Section: Anatomy

Original Research Article

MORPHOMETRY OF AORTIC ARCH BRANCHES: A COMPUTED TOMOGRAPHC STUDY

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Abstract

Background: The aortic arch and supra-aortic branches are important anatomical structures for both surgeons and interventionalists. Knowledge of morphometric data of the aortic arch branches can be of help for conceiving, designing and optimizing all types of diagnostic and therapeutic interventions involving the aortic arch and its branches. **Materials and Methods:** The study was conducted in the department of Anatomy and Radiodiagnosis, K.G.M.U., UP. CT Angiography was performed on a 64-slice multidetector spiral CT scanner. The study included 110 patients, out of which 62 were males and 48 females Age of subjects ranged from 3 months to 75 years across 5 age groups. Morphometry of aortic arch branches was studied in axial, multiplanar reconstructions (MPR) images and in volume-rendered images. **Result:** LSA-MVL distance ranged from 2.8 to 30.6 mm with a mean value of 14.7±5.9 mm. Among different age groups, the mean value ranged from 11.1±5.1 (61-75yrs) to 17.4±6.7 mm (31-45yrs), but the difference among different age groups was not significant statistically (p=0.086). Distance between LSA_MVL was found to be lower (13.73+5.45 mm) in female subjects than male subjects (15.48+6.25 mm). This difference was statistically non-significant (p=0.298). Thus implying that the normative range (13.3mm-16.3mm) is universally applicable across all age groups and both gender. **Conclusion:** Distance of BCT, LCA and LSA from mid vertebral line was not significantly related with age and gender. There was significant strong positive correlation between the distance of LCA and LSA from the mid vertebral line.

INTRODUCTION

The major branches of arch of aorta are the great ways for blood supply to the head and upper limb, and are of particular interest in clinical angiography.[1] The proximal segment of these branches and of the aortic arch is common sites for atherosclerosis with clinical consequences for blood supply to the brain.[2] Morphometric details of supra-aortic branches were observed with the objective of providing a nomogram of these parameters for the north Indian population as the literature is lacking with these values. These parameters will be correlated with age and gender also. It is a pilot study of its kind.

MATERIALS AND METHODS

The study was conducted in the department of Anatomy and Radiodiagnosis, K.G.M.U., UP.. CT Angiography was performed on a 64-slice multidetector spiral CT scanner. The study included 110 patients, out of which 62 were males and 48 females Age of subjects ranged from 3 months to 75 years across 5 age groups. Morphometry of aortic arch branches was studied in axial, multiplanar reconstructions (MPR) images and in volume-rendered images.

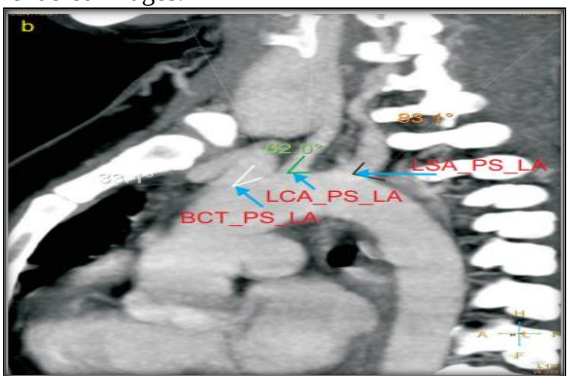

Figure 4: Assay of Biofilm production by Microtiter plate method

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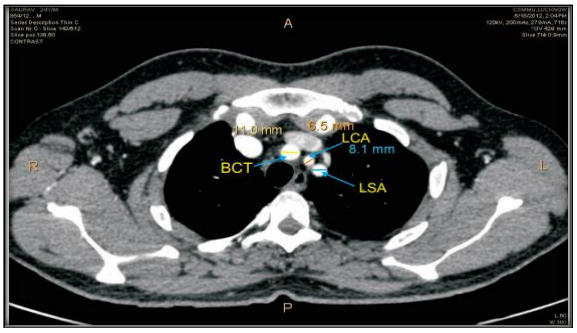

Figure 2: Axial MIP image showing measurement of the diameters of major branches of aortic arch, BCT= brachiocephalic trunk, LCA= left common carotid artery, LSA= left subclavian artery

Distance of the major branches of the arch of the aorta from the mid-vertebral line was measured with the help of electronic calipers in axial view. It was abbreviated as BCT_MVL (distance of BCT from the mid-vertebral line), LCA_MVL (distance of LCA from the mid-vertebral line), LSA_MVL (distance of LSA from the mid-vertebral line) [Figure 1]. Diameter of major branches at their origin was measured with the help of electronic calipers in an axial MIP image [Figure 2]. Distance between the origins of supra-aortic arteries was measured. It was abbreviated as BCT_LCA (distance between BCT and LCA), LCA_LSA (distance between LCA and LSA), and BCT_LSA (distance between BCT and LSA) [Figure 3]. Take-off angles of supra-aortic arteries measured with respect to a line drawn tangentially to the convexity of the aortic arch at the origin of each vessel and abbreviated as BCT_PS_LA, LCA_PS_LA, and LSA_PS_LA [Figure 4].

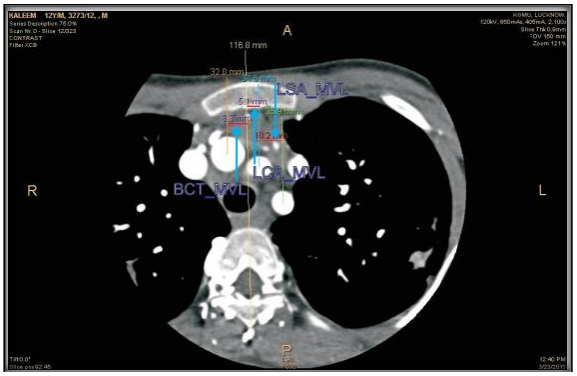

Figure 1: Axial MIP image showing the measurement for the distance from the mid vertebrae line to the origin of the major branches

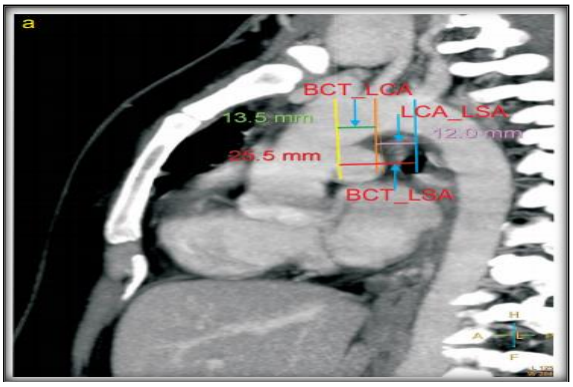

Figure 3: Parasaggital MPR image showing distances between supra aortic arteries

RESULTS

A wide variability in the distance of BCT_MVL was noted, ranging from -26.4 to 18.5 mm with a mean value of -0.6-7.8 mm. Among different age groups, too, the variability was wide, yet not significant statistically (p=0.202). As compared to males, females had higher mean values, but the difference was not significant statistically (p=0.087). These findings imply that a single normative range (5.9 mm-8.9mm) can be applied for all ages and both gender groups.

LSA-MVL distance ranged from 2.8 to 30.6 mm with a mean value of 14.7±5.9 mm. Among different age groups, the mean value ranged from 11.1±5.1 (61-75yrs) to 17.4±6.7 mm (31-45yrs), but the difference among different age groups was not significant statistically (p=0.086). Distance between LSA_MVL was found to be lower (13.73+5.45 mm) in female subjects than male subjects (15.48+6.25 mm). This difference was statistically non-significant (p=0.298). Thus implying that the normative range (13.3mm-16.3mm) is universally applicable across all age groups and both gender.

BCT diameter ranged from 5.3 to 17.5 mm with a mean of 11.9±3.0 mm. Among different age groups mean value ranged from 11.1±2.9 mm (16-30yrs) to 12.8±3.1 mm (46-60yrs), but the difference was not significant statistically among age groups (p=0.763). Though the mean BCT diameter in female subjects (11.35±2.87) was lower than in male subjects (12.39±3.02), this difference was statistically non-significant (p=0.289). Mean LCA diameter ranged from 2.7 to 10.3 mm with a mean value of 7.1±1.4 mm. Among different age groups, the mean value ranged from 6.8±2.5 mm to 7.5±1.7 mm, but the difference among groups was not significant statistically. Males had a higher mean value (7.2±1.3 mm) as compared to females (7.0±1.7 mm), but the difference was not significant statistically (p=0.651).LSA diameter ranged from 2.9 to 16.8 mm with a mean value of 9.5±3.1 mm. Although mean values in younger age groups were lower than in older age groups, the difference was not statistically significant (p=0.497). However,

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compared to females, males had a significantly higher mean value (p=0.005).

Angle BCT_PS_LA ranged from 32.1 to 85.8º with a mean value of 52.4±12.5º. Across different age groups mean value ranged from 47.4±5.3 (61-75yrs) to 62.0±15.0 (0-15yrs), but the difference was not significant statistically (p=0.421). As compared to females (50.8±12.1º), males had a higher mean value (53.7±12.9º), but this difference was not statistically significant (p=0.485).

LCA-PS-LA angle ranged from 31 to 95.9º with a mean value of 63.9±16.3º. Among different age groups, the mean value was minimum (57.9±15.2) in the age group 46-60 years and maximum (73.7±16.3º) in the 16-30yrs age group, but the difference was not significant statistically (p=0.157). Though males had a lower mean value (63.4±16.7º) as compared to females (64.6±16.2º) yet this difference was not significant statistically (p=0.825).

Angle LSA-PS-LA ranged from 32.1 to 101.3º with a mean value of 76.1±18.1º. Among different age groups, the mean value ranged from 66.3±17.0º (61-75yrs) to 82.8±12.9 (16-30yrs), yet the difference was not significant statistically (p=0.306). However, the mean value for angle LSA-PS-LA in females was lower (75.6±16.9º) as compared to that of males (76.5±19.3º), yet the difference was not statistically significant (p=0.864).

Variation in the distance between BCT and LCA (BCT_LCA) ranged from 6.7 to 22.3 mm with a mean value of 11.2±3.4 mm. Among different age groups, the mean value ranged from 10.4 to 12.6±5.0, but the difference was not significant statistically. The distance between BCT and LCA in female subjects was 10.79+3.42; in male subjects, it was 11.55+3.34. This difference was statistically non-significant (p=0.492). LCA-LSA distance ranged from 6.6 to 26.8 mm with a mean of 13.8±4.0 mm. Among different age groups mean value ranged from 12.3±3.0 mm (61-75yrs) to 15.1±6.2 mm (31-45yrs) but the difference was not significant statistically (p=0.779). Mean LCA-LSA distance was higher in males (14.4±4.2 mm) as compared to females (13.1±3.8) but the difference was not significant statistically (p=0.325). BCT_LSA distance ranged from 7.3 to 40 mm with a mean value of 24.1±6.1 mm. Among different age groups, mean BCT_LSA ranged from 20.9±6.2 to 26.8±7.7 but the difference was not significant statistically. Females had lower mean value (23.7±7.3) as compared to males (24.4±5.2) but the difference was not significant statistically (p=0.740).

DISCUSSION

To the best of our effort, even after an extensive search review, we could not find a single study on the morphometry of the arch of the aorta in the Indian population. However, a few cadaveric studies have been conducted on branching patterns. We could not find any angiographic study on the arch of the aorta in the Indian population. In the present study, we observed that BCT, LCA, and LSA deviated from the mid-vertebral line by an average of 7.39±4.69 mm (ranged between 5.30-17.10) and 14.73±5.93 mm (ranged between 2.80-30.60) respectively. These distances were relatively less as compared to that observed by Shin et al,[3] who reported it -.92±7.7,12.3±8.5mm and 22.8±6.8mm, respectively, and Alsaif & Ramadan,[4] who found it to be -9.33 ± 4.66 mm,9.90 ± 5.28 mm,25.73 ± 7.57 mm respectively. The difference in these values could be possible because, in the present study, these parameters were observed by computed tomographic angiography, whereas previous studies were cadaveric. In the present study, it was instituted that there was a significant strong positive correlation between the distance of LCA and LSA from the mid-vertebral line (r = .708), which is akin to the findings of Alsaif & Ramadan,[4] (2010). There was a mild positive correlation between BCT _MVD with LCA_MVD and BCT_MVD with LSA_MVD.

The present study's diameters of BCT, LCA, and LSA were 11.93 ± 2.96 mm, 7.15 ± 1.45 mm, and 9.15 ± 3.09 mm, respectively. These diameters were comparable to that observed by Malkawi et al,[5] (2010) but less than that reported by Shin et al,[3] (2008) and Alsaif & Ramadan[4] (2010). Malkawi et al,[5] (2010) found that the mean diameters of the BCT, LCA, and LSA were 12.3±3.2, 7.6±1.5, and 11.0±2.9 mm, respectively. Shin et al,[3] (2008) found it to be 18.3± 7.00 mm, 9.5 ± 1.9 mm, and 10.6 ±2.4 mm for BCT, LCA, and LSA, respectively. Alsaif & Ramadan[4] (2010) studied 30 adult human cadavers and found that the mean diameter of BCT, LCA, and LSA was 17.97 ± 3.85 mm, 9.77 ± 1.91, and 14.33 ± 3.09 mm, respectively. The difference in the values could be possible because we have studied the parameters on CTA while the studies of Shin et al,[3] and Alsaif & Ramadan,[4] were cadaveric.

The present study found that BCT, LCA, and LSA diameters had a mild correlation(r=0.316-0.406). Alsaif & Ramadan,[4] reported that the diameter of BCT and LSA had a significant correlation(r=.467). The inner diameter of the major aortic arch branches varies depending on the investigators (Gupta and Sodhi).

During endovascular surgery requiring the insertion of a guiding catheter within a significant branch of the aortic arch, knowledge of the inner diameter of the blood vessels is mandatory. This data would be helpful in selecting the appropriate size of the catheter for each blood vessel. The distance between the origins of supra-aortic arteries varies, the most frequent being approximation of the left common carotid artery to the brachiocephalic trunk. (Standring et al).

In the present study distance between the supra-aortic arteries BCT_LCA, BCT _LSA, and LCA_LSA was 11.21.±3.35 mm, 24.11±6.14 mm, and 13.74±4.09 mm, respectively, comparable with

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Demertzis et al,[6] but less than Malkawi et al,[5] findings. Demertzis et al,[6] reported these distances as 13.0±3.4 mm, 23.3±4.8mm, and 18.8±4.2mm, respectively, and Malkawi et al,[5] (reported these as 21.2±5.9, 41.5±9.5, and 10.1±6.5 mm, respectively. In their study on hundred cadavers, Gupta and Sodhi found that an approximation of LCA to BCT was seen in 10.0% of specimens. Variation in distance between supraaortic arteries highlights the current need for custom-made devices for the majority of patients.

Bhatia et al,[7] claimed that the approximation of the LCA artery to the BCT is an important observation while invading the AA and its branches with instruments since all cases are susceptible to surgical attack.

In our average study angle, BCT_PS_LA was 53.18±12.66 degrees, lower than that reported by Zamir et al.[8] Shin et al.[3] Demertzis et al,[6] and Malkawi et al.[5] In our study, angles LCA_PS_LA and LSA_PS_LA were more than reported by Zamir et al.[8] Demertzis et al,[6] and Malkawi et al.[5]

In the present study, angles of supra-aortic arteries did not show any significant correlation with age, similar to the study of Zamir et al.[8] Demertzis et al,[6] reported a positive correlation between age and angle LCA_PS_LA, LSA_PS_LA. The present study reported that angles in females were lower than that of males. Still, this difference was not statistically significant and is similar to Demertzis et al.[6]'s findings.

A strong positive correlation (r = .745) was found between the distance from the origin of LCA to the mid-vertebrae line and that of LSA. However, the distance between the origin of BCT to the mid-vertebrae line and that of LCA showed a mild positive correlation (r = 0.463). Also, the distance between the origin of BCT to the mid-vertebrae line and LSA showed a mild positive correlation(r = .493). BCT, LCA, and LSA diameters had a mild correlation.

CONCLUSION

Distance of BCT, LCA and LSA from mid vertebral line was not significantly related with age and gender.There was significant strong positive correlation between the distance of LCA and LSA from the mid vertebral line. There was mild positive correlation between BCT _MVD with LCA_MVD and BCT_MVD with LSA_MVD.Significantly higher LSA diameter was found in male subjects as compared to female subjects. BCT, LCA and LSA diameters had mild correlation with each other. Distances between supraaortc arteries were not associated with age

This study may provide basic anatomical data to cardiac surgeons for catheterization of aortic arch and its branches for safely performing endovascular surgery.

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