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## An observational study of coronary artery anatomy in patients with normal coronary angiogram

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### Abstract

**Background:** Diameter of coronary artery is an important predictor of outcome after percutaneous coronary interventions and coronary artery bypass graft surgery. There is very limited data available about coronary artery dimensions in Indian population. Our aim is to study the normal dimensions of the coronary artery segments in Indians without coronary artery disease by using quantitative coronary angiography and to study the influence of age, sex and body mass index on coronary artery anatomy and dimensions.

**Materials and Methods:** 100 patients who have undergone coronary angiography with entirely normal coronary angiogram were included in our study

**Results:** This study showed the diameter of vessels in males and females when taken together the left main was larger in size followed by proximal LAD, proximal LCX & proximal RCA respectively (4.4±0.78mm, 3.48±0.53mm, 3.1 ±0.7mm, 3.0±1 mm). The length of vessels in males and females when taken together the LAD was larger in size followed by RCA and LCX respectively (11.35±1.54 cm, 11±3 cm, 6.40±2.5 cm). 86% people in our study population had type III LAD. Study population mostly had right sided dominance 72%. Left main bifurcates in 92%. Females in our study population had smaller size of coronary vessels of which Size of the LAD proximal diameter is statistically significant. Elderly persons have a change in length and diameter of the coronary vessels of which Reduction in the length of Left main stem is statistically significant. Taller persons have an increase in the size of coronary vessels of which Increase in the length and diameter of proximal LAD is statistically significant. Weight of the individual has no correlation with size of coronary arteries Persons with higher BMI has a statistically significant increase in the proximal diameter of RCA and reduction in the length of proximal LAD.

**Conclusions:** We found that Females in our study population had smaller size of coronary vessels of which Size of the LAD proximal diameter is statistically significant. Elderly persons have a change in length and diameter of the coronary vessels of which Reduction in the length of Left main stem is statistically significant. Taller persons have an increase in the size of coronary vessels of which Increase in the length and diameter of proximal LAD is statistically significant. Weight of the individual has no correlation with size of coronary arteries Persons with higher BMI has a statistically significant increase in the proximal diameter of RCA and reduction in the length of proximal LAD.

**Keywords:** Coronary artery, dimensions, age, sex, height, weight, body surface area

### Introduction

Current understanding and development regarding coronary atherosclerosis are predicated on the understanding of the normal coronary anatomy. There are several postmortem studies regarding dimensions of coronary arteries. However there are only few studies regarding real life dimensions [1]. Size of the coronary artery is an important predictor of outcome after percutaneous coronary interventions (PCI) and coronary artery bypass graft surgery (CABG). Coronary artery dimensions are influenced by age, sex, anatomic variation, left ventricular hypertrophy or dilatation and body mass index [2]. It has been shown that men have larger coronaries than women. Left ventricular hypertrophy and dilated cardiomyopathy are also associated with larger coronaries [1, 2]. Only limited data is available about coronary artery dimensions in an Indian population [3, 4]. The aim of this study was to determine coronary artery dimensions in an Indian population with angiographically normal coronary arteries.

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## Material and Methods

This observational study was carried out on patients of department of cardiology at Govt. Stanley hospital, Chennai 600001, Tamilnadu over a period of one year from November 2017 to November 2018. A total of 100 adult subjects (both males and females) of aged >18 years were for in this study.

**Study design:** Observational study

**Study location:** Government Stanley hospital – Chennai 600001.

**Study duration:** 1 year

**Sample size:** 100 patients.

### Inclusion criteria

1. Patients with atypical chest pain
2. Patients with chronic stable angina
3. Patients with pre operative assessment of coronary arteries for valve replacement
4. Patients with pre operative assessment of liver transplantation

### Exclusion criteria

1. Patients with history of CAD
2. Patients undergoing angiogram for myocardial infarction( STEMI & NSTEMI)
3. Any patients having diseased coronary arteries on coronary angiogram
4. Patients having tortuous blood vessels
5. Patients having coronary spasm
6. Patients with significant ecg changes of CAD
7. Patients with significant regional wall motion abnormalities
8. Patients with positive TMT test
9. Patients with LVH by echo

### Procedure methodology

Selection of study population as per inclusion and exclusion criteria. Informed consent was obtained.

We studied 100patients who had coronary angiography and found to have normal coronary angiogram based on visual assessment of absence of any luminal irregularities. Coronary angiography was performed by femoral route with 5f/6f Judkin's or Amplatz right and left catheter and tiger catheter. Contrast filled segments of coronary arteries free of tortuosity were assessed in an end diastolic frame. Standard projections were taken for visualization of main epicardial coronary arteries. Coronary angiograms with evidence of localized atheroma, coronary spasm, and previous history of myocardial infarction with recanalised arteries were excluded. The dimension of the coronary was then measured with reference to the catheter diameter [5]. The dimensions of the coronary artery were measured as a function of the catheter diameter and the absolute diameter in millimeter (mm) was calculated by automated software analysis. No intra coronary nitroglycerine was administered prior to acquisition of images. The measurements were taken in diastole. Each artery was measured in the defined segments and measurements were taken at the widest diameter of the segment. Statistical analysis done with student t-test and independent "t" test. The statistically significant p values in all these tests was assumed at a value < 0.05. The length and

diameter of the left main stem, proximal, mid and distal LAD and the type of LAD is noted. Similarly the length and diameter of proximal and distal LCX and the number of obtuse marginal branches were noted. The length and diameter of proximal, mid and distal RCA and the branches of RCA were noted. The dominance of coronary system was next assessed. The results were compared with respect to age, sex, height, weight and body surface area. Any anomalous origin of coronary artery was mentioned.

### Statistical analysis

The collected data will be entered in MS excel, values entered will be checked for inconsistency. The data will be analyzed using SPSS software. Mean, standard deviation and frequency will be calculated, chi square test will be used as a test of significance. p value of < 0.05 will be considered statistically significant.

### Results

**Table 1:** Distribution of the age of the subjects.

Age Group	Frequency	Percent
< 40 years	21	21.0
40 - 49 years	38	38.0
50 - 59 years	30	30.0
60 years & above	11	11.0
Total	100	100.0

Most of the study populations are between 40 – 60 yrs of age. Only 11% of the population is 60 years and above.

**Table 2:** Distribution of the sex of the subjects.

Sex	Frequency	Percent
M	55	55.0
F	45	45.0
Total	100	100.0

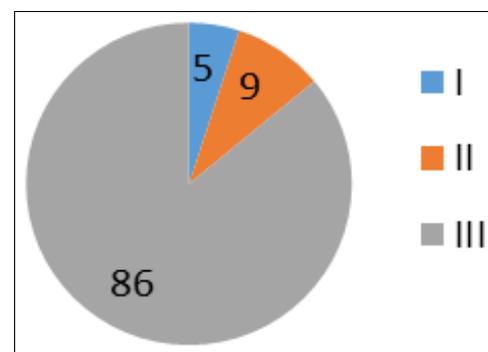
Study population contained almost equal distribution of males and females.

Mean height in men in our study 164 cms.

Mean height of women in ours study is 152 cms.

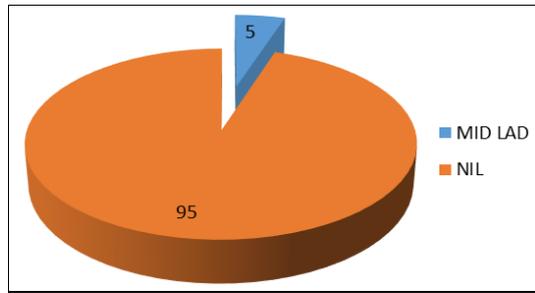
Mean weight of men – 64 kgs.

Mean weight of women- 52 kgs.

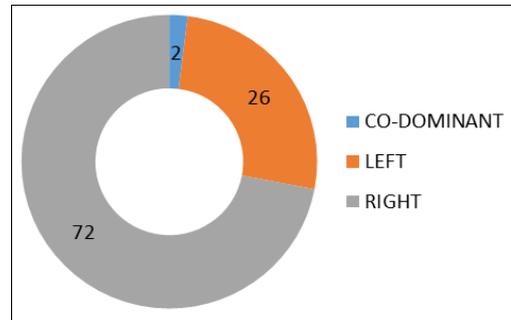


LAD Type

All persons had their origin of left main stem from left sinus. 86% people had type III LAD. 5% of study population had type I LAD and 9% of study population had type II LAD.



Myocardial Bridging



Dominance

- In our study population Myocardial bridging is noted in 5% of population in MID LAD. myocardial bridging is not noted in LCX / RCA/ Ramus.
- Study population mostly had right sided dominance 72%. Left dominant system is seen in 26% of population and co dominance of coronary circulation is seen in 2%.

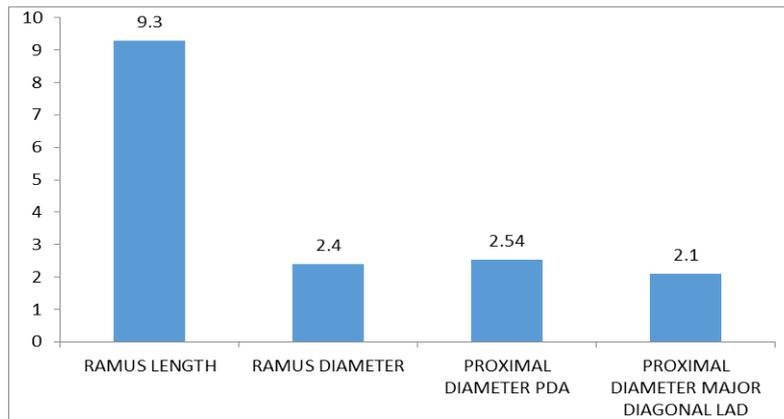


Fig 1: Length and diameter of ramus and diameter of proximal PDA & major diagonal.

- Left main bifurcates in 92% of our study population into LAD and LCX.
  - Left main trifurcates in 8% into LAD, ramus and LCX.
- The mean length of ramus is 9.3 cm with mean diameter of ramus in our study population is 2.4 mm.

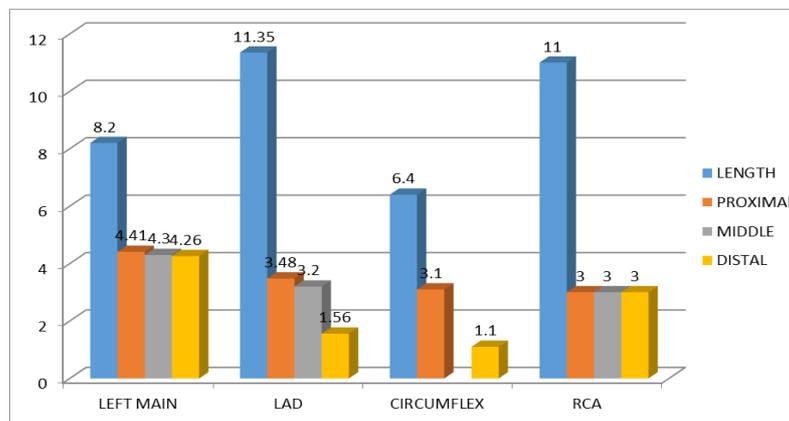
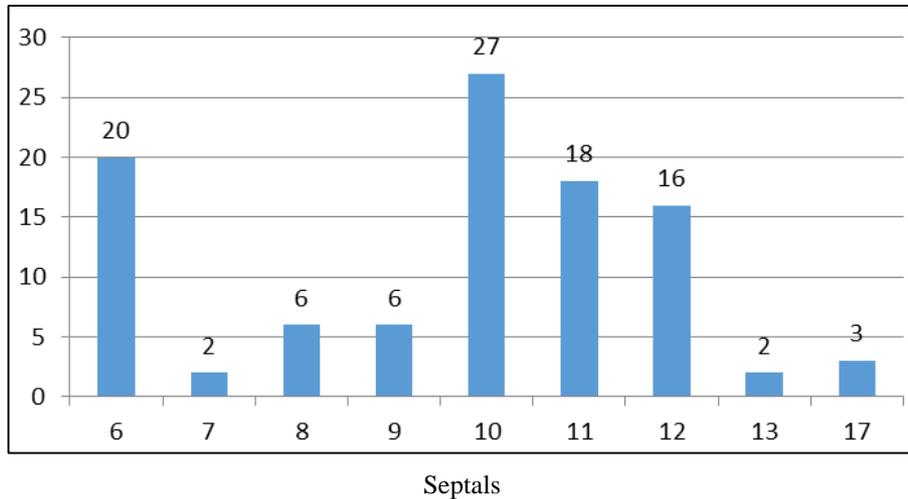
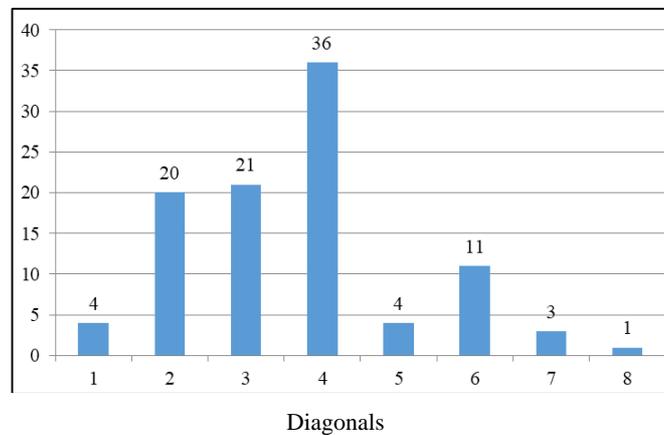
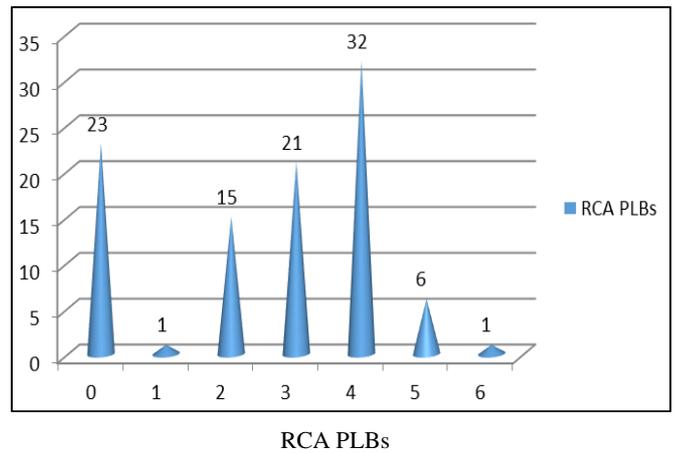


Fig 2: Length and diameter of major coronary vessels.

- Mean length of Left Main is 8.2 mm with standard deviation of 4.2 mm. Maximal size of Left main seen in our population is 22 mm with the Minimal size is 1 mm
- Mean proximal diameter of left main – 4.4 mm +- 0.45 mm, Mean mid diameter – 4.3 mm +- 0.44 mm and the mean distal diameter – 4.2 mm +- 0.36 mm
- Mean length of LAD in our study population : 11.35 cm with a standard deviation of 1.54 mm. Mean proximal diameter of LAD – 3.48 mm +- 0.44 mm, mean mid diameter – 3.2 mm +- 0.38 mm and the mean distal diameter – 1.56 mm +- 0.33 mm.
- Proximal diameter major diagonal is 2.1 +- 0.31 mm
- Mean Circumflex length is 6.4 cm with SD of 2.5 mm. The mean Circumflex proximal diameter 3.1 mm +- 0.26 mm, mean Circumflex distal diameter 1.1 mm +- 0.25 mm
- Mean RCA Length is 11 cm with SD of 3.83 mm. Mean RCA Proximal diameter is 3 mm +- 0.35 mm Mean RCA Middle diameter is 3 mm +- 0.33 mm, mean RCA Distal diameter is 3 mm +- 0.23 mm and the mean Proximal diameter PDA is 2.54 mm +- 0.24 mm.

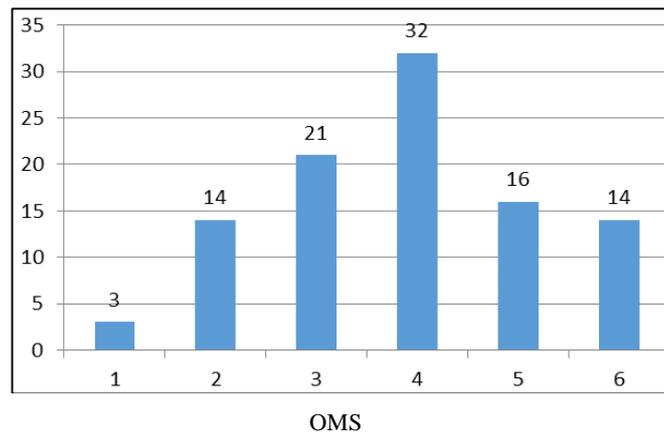
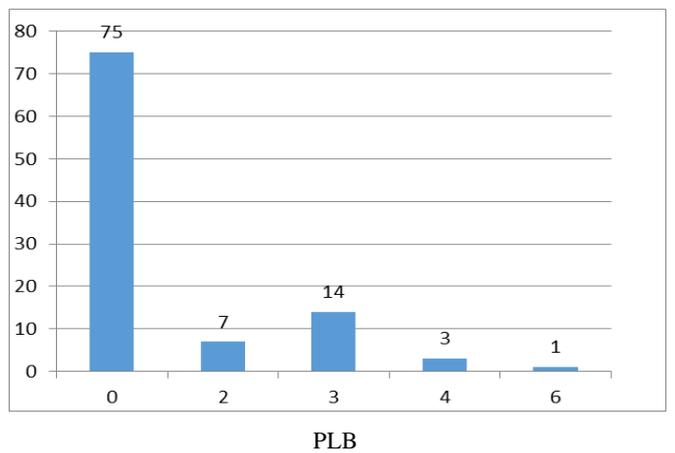


- The mean number of septals in our study population is 10. Maximum number of 17 septals are seen in 3%. Minimum number of septals in our population is 6.



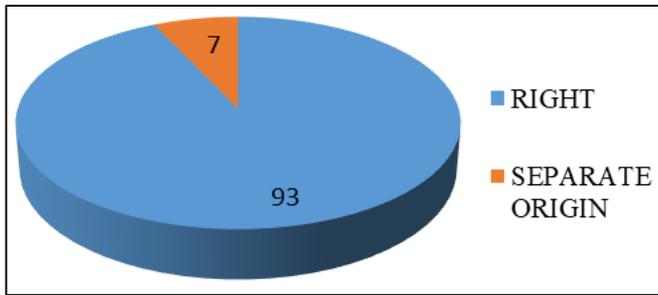
- The mean number of postero lateral branches in our group population is 4. maximum number of RCA PLB in our study population is 6.

- The mean number of diagonals in our group population is 4. maximum number of diagonals in our population is 8 and the minimum number of diagonal is 1.



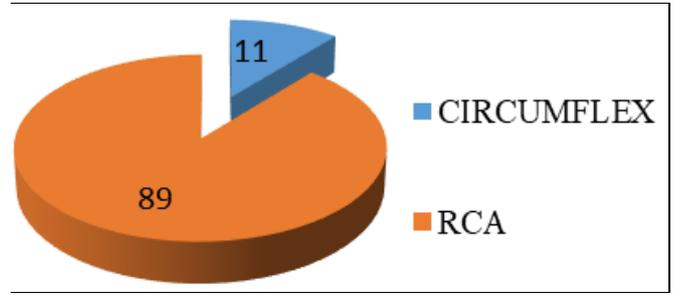
- When left side is dominant, the average number of PLB arising from circumflex artery is 3 with the maximum number being 6 seen in 1%.

- The mean number of obtuse marginal branches in our group population is 4. maximum number of OMs seen in our study population is 6.



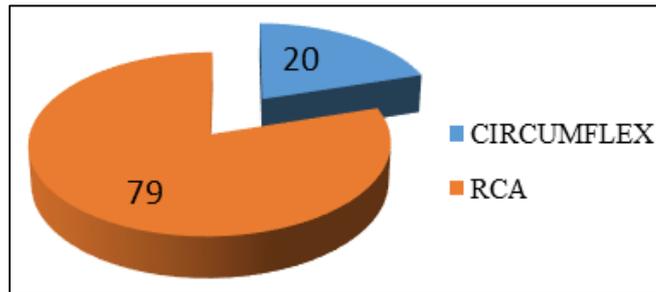
Origin of Conus Branch

Separate origin of conus branch is seen in 7% population. In the rest of the 93 patients conus branch arises from right coronary artery.



Origin of SA Branch

Regarding the origin of SA branch it arises from in RCA in 89% of population and from LCX in 11%.



Origin of AV Branch

Regarding the origin of AV branch, it arises from RCA in 79% and 21% from LCX.

**Table 3:** Correlation of age, height, weight and BMI to the size of coronary vessels.

Correlation		Left Length	Left PROX DIA	LAD Length	LAD PROX DIA	RCA Length	RCA PROX DIA
Age (years)	r value	-0.216	0.248	-0.093	-0.013	-0.125	-0.164
	p value	0.031	0.013	0.358	0.9	0.214	0.103
Height (cm)	r value	0.157	0.151	0.244	0.323	0	0.052
	p value	0.118	0.134	0.014	0.001	0.999	0.608
Weight (cm)	r value	0.051	0.024	0.01	0.202	0.074	0.189
	p value	0.613	0.816	0.918	0.044	0.464	0.06
BMI	r value	-0.118	-0.151	-0.257	-0.073	0.099	0.209
	p value	0.241	0.134	0.01	0.472	0.326	0.037

Elderly persons have a change in length and diameter of the coronary vessels compared to younger individuals of which

1. Reduction in the length of LEFT MAIN CORONARY ARTERY is statistically significant.
2. Reduction in the length of other 3 main coronary vessels which are statistically not significant.
3. Reduction in the diameter of 3 main coronary vessels which are not statistically significant.
4. Increase in the size of left main proximal diameter which is statistically significant.

5. Taller persons have an increase in the size of coronary vessels of which Increase in the length and diameter of proximal LAD is statistically significant.
6. Weight of the patient has no correlation with the size of coronary vessels in our study.
7. Persons with higher BMI increases there is a statistically significant increase in the proximal diameter of RCA and reduction in the length of proximal LAD.

**Table 4:** Comparison of vessels size in both sexes.

	Total	Males	Females
Left main Length	8.2 (± 4.3)	8.33 (± 3.91)	7.98 (± 4.79)
Proximal Diameter	4.41 (± 0.78)	4.43 (± 0.76)	4.38 (± 0.82)
Middle Diameter	4.3 (± 0.9)	4.35 (± 0.8)	4.26 (± 1.06)
Distal Diameter	4.26 (± 0.96)	4.34 (± 0.91)	4.17 (± 1.03)
LAD Length	11.35 (± 1.54)	11.47 (± 1.52)	11.19 (± 1.56)
LAD Proximal Diameter	3.48 (± 0.53)	3.64 (± 0.48)	3.27 (± 0.53)
LAD Middle Diameter	3.2 (± 4.2)	2.68 (± 0.6)	2.61 (± 0.42)
LAD Distal Diameter	1.56 (± 0.55)	1.49 (± 0.57)	1.65 (± 0.52)
Proximal Diameter Major Diagonal LAD	2.1 (± 0.3)	2.19 (± 0.34)	2.09 (± 0.29)
Circumflex Length	6.4 (± 2.5)	6.47 (± 2.65)	6.2 (± 2.39)
Circumflex Proximal Diameter	3.1 (± 0.7)	3.08 (± 0.73)	3.06 (± 0.61)

Circumflex Distal Diameter	1.1 ( $\pm$ 0.9)	1.19 ( $\pm$ 0.92)	1.02 ( $\pm$ 0.84)
RCA Length	11 ( $\pm$ 3)	10.62 ( $\pm$ 2.54)	10.61 ( $\pm$ 2.67)
RCA Proximal Diameter	3 ( $\pm$ 1)	3.25 ( $\pm$ 0.66)	3.22 ( $\pm$ 0.74)
RCA Middle Diameter	3 ( $\pm$ 1)	2.94 ( $\pm$ 0.79)	2.86 ( $\pm$ 0.74)
RCA Distal Diameter	3 ( $\pm$ 1)	2.5 ( $\pm$ 0.84)	2.52 ( $\pm$ 0.72)
Proximal Diameter PDA	2.54 ( $\pm$ 0.48)	2.57 ( $\pm$ 0.51)	2.51 ( $\pm$ 0.45)
RAMUS Length	9.3 ( $\pm$ 1.1)	8 ( $\pm$ 0)	9.7 ( $\pm$ 0.94)
RAMUS Diameter	2.4 ( $\pm$ 0.5)	2.2 ( $\pm$ 0)	2.45 ( $\pm$ 0.6)

**Table 5:** Statistical significance of sizes between males and females:

	Males	Females	p value
Length	8.33 ( $\pm$ 3.91)	7.98 ( $\pm$ 4.79)	0.692
Proximal Diameter	4.43 ( $\pm$ 0.76)	4.38 ( $\pm$ 0.82)	0.728
Middle Diameter	4.35 ( $\pm$ 0.8)	4.26 ( $\pm$ 1.06)	0.66
Distal Diameter	4.34 ( $\pm$ 0.91)	4.17 ( $\pm$ 1.03)	0.426
LAD Length	11.47 ( $\pm$ 1.52)	11.19 ( $\pm$ 1.56)	0.371
LAD Proximal Diameter	3.64 ( $\pm$ 0.48)	3.27 ( $\pm$ 0.53)	< 0.001
LAD Middle Diameter	2.68 ( $\pm$ 0.6)	2.61 ( $\pm$ 0.42)	0.499
LAD Distal Diameter	1.49 ( $\pm$ 0.57)	1.65 ( $\pm$ 0.52)	0.171
Proximal Diameter Major Diagonal LAD	2.19 ( $\pm$ 0.34)	2.09 ( $\pm$ 0.29)	0.126
Circumflex Length	6.47 ( $\pm$ 2.65)	6.2 ( $\pm$ 2.39)	0.593
Circumflex Proximal Diameter	3.08 ( $\pm$ 0.73)	3.06 ( $\pm$ 0.61)	0.893
Circumflex Distal Diameter	1.19 ( $\pm$ 0.92)	1.02 ( $\pm$ 0.84)	0.334
RCA Length	10.62 ( $\pm$ 2.54)	10.61 ( $\pm$ 2.67)	0.977
RCA Proximal Diameter	3.25 ( $\pm$ 0.66)	3.22 ( $\pm$ 0.74)	0.792
RCA Middle Diameter	2.94 ( $\pm$ 0.79)	2.86 ( $\pm$ 0.74)	0.615
RCA Distal Diameter	2.5 ( $\pm$ 0.84)	2.52 ( $\pm$ 0.72)	0.896
Proximal Diameter PDA	2.57 ( $\pm$ 0.51)	2.51 ( $\pm$ 0.45)	0.546
Ramus Length	8 ( $\pm$ 0)	9.7 ( $\pm$ 0.94)	0.051
Ramus Diameter	2.2 ( $\pm$ 0)	2.45 ( $\pm$ 0.6)	0.598

Females in our study population had smaller size of coronary vessels of which size of the LAD proximal diameter is statistically significant.

### Discussion

The dimensions of the coronary arteries are highly variable in the normal population<sup>[5]</sup>. The determinants of coronary artery size are not well understood. Genetic factors undoubtedly play an important role. 2 Age, sex, body weight, BSA, weight of the heart and ethnic/racial factors have all been correlated with the coronary artery anatomy in various studies. 2 Many of these studies were either injection studies in post mortem specimens or dissection studies. There have been numerous reports on the size of coronary arteries in post mortem studies. Several correlations between heart weight & lumen size of the coronary arteries have been made from these studies. The inherent fallacy of these studies has however been the various factors involved in the procurement, preservation, fixation & analysis of the epicardial coronary arteries thereby vitiating, the validity of these observations in estimating the true dimension of coronary arteries.

There have been very few estimates of normal (undiseased) coronary artery size during life based on visual estimates or electronic calliper measurements from cine-angiographic films<sup>[6]</sup>. In this prospective study we attempted to establish a database for normal dimensions of the coronary artery segments during life by using quantitative coronary angiography.

Quantitative coronary angiography (QCA) 5 has been developed with the purpose of geometric assessment of epicardial coronary artery abnormalities since visual interpretation of coronary angiograms is inherently flawed & observer dependent. Several studies have validated the accuracy of digital quantitative estimation of coronary

dimensions<sup>[6, 7]</sup>. We applied the principles of quantitative coronary angiography for assessment of angiographically normal coronary artery segments in 100 patients who had undergone cardiac catheterization & angiography for evaluation of symptoms suggestive of coronary artery disease. Our study population had nearly equal distribution of males and females.

The age group varied from < 40 yrs of age to > 60 yrs of age of which most of the study population belong to 40 – 60 yrs of age. In our study Left main stem had origin in left sinus in 100%. 86% people had type III LAD. Myocardial bridging is noted in 5% of population in Mid LAD.

Study population mostly had right sided dominance 72%. Left main bifurcates in 92% and trifurcates in 8%. Mean length of Left Main is 8.2 mm with standard deviation of 4.2 mm. Mean proximal diameter of left main is 4.4 mm. Mean length of LAD in our study population is 11.35 cm with a standard deviation of 1.54 cm. Mean proximal diameter of LAD is 3.48 cm. Mean Circumflex length is 6.4 cm with SD of 2.5 cm Mean Circumflex proximal diameter 3.1. Mean RCA Length is 11 cm with SD of 3 cm. Mean RCA Proximal diameter is 3 mm in our study. Separate origin of conus branch is seen in 7% population. SA branch arises from in RCA in 89% of population and from LCX in 11%. AV branch it arises from RCA in 79% and 21% from LCX. Females in our study have smaller coronary artery dimensions compared to males but not statistically significant except the size of proximal LAD. Age in our study has no impact on the size of coronary artery dimensions except the length of the left main stem whose reduction in size is statistically significant. Height of the individual has an impact on the length and diameter of proximal LAD as taller individuals have a statistically significant increase in the size. Weight in our study population had no impact on dimensions of coronary arteries.

Person with higher BMI had a statistically significant increase in the proximal diameter of RCA and reduction in the length of proximal LAD.

### Conclusion

Thus in our study 86% people had type III LAD. Study population mostly had right sided dominance 72%. Left main bifurcates in 92% and trifurcates in 8%. Mean length of Left Main is 8.2 mm with standard deviation of 4.2 mm. Mean proximal diameter of left main is 4.4 mm. Mean proximal diameter of LAD is 3.48 cm. Females in our study population had smaller size of coronary vessels of which Size of the LAD proximal diameter is statistically significant. Elderly persons have a change in length and diameter of the coronary vessels of which Reduction in the length of Left main stem is statistically significant. Taller persons have an increase in the size of coronary vessels of which Increase in the length and diameter of proximal LAD is statistically significant. Weight of the individual has no correlation with size of coronary arteries. Persons with higher BMI has a statistically significant increase in the proximal diameter of RCA and reduction in the length of proximal LAD.

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