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Research Article

Morphometric Analysis of the Left Main Coronary Truncus, Left Anterior Descending Artery, Circumflex Artery, and Intermediate Artery: Measurements of Length, Angle, and Diameter

Arzu Mumcu[1], Mesut Gitmez[2]

[1]Batman University, Vocational High School of Health Services, Batman, Türkiye
[2]Batman Training and Research Hospital, Department of Cardiology, Batman, Türkiye

Abstract

Aim: The aim of our study was to group the left main coronary truncus (LMCT) according to its branching structure and to determine its length, angle and diameter measurements together with LMCT's main branches which are left anterior descending artery (LAD), circumflex artery (Cx) and intermediate artery (IA).

Material and Methods: Between June 2019 and June 2021, coronary angiographies of 150 (female-39%, male-61%) patients were analysed by digital subtraction angiography. For each patient, the measurements of the length and diameter of the LMCT, LAD (proximal-middle-distal parts), Cx (proximal-middle-distal parts), and IA were calculated. Measurements were performed with 2-dimensional measurement technique.

Results: The LMCT showed bifurcation pattern in 90.7% and trifurcation pattern in 9.3% of cases. The mean LMCA length and diameter were 15.9±5.7 mm and 6.0±0.9 mm, respectively. The LAD-CX angle defined as the bifurcation angle was 75.8±25.5°. The results that differed significantly between the sexes were the LMCT-LAD angle (159.2±17.8°) and the LAD-distal diameter (2.5±0.5 mm) ($p<0.05$).

Conclusion: In our study, the length-angle-diameter measurements of the LMCT and its main branches (LAD, Cx, IA) were determined in detail. These results are important anatomical data that may contribute to the diagnosis and treatment procedures, especially in cardiology, cardiovascular surgery, and radiology.

Keywords: Left main coronary truncus; left anterior descending artery; circumflex artery; intermediate artery; length-angle-diameter measurements; morphometric analysis

INTRODUCTION

The left coronary artery (LCA), which is the main source of supply to the heart, starts from the left aortic sinus, passes behind the pulmonary truncus and proceeds along the atrioventricular sulcus, before dividing into its main branches, this part is called the left main coronary truncus (LMCT). In classical morphology, the LMCT bifurcates into two main branches, the left anterior descending artery (LAD) and circumflex artery (Cx). In some hearts, there may be a third artery called intermediate artery (IA) between the LAD and Cx origins. In this case, LCA trifurcation is referred. The LCA is very important as it supplies most of the myocardium and interventricular septum, especially the left heart (1-5).

Various studies have shown that there is an important relationship between coronary artery morphology and the diagnosis and treatment of coronary artery diseases. Coronary stenoses of various degrees of stenosis, which require advanced by-pass surgery, are usually seen in the branching regions of coronary arteries. There are several studies showing that there is a significant relationship between the diameters and bifurcation angles of coronary arteries and coronary artery diseases (6-10). There are also studies showing a relationship between the diameter of coronary arteries and long-term graft patency in coronary artery bypass surgery (11).

Currently, stenting is the most preferred non-surgical percutaneous coronary intervention (PCI) to keep the arterial lumen open. For successful stenting, the compatibility between vessel diameter and stent size is very important. If the stent size is larger or smaller than it

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Corresponding Author: Arzu Mumcu, Batman University, Vocational High School of Health Services, Batman, Türkiye
E-mail: arzumumcu55@gmail.com

should be, it may lead to undesirable complications such as rupture, restenosis and thrombosis. For this reason, diameter, length and angle information of coronary arteries are very valuable anatomical information for determining coronary artery surgical or percutaneous treatment procedures and preventing complications (12-14).

Coronary angiography, which has been used in the detection, evaluation and treatment of coronary artery diseases from past to present, is one of the most widely used radiological techniques today, especially in determining the location and degree of coronary stenosis (6,15-17).

The aim of this study was to determine the morphological characteristics as length-diameter-angle measurements of LMCT, LAD, Cx and IA by digital subtraction angiography technique and to find out whether there is a significant difference according to gender.

MATERIAL AND METHOD

This study was approved by the Scientific Research Ethics Committee (Decision No/Date: 15.12.2020/258) and was conducted by applying the principles of the Helsinki Declaration at every stage.

Our study was a retrospective study of coronary angiographies. Angiograpy was performed with digital subtraction angiography (DSA) at the Batman Training-Research Hospital between June 2019 and June 2021. For DSA (Angiostar and Axiom Artis units, Siemens, Erlangen, Germany), angiographic catheters were used and a nonionic contrast medium was delivered to the arteries via the catheter. We included 150 patients (58 females-39%, 92 males-61%) aged between 29 and 85 years. The mean age was 58.40±12.38 years. Patients who underwent coronary angiography and had normal coronary arteries were included in the study. Patients with a history of coronary artery by-pass surgery, coronary artery stenosis, coronary artery balloon angioplasty and/or stenting, coronary artery anomalies, heart failure, cardiomyopathy and valvular heart disease were excluded from the study.

In the study, firstly, the LMCT was divided into two groups according to the branching structure. The patients with classical branching that they had the LAD-Cx were grouped as bifurcation pattern and patients with triple branching they had the Cx-LAD-IA were grouped as trifurcation pattern and the length-diameter measurement of the LMCT, angle measurements (LMCT-LAD, LAD-Cx (bifurcation angle), Cx-LMCT) was performed for each patient (Figures 1 and 2). Afterwards, the length-diameter-angle measurements of the Cx, LAD, and IA for both groups were performed separately according to the criteria described below:

For Cx; Cx-proximal part [between the centre of the Cx ostium and the ostium level of the first obtuse marginal branch (OM1)], Cx-middle part [between the ostium level of OM1 and the ostium level of second obtuse marginal branch (OM2)], Cx-distal part [OM2 ostium level and beyond] were determined (Figure 3).

For LAD; LAD-proximal piece [between the LAD ostium centre and the first diagonal branch (D1) ostium level], LAD-middle piece [between the D1 ostium level and the second diagonal branch (D2) ostium level], LAD-distal piece [D2 ostium level and beyond] were determined (Figure 4).

In addition to the measurements described above, the length and diameter measurements of the IA were performed.

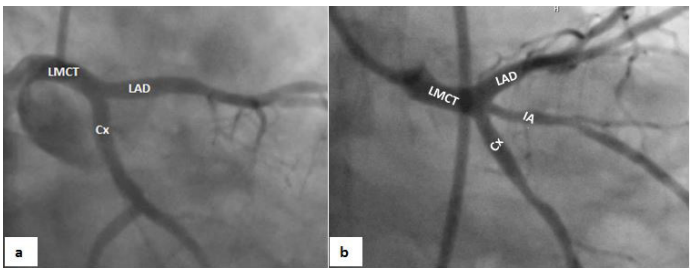

Figure 1. The bifurcation pattern (a) and trifurcation pattern (b) of the LMCT (LMCT: Left main coronary truncus, LAD: Left anterior descending artery, Cx: Circumflex artery, IA: Intermediate artery)

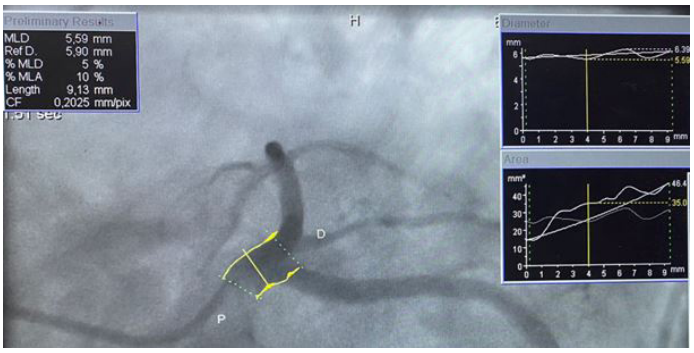

Figure 2. Length and diameter measurements of the left main coronary truncus (yellow lined part) (Ref D: Diameter measurement, Length: Length measurement)

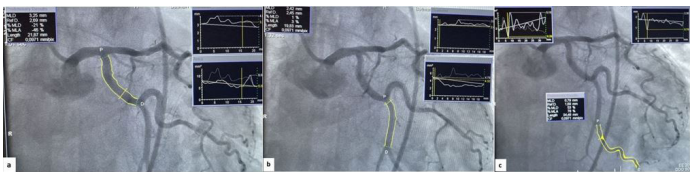

Figure 3. The proximal, middle, and distal parts of Cx (yellow lined parts) (a) The Cx-proximal part [between the centre of the Cx ostium and the level of the OM1 ostium centre]; (b) The Cx-middle part [between the OM1 ostium level and the OM2 ostium level]; (c) The Cx-distal part (OM2 ostium level and beyond] (Cx: Circumflex artery, OM1:First obtuse marginal branch, OM2: Second obtuse marginal branch, Ref D: Diameter measurement, Length: Length measurement)

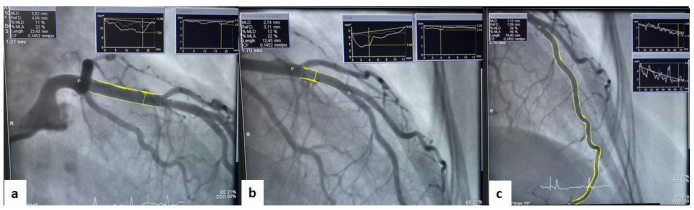

Figure 4. The proximal, middle, and distal parts of the LAD (yellow lined parts) (a) The LAD-proximal part [between the centre of the LAD ostium and the level of the D1 ostium centre]; (b) The LAD-middle part [between the D1 ostium level and the D2 ostium level]; (c) the LAD-distal part [the D2 ostium level and beyond] (LAD: Left anterior descending artery, D1: First diagonal branch, D2: Second diagonal branch, Ref D: Diameter measurement, Length: Length measurement)

Statistical Analyses

SPSS-21 programme (IBM SPSS-Statistics for Windows, New York/USA) was used for statistical analysis of the data recorded in the study. Independent Samples t test was used for comparison between genders and P<0.05 was considered significant. Data were summarised as percentage, mean±standard deviation.

RESULTS

LMCT showed bifurcation pattern in 136 (90.7%) and trifurcation pattern in 14 (9.3%) of 150 hearts (Table 1). Bifurcation pattern was observed in 86.96% of the while trifurcation pattern was observed in 13.04% in a total 92 male cases. In 58 female cases, bifurcation pattern was detected in 96.55% and trifurcation pattern in 3.45%. Table 2 shows the LMCT, Cx, and LAD length-diameter-angle measurements. Among the results presented in this table, in bifurcated hearts, the mean length of the left coronary artery truncus was 15.9±5.7 mm and the mean diameter was 6.0±0.9 mm. In the angle measurements, the angle between the LMCT and the LAD was 159.2±17.8°, this was statistically significant (p=0.000). The LMCT-Cx and LAD-Cx angles are 124.5±21.9°, 75.8±25.5°, respectively. In the LAD measurements, the distal diameter of the LAD was 2.5±0.5 mm (p=0.033).

Table 1. LMCT branching patterns

LMCT branching patterns	Female	Male	Total
Bifurcation	56	80	136 (90.7%)
Trifurcation	2	12	14 (9.3%)
Total	58 (39%)	92 (61%)	150 (100%)

LMCT: left main coronary truncus

In LMCT-trifurcated hearts, the mean length and diameter of IA, LMCT length and diameter were 121.7±28.2 mm, 2.8±0.5 mm, 19.4±6.7 mm, and 6.2±0.8 mm, respectively (Table 3). The results in these hearts were not statistically significant (p>0.05).

Table 2. LMCT (with bifurcation pattern) and Cx-LAD length-diameter-angle measurements and gender distribution (n: 136)

LMCA-Cx-LAD measurements		Gender	Mean±SD	General Mean±SD	t	P
LMCT measurements						
LMCT	**Length (mm)**	Female	14.8±4.9	15.9±5.7	-1.810	0.072
		Male	16.6±6.1			
	Diameter (mm)	Female	6.0±0.9	6.0±0.9	0.074	0.941
		Male	6.0±0.9			
LMCT-LAD-Cx angles	**LMCT-LAD (°)**	Female	165.5±14.5	159.2±17.8	3.662	0.000*
		Male	155.00±18.6			
	LAD-Cx (bifurcation angle) (°)	Female	73.6±22.0	75.8±25.5	-0.842	0.401
		Male	77.3±27.6			
	Cx-LMCT (°)	Female	121.0±19.6	124.5±21.9	-1.575	0.117
		Male	126.8±23.1			
Cx measurements						
Cx-proximal	**Length (mm)**	Female	24.7±18.7	26.3±18.3	-0.884	0.378
		Male	27.4±18.0			
	Diameter (mm)	Female	4.3±0.7	4.2±0.7	0.483	0.630
		Male	4.2±0.8			
Cx-middle	**Length (mm)**	Female	40.7±25.1	39.7±22.9	0.402	0.688
		Male	39.0±21.4			
	Diameter (mm)	Female	3.7±0.7	3.7±0.7	0.495	0.621
		Male	3.7±0.7			
Cx-distal	**Length (mm)**	Female	67.8±29.2	70.8±29.6	-0.988	0.325
		Male	72.8±29.8			
	Diameter (mm)	Female	2.6±0.7	2.5±0.6	0.662	0.509
		Male	2.5±0.5			
LAD measurements						
LAD-proximal	**Length (mm)**	Female	27.6±14.4	29.1±16.9	-0.858	0.392
		Male	30.0±18.4			
	Diameter (mm)	Female	4.4±0.7	4.3±0.6	1.675	0.096
		Male	4.2±0.6			
LAD-middle	**Length (mm)**	Female	42.3±23.6	39.8±24.0	0.915	0.362
		Male	38.3±24.3			
	Diameter (mm)	Female	3.5±0.6	3.5±0.6	0.081	0.936
		Male	3.5±0.6			
LAD-distal	**Length (mm)**	Female	100.1±33.7	99.4±33.3	0.191	0.849
		Male	99.0±33.2			
	Diameter (mm)	Female	2.4±0.4	2.5±0.5	-2.154	0.033*
		Male	2.6±0.5			

LMCT: left main coronary truncus, LAD: left anterior descending artery, Cx: circumflex artery, IA: intermediate artery, *p<0.05

Table 3. LMCT (with trifurcation pattern), IA length-diameter measurements and distribution according to gender (n: 14)

LMCT-IA Measurements		Gender	Mean±SD	General Mean±SD	t	P
LMCT	Length (mm)	Female	16.2±2.3	19.4±6.7	-0.721	0.488
		Male	20.1±7.2			
	Diameter (mm)	Female	5.4±0.5	6.2±0.8	-1.515	0.161
		Male	6.3±0.8			
IA	Length (mm)	Female	137.4±30.5	121.7±28.2	0.849	0.416
		Male	118.5±28.4			
	Diameter (mm)	Female	2.6±0.4	2.8±0.5	-0.599	0.562
		Male	2.8±0.6			

LMCT; left main coronary truncus, IA; intermediate artery

DISCUSSION

Cardiovascular diseases are one of the leading health problems with a mortality rate of 25.1% in the world. There are several studies showing that there is a significant relationship between the occurrence of coronary artery diseases, which constitute an important part of these diseases, determination of treatment procedures and coronary artery morphology, especially bifurcation angles (18-21).

In our study, the average values of the LMCT were 6.0±0.9 mm for its diameter and 15.9±5.7 mm for its length and its angles were found as 159±17°, 75±25°, 124±21°, respectively. Gracia et al. found the mean diameter of the LCA to be 3.5±0.8 mm, the length to be 10.5±5.3 mm, and the LCA-Cx, Cx-LAD (bifurcation angle), and LCA-LAD angles to be 126±21°, 75±23°, and 138±20, respectively, in their study on 3D images obtained from coronary angiographies (22). Kawasaki et al. found the above-mentioned angles as 121±21° (LMCT-Cx), 72±22° (LAD-Cx), 143±13° (LMCT-LAD) in their angle investigations using 3D measurement method in 209 patients with multislice computed tomography technique (23). Gazetopoulos et al. found the LCA length to be 16.8±4.13 mm in their study on 43 angiograms and reported a significant relationship between coronary atherosclerosis and left coronary artery length (24). Pereira da Costa Sobrinho et al. determined the length of the left main coronary artery as 6.44 mm for patients with bifurcation branching pattern and 9.77 mm for the group with trifurcation pattern in their dissection study in 63 cadavers and mentioned the clinical significance of these results (25). In our study, LMCA length was found to be 15.9±5.7 mm in the group with classical branching and 19.4±6.7 mm in the group with triple branching. This difference between the studies may be related to the fact that the DSA technique provides more and more detailed examination.

Raut et al. reported left main coronary artery diameter as 4.08±0.44 mm, LAD-proximal diameter as 3.27±0.23 mm, and Cx-proximal diameter as 2.97±0.37 mm in 229 patients who underwent coronary angiography (26). Zhang et al. determined the mean length and diameter of LAD (origin-distal), mean length and diameter of Cx (origin-distal) as 130 mm, 3.92 mm (origin diameter)-2.10 mm (distal diameter), 130 mm, 3.57 mm (origin diameter)-2.10 mm (distal diameter), respectively, in 526 cases using CT coronary angiography (27). In our study, these values were 168.3 mm (LAD proximal-middle-distal mean sum), 4.3 mm (proximal diameter), 2.5 mm (distal diameter), 136.8 mm (Cx proximal-middle-distal mean sum), 4.2 mm (proximal diameter), 2.5 mm (distal diameter), respectively.

Our study differs from the other studies we discussed, as this study provides detailed results in male and female cases. The studies mentioned above are mostly based on average values. In our study, we evaluated male and female cases separately.

Limitations in our study, unequal female (39%) and male (61%) populations, limited number of patients (150 patients).

CONCLUSION

In conclusion, in this study, the length, diameter and angle of the left coronary artery and its main branches were determined. We believe that this anatomical information will improve the interpretation of diagnostic cardiac imaging and contribute to the success of interventional cardiac procedures, as well as contribute to the development of new therapeutic interventional treatment techniques.

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Conflict of Interest: *The authors declare that they have no competing interest.*

Ethical approval: *This study was approved by the Scientific Research Ethics Committee of Batman Training and Research Hospital (Decision Date/No: 15.12.2020/258).*

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