ORIGINAL ARTICLE

Morphometric analysis of clinically significant parameters of the main trunk of the left coronary artery

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ABSTRACT

Aim To determine the value of angles between the left coronary artery main trunk (LMT) and its branches, the anterior interventricular branch (LAD) and the circumflex branch (CX), and their possible relationship with the LMT length.

Methods A total of 29 cadaveric hearts were used. The left coronary artery and its branches were dissected. The hearts were then classified according to the number of branches. The LMT length was measured with a digital gauge, and the LAD-CX angle, LMT-LAD angle and LMT-CX angle with a manual goniometer.

Results The average value of the LMT length was 9.0 mm (6.0–13.5). In 20 (68.97%) samples, the LMT was divided into two terminal branches. There was no statistically significant difference (p=0.321) in LMT length between the hearts with a bifurcation and without it. The average value of the LAD-CX angle was 89.0º (74.5–93.0), with a statistically significant difference (p=0.020) comparing to hearts with trifurcation. The mean value of the LMT-LAD angle was 30.83±9.23º and it was significantly lower (p=0.006) in the group of hearts with bifurcation compared to the group with trifurcation of the main trunk.

Conclusion The LMT length shows great variability and is not related to the LAD-CX, LMT-LAD or the LMT-CX angle. Knowledge of the left coronary variation is essential in order to avoid misinterpretation of arteriogram.

Key words: anatomical variations, branching pattern, left coronary artery

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INTRODUCTION

The left coronary artery (LCA) originates from the left sinus of the aorta and its main trunk (LMT) passes between the left auricle and the pulmonary trunk and arrives at the front of the heart where it divides into terminal branches. Cases are described where there is no LMT but the anterior interventricular branch (LAD) and circumflex branch (CX) originate independently, directly from the left sinus of the aorta (1,2,3), and sometimes also from the right (4). Apart from the fact that the main trunk of the left coronary artery may be missing, it shows great morphological variability in terms of its length, way of branching, and value of the angle formed by its terminal branches (5,6).

A short trunk of the left coronary artery can make it difficult to perform coronary angiography, with or without stenting, makes surgical revascularization technically more demanding and complex, and represents a risk factor for the development of coronary atherosclerosis (7,8).

The way the LMT branches and the value of the angle that its terminal branches close with each other are factors that influence coronary hemodynamic. It also plays a significant role in the origin and development of coronary atherosclerosis, as well as restenosis after stent implantation, which is especially significant considering the fact that the LAD branch is most often affected by atherosclerotic changes (9,10,11). Recent research suggests that its value is a more reliable predictor of LAD stenosis than the value of the LAD-CX angle (11,12).

The clinical importance of morphological characteristics of LMT, which are highly variable, prompted us to conduct this research. The study of such variations in humans are of a particular interest, since there is no doubt that, at least in many cases, they may have an influence on pathologic conditions in the vessels of the heart.

The aim of this paper was to determine the presence, length, and branching pattern of LMT and to investigate a relationship between its length and the branching pattern, as well as to determine the value of the LAD-CX angle and its possible relationship with the LMT length with special attention to determining the LMT-LAD angle.

MATERIAL AND METHODS

The present observational descriptive study was conducted at the Department of Anatomy, School of Medicine of the University of Sarajevo. Ethical approval for this research was granted by the Ethics Committee of the University of Sarajevo, School of Medicine and Federal authorities.

In this study, a total of twenty-nine cadaveric heart specimens irrespective of age, sex, and race were collected between September 2011 and August 2017. The hearts were stored for 3-5 days in a 10% formalin solution. After that, fatty tissue was removed and the coronary arteries and their branches, which have a subepicardial flow, were prepared by careful dissection.

The left coronary artery (LCA) was dissected carefully to avoid damage to small branches. The number of terminal branches of the main trunk was noted. In the cadavers, the LCA and its branches dissection *in situ* involved careful removal of any tissues, particularly fascia, around the blood vessels. Once the left coronary artery and its branches were fully exposed, the identification of the branching vessels in situ was documented. The hearts are classified into appropriate groups based on the number of terminal branches. The LMT length was measured with a digital gauge with a range of 0 to 200 mm (Black and Decker, USA).

A manual goniometer (GPM Model 117, Switzerland) was used for the measurement of corresponding angles between branches: LAD-CX angle, LMT-LAD angle, and LMT-CX angle. At the end of research, photographs were made with a high-resolution digital camera.

Statistical analysis

Results are expressed as mean ($\bar{X}$) and standard deviation (SD), and as the median and interquartile range (25-75 percentile). The Shapiro–Walk test was used to determine if the data had a normal distribution. Differences between the groups were tested using Student's t-test for normally distributed data and Mann-Whitney U-test for non-normally distributed data. A value of $p<0.05$ was taken as statistically significant. The correlation between the LMT and the examined angles (LMT-LAD, LMT-CX, LAD-CX) was calculated using Spearman rank correlation test.

RESULTS

The presence of the main trunk of the left coronary artery (LMT) was recorded on a complete sample of 29 human hearts. The average value of LMT length was 9.0 mm (6.0–13.5), and it ranged from 4 mm to 22 mm. In 20 (68.97%) heart samples, the LMT was divided into two terminal branches (Figure 1).

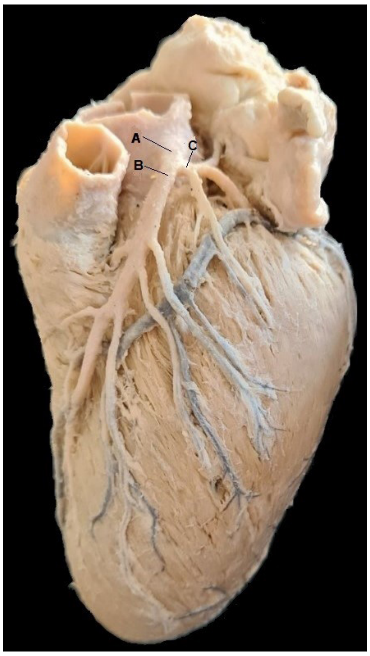

Figure 1. Human heart (dissected sulpha). Left coronary artery with bifurcation; A) left coronary artery main trunk (LMT); B) anterior interventricular branch (LAD); C) circumflex branch (CX) (Lujinović A, 2022)

LMT trifurcation was present in heart samples (31.03%) of the examined hearts (Figure 2).

There was no statistically significant difference (p=0.321) in LMT length between the hearts with bifurcation and the hearts with trifurcation. The average value of the LAD-CX angle was 89.0º (74.5–93.0). There was a statistically significant difference (p= 0.020) in the value of this angle in hearts with bifurcation of the main stem compared to hearts with trifurcation. The mean value of the LMT-LAD angle was 30.83º±9.23. The value of this angle was significantly lower (p=0.006) in the group of hearts with bifurcation compared to the group of hearts with trifurcation of the main trunk.

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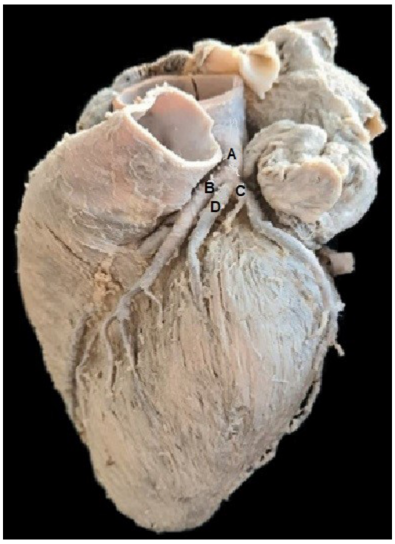

Figure 2. Human heart (dissected sulpha). Left coronary artery with trifurcation. A) left coronary artery main trunk (LMT); B) anterior interventricular branch (LAD); C) circumflex branch (CX); D) Diagonal branch (Lujinović A, 2022)

The LMT-CX angle was 52.28º±13.61. The value of this angle in the group with bifurcation was 50.60º±12.85 and did not differ significantly (p=0.116) from the value in the group with trifurcation (59.22º±14.06) (Table 1).

No significant correlation was observed between LMT length and the examined angles (Table 2).

Table 1. Comparative analysis of left coronary artery main trunk (LMT) length and LMT- circumflex branch (CX), anterior interventricular branch (LAD) - CX angles, in human hearts grouped according to the number of terminal branches of LMT

Variable	Bifurcation (n=20)	Trifurcation (n=9)	p
LMT lenght (mm)	9.65±4.79	11.65±5.36	0.321
LMT-LAD angle	28.5º (20.25-31.75)	36.0 (31.0-42.0)	0.006
LMT-CX angle	50.60º±12.85	59.22±14.06	0.116
LAD-CX angle	88.5º (59.25-92.0)	93.0 (87.5-99.5)	0.020

Results are presented as median and interquartile range (25-75 percentiles), and as mean±standard deviation (± SD)

Table 2. Correlation of left coronary artery main trunk (LMT) length and left coronary artery main trunk (LMT) - circumflex branch (CX), anterior interventricular branch (LAD) - CX, and left coronary artery main trunk (LMT) - CX angles

Variable	Lenght LMT (mm)
LMT-LAD angle	Rho=0.107
LMT-CX angle	Rho=0.080
LAD-CX angle	Rho= -0.026

DISCUSSION

The left coronary artery represents the dominant artery in the perfusion of the myocardium and supplies blood to over 60% of the heart muscle, and on the other hand, this artery and its terminal branches are the blood vessels that are most often affected by atherosclerosis, and therefore its variations are the subject of interest of numerous researchers (5,8).

The length of the main trunk of the left coronary artery is a parameter of particular clinical importance. In this study, an average tree length of the main trunk of the left coronary artery of 9.0 mm was found, with an interquartile range (25-75 percentiles) of 6.0 mm to 13.5 mm. These findings are in agreement with the results obtained by other researchers (5,7,13).

Gazetopoulos et al. study (8) suggested that a short trunk is a risk factor for the occurrence, faster progression and more severe outcome of atherosclerosis of the LAD and CX.

Other authors also point out that short LMT is an innate predisposing factor for the development of coronary atherosclerosis and suggest that people who have it should pay special attention to other risk factors that can be controlled (5,6,13).

In this research, no correlation was found between the length of the LMT and the pattern of its branching, thus confirming the results reached by Deepa et al. (14). However, our results are in contrast to those obtained by Pereira et al. (5) who found that hearts with trifurcation had a significantly longer LMT compared to hearts with bifurcation (9.77±4.31 mm vs. 6.44±3.01mm).

It is known that vascular regions exposed to low "shear stress" show increased endothelial activation characterized by reduced production of nitric oxide (NO), with increased oxidative stress and proinflammatory activation, so it can be said that low "shear stress" represents a strong atherogenic factor (12). The value of the LMT bifurcation angle is closely related to the change in hemodynamic forces in the bifurcation area. Numerous researchers have emphasized that the wider LAD-CX angle, due to the low "shear stress" that forms in that area, represents a clear predisposing factor for coronary atherosclerosis (10,11).

In the literature, the value of the LAD-CX angle of 60° (13) or 80° is considered to be the limit in predicting the development and presence of coronary disease (15,16). The value of the LAD-CX angle in this study was an average of 89° (with an interquartile range from 74.50° to 93.00°), which is in agreement with the results obtained by other researchers (16,17). Here we must emphasize that as many as 72.41%, that is, 82.76% of the examined hearts had a LAD-CX angle greater than the stated limit of 80°, that is, 60°.

Moon et al. (12) pointed out that the LMT-LAD angle is a more accurate predictor of significant LAD stenosis than the LAD-CX angle and that its limit value is 40°. Konishi T et al. (11) emphasize the importance of the value of the LMT-CX angle for predicting restenosis after stent placement in the proximal part of the LAD. In our research, the value of the LMT-LAD angle was 30.83°±9.23° and only in 17.24% of the examined hearts the value of this angle was higher than the suggested limit value of 40°. Considering the large difference in the percentage of hearts that had a LAD-CX angle greater than the limit, in relation to the percentage of hearts with an LMT-LAD angle greater than the proposed limit, we believe that *in vivo* research should be continued in order to standardize the data on which of these two angles is the more reliable predictor of coronary atherosclerosis and what is its threshold value.

In conclusion, the LMT length showed great variability and is not related to the LAD-CX, LMT-LAD or the LMT-CX angle. It is necessary to evaluate the LMT length and the LMT branching pattern independently in order to pay attention to potential variations in the origin, number, length of the main stem, branching pattern, termination and distribution of LCA that can greatly enhance clinical outcomes.

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TRANSPARENCY DECLARATION

Conflict of interest: None to declare.

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