International Journal of Anatomy and Research,
Int J Anat Res 2015, Vol 3(2):1079-83. ISSN 2321- 4287
DOI: http://dx.doi.org/10.16965/ijar.2015.168

Original Article

MORPHOMETRIC STUDY OF ARCH OF AORTA AND ITS BRANCHES

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ABSTRACT

Aim: The purpose of this study is to understand the anatomical characteristics of arch of aorta and orientations of its major branches.

Materials and methods: 60 male cadavers were dissected for arch of aorta and its branches namely brachiocephalic truck, left common carotid and left subclavian arteries. Height of arch of aorta was measured from upper surface of body of sternum. Distances of site of origin of brachiocephalic trunk, left common carotid artery and left subclavian artery were measured from the mid-vertebral line. Angles formed between arch of aorta and its major branches were measured. Inner diameter of the arch of aorta was measured at its commencement and termination. Inner diameters of the three major branches were also measured at their respective origins. The data so obtained was statistically analysed for range, mean and standard deviation.

Results: Mean height of summit of arch of aorta from sternal angle was 39.98 ± 10.05 mm (range 23 to 66 mm). Origin of brachiocephalic trunk deviated by an average of 1.6 ± 7.53 mm on right side, left common carotid artery origin deviated by an average of 10.28 ± 8.69 mm on left side and left subclavian artery origin deviated by an average of 20.65 ± 9.65 mm on left side from mid-vertebral line. Average angles formed by brachiocephalic trunk, left common carotid artery and left subclavian artery with the arch of aorta were 94.79 ± 17.77 degree, 82.44 ± 14.95 degree and 99.71 ± 13.68 degree respectively. Average inner diameter of arch of aorta at its commencement was 20.02 ± 3.26 mm and at termination was 15.88 ± 2.53 mm. Average inner diameters of brachiocephalic trunk, left common carotid artery and left subclavian artery were 9.43 ± 2.17 mm, 6.4 ± 1.22 mm and 7.62 ± 1.76 mm respectively.

Conclusion: Knowledge of morphometry of arch of aorta and its major branches shall be helpful for surgeons for performing safe and effective endovascular surgeries.

KEY WORDS: Aorta, Brachiocephalic trunk, Left common carotid artery, Left subclavian artery.

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Access this Article online

Quick Response code

DOI: 10.16965/ijar.2015.168

Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 30 Apr 2015 Accepted: 21 May 2015
Peer Review: 30 Apr 2015 Published (O):31 May 2015
Revised: None Published (P):30 June 2015

INTRODUCTION

The progress in the fields of cardiac and vascular surgery has served to revive interest in the anatomy of aortic arch and its branches.

The arch of aorta (AA) is a continuation of ascending aorta behind the right half of sternal angle and it ends in the same horizontal plane (at the level of disc of 4th and 5th thoracic vertebral bodies) behind left half of sternal angle and continues as descending thoracic aorta. Arch of aorta lies in the superior mediastinum. Three branches, the brachio-cephalic trunk (BCT), left common carotid (LCCA) and left subclavian (LSCA) artery usually branch from arch of aorta [1-4].

The surgeons and interventionalists have to negotiate the arch of aorta with catheters to access the supra-aortic branches. Knowledge of

distribution, regularity or irregularity and topology of arch of aorta and its branches is crucial for developing new diagnostic and therapeutic procedures and optimizing the existing ones. Despite of improvement in catheter quality and rapid development of imaging techniques, it may be very difficult to perform these procedures in some cases due to anatomic variations of arch of aorta.

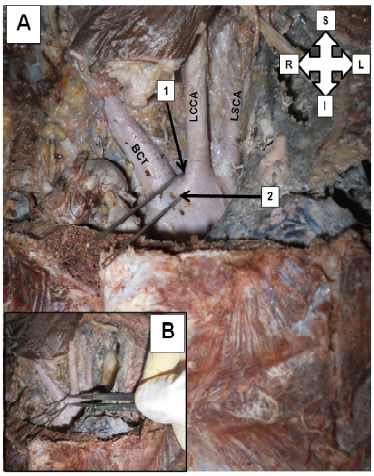
The purpose of this study is to understand the anatomical characteristics of arch of aorta and orientations of its major branches. The data thus collected will of help to surgeons in performing safe and effective endovascular surgeries.

MATERIALS AND METHODS

Sixty male (age group of 18-65 years) cadavers embalmed with 10% formalin were obtained from Department of Anatomy, Seth G. S. Medical College, Mumbai. The study was conducted from 2011 to 2013.

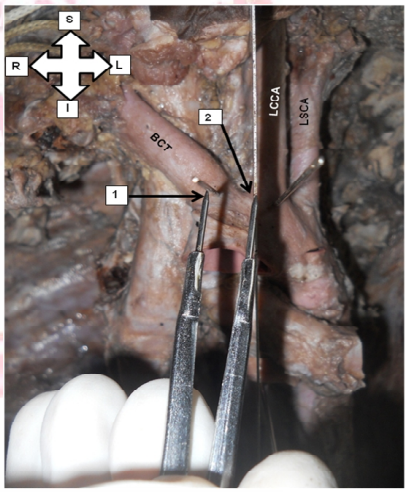
After skin incision, sternum was cut transversely at the manubrio-sternal joint. 1st and 2nd ribs were cut on both sides and manubrio-clavicular joint was disarticulated. Manubrium was removed to visualize superior mediastinum. Height of arch of aorta was measured from upper surface of body of sternum (at the level of sternal angle) with the help of pair dividers and scale (figure 1). Then body of sternum, lungs and heart along with ascending aorta upto beginning of arch of aorta were removed. Mid-vertebral line was identified with the help of scale and needles after clearing anterior surface of bodies of vertebrae. Distances of site of origin of brachiocephalic trunk, left common carotid artery and left subclavian artery were measured from the mid-vertebral line (figure 2). Angles formed between arch of aorta and its major branches were measured using wire and protractor (figure 3). Inner diameter of the arch of aorta was measured at its commencement and termination. Inner diameters of the three major branches were also measured at their respective origins. For measuring the inner diameter the artery was cut open and its circumference was measured. Diameter was then calculated by using formula πd. The data so obtained was statistically analysed for range, mean and standard deviation.

Fig. 1 A and B: Illustration showing the measurement of the height of summit of arch of aorta from angle of Louis.



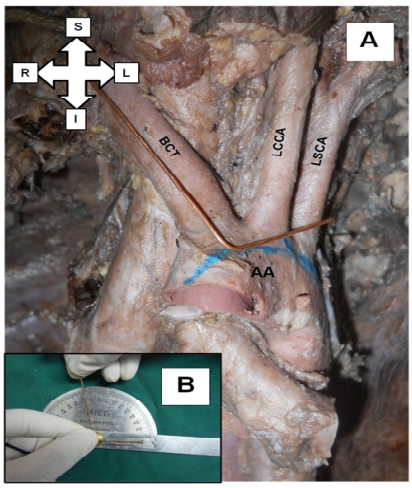
(BCT- Brachiocephalic trunk, LCCA- Left common carotid artery, LSCA- Left sub-clavian artery, 1- summit of arch of aorta, 2- sterna angle)

Fig 2: Illustration showing the measurement of the distance of site of origin of brachiocephalic trunk from mid-vertebral line.



(BCT- Brachiocephalic trunk, LCCA- Left common carotid artery, LSCA- Left sub-clavian artery MVL- Mid-vertebral line, 1- origin of brachiocephalic trunk, 2- ruler kept on mid-vertebral line)

Fig. 3A and B: Illustration showing the measurement of the angle between origin of brachiocephalic trunk and arch of aorta.



(BCT- Brachiocephalic trunk, LCCA- Left common carotid artery, LSCA- Left sub-clavian artery, AA- Aortic arch).

RESULTS

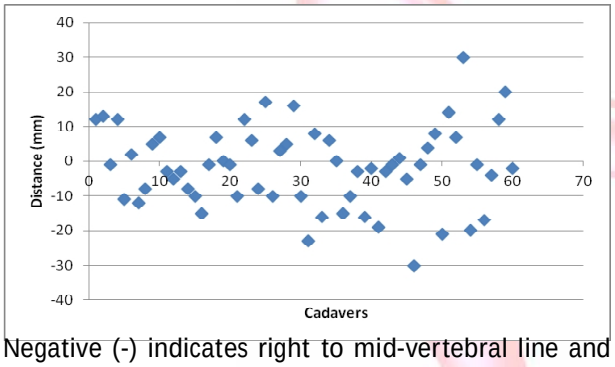
Mean height of summit of arch of aorta from angle of loius or sterna angle was 39.98 ± 10.05 mm within the range of 23 to 66 mm. The distances of site origin of branches of arch of aorta from mid-vertebral line and their angles formed with aorta are tabulated in table1 and table 2 respectively. The inner diameters of arch of aorta at its commencement and termination along with inner diameters of its major branches are tabulated in table 3.

Table 1: Distances of site of origin of branches of arch of aorta from mid-vertebral line.

Parameter	Range	Mean	Standard deviation
Brachiocephalic trunk	-30 to +30	-1.60	7.53
Left common carotid artery	-18 to +43	+10.28	8.69
Left subclavian artery	+1 to +46	+20.65	9.65

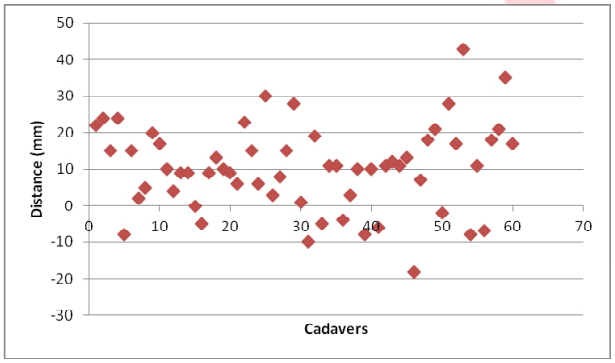
All measurements are in millimetre. Negative (-) indicates right to mid-vertebral line and positive (+) indicates left to mid-vertebral line.

Graph 1: Distances of site of origin of brachiocephalic trunk from mid-vertebral line in 60 cadavers.



Negative (-) indicates right to mid-vertebral line and positive (+) indicates left to mid-vertebral line.

Graph 2: Distances of site of origin of left common carotid artery from mid-vertebral line in 60 cadavers.



Negative (-) indicates right to mid-vertebral line and positive (+) indicates left to mid-vertebral line

Table 2: Angles formed between aorta and its branches. All measurements are in millimetre.

Parameter	Range	Mean	Standard deviation
Brachiocephalic trunk	45 to 133	94.79	17.77
Left common carotid artery	45 to 105	82.44	14.95
Left subclavian artery	60 to 125	99.71	13.68

Table 3: Inner diameters of arch of aorta and its branches. All measurements are in millimetre.

Parameter	Range	Mean	Standard deviation
Arch of aorta at beginning	14.6 to 29.5	20.02	3.26
Arch of aorta at termination	9.5 to 22.2	15.88	2.53
Brachiocephalic trunk at origin	3.2 to 14.6	9.43	2.17
Left common carotid artery at origin	3.4 to 9.8	6.4	1.22
Left subclavian artery at origin	3.4 to 12	7.62	1.76

Graph 3: Distances of site of origin of left subclavian artery from midvertebral line in 60 cadavers.

DISCUSSION

The arch of aorta has been the area of interest for many cardiothoracic surgeons and researchers. Accurate anatomical knowledge of the arch of aorta and its major branches is of great importance in diagnostic and therapeutic procedures. Despite accurate preoperative assessment and adequate preparations, unexpected complications can occur during vascular surgery that may cause ischemic problem.

Demertzis et al [5] used thoracic computed tomography angiography scans of 92 living patients for classifying the aortic arch into various types. By using the criterion of the vertical distance from the origin of brachiocephalic trunk to the top of arch in the parasagittal stretched-out projection, they

Parameter	Alsaif et al. [7] (2010, Saudi Arabia)	Shin et al. [6] (2008, Korea)	Zamir et al. [8] (1991, Canada)	Present study
Distance of BCT from MVL(mm)	-4.67	6.78	-	5.93
Distance of LCCA from MVL(mm)	15.18	20.8	-	18.97
Distance of LSCA from MVL(mm)	33.3	29.6	-	30.3
Angle between AA and BCT(degrees)	-	65.3±25.7	54.36±13.29	94.79±17.77
Angle between AA and LCCA(degrees)	-	46.9±28.2	58.44±9.35	82.44±14.95
Angle between AA and LSCA(degrees)	-	63.8±24.3	64.56±11.40	99.71±13.68

Table 4: Comparisons between studies for parameters studied. (MVL- mid-vertebral line)

Parameter	Alsaif et al. [7] (2010, Saudi Arabia)	Shin et al. [6] (2008, Korea)	Yeri et al. [12] (2011, Argentina)	Present study
Inner diameter of BCT at origin (mm)	17.97±3.85	18.3±7.0	11.5±3.0	9.43±2.17
Inner diameter of LCCA at origin(mm)	9.77±1.91	9.8±1.9	7.9±2.3	6.40±1.22
Inner diameter of LSCA at origin(mm)	14.33±3.09	10.6±2.4	10.1±2.9	7.62±1.76

Table 5: Comparisons between different studies for inner diameters of arteries.

classified the aortic arch into three types. In the present study, 60 cadavers were studied and the mean height of summit of arch of aorta from the angle of Louis was found to be 39.98±10.05 mm.

Shin et al. [6] examined 25 Korean cadavers and found that origin of brachiocephalic trunk deviated by an average of 0.92±7.7mm right side, left common carotid artery origin deviated by an average of 12.30±8.5mm left side and left subclavian artery origin deviated by an average of 22.80±6.8mm left side. They also measured the take off angles of the three branches of arch of aorta which were 65.3±25.7 degree, 46.9±28.2 degree and 63.8±24.3 degree for brachiocephalic trunk, left common carotid and left subclavian arteries respectively.

In 2010 Alsaif et al. [7] studied thirty adult human cadavers, for branching pattern of aortic arch, the diameter of its branches and the distance from their origin to the mid-vertebrae line (table 4). There was significant correlation between the diameter of brachiocephalic trunk and left subclavian artery. A significant strong positive correlation was also found between the distance from the origin of left subclavian artery and left common carotid from mid vertebral line.

In 1991 Zamir et al. [8] measured branching angles of the brachiocephalic trunk, left carotid, and left subclavian arteries at their points of origin from the arch in 117 human specimens (table 4). Authors also examined possible correlations with age and with the presence of atherosclerotic lesions. Hager et al. [9] in 2002 measured aortic diameter at seven predefined thoracic levels in seventy adults, without any signs of cardiovascular disease with helical computed tomography. Men had slightly greater diameters than women and all diameters increased with age.

The aortic diameters of 73 Thai males and 56 Thai females were measured using CT images, by Euathrongchit et al. [10] in 2009 and correlated with age, sex and vertebral levels. Mean aortic diameters were 3.12 cm at proximal ascending aorta, 2.95 cm at distal ascending aorta, 2.33 cm at proximal descending aorta, 2.14 cm at distal descending aorta, and 2.03 cm at diaphragm. In males the aorta was larger than females, and all levels of the aorta were significantly enlarged with increasing age.

Krejza et al. [11] in 2006 explored relationship among gender, body size, neck size and the common carotid artery and internal carotid artery in 500 consecutive patients. Their study showed that sex significantly influenced the diameter after controlling for body size, neck size, age and blood pressure with women having smaller carotid artery which further explains the gender gap in natural history and treatment of carotid artery disease.

The present study is a dissection study on 60

male cadavers. The same parameters can also be considered for female cadavers in future using sophisticated scanning techniques. The finding of our study will certainly help the cardiothoracic surgeons in planning and implementing surgeries successfully.

Acknowledgement:

We would like to acknowledge Dr. Pritha Bhuiyaan (Professor and Head of Anatomy Department, Seth G S Medical College, Parel, Mumbai) and Dr. M. Natarajan (Professor, Department of Anatomy, Seth G S Medical College, Parel, Mumbai) for giving us the opportunity of conducting the research work in their department. . The authors are also grateful to authors / editors / publishers of all those articles, journals and books from where the literature for this article has been reviewed and discussed.

Conflicts of Interests: **None**

Source of funding: **None**

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How to cite this article:

Kamalkant Chhabra, Kopal Saini. MORPHOMETRIC STUDY OF ARCH OF AORTA AND ITS BRANCHES. Int J Anat Res 2015;3(2):1079-1083. **DOI:** 10.16965/ijar.2015.168