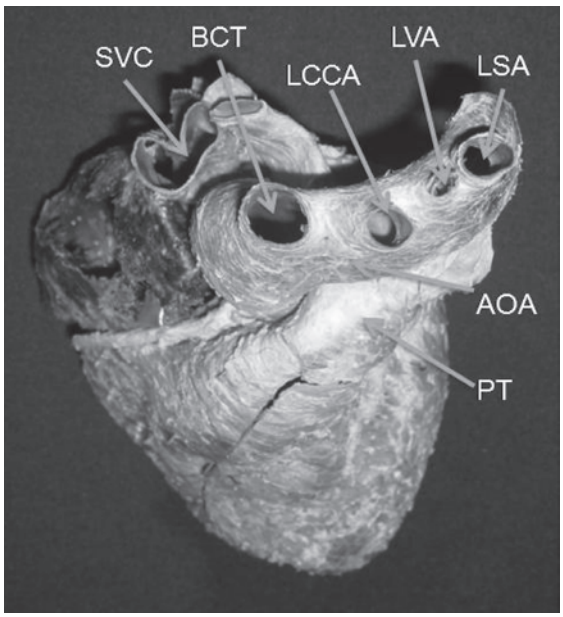

Fig. 2. Direct origin of left vertebral artery from arch of aorta

SVC=Superior Venacava, BCT=Brachiocephalic Trunk, LCCA=Left Common Carotid Artery, LVA=Left Vertebral Artery, LSA=Left Subclavian Artery, AOA=Arch of Aorta, PT=Pulmonary Trunk

of the left subclavian artery between the origin of the arch of aorta and the vertebral artery. Variations, when there are more than three branches originating from the arch of aorta may include the vertebral arteries.[14-16] Momma *et al* described that arch of aorta anomalies are also associated with chromosome 22q11 deletion.[17]

The present study on Nepalese may provide adequate information on the branching pattern of arch of aorta to catheterize the same and its branches for safely performing endovascular surgery. The clinical presentations which these variations give rise to be well known and may present during the first days of life or later in adulthood, or remain clinically silent. Non-recognition of the latter situation in the presence of vascular trauma may have fatal consequences. Even though the branching patterns of the arch of aorta are considered to be variants of some deviations from the commonest pattern of development, there were not any noticeable signs of anatomical pathology associated with those variations. These variations have to be taken into consideration by surgeons when they are planning surgical or diagnostic interventions involving the arch of aorta and its branches. Surgeons must be aware of possible variations of the major arteries and be able to identify them. Correct identification of these vessels is very important for appropriate invasive techniques in order to achieve desired objectives and to avoid major complications especially during vascular surgery. The anatomic and morphologic variations of the arch of aorta and its branches are significant for diagnostic and surgical procedures in the thorax and neck.[18,19]

REFERENCES

1. Bergman RA, Afifi AK, Miyauchi R.Illustrated encyclopedia of human anatomic variation(online).Available:http://www.vh.org/Providers/Textbooks/AnatomicVariants/Cardiovascular/Text/Arteries/Aorta.html. 2000; 1-35.
2. Adachi B. Das arteriensystem der Japaner. In: Kyoto editor. Verlag der Kaiserlich- Japanischen Universitat, Vol 1. Kenyusha Press 1928; 29-41.
3. McDonald JJ, Anson BJ. Variations in the origin of arteries derived from the aortic arch, in American whites and Negroes. *Amer J Phys Anthrop* 1940; 27: 91-107.
4. Skandalakis JE, Gray SW. Embryology for surgeons, the embryological basis for the treatment of congenital anomalies, 2nd ed. Baltimore: Williams & Wilkins 1996; 976-1018.
5. Johnson D, Shah P, Collins P *et al*. Thorax. In: Standring S, editor. Gray's Anatomy. 39th ed. Newyork: Elsevier Churchill Livingston 2001; 1021-3, 1042-3.
6. Bhatia K, Ghabriel MN, Henneberg M. Anatomical variations in the branches the human aortic arch: a recent study of a South Australian population. *Folia Morphol* 2005; 64: 217-23.
7. Suresh R, Ovchinnikov N, McRae A. Variations in the branching pattern of the aortic arch in three Trinidadians. *West Indian Med J 2006*; 55: 1-3.
8. Barry A. The aortic arch derivatives in the human adult. *Anat Rec* 1951; 111: 221–38.
9. Moskowitz WB, Topaz O. The implications of common brachiocephalic trunk on associated congenital cardiovascular defects and their management. *Cardiol Young* 2003; 13: 537-43.
10. Ruddy JM, Jones JA, Spinale FG. Regional heterogeneity within the aorta:relevance to aneurysmdisease. *J Thorac Cardiovasc Surg* 2008; 136: 1123-30.
11. Moore KL, Persaud TVN. Cardiovascular system. In: Moore KL, Persaud TVN, editors. The developing human: clinically oriented embryology. 8th ed. Philadelphia: Saunders Elsevier. 2008; 305-6, 316-25.
12. Sadler TW. Cardiovascular system. In: Sadler TW, editor. Langman's Medical Embryology.10th ed. Philadelphia: Lippincott Williams & Wilkins 2006; 173-5, 180-5.
13. Larsen WJ. Development of vasculature. In: Larsen WJ, Sherman LS, Potter SS et al editors. Human Embryology.3rd ed. Philadelphia: Churchill Livingstone 2001; 199-204.
14. Nelson ML, Sparks CD. Unusual aortic arch variation: distal origin of common carotid arteries. *Clin Anat* 2001; 14: 62-5.
15. Satyapal KS, Singaram S, Partab P *et al*. Aortic arch branch variations - case report and arteriographic analysis. *S Africa J Surg* 2003; 41: 48-50.
16. Gabella G. Cardiovascular system: In: Willam P, Lawerence HB, Martin MB *et al* editors. Grays Anatomy, 38th ed. Great Britain: Churchill Livingstone 1996; 1510–3.
17. Momma K, Matsuoka R, Takao A. Aortic arch anomalies associated with chromosome 22q11 deletion (CATCH 22). *Pediatr Cardiol* 1999; 20: 97-102.
18. Fazan VPS, Ribeiro RA, Ribeiro JAS *et al*. Right retroesophageal subclavian artery. *Acta Cir Bras* 2003; 18: 54-6.
19. Anson BV, Mcvay CB. Thoracic cavity and its contents. In: Anson BV, Mcvay CB, editors. Surgical anatomy. 5th ed. Philadelphia: WB Saunders 1971; 370-460.