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Normal and variant anatomy of Left Coronary Artery: 64-Slice Multi Detector Computed Tomography (MDCT) Coronary Angiographic Depiction in North Indian population

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Abstract- The aim of this study was to review the appearance of normal patterns of left coronary artery, its anatomic variants and anomalies and to assess their incidence in subjects of North India who underwent 64-slice Computed Tomographic Coronary Angiography (CT-CA) for suspected or known coronary artery disease (CAD).

This study was carried out in the Departments of Anatomy and Radiodiagnosis, KGMU, U.P, Lucknow, India. Fifty CT Coronary Angiograms of routine subjects of either sex and of different age groups coming to the department of Radiodiagnosis were evaluated prospectively to see the normal and variant anatomy of Left Coronary Artery (LCA) regarding its origin, length of main trunk and branching pattern.

In all the cases LCA arose either below the Sinotubular (ST) junction from Left Posterior Aortic Sinus (LPAS) or from ST junction except one which demonstrated a high take off from tubular part of ascending aorta. The LCA had a mean length of *7.11 ± 3.04* mm. The two main branches of LCA are Left Circumflex (LCX) artery and Left Anterior Descending (LAD) artery. This study revealed that the main trunk of LCA bifurcated into LCX artery and LAD artery in *38 (76%)* subjects. The artery was seen to be trifurcating in *12 (24%)* cases with the Ramus Intermedius (RI) being the third artery.

Left coronary artery is one of the feeding arteries of the heart, so a detailed knowledge of its anatomy is very important. High takeoff of LCA may cause difficulty in cannulation during coronary arteriography. Its trifurcation can cause technical problems during catheterization and may be a source of complication or misdiagnosis.

Index Terms- Coronary angiography (CA), Left coronary artery (LCA), Main trunk, Ramus intermedius (RI), 64-Slice Multi-detector Computed Tomography (MDCT).

I. Introduction

The cardiovascular diseases are the leading cause of mortality worldwide; responsible for one-third of all deaths. With the ever increasing load of coronary heart diseases, a detailed study of coronary arteries has been felt by the medical fraternity.

There are two coronary arteries, *Right Coronary Artery* (RCA) and *Left Coronary Artery* (LCA) which delivers oxygen-rich blood to the heart.

The *Left Coronary Artery* (LCA) is an artery of great challenge for interventional cardiologists and radiologists. Therefore a detailed knowledge of its accurate anatomy is mandatory for avoiding misdiagnosis of left coronary illnesses and for proper placement of a stent during percutaneous coronary intervention. Proficiency in the anatomy of coronary arteries and their variations is significant for proper interpretation of the coronary angiographies, assessment of the complexity and result of the coronary insufficiency as well as surgical myocardium revascularization [23].

LCA presents a wide range of variations in its origin, length and branching pattern. The high degrees of variations have anatomical, pathophysiological diagnostic and therapeutic implications. An in-depth knowledge of these variations is of paramount importance in management of congenital and acquired heart diseases. Failure to distinguish these variations may lead to misinterpretations and disastrous complications during heart surgery.

LCA "normally" originates from *Left Posterior Aortic Sinus* (LPAS) of ascending aorta. "High takeoff" refers to the origin of LCA at a point above the junctional zone between its sinus and the tubular part of the ascending aorta [19]. LCA divides in several ways. It bifurcates into Anterior Inter-Ventricular Artery (AIVA) & Left Circumflex (LCX) artery and trifurcates into AIVA, LCX artery and Ramus Intermedius (RI) artery. Ramus Intermedius artery is also called intermediate branch (IMB) or Ramus Medianus, arising between LAD and LCX arteries Presence of ramus intermedius artery is the most common anatomic variation observed in the left coronary system and its prevalence is 33% [7]. The size of ramus intermedius artery varies greatly from a very small vessel to a very large branching vessel [20]. Bifurcation is the most frequent branching pattern [25]. AIVA is also known as Left Anterior Descending (LAD) artery.

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Since decades the anatomy of LCA has been studied in various populations by cadaveric dissection, corrosion casting techniques and different modes of angiography such as Magnetic Resonance Angiography (MRA), Computed Tomographic (CT) angiography etc. But no such study was conducted in North Indian population to the best of our knowledge, so this endeavor was made to study the normal and variant anatomy of LCA by 64 slice CT coronary angiography in North Indian population.

II. MATERIALS AND METHODS

To study the anatomy of LCA, CT coronary angiograms of 50 subjects of both sex and different age groups [32 males (14-75 years), 18 females (12-70 years); mean age 51.36±14.07 years, age range 12-75 years] were analyzed.

CT scan and reconstruction parameters

Coronary Angiography (CA) was performed on 64 Slice Multidetector Computed Tomographic (MDCT) scanner (BRILLIANS^{TM}CT, Version 2.45.22042, manufactured by Philips) which is installed in the department of Radiodiagnosis, King George .Medical University (KGMU), Lucknow, Uttar Pradesh (U.P.), India. Retrospective Electrocardiographically (ECG) gated imaging was performed (scan protocol is given in Table1)

Pre-procedure precautions

- The subjects were enquired, to rule out the presence of any drug allergy, to avoid the occurrence of any untoward anaphylactic reaction during the procedure.
- Two days prior to the procedure the patients were advised to avoid the intake of fatty food.
- They were advised to drink only water just prior to the procedure.
- Blood urea and creatinine levels were evaluated.

Procedure

The subjects were laid supine. Their heart rate was stabilized with an oral dose of 50-100 mg Metoprolol one hour before the scan. If heart rate was not stabilized with an oral dose, then intravenous (IV) Metoprolol was given. Electrocardiogram (ECG) and pulse rate were monitored half an hour prior to the procedure. The subjects were counseled to reduce their anxiety.

The subjects were connected to a cardiac monitor. For venous access, an upper extremity vein (antecubital vein) and a 20-gauge intravenous canula was used. 80-85 ml of non-ionic contrast Iohexol (Omnipaque, GE, GE Healthcare Ireland, Cork)containing iodine concentration of 350 mgI/ml, injected with a flow rate of 5.5ml/sec, followed by a 20 ml saline flush at a rate of 4ml/sec with a pressure injector (PSI-325). The scan timing was determined with automated bolus tracking technique by placing the region of interest over mid ascending aorta and setting the trigger threshold to 180 Hounsfield (Hu). The subjects were asked to lie still on the "scanning bed" for a period of 5-10 minutes. The instruction was given to the subjects to maintain an inspiratory breath hold during which CT data and ECG tracings were taken. CTCA was performed 5 seconds after aortic peak density. Scanning coverage was from the level of carina to the bottom of the heart. Raw spiral CT data of coronary arteries were reconstructed in various phases of cardiac cycle on a work station (Brilliance 64 version 4.5) to obtain images with the highest quality (without motion artefact).Reconstruction performed at 75% of R-R interval was found to be optimal for image analysis in most of the subjects. In some, if heart rate could not be stabilized properly, then reconstructions were performed at 45% of R-R interval. The images generated were reconstructed and viewed utilizing a separate workstation which enabled generation of the coronary arteries in the standard and in various other anatomical planes as and when required and were interpreted with the help of a cardiac radiologist. Subjects with previous bypass surgery and also those with suboptimal study due to breath hold artefacts were excluded.

All images were reviewed first in axial projection and then with post processing tools such as Multiplanar Reconstruction (MPR), Curved Planar Reformation (CPR), thin-slab Maximum Intensity Projection (MIP), and Volume-Rendering Technique (VRT) with transparent background display. MIPs were obtained using various thicknesses (5–30 mm). Volume-rendered images were also obtained using various orientations.

The length of main trunk of LCA was measured in straight MPR format (Figure 1) from its orifice to its division into the Left Anterior Descending (LAD) and Left Circumflex (LCX) arteries in case of bifurcation and into LAD, LCX and Ramus Intermedius (RI) arteries in case of trifurcation

CTCA images of LCA were observed for: (1) Origin (2) Length of main trunk (3) Branching pattern

The origin of LCA was studied with relation to Sino-tubular (ST) junction.

The statistical analysis was performed by using software SPSS (Statistical Package for Social Sciences) version 15.0. The values were represented in Number (%) and Mean ± Standard Deviation (SD).

III. RESULTS

A complete visualization of all the images revealed that LCA was originating from ascending aorta in all the cases. In 84% of cases the LCA was arising below the ST junction (Figure 2 a, b & c). In 14% of cases the LCA was arising at the level of ST junction (Figure 3) and in 2% of cases the LCA was arising above the ST junction (*High takeoff*) ((Figure 4 a, b & c) (Table 2). None of the case showed anomalous origin of LCA.

The main trunk of LCA presented a variable length (mean *7.112 ± 3.04* mm, range 1.8–15 mm) (Figure 5) <5mm (n= 9, 18%), 5–10mm (n=34, 68%), and 10-15mm (n=7, 14%). The length of shortest LCA was 1.8mm and of longest LCA was 15mm. (Figure 6)
The length of main trunk of LCA had no statistically significant difference among males and females (p=0.15) (Table 3).

The most common branching pattern of LCA observed in the present study was the bifurcation into LAD and LCX arteries (Figure 7 a, b, c & d). Another branching pattern observed was the trifurcation into LAD, LCX and RI arteries. Variable patterns of RI artery were observed viz. small and large RI artery without branching (Figure 8 a & b) and RI artery with branching (Figure 9) Bifurcation and trifurcation was seen in 76% and 24% of cases respectively (Figure 10). No other branching pattern was observed. The branching pattern of LCA had no statistically significant difference among males and females (p=0.825) (Table 4).

IV. DISCUSSION

The LCA can have a variant origin. Normally the LCA arises from left posterior aortic sinus of ascending aorta. If LCA arises from tubular part of ascending aorta, then its origin is called as *'High takeoff'*. The definition of High takeoff differs among different authors. According to *Montaudon et al.*[24]. LMCA originating from the proximal 1-cm segment of the ascending aorta might be considered as a normal variant, while a takeoff distal to the first 1-cm segment of the ascending aorta should be considered as an anomaly. In the present study, High takeoff of LCA is referred to its origination above the Sinotubular junction (junctional zone between sinuses and tubular part of ascending aorta). *High takeoff* of LCA may cause mainly a technical difficulty in cannulation of vessels during coronary angiography without crucial clinical problems [31]. In high takeoff position of LCA, acute angle between aortic cusp and coronary artery is suspected as a possible mechanism of ischemia.

The length of LCA varies from *0-15mm*. [7]. The mean length of main trunk of LCA observed in the present study was *7.11 ± 3.08* mm and there is no statistically significant difference among males and females (p= 0.15) (Table 3). This length is similar to the observations (6.48 ± 2.57mm) of an autopsy study done by *L. E. Ballesteros* & *L. M. Ramirez* [1]. The mean length in the present study is considerably smaller than that is reported in some previous studies conducted on different populations [3, 4, 6, 10, 13, 15, 21, 22, 26, 27]. None of the case showed a length >15mm, while this is reported by some authors [4, 13] (Table 6).

In the present study *18% of cases had a very short main trunk of LCA* (<5mm). *Fry* in 1968 postulated that a short left main coronary artery results in a <u>small pressure drop</u> and a <u>large flow</u> at the bifurcation. The resulting <u>high wall shear</u> favours atherogenesis at the bifurcation and in the proximal segments of the LAD and LCX arteries [12]. The report of an angiographic study said that the length of main trunk of LCA was significantly shorter in patients with either a dominant left or balanced circulation than that of patients with a dominant right coronary circulation [21]. *Stephen saltissi et al* also had the similar observations and found shorter mean length of main LCA in cases of dominant LCX artery than in the cases having dominant right coronary artery [27]. In other angiographic study, *Lewis CM et al* postulated that an *unusually short* (less than 6 mm) or *absent main LCA predisposes* to *Left Bundle Branch Block* (LBBB) [22]. This was the first study in which a correlation was established between the length of main trunk of LCA and the development of LBBB. They presume that the main trunk of LCA provides a slack which minimizes disruption of the coronary blood flow to the endocardial surface of the left ventricle near the summit of the muscular part of inter-ventricular septum, where the left bundle branch originates. *Gazetopoulos et al* also found that the length of main trunk of LCA was <6mm in patients of LBBB in their study group [13]. The findings of this study also showed a shorter length of the main LCA in patients with coronary atherosclerosis than in subjects without coronary artery disease (CAD). After these observations they suggested that a *short main LCA should be considered as a congenital predisposing factor for the development of CAD* and it also increase the chance of development of atherosclerosis at origin of LAD artery.

Stephen saltissi et al found a correlation between length of main trunk of LCA and the location of atherosclerotic lesions in CAD. They found a much shorter mean length of main LCA in patients with proximal CAD than those with distal lesions [27]. The length of LAD and LCX arteries is inversely proportional to the length of main trunk of LCA. Thus a shorter main trunk of LCA is associated with long untethered proximal segments in the LAD and LCX arteries which may then be prone to excessive systolic motion and hence to increased risk of atheromatous degeneration.

The length of main trunk of LCA is an anatomical variable which alter haemodynamics and thus may affect distribution of atherosclerotic lesions. In view of the poor prognosis of proximal lesions and their suitability for bypass grafting the discovery of innate anatomical risk factors which favors their formation is of importance. [16].

A wide variety of branching pattern of LCA was reported in previous studies conducted on different populations, and the most common branching pattern of LCA reported till date is bifurcation into LAD & LCX arteries. Results of the present study are consistent with earlier reports that bifurcation is the most common branching pattern .The incidence of bifurcation in the present study is greater than that reported by some authors [1, 2, 3, 9, 15, 17, 23, 26,] (Table 7).

Trifurcation is less common and lowest reported in the present study (Table 7). The incidence of both these patterns did not differ significantly between males and females (p value 0.825) (Table 4). Table 8 shows that the incidence of trifurcation in the present study is nearer to the finding of Cademartiri et al [4]. By comparing Table-7 & Table-8 it is concluded that the incidence of trifurcation reported in autopsy and cadaveric studies is more than that is reported in CT angiographic studies. It can be explained on the basis of adoption of different definitions of Ramus Intermedius artery. Ramus intermedius artery including its anastomoses, presents important pattern of the collateral blood flow, under conditions of coronary insufficiency. Left main trifurcating coronary artery disease (LMT CAD) is a complex and challenging anatomy to treat percutaneously [25]. *Trifurcation of LCA* can cause *technical difficulties in catheterization* and may be a source of *complication or misdiagnosis*. [20]. Left main trifurcation stenting carries an overall high rate of adverse events and may need to be reserved for patients who are at high risk or who refuse bypass surgery [28].

Tetrafurcation and Pentafurcation were also observed in previous studies [1, 2, 3, 9, 15, 17, 23] but no such pattern was seen in the present study, as well as single branch which was reported earlier [17] was not seen. Usually the incidence of bifurcation is more than the incidence of trifurcation, although *Huseyin S Surucu et al* [15] reported exactly the same incidence of both these patterns and *Fazliogullari Z et al* reported almost equal incidence [9] (Table-7). In the present study the incidence of trifurcation (24%) is approximately one third the incidence of bifurcation (76%).

Congenital abnormalities of the coronary arteries are significant cause of chest pain and sudden cardiac death. The findings of present study will be beneficial in making a correct diagnosis and treat the patient accordingly. Variations in the origin, length and branching pattern of LCA have anatomical, pathophysiological, diagnostic and therapeutic implications. A detailed knowledge of all these variations is crucial for the interpretation of coronary angiograms, implementation of stenting procedures and surgical revascularization of myocardium.

V. CONCLUSION

Several variations can occur in the anatomy of left coronary artery. A higher incidence (2%) of *'High takeoff'* of LCA was found in the present study. The length of main trunk of LCA is relatively smaller in North Indian population as compared to other populations. The reported incidence of bifurcation is highest and that of trifurcation is lowest in the present study.

The findings of this study are of immense use for interventional cardiologists and radiologists during planning and performing any procedure on left coronary artery.

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FIGURES

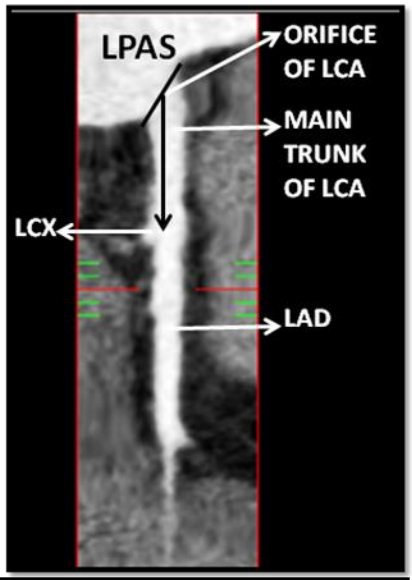

Figure1: Straight Multi-planar Reconstruction (MPR) image showing measurement of length of main trunk of LCA in case of bifurcation. **LPAS-** *Left Posterior Aortic Sinus*, **LCA-** *Left Coronary Artery*, **LAD-** *Left Anterior Descending*, **LCX-** *Left Circumflex.*

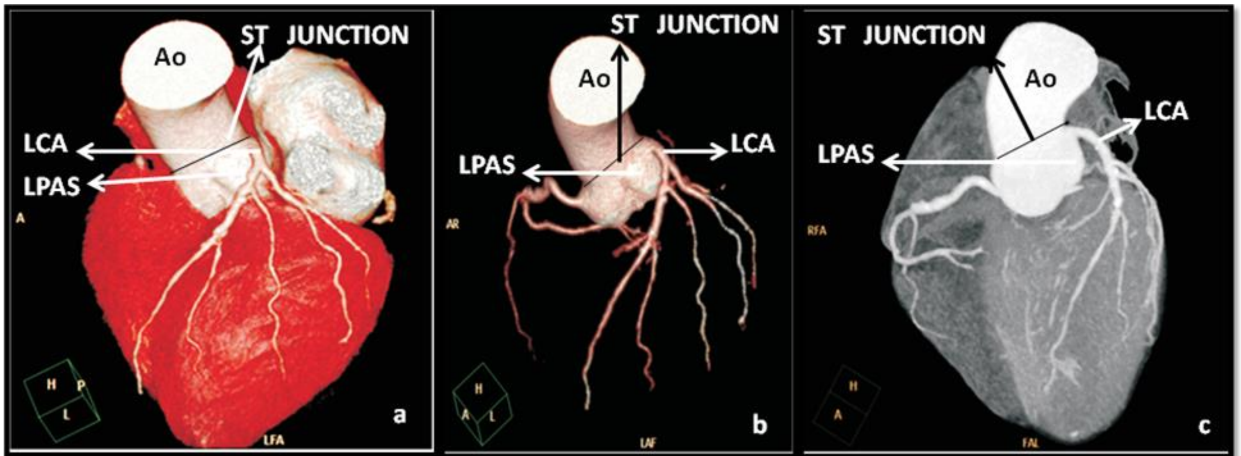

Figure 2: MDCT Coronary Angiographic images of the heart showing **origin of LCA below ST junction**. **a-** Three Dimensional Volume Rendered (3D-VR) image, **b- 3**D-VR image (contrast vessel tracking tree), **c-** 3D-VR image (cardiac outline protocol). **Ao**-*Aorta*, **ST JUNCTION-** *Sinotubular Junction*, **LPAS-** *Left Posterior Aortic Sinus*, **LCA-** *Left Coronary Artery*.

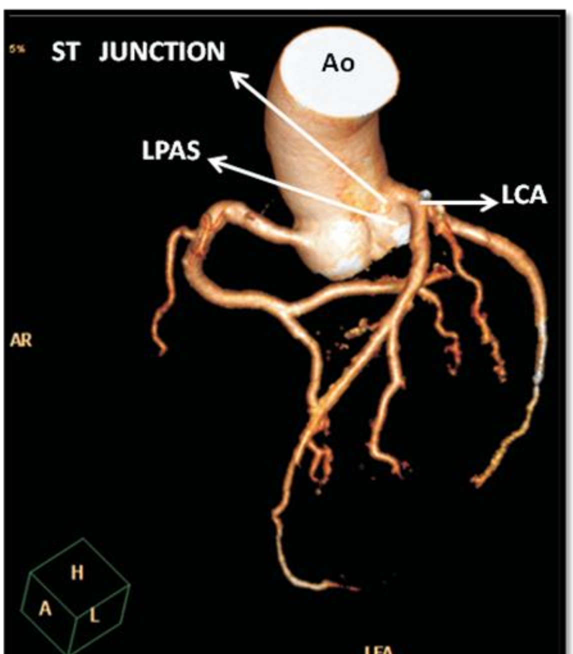

Figure 3: 3D-VR image (contrast vessel tracking tree) showing **origin of LCA at ST junction**. **Ao**-*Aorta*, **ST JUNCTION-** *Sinotubular Junction*, **LPAS-** *Left Posterior Aortic Sinus*, **LCA-** *Left Coronary Artery*.

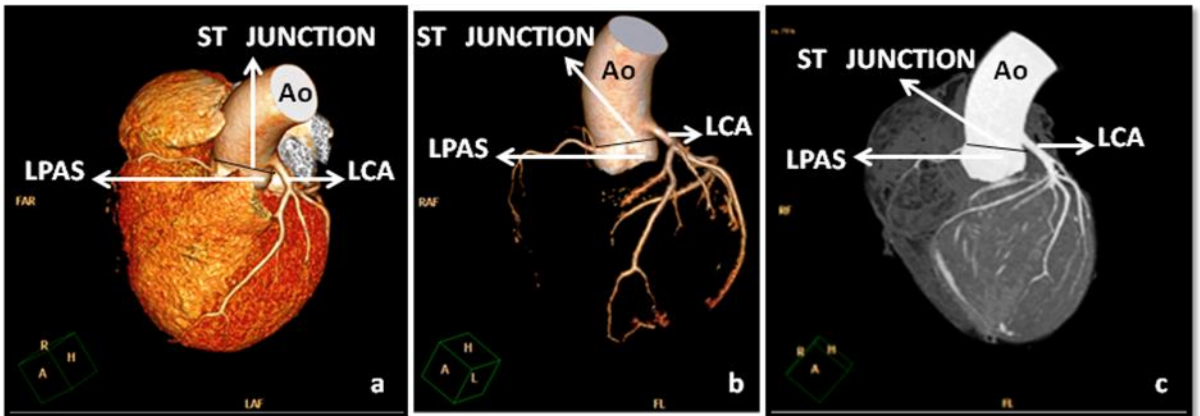

Figure 4: MDCT Coronary Angiographic images of the heart showing **origin of LCA above ST junction**. **a-** Three Dimensional Volume Rendered (3D-VR) image, **b- 3**D-VR image (contrast vessel tracking tree), **c-** 3D-VR image (cardiac outline protocol). **Ao**-*Aorta*, **ST JUNCTION**- *Sinotubular Junction*, **LPAS-** *Left Posterior Aortic Sinus*, **LCA-** *Left Coronary Artery*.

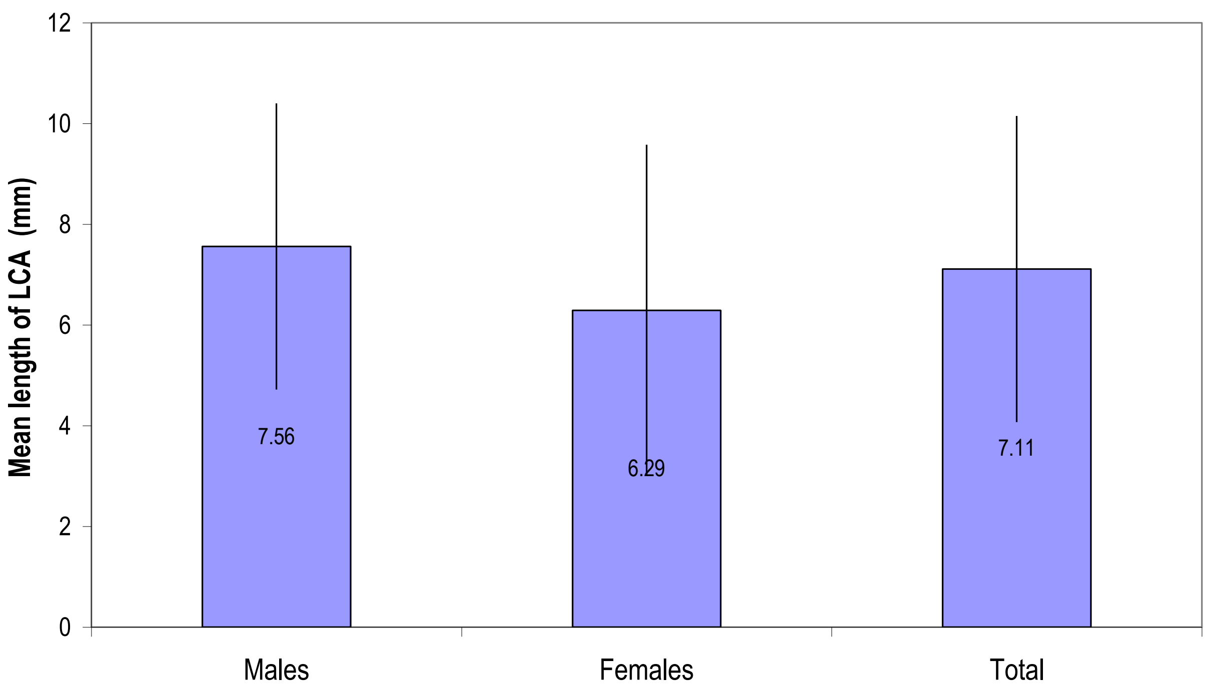

Figure 5: Bar diagram showing gender wise **mean length of main trunk of LCA**

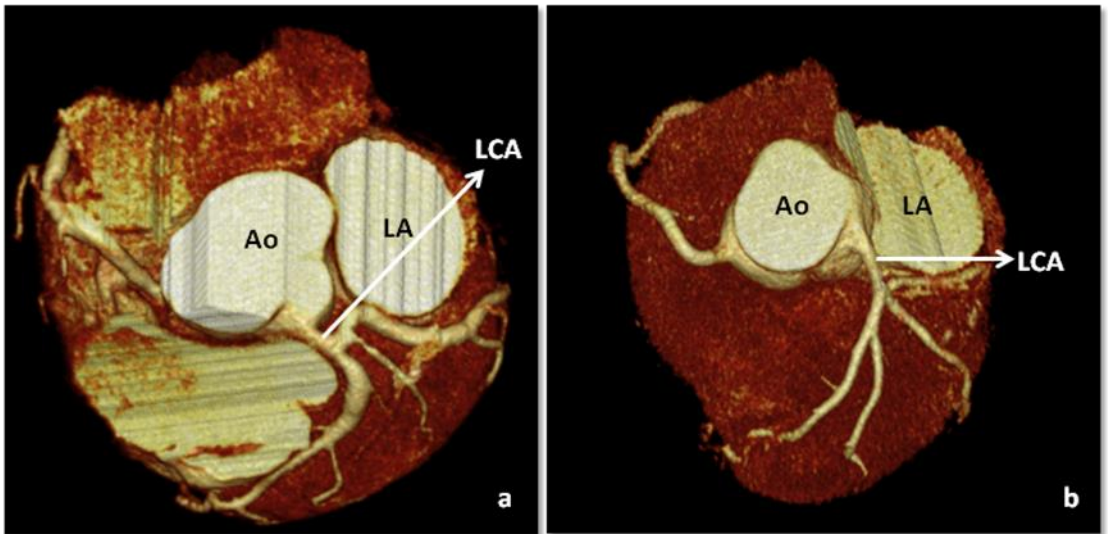

Figure 6: 3D-VR images of the heart showing variable length of LCA. **a-** shortest LCA (*1.8mm*) & **b-** longest LCA (*15mm*). **Ao**- *Aorta*, **LA-** *Left Atrium*, **LCA-** *Left Coronary Artery*.

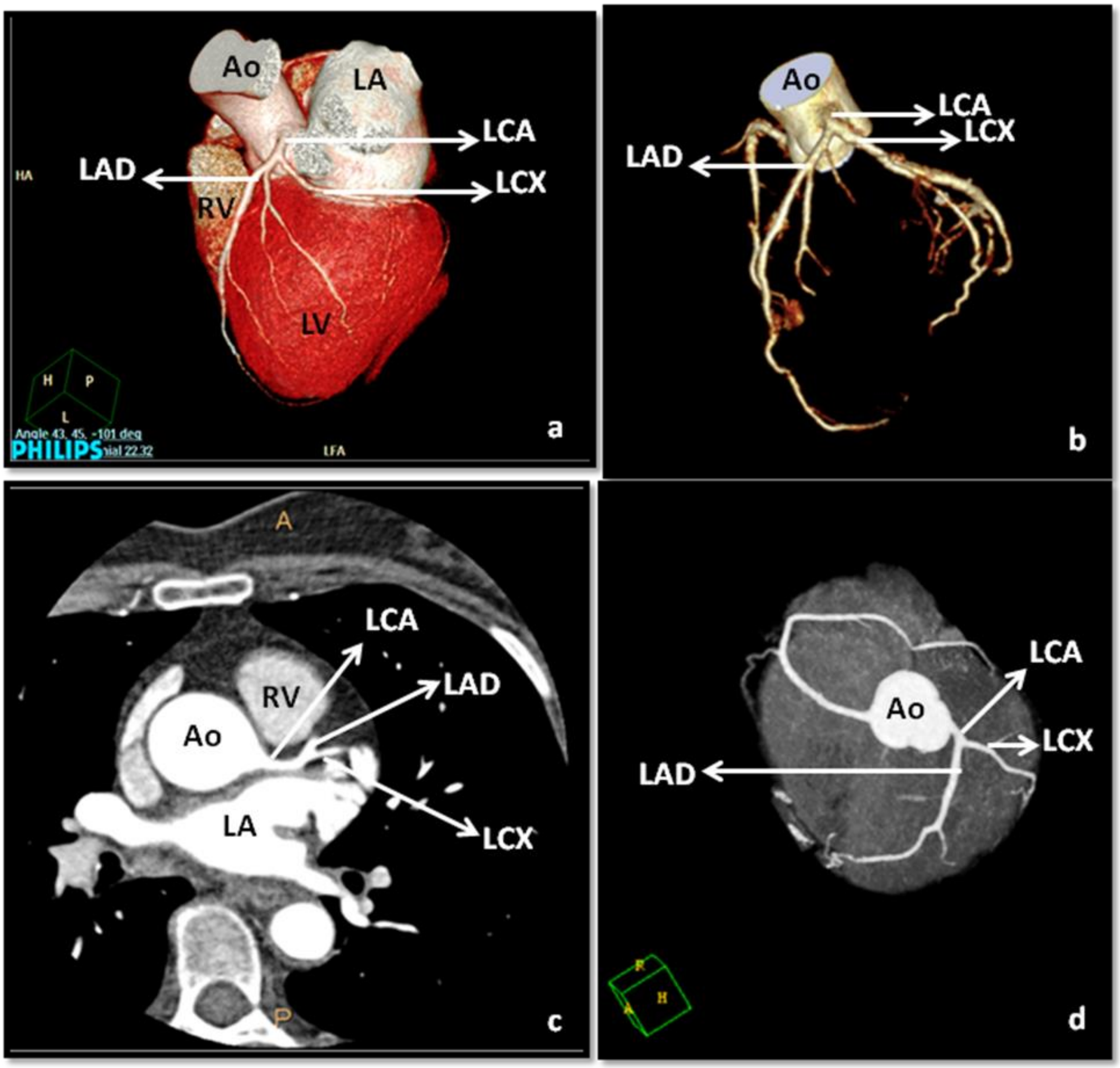

Figure 7: MDCT Coronary Angiographic images of the heart showing **bifurcation of LCA**. **a-** 3D-VR image, **b- 3**D-VR image (contrast vessel tracking tree), **c-** Axial maximum intensity projection (MIP) image, **d-** 3D-VR image (cardiac outline protocol). **Ao**-*Aorta*, **LA-** *Left Atrium*, **LV-** *Left Ventricle.* **RV-** *Right Ventricle***, LCA-** *Left Coronary Artery*, **LAD-** *Left Anterior Descending*, **LCX-** *Left Circumflex.*

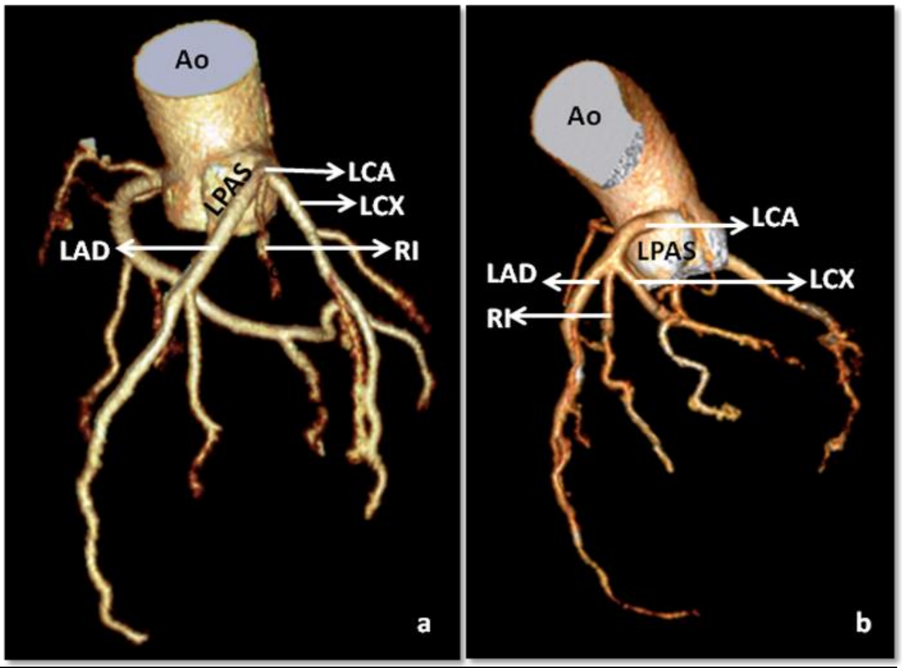

Figure 8: 3D-VR image (contrast vessel tracking tree) showing trifurcation of LCA**. a-** Small Ramus Intermedius (RI) artery, **b-** Large Ramus Intermedius (RI) artery. **Ao**-*Aorta*, **LPAS-** *Left Posterior Aortic Sinus.* **LCA-** *Left Coronary Artery*, **LAD-** *Left Anterior Descending*, **LCX-** *Left Circumflex.*

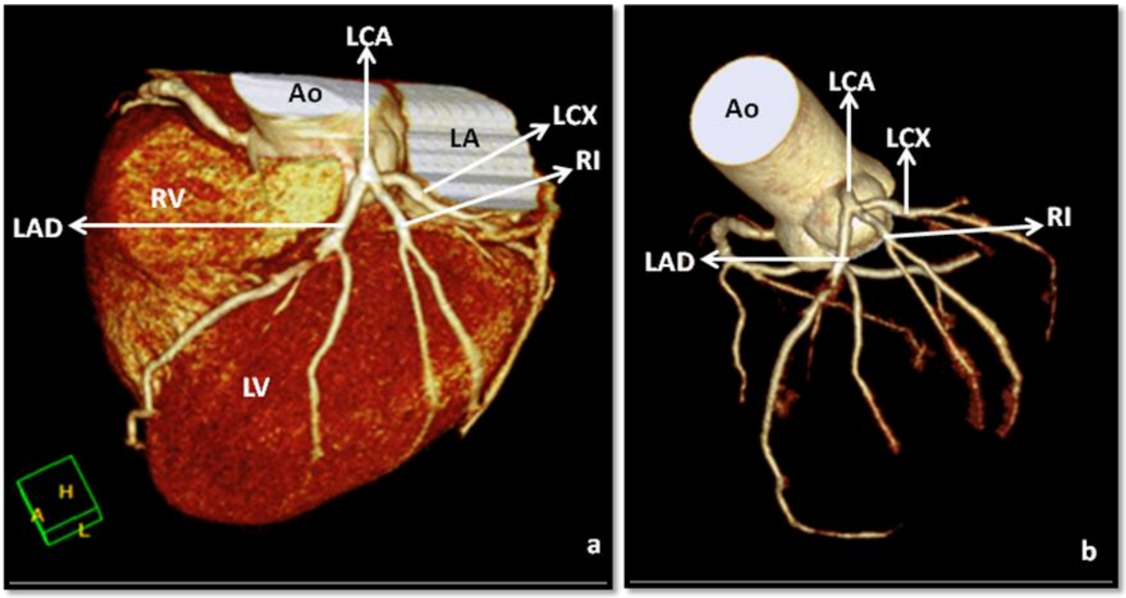

Figure 9: MDCT Coronary Angiographic images of the heart showing **branching RI artery**. a- 3D-VR image, b- 3D-VR image (contrast vessel tracking tree). **Ao**- *Aorta*, **LA-** *Left Atrium*, **LV-** *Left Ventricle.* **RV-** *Right Ventricle***, LCA-** *Left Coronary Artery*, **LAD-** *Left Anterior Descending,* **LCX-** *Left Circumflex,* **RI**- *Ramus Intermedius.*

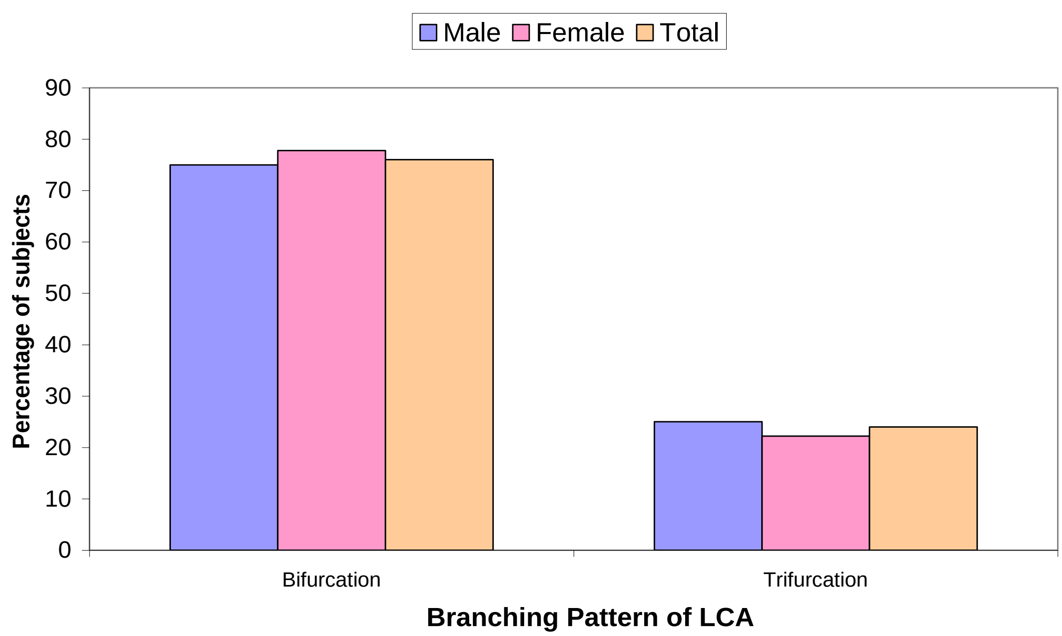

Figure 10: Bar diagram showing gender wise distribution of **branching pattern of LCA.**

TABLES

Table - 1
Scan protocol of 64 slice CTCA

Slices/collimation	64/0.625mm
Effective temporal resolution (with 180°algorithm)	165 ms
Tube current	800mAs
Pitch	0.2
Tube voltage	120kV
Tube rotation time	400ms
Section thickness	0.9mm
Reconstruction Increment	0.45mm
Field of view (FOV)	220mm
ECG gating	Retrospective
Isotropic voxel resolution	0.4× 0.4× 0.4 mm.
Scanning time	10-12 seconds

Table – 2
Origin of LCA

Level of origin	Males (n=32)		Females (n=18)		Total (n=50)	
	No.	%	No.	%	No.	%
Above ST junction	0	0	1	5.56	1	2
At ST junction	4	12.5	3	33.33	7	14
Below ST junction	28	87.5	14	77.78	42	84

Table – 3
Length of main trunk of LCA

Length of main trunk of LCA	Males (n=32)	Females (n=18)	Total (n=50)	‘t’	‘p’ value
<5mm	2	7	9		
5-10mm	26	8	34		
10-15	4	3	7		
Range(mm)	1.8-15	2.9-13	1.8-15		
Mean±SD (mm)	7.56±2.84	6.29±3.29	7.11±3.04	1.433	0.15

Table - 4
Branching pattern of LCA

Branching pattern of LCA	Males (n=32)		Females (n=18)		Total (n=50)		χ^2	'p' value
	No.	%	No.	%	No.	%		
Bifurcation	24	75	14	77.78	38	76	0.0487	0.825
Trifurcation	8	25	4	22.22	12	24		

Table-5
Incidence of different sites of origin of LCA in various studies

Authors and Year of study	Type of study	Population and Number of cases	Origin of LCA				
			AAS*	LPAS	RPAS**	Pulmonary Trunk	High takeoff
Chaitman BR et al., 1976	Catheter angiography	Canadian 3750	7				
Charles E.Wilkins et al., 1988	Catheter angiography	American 10,672	3			3	
Carla Frescura et al., 1998	Autopsy	Italian 1200	4	7	1	5	
Harikrishnan S et al., 2002	Catheter angiography	South Indian 7400	1				
Duran C et al., 2006	MDCT angiography	Turkish 725	1				
G.J.R. ten Kate et al., 2008	64-slice CT angiography	Dutch 1000	2			1	
Pinar Kosar et al., 2009	64-slice CT angiography	Turkish 700					0.7%
Franz von Ziegler et al.,	CT angiography	American					.oo1%

2009		748					
Yang Shan et al., 2010	64-slice CT angiography	Chinese 6014			0.00%		.001%
Present study **2011**	64-slice CT angiography	North Indian 50		**98%**			**2%**

***AAS-** *Anterior aortic sinus.*
****RPAS-** *Right Posterior aortic sinus.*

Table - 6
<u>A comparison of length of main trunk of LCA among different studies</u>

Authors And Year of study	**Type of study**	**Population and Number of cases**	**Mean length of main trunk of LCA**	**Range of length of main trunk of LCA**
Lewis C. M. et al, 1970	Catheter angiography	American 366	*12.8* ± *0.8* mm (in control) *4.5* ± *1.7* mm (in patients)	*7.5-20.5* mm
Fox C. et al, 1973	Autopsy and Coronary cineangiography	English 200 (100-by Autopsy, 100-by Coronary cineangiography)	*5.5* mm (by Autopsy) *9.5* mm (by Coronary Cineangiography)	Maximum- *32* mm
Kronzon I. et al, 1974	Catheter angiography	100	*10.4* mm	
Gazetopoulos N. et al, 1976	Catheter angiography	Greek 43	*16.8* ± *4.13* mm (without atherosclerosis) *10.28* ± *2.57* mm (with atherosclerosis *3.75* ± *1.89* mm (with complete LBBB)	
Saltissi S. et al, 1979	Catheter angiography	English 149[54 (normal), 95 (patients)]	*12.9* mm (in normal) *10.6* mm (in patients)	
Reig J. & Petit M., 2004	Autopsy	Spanish 100	*10.8±5.52* mm	*2-23* mm
Surucu H.S. et al, 2004	Autopsy and Cadaveric	Turkish 40	*14.1* mm (in bifurcation), *15* mm (in trifurcation), *9.1* mm(in tetrafurcation &pentafurcation)	
Ballesteros L.E. & Ramirez L.M., 2008	Cadaveric	Colombian mixed race 154	*6.48* ± *2.57* mm	
Cademartiri F. et al, 2008	64 slice CT coronary angiography	Multiethnic dutch 543	*112* ± *55* mm	
Christensen K.N. et al, 2010	MDCT coronary angiography	American 105	*9.9* ± *4.15* mm	*2-21* mm
Bhimalli S. et al, 2011	Cadaveric	Indian 60	*13.5* ± *0.27* mm	

Present study 2011	64 slice CT coronary angiography	North Indian 50	***7.11* ± *3.08* mm**	***1.8-15*mm**

Table-7

A comparison of the frequency of LCA branching pattern among various studies

Authors and Year of study	Type of study	Population and Number of cases	Branching pattern of LCA				
			Bifurc-ation	Trifurc-ation	Quadrifurc-ation	Pentafurc-ation	One branch
Baptista CA et al, 1991	Cadaveric	American 150	54.7	38.7	6.7		
Kalpana R., 2003	Cadaveric	Indian 100	47	40	11	1	1
Reig J. & Petit M., 2004	Autopsy	Spanish 100	62	38			
Huseyin S. Surucu et al., 2004	Autopsy & Cadaveric	Turkish 40	47.5	47.5	2.5	2.5	
Lujinovic A et al., 2005	Coronary angiography	Bosnian 100	71	29			
Lujinovic A et al., 2005	Cadaveric	Bosnian 20	65	35			
Ballesteros L.E. & Ramirez L.M., 2008	Cadaveric	Colombian mixed race 154	52	42.2	9		
Fazliogullari Z et al, 2010	Cadaveric	Turkish 50	46	44	10		
Bhimalli S. et al, 2011	Cadaveric	Indian 60	56.66	33.33	8.33	1	
Present study, 2011	64-sliceCT angiography	North Indian 50	**76**	**24**			

All values represent percentage of cases.

Table-8

A comparison of the frequency of trifurcation of LCA among various 64-slice CT angiographic studies

Authors & Year of study	**Type of study**	**Population & Number of cases**	**Trifurcation of LCA**
Cademartiri F.et al, 2008	64-sliceCT angiography	Italian 543	21.9
Pinar Kosar et al, 2009	64-sliceCT angiography	Turkish 700	31
Kevin N. Christensen et al, 2010	64-sliceCT angiography	American 105	19
Present study, 2011	64-sliceCT angiography	North Indian 50	**24**

All values represent percentage of cases.