Morphological variation and dimensions of left coronary artery: a cadaveric study

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 describe variation of left coronary artery.

Materials and methods: We dissected and grossly examined a total of 78 human hearts to describe coronary artery variations in origin and course.

Results and discussion: The mean outer diameter of left coronary artery (LCA), left anterior descending (LAD) and circumflex artery (CA) was 4.34±2.01mm, 4.21±0.28mm, and 2.73±0.60mm respectively. Whereas the mean length of LCA, LAD and CA was 10.2±3.5mm, 83.4±17.8mm, and 44.6±17.9mm respectively. The main trunk of LCA bifurcated in 63 specimens (80.76%), trifurcated in 8 specimens (10.25%), quadrifurcated in 6 specimens (7.69%) and pentafurcated in 1 specimens (1.28%).

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 interventional procedures requires a sound, basic knowledge of the coronary artery pattern.5

Numerous data on the variations of the arteries have been reported, but still it is better to explore them further with respect to their clinical significance. The present study intends to establish the branching patterns for the LCA in western population. This knowledge has significance as these variations have anatomical, pathophysiologial diagnostic and therapeutic implications.

Materials and methods

Materials

The present observational descriptive study was conducted at the department of Anatomy and Neurobiology, Oman Medical College affiliated with West Virginia University (WVU), Sohar, and Sultanate of Oman. The specimens were collected from a cadaver sample provided by Department of Anatomy, West Virginia University, United States. With respect to the West Virginia University cadaver sample, the left coronary artery and its branches were dissected in situ and were used to document the variation of branching patterns of the aorta.

Ethical approval

Ethical approval for this research was granted by the Research Ethics Committee (REC) of the Oman Medical College affiliated with West Virginia University (WVU), Sohar, and Sultanate of Oman.

Cadaver sample

In this study, total seventy eight formalin fixed cadaveric hearts specimens irrespective of age, sex, and race were collected from year September 2011 to August 2017 for the purpose of teaching undergraduate students were utilized. As part of routine forensic examination the pathologists bisect the aorta longitudinally and examine the macroscopic appearance of the luminal surface from the proximal ascending aorta to the point of bifurcation into the common iliac arteries. The gross appearance of the vessel is recorded in situ and were used to document the variation of branching patterns of the aorta.
Methodology

By cutting the ribs and sternum, the thoracic cavity was opened. The great vessels were ligated by thread at two then cut in between. The parietal pericardium was incised heart along with great vessels was taken out of the pericardial cavity. The aorta and pulmonary trunk were excised above the supra-valvular ridge. With gradual separation and retraction of the myocardial fasciculi, the coronary arteries and their branches were dissected on the surface of the heart in the atrioventricular and interventricular grooves. At collection, samples were placed in plastic jars containing 10% neutral buffered formalin and labelled according to the serial number allocated.

By micro dissection the epicardium was removed, and coronary arteries were observed. The left coronary artery (LCA) was dissected out carefully to avoid damage to small branches. The number of terminal branches of the main trunk was noted.

In the cadavers, the left coronary artery and its branches dissection in situ involved careful removal of any tissues, particularly fascia, from around the blood vessels. Once the left coronary artery and its branches were fully exposed, the identification of the branching vessels and their relative positions to key anatomical landmarks in situ were documented. Evidence of variations or anomalies in the vessels was recorded. The external diameters at the starting points of these branches were measured using 0.01mm sensitive digital calipers. Following dissection, a metal tag with the cadaver identification number was sutured to each heart, which was then stored in a large plastic container containing neutral buffered formalin. All data were initially recorded by hand on data sheets and subsequently transferred into Microsoft Office Excel 2007 for analysis. The dissected vessels and their branches were also photographed using a Sony Cyber-shot 7.2 mega pixel camera. Graphs and tables were generated using Microsoft Office Excel 2007.

Statistical analysis

All statistical analysis was conducted with help from the Department of public health and epidemiology (Statistical Sciences), Oman Medical College affiliated with West Virginia University (WVU), Sohar, and Sultanate of Oman. The data is reported as mean±standard deviation. Statistical analysis was performed using the Statistical Package for the Social Sciences version 16.0.0 for Windows (SPSS Inc, Chicago, IL, USA). Normality of the sample data was ascertained using the Shapiro-Wilk W Test, using a level of significance of 5%. Parametric analysis was performed on variables found to be normally distributed. The independent t-test was used in order to determine significant differences between mean values as the analysis looked at significant differences different sample sites.

Results

In all 78 heart specimens, the dissected left coronary artery (LCA) was found to arise from the left posterior aortic sinus of the ascending aorta. As mentioned in Table 1, the mean outer diameter and length of LCA was 4.34±2.01mm and 10.2±3.5mm respectively. The mean diameter of left anterior descending (LAD) was 4.21±0.28 mm and its length was 83.4±17.8mm whereas the mean diameter of circumflex artery (CA) was 2.73±0.6 mm and its length was 44.6±17.9mm.

![Figure 1](image-url) (A) Photographs show bifurcation in two branches of LCA arising as LAD and CA. (B) Photographs show bifurcation in three branches of LCA arising as LAD, CA, diagonal branch (DB). (C) Photographs show quadrifurcation in four branches of LCA arising as LAD, CA, 2 diagonal branches. (D) Photographs show pentafrication in five branches of LCA arising as LAD, CA, 3 diagonal branches. 

Abbreviations: LCA, left coronary artery; LAD, left anterior descending; CA, circumflex artery; DB, diagonal artery

Table 1: Mean diameter and mean length of LCA and its branches

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of artery</th>
<th>Diameter (in mm)</th>
<th>Length (in mm)</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td>Left coronary artery (LCA)</td>
<td>4.34±2.01</td>
<td>10.2±3.5</td>
</tr>
<tr>
<td>2</td>
<td>Left anterior descending artery (LAD)</td>
<td>4.21±0.28</td>
<td>83.4±17.8</td>
</tr>
<tr>
<td>3</td>
<td>Circumflex artery (CA)</td>
<td>2.73±0.6</td>
<td>44.6±17.9</td>
</tr>
</tbody>
</table>

Main trunk of LCA after its origin runs for little distance and then mainly divides into LAD and circumflex artery CA. The most frequent type of division was a bifurcation into two terminal branches as LAD and CA (Figure 1A). Third branch coming from the main trunk of LCA other than LAD and CA is called ramus intermedius (diagonal) which is seen in trifurcation of LCA (Figure 1B). In quadrifurcation total four branches arise from main trunk, they are LAD, CA and two diagonal arteries (Figure 1C). In pentafrication, it is divided into LAD, three diagonal and one circumflex branch (Figure 1D). The main trunk of LCA bifurcated in 63 specimens (80.76%), trifurcated in 8 specimens (10.25%), quadrifurcated in 6 specimens (7.69%) and pentafricatured in 1 specimens (1.28%).

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Discussion

Nowadays, with the extensive use of advanced image diagnostic techniques and the development of non-aggressive treatments, an in-depth 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. 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, James Sahni & Jit et al., and Kulkarni J. The LCA is the main source of blood supply to the heart. Kalbfleisch and Horti, 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.

Bhele et al., reported, when the common trunk of LCA is less than 5 mm then it is considered to be short and when it is more than 15 mm it’s considered as common long trunk. In the present study 60 (77%) of the cases, the trunk of the LCA was short measuring less than 5 mm and in 18 (13%) of the specimens, found more than 10 mm. The average length ranged from 2 mm to 16 mm. Results were consistent with Reig & Petri’s study, an average of 10.8 mm. Kalpana RA observed the length of main trunk of LCA ranges between 6 mm to 15 mm. Study conducted by Kulkarni et al., revealed the length of LCA to be 5 mm in 76.7% of specimens, while it was observed to be 10 mm in 5% of specimens. Walker & Schlant observed the length of LCA to be 6 mm in 76% of all specimens and 10 mm in 3% of specimens. Banuchi observed the length of the trunk of LCA was <5 mm in 2% of specimens. Fox et al., found the length of LCA to be <6 mm in 36% of all specimens while >20 mm in 5% of all specimens on cine angiograms. Reddy & Pusala reported, the left main (LM) coronary artery ranges in length from 1 to 25 mm before bifurcating into the LAD and CA. The LAD coronary artery measures from 10 to 13 cm in length whereas the CA artery measures about 6 to 8 cm in length. In the current study, the mean length of LAD and CA was 83.4±17.8 mm and 44.6±17.9 mm respectively. Dattatray D et al., reported the mean length of LAD and CA was 85±25.2 mm and 45.6±19.9 mm respectively.

The short main LCA explain some failures of adequate coronary perfusion. During aortic valve surgery, myocardial perfusion depends on the placement of one or more cannulas in the coronary arteries. In this regard, the length of main LCA prior to its bifurcation is particularly important. Short trunk of LCA could be a risk during aortic valve replacement surgeries. The catheter may be inserted into one of the terminal branches, thereby producing an ischemic area, which can lead to arrhythmia, myocardial ischemia or both. Short trunk also been considered as a risk factor in developing coronary atherosclerosis.

No relationship has been described between a long main LCA trunk and any type of pathology or technical complications.

The diameter of main stem and larger branches of LCA was recorded. The mean diameter of LCA, LAD and CA was 4.34±2.01 mm, 4.21±0.28 mm and 2.73±0.6 mm respectively. Similar findings were reported by Dattatray D et al., the mean diameter of LCA, LAD and CA was 4.64±1.02 mm, 3.19±0.5 mm and 2.94±0.7 mm respectively. Fazioogullari Z et al., noted that the average diameter of LCA, LAD and CA was 4.4±1.79 mm, 3.13±0.64 mm, and 2.98±1.08 mm respectively. Also Rex N et al., measured the human coronary artery size by cine-angiography reported the mean diameter of LAD and CA was 3.5±0.5 mm and 3.2±0.7 mm respectively. Reg & Petri studied all characteristics of the main trunk of LCA in 100 autopsy heart specimens found the diameter of the main trunk measured at its mid-point was between 3 to 7 mm with average value 4.86±0.8 mm. Jeffery JP reported that balloon angioplasty of aorto-ostial lesions and ostial lesions of LAD and CA coronary arteries has been associated with reduced success and high recurrence rates owing to smooth muscle and eccentric intimal proliferation noted pathologically in ostial lesions.

As per the observations of Loukas et al., it is necessary to determine the incidence of the variations, which are possibly capable of inducing sudden cardiac death, in order to evaluate the value of screening. Variation in the origin of coronary arteries and their branching pattern can pose difficulties in imaging by conventional catheters, thereby creating problems in diagnostic and therapeutic interventions. In present study, bifurcation of LCA was found in majority of cases 63 specimens (80.76%), trifurcated in 8 specimens (10.25%), quadrifurcated in 6 specimens (7.69%) and pentafurcated in 1 specimens (1.28%). Similar results have been reported by Fazioogullari Z et al., Surucu et al., Reig & Petri and Kalpana R. Bosco observed that in 2% of the specimens, there was no division of the main LCA trunk, while 42% of the specimens had bifurcation and 55% had trifurcation. Hadziselimovic reported that out of the 52% of cases with bifurcation in the series, 48% had trifurcation and only 4% had more than three branches. Benthier et al., observed 2% of specimens with no division of the trunk, 89% with bifurcation and 9% with trifurcation. The published data from different studies show a certain degree of disparity in results, depending on the technique used by the authors. A comparison of the various studies is shown in Table 2. The Diagonal branch may be considered to be the artery located in the angle formed by the LAD and CA whereas a broader approach envisages that the Diagonal branch originates in the vertebra of the angle formed by the terminal branches of the LCA or in the initial millimetres of the LAD and CA. Identification of the diagonal artery is important clinically. Its area of distribution to the heart is small. In the absence of this artery the area is irrigated by the branches of LAD and CA. Therefore due to the occlusion of LAD & CA more area of the heart would be affected.

Table 2 Comparison of branching pattern of left coronary artery with previous studies

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<th>S.No.</th>
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<th>No. of cases (n)</th>
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<th>Trifurcation (%)</th>
<th>Quadrifurcation (%)</th>
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Conclusion

The high degree of variability of left coronary artery and its branching patterns have anatomical, pathophysiological diagnostic and therapeutic implications. Adequate knowledge of these variations with regard to source, and incidence is important for the interpretation of coronary angiography, stenting procedures and surgical myocardial revascularization.

Acknowledgments

The authors would like to acknowledge the support exerted by Dr. M. L. Ajmani, Professor and Head, Department of Human structure and Neurobiology, Oman Medical College (OMC), Oman. The authors submit their sincere thanks to the Head and all the faculty of Department of Anatomy, West Virginia University, United States, for providing the specimens. The authors extend their gratitude to Dr. Saleh Al Khusaiby, Dean, Dr. Mohammad Al Shafaee, Vice Dean, and Dr. Mubarak Pasha, Deputy Dean of OMC. The authors also thank the faculty and technicians of OMC for their help to complete this study.

Conflicts of interest

All Authors have none to declare.

Table continued...

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References


