

Branching pattern of the left coronary artery and an important branch

The median artery

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ABSTRACT

Objectives: This study was performed to assess the variations in the branching pattern and diameters of the terminal branches of the left coronary artery and discuss various names given to the third branch.

Methods: Hearts of 21 autopsies and 19 cadavers were fixed with 10% formalin and their coronary arteries were examined by dissecting the epicardium. The dissections were performed at the Anatomy Departments of Faculties of Medicine, Ankara and Hacettepe Universities, Ankara, and Cerrahpasa Faculty of Medicine, Istanbul University, Istanbul, Turkey, between April 2001 and June 2003.

Results: There were 2 branches in 19 hearts, 3 branches in 19 hearts, 4 branches in one heart and 5 branches in another. Diameter and length of these vessels are noted.

Conclusion: Upon examination of the diameters and important variations of the branches of the left coronary artery, the importance of the median artery has been noted. Various names given to this artery in the literature should be replaced with the name "median artery".

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Anatomies of the coronary arteries have been widely studied due to its clinical importance.¹⁻⁴ The branches of the left coronary artery may be from 2-4 in number. There is controversy between authors in naming the third and the fourth branches. As it is proposed that the names such as diagonal artery, diagonal branch, median branch, left atrioventricular, median artery, left ventricular artery, oblique branch, lateral branch, marginal branch are all refer to the same artery.⁵ There are also articles declaring that these names indicate different arteries.⁶

The aim of this study is to determine the branches of the left coronary artery in the anterior ventricular

wall, investigate the variations in their distribution, diameter and length, and discuss their nomination.

Methods. In this study, 21 autopsy and 19 cadaveric human bodies were used among which death causes were not related to cardiac reasons. The autopsy cases were donated from the University Hospital morgues. The cases with cardiomegaly pathologically established valvular disease and coronary artery disease were not included in the study. The ages of the individuals were from 28-66 years. Twenty-six of them were male and 14 were female. After immersion fixation

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of the hearts with 10% formaldehyde, they were kept in the fixation solution until they are examined. This duration was between 24 hours to 6 months. After this duration, the epicardium was removed by microdissection and the coronary arteries were observed. The length, diameter of the main trunk of left coronary artery; the diameter, length and distribution of the circumflex, the anterior interventricular and other branches of the left coronary artery were measured. In addition, the arteries that supply the anterior wall of the left ventricle were observed and their distribution areas were determined. The diameter of the arteries was measured by longitudinal sectioning of their first 0.5 cm segment. Their perimeter was measured and the diameter was calculated by the formula "perimeter = $\pi \cdot D$ ".⁷ The length of each artery was measured as the distance between the origin and the point where it enters the myocardium. All the measurements were made with a 0.1cm sensitive caliper.

Results. The left coronary artery divided into 2 branches in 19 of the 40 hearts (bifurcation), into 3 branches in 19 hearts (trifurcation), into 4 branches in one heart (quadrifurcation) and into 5 branches in another (quintifurcation). In the bifurcation group (**Figure 1a, 1b**), the mean length of the main trunk of the left coronary artery was calculated as 14.1 mm (**Table 1**). In 10 of these, the anterior wall of the left ventricle was supplied by anterior interventricular branch, circumflex branch and branches of these 2 arteries. Anterior wall of the left ventricle was supplied by the anterior interventricular branch in 7 hearts and by the circumflex branch in 2 hearts. The average diameters of these vessels were 3.8 mm for the main trunk of the left coronary artery, 3.4 mm for the anterior interventricular branch and 3.1 mm for the circumflex branch (**Table 1**).

In the trifurcation group, 2 branches of the left coronary artery were the anterior interventricular and circumflex branches whereas the median artery descended in the anterior wall of the left ventricle for variable distances (**Figure 1c**). The average length of the left coronary artery was 15 mm and its average diameter was 3.7 mm. The mean diameter of the anterior interventricular branch was 3.0 mm and that of the circumflex branch was 2.5 mm. The mean diameter of the median artery was 2.0 mm. Fifteen of these median arteries penetrated into the myocardium as single branch. Three of them penetrated by dividing into 2 and one of the third branches penetrated by dividing into 3. The mean length of the median artery was 25.1 mm (**Table 2**). In the trifurcation group, in addition to median artery other branches also supplied the anterior wall of the left ventricle. These small branches originated from both the anterior interventricular and circumflex branches in 6 hearts, from the circumflex

branch in 3 hearts, from the anterior interventricular branch in 8 hearts and from the posterior interventricular branch in 2 hearts.

In the quadrifurcation group, in addition to the circumflex branch and the anterior interventricular branch, 2 branches originated between these 2 vessels and descended on the anterior wall of the left ventricle (**Figure 1d**). The left coronary artery divided into 5 terminal branches in one of the hearts (**Figure 1e**). These branches were similar to the quadrifurcation group but there was an additional branch originating between the circumflex branch and the main trunk of the left coronary artery. This artery coursed between the left auricle and aortic bulb. The diameters and lengths of these branches are seen on **Table 3**.

Discussion. The left coronary artery usually terminates by dividing into 2 branches: the anterior interventricular branch and the circumflex branch.^{5,8} Sometimes it may terminate by dividing into 3 or rarely 4 branches. The third and fourth branches of the left coronary artery supply the anterior wall of the left ventricle. If the left coronary artery terminates by dividing into 2, the same region is supplied by branches from the anterior interventricular and circumflex branches.⁹ The left coronary artery had been found to give more than 2 branches at different rates and diameters by different authors (**Table 4**). If present, the third branch of the left coronary is reported as 37.39 mm in males, 33.57 mm in females and 34.01 mm (minimum of 9.34 mm, maximum of 101.23 mm) in the overall population.⁵ In our study, the mean diameter of the third branch is found as 2 mm, which is very comparable to the anterior interventricular (3,0 mm) and circumflex branches (2.5 mm). Angelini¹⁰ defined the ramus medianus or intermedius as a secondary nonessential branch of the anterior interventricular branch. This branch was described by its distribution between the diagonal branch and the left marginal branch (obtuse marginal branch). The ramus medianus was defined as originating from the main trunk of the left coronary artery or proximal left anterior descending or circumflex branch. He described that if the anterior interventricular branch does not descend until the lower parts of the anterior interventricular sulcus, the diagonal branch courses in its place and supplies the lower parts of the sulcus.

Some authors define the third branch of the left coronary artery as the median branch.⁹ According to Braunwald¹¹ the diagonal branches are originated from the anterior interventricular branch and supplied the anterior wall of the left ventricle. Baptista et al⁹ in his study on 150 hearts, indicated that the third branch of the left coronary artery should be named as the diagonal branch. Also they named the branch that originated from the proximal

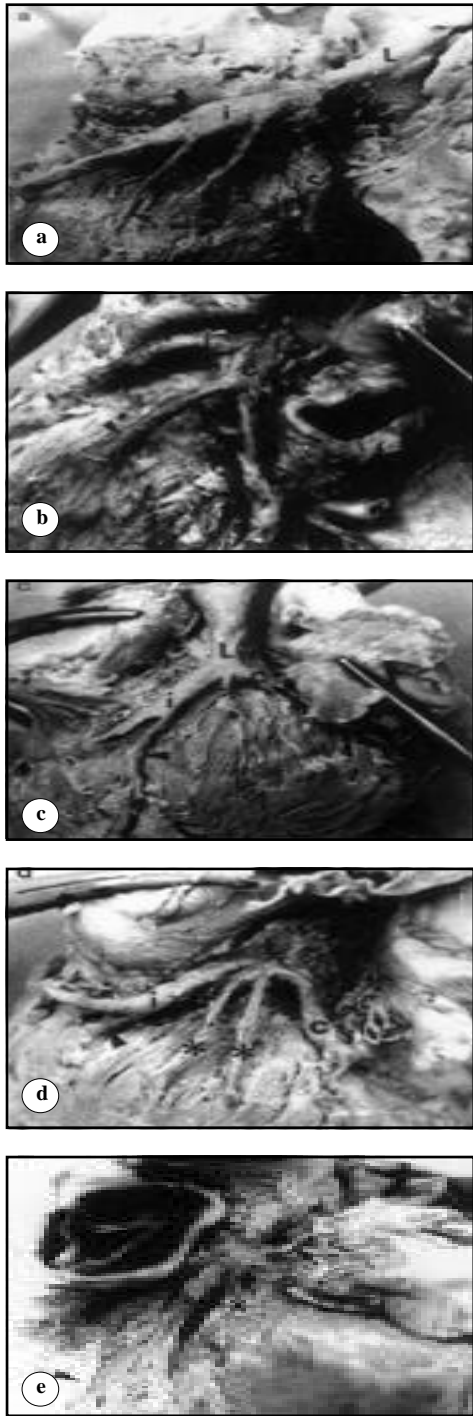


Figure 1 - Branching of the left coronary artery (a) and (b) bifurcation; (c) trifurcation; (d) quadrifurcation (e) quintifurcation. The anterior wall receives branches, from the anterior interventricular branch in (a) and (c), from the circumflex branch in (b). The median branch bifurcates in (c), it is double in (d) and (e). L - left coronary artery, i - anterior interventricular branch, c - circumflex branch, *median artery or arteries, arrowhead - branches supplying the anterior wall of the left ventricle, arrow - the fifth branch coursing towards the left atrium.

part of the anterior interventricular branch and coursed on the anterior surface of the left ventricle as the ramus anterior ventriculi sinistri superior and the branch that originated from the proximal part of the circumflex branch as the ramus anterior ventriculi sinistri medialis. All 3 branches named describe the median branch defined by Angelini.¹⁰ Gabella⁸ indicated that the anterior interventricular branch gives 2-9 diagonal branches, which course on the anterior surface of the left ventricle. One of these branches is larger than the others and named as the left diagonal artery. Anderson and Becker¹² named the third branch originating from the main trunk of the left coronary artery and coursing on the anterior surface of the left ventricle as the intermediate artery. The branches that originate from the anterior interventricular branch and coming to the anterior surface of the left ventricle were defined as the diagonal artery. Verna et al⁶ investigated the septal branches that do not originate from the anterior interventricular branch and they pointed out that it may originate from the intermediate artery or the diagonal artery. In this article, the definition of the "intermediate branch" is not given but according to the figure, it refers to the branch originating between the anterior interventricular and the circumflex branches (trifurcation). There is no figure regarding the intermediate branch. Spindalo-Franco et al¹³ described 23 cases of double left anterior descending artery "dual LAD" out of 2140 coronary

Table 1 - The measurements related to the cases where the left coronary artery bifurcates (in mm).

Case	LMT		Diameters	
	Length	LMT	AIB	CB
1	10.4	3.8	3.1	3.6
2	9.4	2.6	5.0	3.4
3	8.8	3.5	5.4	3.6
4	7.3	3.9	2.8	2.8
5	7.5	3.0	2.7	2.7
6	10.7	2.6	1.7	1.6
7	5.5	4.3	3.4	2.3
8	16.3	3.2	3.7	2.5
9	14.3	4.3	2.6	3.0
10	10.4	5.0	3.3	3.2
11	11.7	4.1	3.7	3.5
12	10.8	4.3	4.2	3.8
13	18.7	3.4	2.7	3.0
14	27.1	2.6	1.9	2.1
15	18.1	4.3	3.8	3.6
16	16.8	4.0	3.9	3.1
17	18.8	3.9	4.5	3.6
18	22.7	4.7	3.8	4.1
19	17.3	3.9	2.9	3.2
Means	14.1	3.8	3.4	3.1

LMT - main trunk of the left coronary artery,
AIB - anterior interventricular branch, CB - circumflex branch.

Table 2 - The measurements related to the cases where the left coronary artery trifurcates (in mm).

Case	LMT		Diameters			MB terminal	Length of median branch			
	Length	LMT	AIB	CB	MB	Branch #	Trunk	Medial	Middle	Lateral
1	12.9	2.9	2.7	1.9	1.2	1	16.5			
2	8.9	4.0	3.3	2.7	1.2	1	22.9			
3	12.6	2.8	1.9	1.9	0.8	2	9.5	14.7		13.6
4	8.9	4.3	2.6	2.8	2.5	1	26.9			
5	8.8	2.6	2.7	1.7	1.8	3	7.4	12.5	8.9	27.4
6	12.9	4.5	4.0	1.2	1.7	1	32.5			
7	9.2	4.8	3.6	2.2	2.5	1	28.6			
8	12.9	3.8	2.8	2.2	1.9	1	20.6			
9	11.5	3.5	2.0	2.4	1.0	1	26.7			
10	14.0	4.5	3.9	3.7	2.5	1	30.8			
11	9.5	3.5	2.7	1.4	2.3	1	30.9			
12	12.2	4.3	2.7	2.5	0.9	1	25.0			
13	21.3	2.6	2.2	2.1	1.7	1	19.3			
14	17.7	4.0	3.4	2.8	2.1	2	9.1	19.3		12.7
15	21.8	4.4	4.4	4.0	3.6	1	32.1			
16	16.7	3.8	3.4	2.9	2.3	1	20.9			
17	30.7	3.3	2.7	2.9	2.3	1	31.1			
18	20.4	3.9	3.3	3.7	3.0	2	7.1	9.2		11.7
19	21.1	3.4	2.8	2.8	2.4	1	22.7			
Means	15	3.7	3.0	2.5	2.0		25.1	13.9	8.9	16.4

LMT - main trunk of the left coronary artery, AIB - anterior interventricular branch, CB - circumflex branch, MB - median branch, medial, middle and lateral, branches of the median branch from the anterior interventricular groove to the obtus margin

Table 3 - The measurements related to the cases where the left coronary artery quadrifurcates and quintifurcates (in mm).

Case	LMT length	LMT	AIB	Diameters CB	MB		Branch # of LMT	MB length	
					Medial	Lateral		Medial	Lateral
1	8.8	3.4	3.4	2.3	1.5	1.3	4	30.5	24.8
2	9.5	2.9	2.3	2.0	1.8	0.9	5	27.4	8.5
Means	9.1	3.1	2.8	2.1	1.6	1.1		28.9	16.6

LMT - main trunk of the left coronary artery, AIB - anterior interventricular branch, CB - circumflex branch, MB - median branch, medial, lateral, branches of median branch from the anterior interventricular groove to the obtus margin

Table 4 - Branching frequencies of the left coronary artery versus authors.

References	Bifurcation %	Trifurcation %	Quadrifurcation %
Klabfleisch and Hort 1976 ¹⁶	41	53	6
Leguerrier et al 1976 ¹⁷	65-70	20-30	5-10
Kalbfleisch et al 1977 ¹⁸	51.1	44.4	6/141 (4.3)
Lo et al 1994 ¹⁹	69.35	36.6	1/40
Present study	19/40 (47.5)	19/40 (47.5)	

angiograms performed on adult patients. In this study, the diagonal artery term is used for the arteries that distribute on either the left or the right ventricle and originate from the anterior interventricular branch or the right coronary artery. It is not mentioned if the circumflex branch gives these diagonal branches. The term "diagonal artery" is sometimes used for the branch of the anterior interventricular branch supplying the anterior wall of the left ventricle.^{14,15} Kalbfleisch and Hort⁶ used the same term for the trifurcation and quadrifurcation branches of the left coronary artery. Leguerrier et al¹⁷ refers to the diagonal artery as the branch of the main trunk of the left coronary artery. The dimensions of the third branch indicate an indispensable arterial supply and a common nomination of this artery is essential for easy communication in clinical practice. Among the names used to describe this artery, "intermediate" means between, "median" means in the midline, "diagonal" means oblique or connecting 2 corners. Thus, "intermediate" and "median" refers to the origin but "diagonal" refers to the course of the artery. Considering these definitions, "diagonal" should be used for the branches that originate from the anterior interventricular branch or the circumflex branch, which course on the anterior surface of the left ventricle. The terms "intermediate" or "median" should be used for the third branch of the left coronary artery originating between the circumflex branch and anterior interventricular branch. For this reason, the third or fourth branches, or both, of the left coronary artery coursing on the anterior surface of the left ventricle should be referred as the "median" branch.

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