Angiographic analysis of morphometry pattern of human coronary arteries

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Abstract

Background: Coronary arteries play an important role in perfusion of the heart tissues. Variations or anomalies in coronary arteries may be asymptomatic while some can be symptomatic and even cause sudden death. Knowledge of coronary artery variations is important in diagnosis and treatment of cardiovascular diseases. **Aim:** To study the angiographic analysis of morphometry pattern of human coronary arteries **Materials and methods:** We dissected and grossly examined a total of 78 human hearts to describe coronary artery variations in origin and course.   The study was carried out at Dr V.R.K Womens medical and Deccan College of Medical Sciences during the period from Jan 2018 to June 2019.**Results and discussion:** Diameter of LCA was 4.14 ± 0.81, LAD was3.12 ± 0.58, LCx was 2.28 ± 0.48, and diameter of RCA was 3.10 ± 0.38. Bifurcation of LCA was seen in 40 (80 %) males and 42 (84%) females. Trifurcation of LCA was seen in eight (16%) males and six (12%) females. two male (3.92 %) and two (3.92 %) females have quadrification of LCA. Length of LCA was significantly high in females ($p < 0.00$) and diameter was more in males ($p < 0.01$) when compared to females. However, there was no significant difference across gender in angle of division of LCA.**Conclusion:** Knowledge of the normal and variant anatomy of coronary arteries is indispensable and imperative both in diagnosis, treatment and implementation of interventional measures.
 Keywords: left coronary artery, variation, branching pattern, left anterior descending artery, circumflex artery

Introduction

The heart is supplied by two coronary arteries (left and right) and their branches, which are located between the epicardium and myocardium. The right (RCA) and the left coronary arteries (LCA) arise from the aortic sinus of valsalva at the root of the aorta and encircle the base of ventricles like a crown[1]. The LCA is responsible for irrigation of most of the left ventricle and also a considerable proportion of the right ventricle[2]. It lies between the pulmonary trunk and the left atrial auricle, emerging into the atrioventricular (AV) groove, in which it turns left. Reaching the atrioventricular (AV) groove, the LCA usually divides into two main branches: left anterior descending (LAD) and circumflex artery (CA)[3]. Knowledge of normal and variant anatomy and anomalies of coronary circulation is an increasingly vital component in the management of congenital and acquired heart diseases. The term "anomaly " is used for variations that occur in less than 1% of the general population[4].

The LCA presents wide variability in its morphological expression. Thus, this study aimed to determine these variations in the LCA and its branches. The study of coronary arteries will be useful to the cardiologists and radiologists to predefine abnormalities by invasive and non-invasive studies. Hence increasing use of diagnostic and therapeutic inter-ventional procedures requires a sound, basic knowledge of the coronary artery pattern[5].Since decades the anatomy of coronary arteries has been studied in various populations by cadaveric dissection, but no such study was conducted in Indian population to the best of our knowledge, so in thisstudy, we plan to study the normal and variant anatomy of coronary arteries in normal healthy Indian population.

Objectives of the Present study
 1. To evaluate the morphometry of coronary arteries.
2. To study the dominance pattern of coronary arteries in Indian population by Quantitative Coronary angiography Technique (QCAT).

Materials and Methods
- **Study design: Cross Sectional (Descriptive)**
- **Number of groups --- 02**
- **Sample size: 100**

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❑ **Sample size**: Sample size was carried out with expected difference in morphological parameters between genders as 5.5 % with 80% power. We need to study 210 samples. With expected errors we adjusted it to 250.

a. Inclusion Criteria: Angiographic films from both gender(Age between 18 to 35) healthy individuals

b. Exclusion Criteria: Angiographic studies with abnormal findings which affect morphometry and branching pattern of coronary arteries.

This study was conducted at Department of Anatomy and Department of Radiology, Dr.V.R.K Womens Medical College & Deccan College of Medical Sciences during the period from Jan 2018 to June 2019., Hyderabad. The basic info includes age, height and weight of participants was taken. The blood, lipid and virology profiles were noted down before the actual procedure.After successful angiography, consecutive coronary angiograms were obtained and reviewed. The RCA length and diameter (segment wise) and dominance were measured. The Left Coronary Artery (LCA) length was measured in each of the angiograms from its orifice to its point of division into terminal branches. This was visualized by spillback of contrast medium into the aorta during selective injection. Measurements were made in a single frame projection that shows the LCA and its point of branching clearly, in all patients. Correction for magnification was done by calibrating the size of the Judkins@ catheter to its actual size. This was achieved by auto calibrating the catheter on the software used for analyzing the angiographic images. This calibration ensures that the values recorded are the actual not the magnified sizes of the coronary vessels seen on the screen. The projected radiological angle between the origins of the Anterior Interventricular artery (AIA) and Circumflex artery (bifurcation angle) will be measured in a single frame projection that shows the LCA and its point of branching clearly.Coronary angiography was done by Allenger's medical system (Model– MARS 6, Equip. ID: G-XR-77346) machine. This was based on HF X-Ray generation technology.

SYNGO -- Quantitative Coronary Angiography

This was a scientifically validated 2D coronary quantification software which provides quantitative coronary vessel analysis, and it's optimized for small vessels like coronary arteries.

The following parameters were observed:

• Patient basic information, general physical examination will be taken before the actual procedure.

• Right Coronary Artery: Origin, Length & External diameter of RCA (1st and 2nd segments)

• Left Coronary Artery: Origin, length, diameter, division, Level of termination and branching pattern

Statistical analysis plan: Statistical analysis was performed using the Statistical Package R for windows. The data expressed as mean ±SD (Standard Deviation). Normality was tested with Kolmogorov–Smirnov test (two sample KS test).The differences between two groups (male & female) was calculated with ANOVA (post hoc. Test). The null hypothesis was rejected at $P \leq 0.05$.

Results

This study was carried out in two hundred and fifty apparently healthy individuals out of whom one hundred and twenty five were male. Age of study participants was 29.53 ± 5.13. The demographic and clinical profile of the study participants were depicted in Table 1. There were no significant difference in age and heart rate in the study participants. Coronary artery dominance pattern was depicted in Table 2. Out of hundred, eighty people i.e. 80 % were right dominant, eleven out of hundred i.e. 11 % were left dominant and nine participants i.. 9 % were co dominant. Forty two (84 %) and forty females (80 %) were right dominant. six (12 %) out of males were left dominant and eight (16 %) out of fifty females were left dominant. Co dominant pattern was seen in 2 (3.92 %) of males and 2 (3.92 %) females.Diameter of LCA was 4.14 ± 0.81, LAD was 3.12 ± 0.58, LCx was 2.28 ± 0.48, and diameter of RCA was 3.10 ± 0.38. The gender differences of diameters of coronary arteries were depicted in Table 5.There was no significant gender difference in the diameter of LCx. But, the diameters of LCA ($p < 0.00$), LAD ($p < 0.00$) and RCA ($p < 0.00$) was significantly high in males when compared to females.Table 6 shows the gender difference in segment wise measurement of RCA. First ($p < 0.00$) and second segments ($p < 0.01$) of RCA was significantly high in males when compared to females.

Length, diameter, angle of division and branching pattern of LCA was depicted in Table 7.Bifurcation of LCA was seen in 40 (80 %) males and 42 (84%) females. Trifurcation of LCA was seen in eight (16%) males and six (12%) females. two male (3.92 %) and two (3.92 %) females have quadrification of LCA. Length of LCA was significantly high in females ($p < 0.00$) and diameter was more in males ($p < 0.01$) when compared to females. However, there was no significant difference across gender in angle of division of LCA .

Table 1:Demographic & clinical profile of the study population

Sl.No	Parameter	Mean + SD
1	Age	28.43 + 4.13
2	Gender (Male/Female)	50/50
3	Height	163.75 + 26.22
4	Weight	70.00 +14.00
5	HR	76.62 + 10.49
6	SBP	120.00 + 18.17
7	DBP	77.21 + 12.81

Table 2: Coronary dominance pattern of study participants

Sl.No	Parameter	No. (%)
1	RT dominance	80 (80%)
2	LT dominance	11 (11%)
3	Co dominant	09 (9%)

Table 3:Diameters of coronary arteries

Sl.No	Parameter	Mean + SD
1	Diameter of LMCA	4.14 + 0.81
2	Diameter of LAD	3.12 + 0.58
3	Diameter of LCx	2.78 + 0.48
4	Diameter of RCA	3.10 + 0.38

Table 4: Gender differences in coronary dominance pattern of study participants

Sl.No	Parameter	Male	Female	P value
1	RT dominance	42 (84%)	40(80%)	NA
2	LT dominance	6 (12%)	8 (16%)	NA
3	Co dominant	2 (3.92%)	2 (3.92%)	NA

Table 5. Gender differences in diameters of coronary arteries

Sl.No	Parameter	Male	Female	P value
1	Age	30.020+ 3.12	30.41 + 3.30	0.35
2	Diameter of LMCA	5.05 + 0.56	4.13 + 0.58	0.00
3	Diameter of LAD	3.77 + 0.38	2.82 + 0.51	0.00
4	Diameter of LCx	3.28 + 0.42	3.04 + 0.42	0.34
5	Diameter of RCA	3.58 + 0.15	3.09 + 0.42	0.00

Table 6: Gender differences in Segment wise measurement of RCA

Sl.No	Parameter	Male	Female	P value
1	RCA 1st segment	6.34 + 0.46	5.64 + 0.89	0.00
2	RCA 2nd segment	4.35 ± 0.59	4.00 ± 0.45	0.01

Table 7: Gender differences in measurements of LCA

Sl.No	Parameter	Male	Female	P value
1	LCA bifurcation	107 (85.6 %)	111 (88.8 %)	NA
2	LCA trifurcation	17 (13.6 %)	12 (9.6 %)	NA
3	LCA quadrification	1 (0.8 %)	2 (1.6 %)	NA
4	LCA length	8.40 + 1.11	17.98 + 1.05	0.00
5	LCA diameter	4.72 + 1.00	4.43 + 1.01	0.01
6	LCA angle of division	71.38 + 17.35	72.16 + 15.95	0.61

Discussion

Nowadays, with the extensive use of advanced image diagnostic techniques and the development of non-aggressive treatments, a indepth knowledge of anatomy of the normal coronary and its variations and anomalies is important. Branches of coronary arteries may vary in origin, distribution, number and size. The origins of coronary arteries show great variability, about 90% of anomalies were anomalies of origin[6]. It was observed that in all the 78 heart specimens[3] aortic sinuses were present and LCA arises from left posterior aortic sinus. Similar observations were reported by the Kalpana RA[7] James[8] Sahni & Jit et al.[9] and Kulkarni J[10]The LCA is the main source of blood supply to the heart.[2,3] Kalbfleisch and Hort[11], who conducted a study on the area irrigated by each of the coronary arteries using postmortem angiography, showed that the LCA irrigated 68.8% of the cardiac muscle mass and 79% of the left ventricular cardiac muscle mass. Hence, obstructive disease of the LCA may reduce the coronary flow to a large proportion of the ventricular myocardium, and as a result, atherosclerotic diseases of the LCA have more serious complications than those of the RCA.This study was carried out in two hundred and fifty apparently healthy individuals out of whom one hundred and twenty five were male. Age of study participants was 29.53 ± 5.13. We have recruited one hundred and twenty five male, age matched female individuals to see the gender differences in various parameters. There were no significant difference in age and heart rate of the study participants. However, males have

higher systolic blood pressure (p < 0.00), diastolic blood pressure (p < 0.00), pulse pressure (p < 0.00) and rate pressure product (p < 0.00) when compare to females.In this study, right coronary artery was dominant was seen in eighty two individuals i.e. 82% were right dominant, fourteen out of hundred i.e. 14 % were left dominant and 4 participants i.e. 4 % were co dominant. The gender difference in coronary artery dominant pattern was depicted in Table 5. Forty males (80 %) and forty two females (84 %) were right dominant. six (12%) out of fifty males were left dominant and eight (16 %) out of fifty females were left dominant. Co dominant pattern was seen in two (3.92 %) of males and two (3.92%) females.Diameter of Left Coronary Artery(LCA) was 4.14 $\pm$ 0.81, Left Anterior Descending(LAD) was 3.12 $\pm$ 0.58, Circumflex(LCx) was 2.78 $\pm$ 0.48, and diameter of Right Coronary Artery was 3.10 $\pm$0.38. The gender differences of diameters of coronary arteries were depicted in Table 5. There was no significant gender difference in the diameter of Circumflex. But, the diameters of Left Coronary Artery (p < 0.00), Left Anterior Descending (p < 0.00) and Right Coronary Artery (p < 0.00) was significantly larger in males when compared to females.A detailed knowledge of the LCA anatomy is very important due to the extensive use of radio-graphical images for both diagnostic and interventional purposes. The present study found a significant correlation between the length of the LCA and its angle of division.[12,13].

Conclusion

The gender difference in segment wise measurement of RCA. First and second segments of RCA was significantly high in males when compared to females. A detailed knowledge of the LCA anatomy is very important due to the extensive use of radio-graphical images for both diagnostic and interventional purposes. The present study found a significant correlation between the length of the Left Coronary Artery and its angle of division. The present study found an important correlation between the length of the LCA and its angle of division.

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