

ORIGINAL COMMUNICATION

Main Trunk of the Left Coronary Artery: Anatomic Study of the Parameters of Clinical Interest

J. REIG^{1,2} AND M. PETIT²¹*Department of Morphological Sciences, Unit of Anatomy and Embryology, Medical School, Universitat Autònoma de Barcelona, Barcelona, Spain*²*Cardiac Morphology Laboratory, Department of Cardiology, "Sant Jordi" Monographic Cardiovascular Centre, Barcelona, Spain*

The objective of this study was to analyze in one single series all the characteristics of the main trunk of the left coronary artery (MT) that may be of use in the diagnosis and treatment of its pathologies. One-hundred human hearts from autopsies were used. The average age of the sample studied was 63.15 ± 18.76 (range = 17–94 years). The heart was removed after resection of the costosternum and placed in 10% formaldehyde. With gradual separation and retraction of the myocardial fasciculi the MT was exposed. The length of the MT, the luminal diameter of the MT at its midpoint, and the luminal diameter of the left coronary orifice were measured with a caliper. The angle of division between the anterior interventricular and circumflex branches was also measured, and the number of terminal branches originating from the MT was recorded. In four cases, there was no MT and the anterior interventricular and circumflex branches originated directly from the left aortic sinus. The average length of the MT was 10.8 ± 5.52 mm (range = 2–23 mm); the average diameter at its midpoint was 4.86 ± 0.80 mm; and there was no significant difference noted between the midpoint diameter of the MT and the diameter of the left coronary orifice. The most frequent type of division of the MT was bifurcation (62%); in 38% of cases the MT divided into three or more branches. An average value of $86.7 \pm 28.8^\circ$ was obtained for the angle of division of the terminal branches of the MT (range = 40 – 165°). There was a positive correlation between the length of the MT and the angle of division of its terminal branches, with the longest MTs having the largest angle of division. Clin. Anat. 17:6–13, 2004.

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INTRODUCTION

Patency of the left coronary artery is vital for sufficient perfusion of most of the heart. The left coronary artery is responsible for irrigation not only of most of the left ventricle, but also a considerable proportion of the right ventricle (Reig and Petit, 2001). The study by Kalbfleisch and Hort (1977) of the area irrigated by each of the coronary arteries using postmortem angiography showed that the left coronary artery irrigated 68.8% of the cardiac muscle mass (41.5% by the anterior interventricular branch and 27.3% by the circumflex branch) and 79% of the left ventricular cardiac muscle mass (52.6% by the anterior interventricular branch and 26.4% by the circumflex branch). These percentages are average values and present some degree of variation, especially in the percentages of myocardial irrigation by the right coronary artery

and circumflex branch of the left coronary artery, depending on the type of arterial distribution. Even in cases of extreme right coronary artery dominance, however, the right coronary artery almost always irrigates less than 50% of the ventricular myocardium (Reig et al., 1994b). As a result, left coronary artery

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*Correspondence to: Dr. J. Reig, Departament de Ciències Morfològiques, Unitat d'Anatomia i d'Embriologia, Facultat de Medicina, Universitat Autònoma de Barcelona, E-08193, Barcelona, Spain. E-mail: Josep.Reig@uab.es

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TABLE 1. Characteristics of the Main Trunk of the Left Coronary Artery

Author	Specimens	Method	Length (mm)	Diameter (mm)	Type of division	Angle of division
Banchi, 1904	100	Dissection	<5 : 2% 5–10 : 87% >10 : 11%		2 : 64% 3 : 31% 4 : 5%	
Baroldi and Scomazzoni, 1965	522	Corrosion cast	$\bar{x}$: 13.5	2.0–5.5 $\bar{x}$: 4.0	2 : 66% 3 : 31% 4 : 3%	
Bosco, 1935	135	Dissection	$\bar{x}$: 10	1.5–5.0	0 : 2% 2 : 42% 3 : 55%	
Crainicianu, 1922	200	Postmortem angiography Dissection	$\bar{x}$: 8–10	1.5–5.0	2 : 38% 3 : 60% 4 : 2%	
Fox et al., 1973	100	Dissection	$\bar{x}$: 5.5			
	100	Coronary angiography	$\bar{x}$: 9.5			
Gazetopoulos et al., 1976	204	Dissection	$\bar{x}$: 11.02			
	43	Coronary angiography	$\bar{x}$: 15.0			
Green et al., 1967	50	Dissection	$\bar{x}$: 11.6	4.0–7.0		
Hadžiselimović, 1982	100	Dissection			2 : 52% 3 : 44% >3 : 4%	
James, 1961	106	Corrosion cast		5.0–10.0		30–180
Kronzon, 1974	100	Coronariography	$\bar{x}$: 10.4			
McAlpine, 1975	100	Dissection	<6 : 12 6–15 : 74 >15 : 14	1.8–8.5 $\bar{x}$: 4.7 $\pm$ 1.2		
Penther et al., 1976	125	Dissection	$\bar{x}$: 11		0 : 2% 2 : 89% 3 : 9%	
Penther et al., 1977	132	Dissection	$\bar{x}$: 10.36			

disease may reduce the coronary flow to a large proportion of the ventricular myocardium and, therefore, occlusive atherosclerosis in the left coronary artery has more serious consequences than in the right coronary artery.

In various published series, the incidence of total left coronary artery occlusion ranges between 0.03% and 0.43% of angiographic examinations (Topaz et al., 1991; Shahian et al., 1988). In arteriosclerotic diseases, it is common for the other main coronary arteries to be affected. Even when this is not the case, however, occlusion of the left coronary artery is equivalent to occlusion of the anterior interventricular and circumflex branches, whose territories will suffer the consequences of ischemia to a greater or lesser extent according to the degree of intercoronary collateral circulation.

Knowledge of the morphological characteristics of the main trunk of the left coronary artery (MT) as well as its variations is essential for hemodynamic and surgical manipulation as well as for correctly interpreting angiographic data. Various reports include some details of the morphology of the MT (length, diameter) but omit other characteristics (type and angle of division) that may be important in clinical and surgical practice (Table 1).

The objective of this study was to analyze in a single series the anatomical characteristics of the MT (length, diameter, type of division and the angle of division between the terminal branches) that may be of use in the diagnosis and treatment of its pathologies.

MATERIALS AND METHODS

One-hundred human hearts taken from autopsies were used. The average age of the sample studied was 63.15 years $\pm$ 18.76 (SD) (range = 17–94 years) and the gender distribution was 62 male and 38 female. Hearts with evidence of significant arterial lesions in the MT were not included in the study.

The heart was removed after resection of the costosternum and placed in 10% formaldehyde for a period of 5–10 days, depending on the weight of the heart. With gradual separation and retraction of the myocardial fasciculi, the left coronary artery was dissected under 5 $\times$ magnification. The length of the MT, the luminal diameter at its midpoint, and the luminal diameter of the left coronary orifice were measured in each specimen using a caliper. The angle of division between the anterior interventricular and circumflex branches and the number of terminal

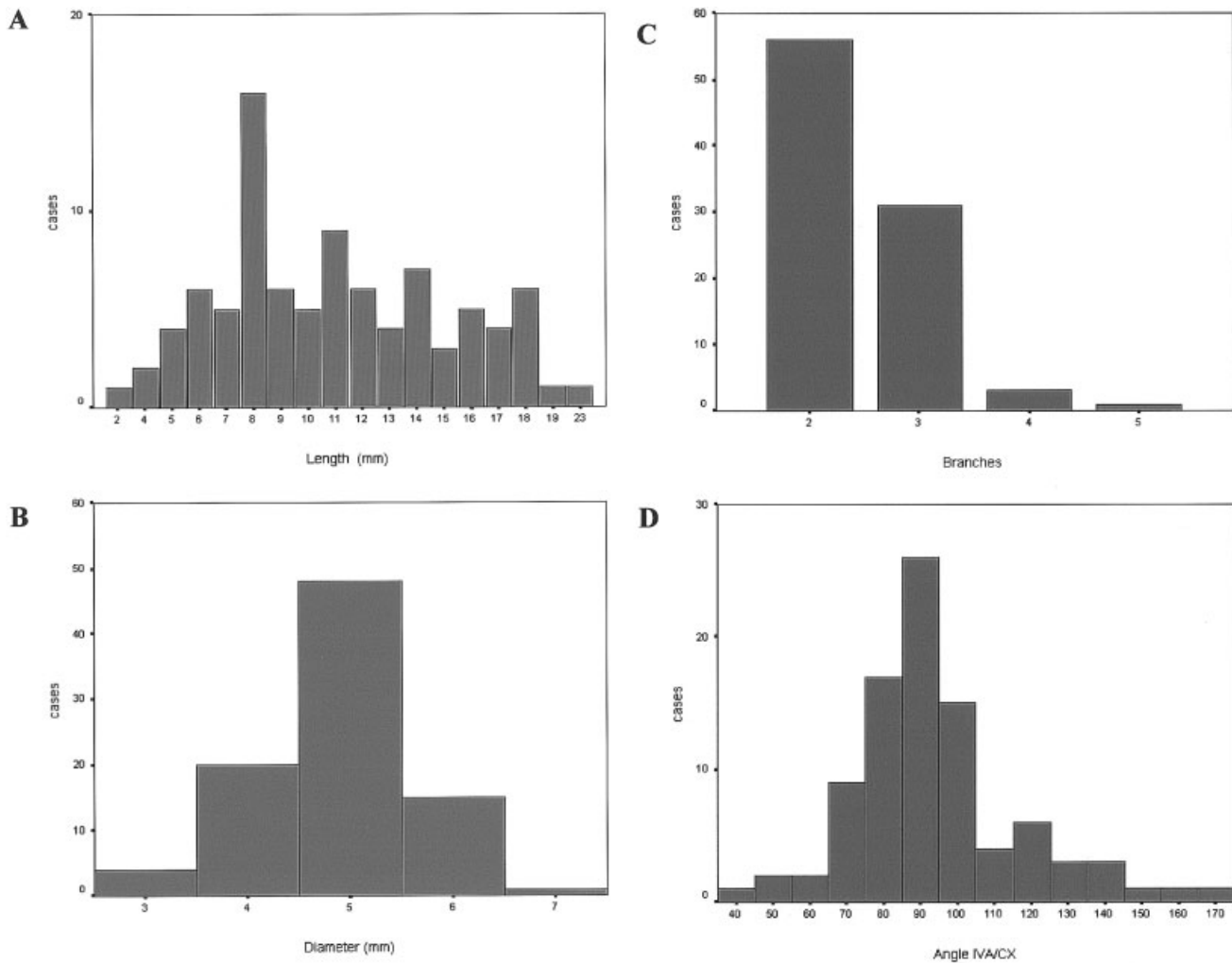


Fig. 1. Number of cases demonstrating characteristics of the main trunk of the left coronary artery. **A:** Length; **B:** diameter; **C:** number of terminal branches; **D:** angle of division between the anterior interventricular (IVA) and circumflex (CX) branches.

branches originating from the MT were also determined.

The data obtained were tabulated and analyzed using the SPSS (Statistical Package for Social Sciences-Basic and Advanced Statistics, version 9.0) program. Values of $P < 0.05$ were considered to be significant.

RESULTS

In four of the cases, there was no MT. The anterior interventricular and circumflex branches originated directly from the left aortic sinus. These cases were excluded from the series. A case with a MT length of 39 mm was also excluded; this anomalous MT originated in the right aortic sinus and had a retroaortic course.

Location

The location of the left coronary artery may be defined according to its orientation on the horizontal (anterior, middle, or posterior) or the frontal (upper, middle, or lower) plane (McAlpine, 1975). In our series, the most commonly found position of the MT in the horizontal plane was the anterior position (54/95; 56.8%); in the frontal plane, the most frequent position was the lower (71/95; 74.7%).

Length

Figure 1A shows the distribution of the length of the MT; the average length was 10.8 ± 5.52 mm (range = 2–23 mm). Using the criteria of extreme values (McAlpine, 1975; Vlodaver, 1976), two categories may be defined: a short MT (≤ 5 mm; Fig. 2) and

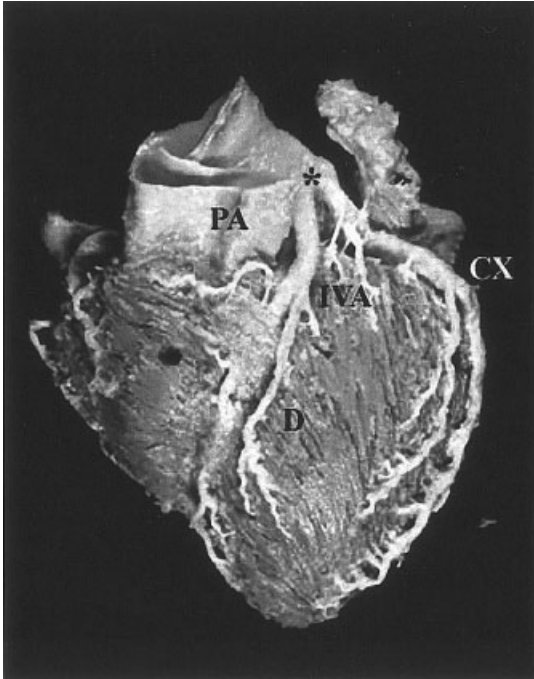


Fig. 2. Example of a short main trunk of the left coronary artery (*). In this specimen the length was 2 mm. CX, circumflex branch; D, left ventricular (diagonal) branch; IVA, anterior interventricular branch; PA, pulmonary artery.

a long MT (>15 mm; Fig. 3). Applying these criteria to the series we studied, we found a short MT in 7 out of 95 cases (7.4%), a long MT in 18 out of 95 cases (18.9%) and a MT of medium length in 70 out of 95 cases (73.7%).

Diameter

Figure 1B shows the distribution of values for the diameter of the MT measured at its midpoint: range = 3–7 mm; average value = 4.86 ± 0.80 mm. The values obtained presented no significant differences compared to those for the luminal diameter of the left coronary orifice in the aortic sinus.

Division Type

Figure 1C shows the various forms of division of the MT. The most frequent type of division (59/95 cases; 62%) was a bifurcation into two terminal branches: anterior interventricular and circumflex branches (Fig. 4). In 36 out of 95 cases (38%) the division of the MT led to three or four branches; these complementary branches are termed intermediate or median arteries (Fig. 5).

Where there was a division into three or more branches, two morphologic types can be distinguished based on the course and distribution of the median artery. In the first type, the median artery has a course

similar to that of a left ventricular or diagonal branch of the anterior interventricular branch; in the second type, the median artery has a course similar to that of a left marginal branch of the circumflex branch. The first of these varieties usually divides after a relatively long course into one branch that descends more or less parallel to the anterior interventricular branch, and another that goes obliquely toward the *margo obtusus* (Fig. 6). The second variety goes obliquely toward the *margo obtusus*, and once there, usually changes direction and descends around the edge (Fig. 7). In our series, the median artery with a course similar to that of a diagonal artery was observed in 21 out of 36 cases (58% with a median artery). A course type similar to a left marginal branch was observed in the 15 out of 36 (42%) of the cases with a median artery.

Angle of Division

Figure 1D shows the distribution of values for the angle of division of the terminal branches of the MT. The average value was $86.7 \pm 28.8^\circ$ (range = $40-165^\circ$). A Spearman analysis of non-parametric correlation showed a positive correlation ($r = 0.32$; $P < 0.01$) between the length of the MT and the angle of

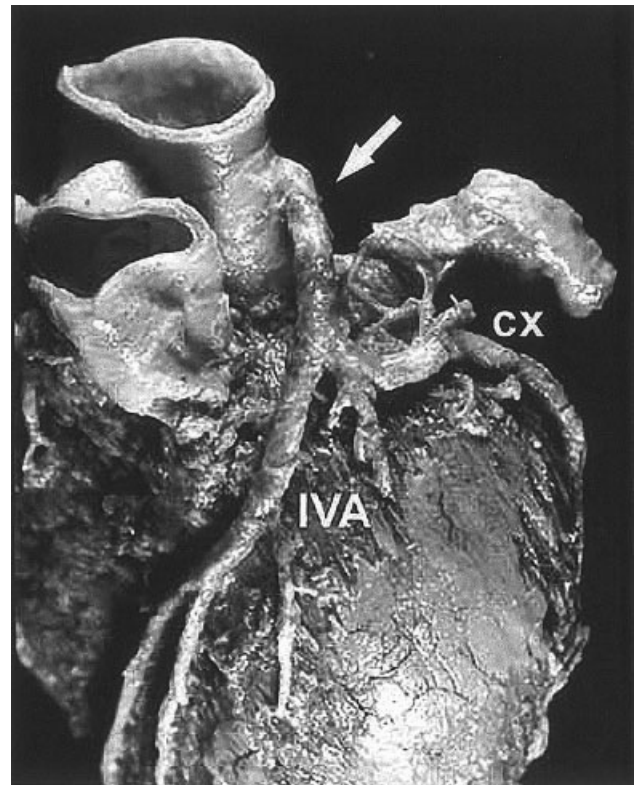


Fig. 3. Example of a long main trunk of the left coronary artery (arrow). In this specimen the length was 23 mm. Note the large angle of division between the terminal branches of the left coronary artery. CX, circumflex branch; IVA, anterior interventricular branch.

division of its terminal branches, with the longest MTs having the largest angle of division (Fig. 3).

DISCUSSION

The MT is generally considered to be between 5–15 mm long, although data published by several authors show a certain degree of disparity in results, depending on the technique used (Table 1). Interestingly, those data obtained by *in vivo* coronary angiography tended to be longer (Fox et al., 1973; Gazetopoulos et al., 1976a,b). This may indicate a tendency to overestimate the length in angiographies because of superimposition of the terminal branches on the MT.

Kronzon et al. (1974) described the presence of a statistically significant relationship between the length of the MT and the type of coronary artery dominance (Schlesinger, 1940). They reported that left artery dominance predominated in short MTs (3.2 ± 2.8 mm), whereas in relatively long MTs (11.6 ± 4.9 mm) right artery dominance predominated. In our study, as in other reports (Green et al., 1967; Penther et al., 1977; Levin, 1983), the existence of a relationship between the type of coronary distri-

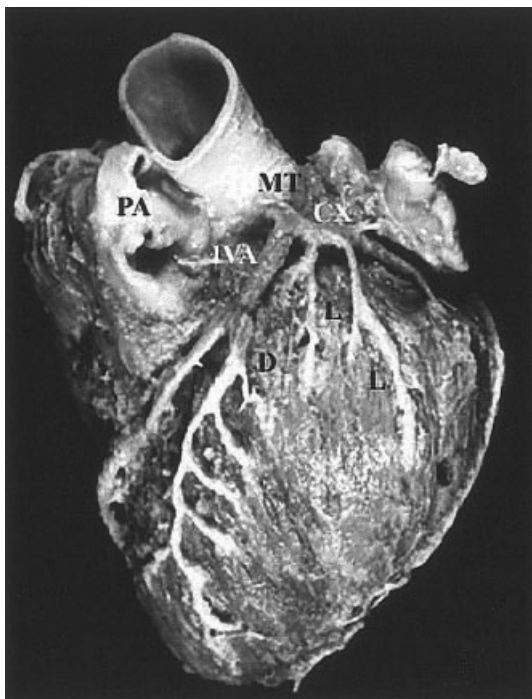


Fig. 4. The main trunk of the left coronary artery shows a bifurcation into two terminal branches: the anterior interventricular and circumflex branches. CX, circumflex branch; D, left ventricular (diagonal) branch; IVA, anterior interventricular branch; L, lateral branch of the circumflex branch; MT, main trunk of the left coronary artery; PA, pulmonary artery.

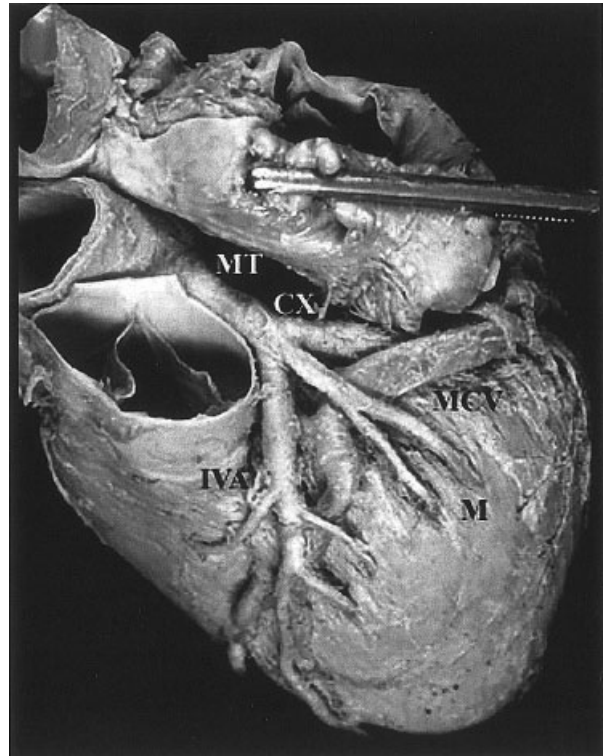


Fig. 5. The main trunk of the left coronary artery shows a division into three branches: the anterior interventricular branch, the median artery, and the circumflex branch. Note that the median artery is located at the exact angle formed by the two terminal branches. CX, circumflex branch; IVA, anterior interventricular branch; M, median artery; MCV, great cardiac vein; MT, main trunk of the left coronary artery.

bution and the length of the MT and its diameter (Vieweg et al., 1976) could not be confirmed.

A “short” MT and “long” MT were considered as variants in the length of the left coronary artery (Angelini et al., 1999). A short MT was considered to be one with a length of ≤ 5 mm (Vlodaver, 1976). Fox et al. (1973) reported that in 73% of their cases the MT was ≤ 6 mm in length. The surprising data supplied by Fox et al. (1973) are not similar to those found in most of the studies carried out on the characteristics of the MT. Only 7.4% of the cases in our series presented a MT length of < 5 mm, and these values were more in agreement with those described by McAlpine (1975) and Leguerrier et al. (1976).

A short MT has been considered a risk factor in the development of coronary arteriosclerosis (Gazetopoulos et al., 1976a,b) owing to, during systole, a certain degree of twisting of the terminal branches that increases the mechanical effort undergone by its walls, which leads to greater arteriosclerotic degeneration. A statistically significant relationship has also been described between a shorter MT and the presence of a

blockage in the left branch of the bundle of His (Lewis et al., 1970; Gazetopoulos et al., 1976a,b). Subsequent studies (Penther et al., 1977) have not been able to confirm this relationship, and these results should therefore be interpreted with caution.

A short main trunk is also considered a risk factor in coronary perfusion during surgical operations, such as during replacement of the aortic valve (Vlodaver, 1976). In this case the catheter may be inserted into one of the terminal branches leading to an ischemia in the territory of the terminal branch, which may cause ventricular arrhythmia, myocardial infarction, or both (Vlodaver, 1976). A short MT may also make carrying out coronary angiography difficult because when the catheter is inserted into one of the terminal branches, the opacification of the other branch does not occur, and an incomplete image of the coronary tree is seen. As McAlpine (1975) pointed out, a short MT would have the same potential risk as the absence of the left coronary artery.

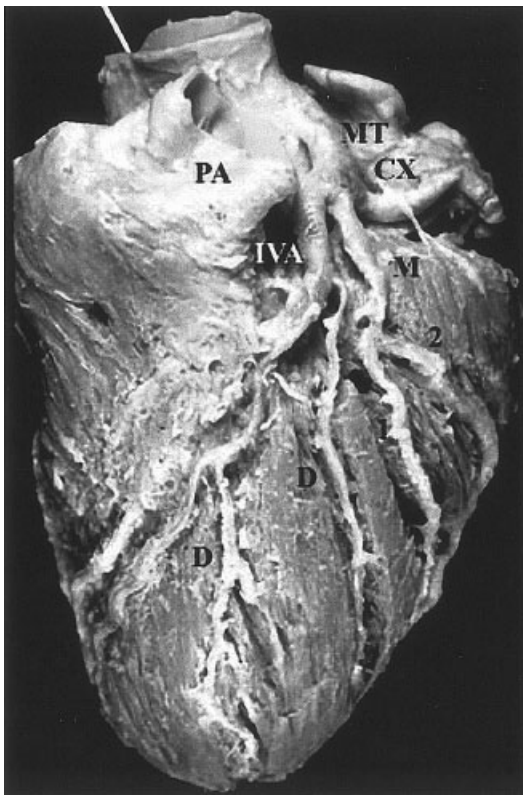


Fig. 6. The main trunk of the left coronary artery shows a division into three branches. The median artery has a course similar to that of a diagonal artery and divides after a relatively long course into one branch that descends more or less parallel to the anterior interventricular branch (1), and another branch that converges obliquely toward the *margo obtusus* (2). CX, circumflex branch; D, left ventricular (diagonal) branch; IVA, anterior interventricular branch; M, median artery; MT, main trunk of the left coronary artery; PA, pulmonary artery.

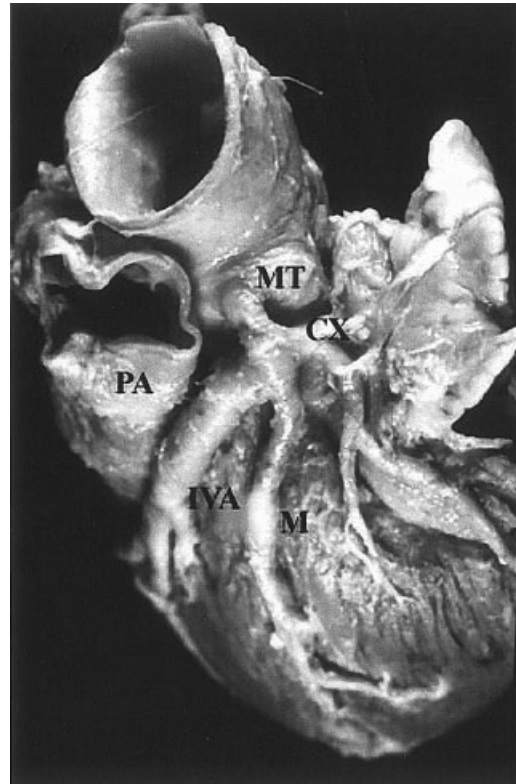


Fig. 7. The main trunk of the left coronary artery shows a division into three branches. The median artery goes obliquely toward the *margo obtusus* where it changes direction and descends. CX, circumflex branch; IVA, anterior interventricular branch; M, median artery; MT, main trunk of the left coronary artery; PA, pulmonary artery.

There is no commonly agreed upon definition of a long MT. We consider it to be one that is over 15 mm in length; Green et al. (1967) found these in 26% of cases, McAlpine (1975) in 14%, and we found them in 18.9% of our series. No relationship has been described between a long MT and any type of pathology or technical complication.

The MT does not usually have collateral branches, although an early origin of the sinu-atrial nodal branch and of the Kugel's artery (*ramus atrialis anastomoticus*) have been described (James, 1961), as well as aortic arch branches, the left conal branch, left auricular branches (Baroldi and Scmazzone, 1965), and anterior septal branches (Paulin, 1964). We did not observe any collateral branch of the MT in our series.

With regard to the type of left coronary artery division, Banchi (1904) describes a termination varying between two or three branches with the most common situation (64%) the bifurcation of the MT into its terminal branches, the anterior interventricular and circumflex branches. He also mentions the possibility of the MT dividing into three or four branches

(31% and 5%, respectively); these complementary branches are termed median arteries.

The division of the MT is a controversial topic since Banchi's study (1904) because contradictory data have been published regarding the frequency of bifurcation or trifurcation. According to Crainicianu (1922), Bosco (1935), and Kalbfleisch and Hort (1977), the most common form of termination of the MT is trifurcation into the anterior interventricular branch, median artery and circumflex branch. Other authors report a greater frequency of bifurcation, with the median artery present in between 9–40% of cases (Baroldi and Scmazzone, 1965; Leguerrier et al., 1976; Penther et al., 1976; Hadžiselimović, 1982; Baptista et al., 1991). This apparent discrepancy may be explained by the different criteria used to define the median artery (Angelini et al., 1999). For some authors, the median artery is the artery located at the exact angle formed by the two terminal branches, whereas those that have their origin in the initial millimeters of these branches are considered to be collateral branches (Paulin, 1983). Others used wider criteria, taking the median artery to be one that originates in the vertex of the angle formed by the terminal branches or their initial millimeters, providing it is of a sufficient size, and that its area of distribution extends to the middle portion of the sternocostal wall of the left ventricle (James, 1961; Angelini et al., 1999). In our case, we followed the stricter criterion and obtained an incidence of 62% bifurcation and 38% of cases with one or more median arteries (Figs. 5,7). We feel that the wider criterion leads to some degree of subjectivity in the analysis of data and removes the possibility of comparison between the series studied.

Identification of the median artery may be of clinical importance. Although its area of distribution is usually small, it irrigates areas that in the absence of trifurcation of the left coronary artery are irrigated by the anterior interventricular and circumflex branches, and its existence may decrease the effects of occlusion of these arteries (Reig et al., 1994b). As a result, as Levin (1983) points out, the tendency noted in some hemodynamists to focus angiographic examinations on the search for lesions in the anterior interventricular and circumflex branches must be overcome, as occlusion of the median artery, depending on its distribution, may be as dangerous as alteration of the other two branches.

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