

BRANCHING PATTERN OF THE LEFT ANTERIOR DESCENDING CORONARY ARTERY IN A BLACK KENYAN POPULATION

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ABSTRACT

Branching pattern of the left anterior descending coronary artery is important in explaining variations in occurrence of coronary atherosclerosis, informing management strategies for coronary heart disease and interventional cardiology. Data on African populations are, however, scarce. Since coronary heart disease is increasing in Africa, the aim of this study was to describe branching pattern of the left anterior descending coronary artery in an indigenous Kenyan population. Two hundred and eight hearts obtained during autopsy were dissected at the Department of Human Anatomy, University of Nairobi, Kenya. The entire left anterior descending coronary artery was exposed. Number of branches, pattern of termination and level of bifurcation were determined. Images of representative patterns were taken using a high resolution digital camera. Data are presented in macrographs and tables. The number of septal and diagonal branches varied between 1 and 3. Termination occurred in the posterior interventricular sulcus in 68.8% and at the apex in 23% cases. Most common mode of terminal branching was bifurcation (76.9%) followed by trifurcation (11.3%), quadrifurcation (3.4%) and pentafurcation (1.5%). Bifurcation occurred in the distal segment in 48.8% and in the proximal segment in 15% of cases. The left anterior descending coronary artery displays high variability in number of septal and diagonal branches, level of termination, mode of terminal branching and level of terminal bifurcation. These patterns may constitute risk factors for atherosclerosis and should also be acknowledged during cardiac procedures. Pre-operative ultrasound evaluation is recommended to minimize inadvertent iatrogenic injury.

Keywords: Left anterior descending, branching, termination, atherosclerosis.

INTRODUCTION

Left anterior descending (LAD) coronary artery, usually a branch of the left coronary artery (LCA), commonly gives rise to a variable number of diagonal and septal branches designated D_1 , D_2 , D_3 ... and S_1 , S_2 , S_3 ..., respectively (Kini et al., 2007; Sundaram et al., 2009) and terminates in the distal part of the posterior interventricular sulcus (Vilallonga, 2003; Ballestros and Ramirez, 2008). The artery is divided into three parts: the proximal one extending from the origin to D_1/S_1 ; the middle one between S_1/D_1 and D_2 and the distal one between D_2 and the termination (Fiss, 2007; Sundaram et al., 2009; Erol et al., 2013). It is the most commonly involved artery in

coronary atherosclerosis. Of the three segments, the proximal one is the most frequently afflicted in atherosclerosis (Kimura et al., 1999; Gziut et al., 2006; Garg et al., 2011; Jha et al., 2013). Angiographic studies reveal, for example, that 50 – 55% of the lesions occur in the proximal segment (Sato et al., 2010; Ghaffari et al., 2013). Further, that continuous plaque from left main coronary artery into the LAD may be seen in upto 90% of cases (Oviedo et al., 2010; Yakushiji et al., 2013). The reason for this segmental preference and adverse outcome are probably related to geometric features of the artery (Friedman et al., 1996; Friedman and

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Ding, 1998), including branching pattern (Balghith et al., 2003). The branching pattern shows ethnic variations (Baptista et al., 1999; Dhall et al., 2003; Lip et al., 2006). Knowledge of these variations is important to explain individual and ethnic differences in pattern of atherosclerosis (Budoff et al., 2002; Kuller, 2004; Kurian and Cardarelli, 2007) and to inform management strategies for coronary atherosclerosis including catheter based

intervention (Kimura *et al.*, 1999; Moore et al., 2010). In Sub-Saharan Africa, as the incidence of atherosclerotic coronary artery disease is increasing (Churchill, 2013), data on branching pattern of LAD are important, but scarce and altogether absent from the Kenyan population. This study, therefore, aimed at describing the branching pattern of LAD in this African population.

MATERIALS AND METHODS

Two hundred and eight hearts obtained during autopsy on adult black Kenyans were dissected at the Department of Human Anatomy, University of Nairobi, Kenya. The pericardium was incised longitudinally and the heart exposed. Aorta was exposed and left coronary artery identified arising from the left aortic sinus. Left anterior descending artery was identified as the larger branch of the LCA that coursed in the anterior interventricular sulcus. It was cleaned of fat from origin to termination. Those branches that ran over and supplied the anterolateral surface of the left ventricle were designated

diagonal (D) while those that arose perpendicular to LAD and perforated the myocardium were designated septal (S). The mode of branching, termination level, pattern and level of bifurcation were recorded. The termination level was examined relative to the apex and recorded as anterior to the apex, at the apex and in the distal part of posterior interventricular sulcus. Representative patterns were photographed with a high resolution digital camera. The data were analyzed for frequency and presented in tables and macrographs.

RESULTS

The LAD was a branch of LCA in all except one case in which it originated directly from the aorta. It ramified over left and right ventricles and gave diagonal and septal branches before termination. There were differences in mode of branching, level of termination, mode of terminal branching and level of bifurcation.

Mode of branching

The number of diagonal branches ranged from 1-3 (Fig 1A, B). The number of septal branches also varied from 1-3 (Fig 1C, D). These arose at different levels and supplied various parts of the heart. There were various combinations of branches. The most frequent was 2 diagonal and 1 septal (22.6%) followed by 3 diagonal, 1 septal (19.2%); 2 diagonal, 2 septal (15.4%) [Table 1].

Level of termination

In the majority of cases (143; 68.8%), LAD and its branches terminated in the distal part of posterior interventricular sulcus, 23.0% at the apex and the rest (8.2%) terminated in the distal part of anterior interventricular sulcus.

Mode of terminal branching

The most common mode of termination was bifurcation (Fig 2A) in 76.9%, followed by trifurcation (Fig 2B) in 11.5%; single trunk [Fig 2C] in 6.7%, quadrifurcation (Fig 2D) in 3.4%, and pentafurcation in 1.5% cases [Table 2].

The bifurcation occurred into diagonal and interventricular branches. The diagonal branches ramified over the anterolateral surface of the left ventricle while the artery continued as interventricular to give rise to septal branches.

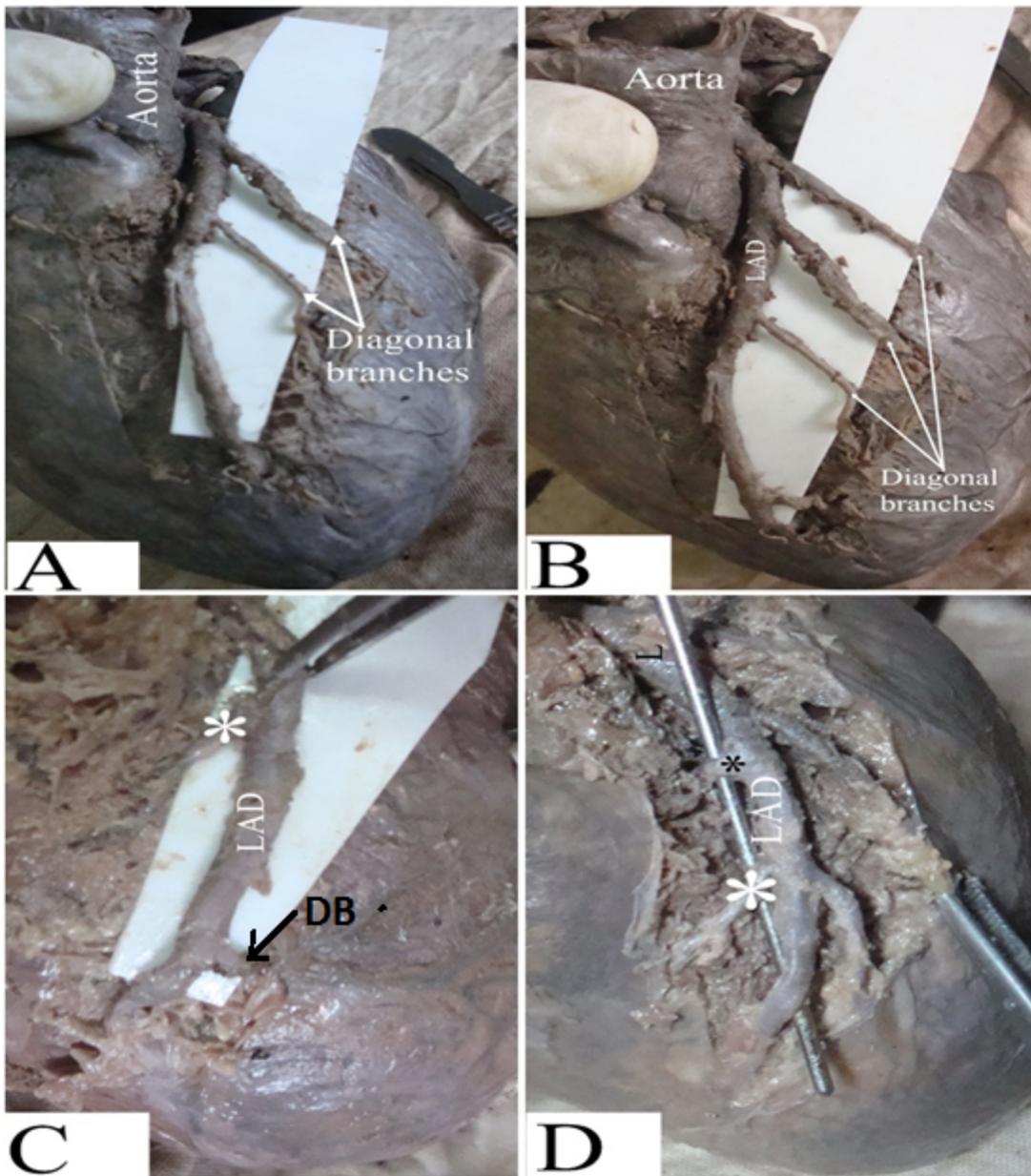


Figure 1 A - D: Pattern of branching of the left anterior descending coronary artery in a black Kenyan population. A: Two diagonal branches. **B:** Three diagonal branches. Note direct origin of LAD from the aorta. **C:** LAD running as a single trunk. Note one septal (*) branch and one diagonal branch (DB) of the artery. **D:** Two septal branches (*) and termination by bifurcation.

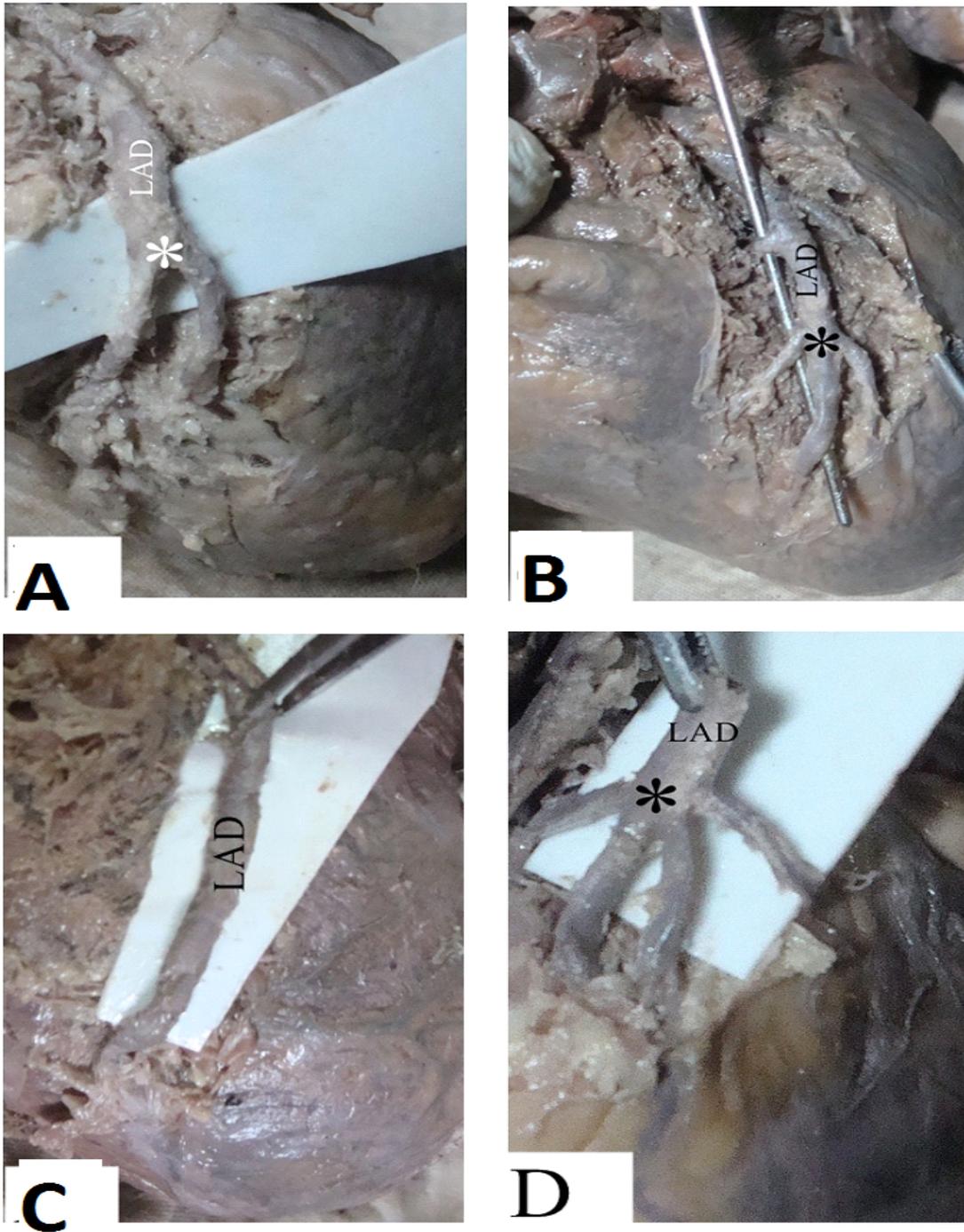


Figure 2: Mode of terminal branching of the left anterior descending coronary artery. A: Bifurcation B: Trifurcation C: Single Trunk D: Quadrifurcation

Table 1: Mode of branching of LAD in a black Kenyan population

D - No	S - No	Frequency	%
3	1	40	19.2
3	2	32	15.4
3	3	07	3.4
2	1	47	22.6
2	2	32	15.4
2	3	05	2.4
1	1	32	15.4
1	2	07	3.4
1	3	06	2.3
Totals		208	100

Key: D-No = Number of diagonal branches

S – No= Number of septal branches

Level of bifurcation

Bifurcation of the LAD was classified as early if it occurred in the proximal segment, intermediate when it occurred in the middle segment and late

if it occurred in the distal segment. The most frequent level was late (48.8%) followed by intermediate (30%) and early (15%). In 10 (6.2%) of the hearts, it ran as a single trunk all the way to the apex (Table 3).

Table 2: Mode of terminal branching of LAD in a black Kenyan population

Pattern of Termination	Frequency	%
Bifurcation	160	76.9
Trifurcation	24	11.5
Single trunk	14	6.7
Quadrifurcation	7	3.4
Pentafurcation	3	1.5
Total	208	100

Table 3: Level of bifurcation of LAD in a black Kenyan population

Level	Frequency	%
Early	24	15
Intermediate	48	30
Late	78	48.8
Single trunk	10	6.2
Total	160	100

DISCUSSION

Nearly all (99.5%) of the LADs arose from LCA. There was only one case of LAD arising directly from the aorta. This is concordant with literature reports that anomalous origins of LAD are rare (Greenberg et al., 1989; Ilija et al., 1991).

Mode of branching

The LAD usually gives a variable number of septal and diagonal branches (Kini et al., 2007; Sundaram et al., 2009). Observations of the current study reveal that the number of diagonal and septal arteries varies from 1-3. This is within the range in literature reports of up to 9 diagonal and 5 septal branches (Fiss, 2007). It suggests that mode of branching of LAD shows wide variations among various populations. The higher propensity of the proximal segment to atherosclerosis has been related to complexity of fluid dynamics near branching points (Balghith et al., 2003). In view of the differences in frequency of number of branches, evaluation is recommended before interventional procedures.

Level of termination

LAD may end before reaching the apex, but more frequently passes around the apex to reach the posterior interventricular sulcus (PIVS) (Gabella, 1999; Vilallonga, 2003; Ballestros and Ramirez, 2008). In the current study, it terminated in the PIVS in 68.8% cases. This is comparable to 63.6% reported by Ballestros and Ramirez (2008) and within the 42 – 80% in contemporary literature (Das, 2013). The 23.0% termination at the apex is within the range 6 – 33% widely reported (Sahni and Jit, 1990; Kalpana, 2003; Das, 2013). The frequency of 8.2% termination proximal to the apex is also comparable to 8% reported by Kalpana (2003) among Indians. It is, however, higher than 1.3% reported by Ballestros and Ramirez (2008) in a Colombian population and significantly lower than 12% reported by Das (2013). Arterial curvatures are atherosclerosis prone sites. Accordingly, the high proportion of arteries curving around the apex of the heart may constitute part of the anatomical basis for

increased propensity of LAD to atherosclerosis. Interventional cardiologists should also be aware of this anatomy.

Mode of terminal branching

Literature is relatively silent on the mode of terminal branching of LAD. Bifurcation is reported in 1% of cases and is considered a variation anomaly (Villalonga, 2003). A remarkable observation of the current study, seldom reported, is the high frequency of variant termination especially with more than two branches, that is trifurcation, quadrifurcation and pentafurcation. Although it is probable that this is due to the position of enlarged diagonal branches (Vilallonga, 2003), pattern of termination is important because atherosclerosis occurs most commonly at branching points where there is flow disturbance (Ku *et al.*, 1985; Ding *et al.*, 1997). At such points, WSS is low in the distal main vessel and initial segments of the daughter branches (Moore *et al.*, 2010). Since complex branching patterns are associated with higher vulnerability to atherosclerosis (Furuichi et al., 2007; Rubinstein *et al.*, 2012), it is plausible that the propensity of LAD to develop atherosclerosis is related to the branching pattern. This suggests that the African population is more vulnerable to atherosclerosis.

Level of bifurcation

Observations of the present study reveal that in fifteen percent of cases bifurcation occurs in the proximal segment where atherosclerosis is most common (Kimura *et al.*, 1996; Dhruva et al., 2012; Ghaffari et al., 2013; Sato et al., 2010; Yakushiji et al., 2013). This implies that the LAD in these cases, had a short stem. Length of coronary arteries is important during interventional cardiac procedures. Further, short stem arteries have been reported to constitute geometric risk factors for atherosclerosis (Gazetopoulos et al., 1976a, b; Ogeng'o et al., 2015). Accordingly, the early branching of the LAD may constitute part of the explanation for high propensity of the proximal segment to

atherosclerosis. Interventional cardiologists should be aware of this

evaluation is recommended to minimize inadvertent iatrogenic injury

In conclusion, the left anterior descending coronary artery displays high variability in number of septal and diagonal branches, level of termination, mode of terminal branching and level of bifurcation. These patterns may constitute geometric risk for atherogenesis and should also be acknowledged during cardiac procedures. Pre – operative ultrasound

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