Role of multidetector CT Coronary Angiography in assessment of the prevalence and plaque composition between dyslipidemic and non dyslipidemic patients

A Thesis

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Introduction

Coronary artery disease (CAD) is the leading cause of morbidity and mortality worldwide. The treatment of CAD has changed significantly in the last two decades **(Rochette et al., 2013).**

Elevated levels of atherogenic lipoproteins and dyslipidemia are associated with an increased plaque thrombotic potential. Dyslipidemia includes elevated levels of serum TC (total cholesterol), TG (total triglycerides), and LDL-C (low-density lipoprotein cholesterol), and reduced levels of HDL-C (high-density lipoprotein cholesterol) (**Te Mi et al., 2016)**

There are different types of coronary atherosclerotic plaques:

- Predominantly adipose atherosclerotic plaques: ≤60 HU
- Mixed plaques: 61–119 HU
  - Fibroadipose: 61–90 HU
  - Fibrocalcified: 91–119 HU
- Predominantly calcified atherosclerotic plaques: ≥120 HU

This information on plaque composition is potentially relevant, provided the histological features known to distinguish high-risk atherosclerotic plaques, such as their large lipidic core, and thin fibrous cap.

The primary advantage of CT was the ability to obtain thin cross-sectional axial images, with improved spatial resolution over ultrasound, nuclear medicine and magnetic resonance imaging. CT images allowing for ultimately nearly an infinite number of projections **(Budoff, 2016).**

The development of drug-eluting stents initially increased the number of revascularization procedures. However recent trials have demonstrated that both anatomical and functional significance are crucial to clinical outcomes for symptomatic CAD patients considered for revascularization **(Rochette et al., 2013).**

The exceptional contrast resolution of CT (ability to differentiate fat, air, tissue and water), allows visualization of more than the lumen or stent, but rather the plaque, arterial wall and other cardiac and non-cardiac structures simultaneously **(Budoff, 2016).**

CCTA not only substitutes invasive coronary angiography under certain conditions but it furthermore emerges as a useful prognostic tool for prediction of subsequent cardiac events **(Nadjiri et al., 2016).**

AIM OF WORK

The aim of the current study is:

- To highlight the role of multislice CT coronary angiography with its new applications such as reformatted images, and high resolution imaging, regarding coronary plaque composition and prevalence in dyslipidemic and non dyslipidemic patients.

GROSS AND CT ANATOMY OF THE CORONARY ARTERIES

The coronary arteries arise from the ascending aorta at its anterior (right coronary artery) and left posterior (left coronary artery) aortic sinuses. No artery arises from the right posterior sinus, which called as the non coronary sinus. The branches of the coronary arteries are considered to be end arteries. However anastomoses present in the atrioventricular groove and between the interventricular branches around the apex of the heart in approximately 10% of normal hearts. Also, there are anastomoses between coronaries and extra cardiac vessels such as the thoracic vessels. Anastomoses between branches of the coronary arteries provide a collateral circulation, but in most cases they are not sufficient to provide an adequate blood supply to the myocardium. ***(Badshah et al., 2015)***

Left Coronary Artery:

The left coronary artery is a large artery (Figure 1) with an approximate diameter of 5 mm at its origin that supplies an extensive portion of the walls of the left chambers of the heart, including most of the interventricular septal mass.

The Left main (LM) artery, a common initial segment of the left coronary artery, has variable length. It is embedded in adipose tissue, and courses between the main pulmonary artery and the left atrial appendage (Figure 2). Rarely (<1% of individuals), the LM is absent (Figure 3), with independent origins of its main branches from the left coronary sinus. In addition to its main ramification, the LM emits no other branches, except in those rare instances where the artery of the sinus node originates from it. At the level of the left atrioventricular groove, the LM gives two or three branches, namely the left anterior descending, the left circumflex artery and, occasionally, the intermediate artery. ***(Leta-Petracca, 2006)***

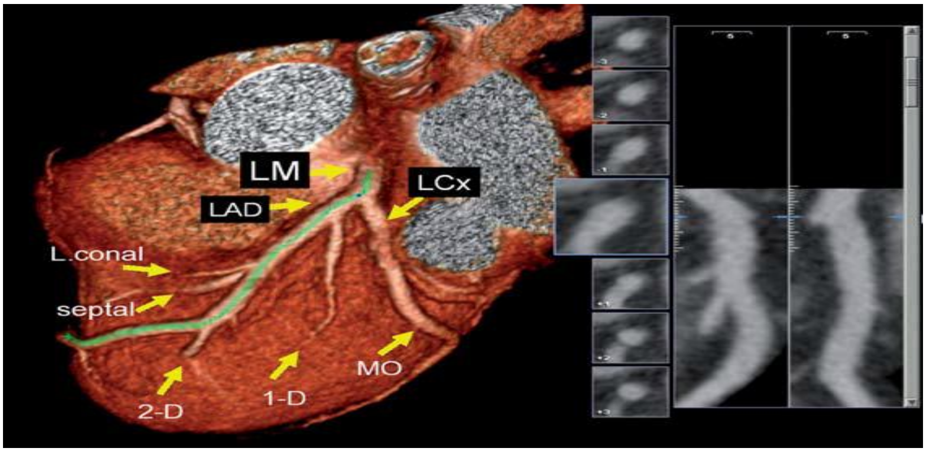

Figure 1: Left coronary artery with its branches, as seen on 3D (left) and a multiplanar construction (MPR) of its proximal segment (right). LM: left Main, LAD: left anterior descending; LCx: left circumflex; L.Conal: left conal branch; Septal: first septal anterior branch of the LAD; 1D and 2D: first and second diagonal branches of the LAD; MO: marginal obtuse branch of the LCx. ***(Leta-Petracca, 2006)***

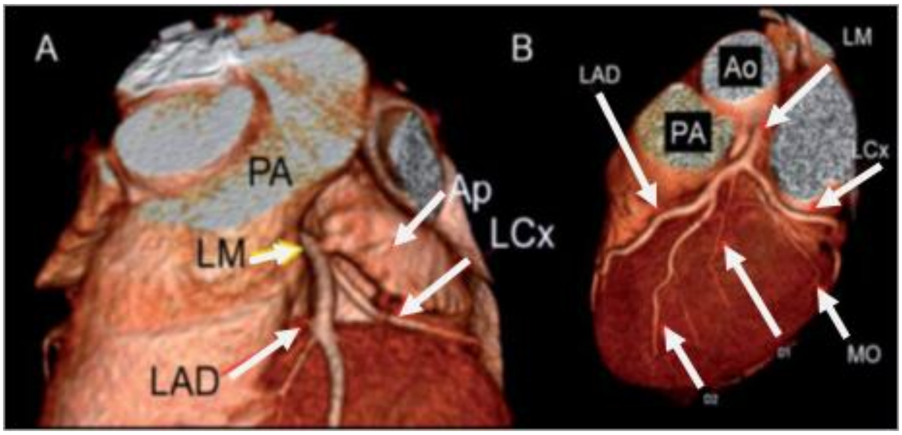

Figure 2: Anatomical relationships of the proximal segments of the main branches of the left coronary artery. Observe the course of the vessels below the left atrial appendage (Ap) in A, which is adequately displayed when the Ap is removed, in B. Ao: aorta; LAD: left anterior descending; LCx: circumflex artery; LM: left main; MO: marginal obtuse branch of the LCx; PA: pulmonary artery; 1D and 2D: first and second diagonal branches of the LAD. ***(Leta-Petracca, 2006)***

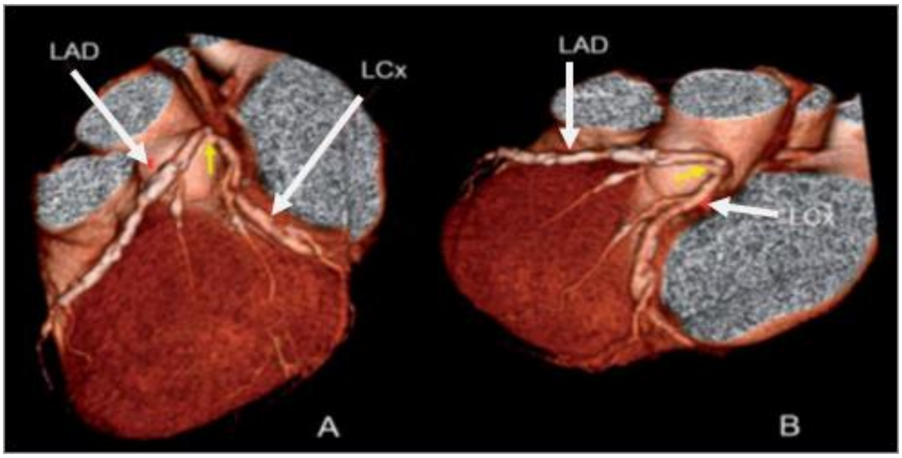

Figure 3 : Left oblique (A) and left lateral (B) views in a case of absent left main (LM) (yellow arrow), with an independent origin of the left anterior descending (LAD) and circumflex (LCx) arteries. Observe the extensive vessel wall calcification. ***(Leta-Petracca, 2006)***

Left anterior descending (LAD):

LAD coronary artery is a large vessel, 4– 5 mm in diameter at its proximal portion, that occupies the anterior interventricular groove, running in parallel with the great cardiac vein (Figure 4), with which it exhibits crossover points. It usually extends to the apical region of the left ventricle and, in two thirds of individuals; it reaches the distal (Figure 5) or even the middle portion of the posterior interventricular groove. In these cases, the LAD frequently shows anastomotic connections with the posterior descending artery (PDA). ***(O'Brien et at., 2007)***

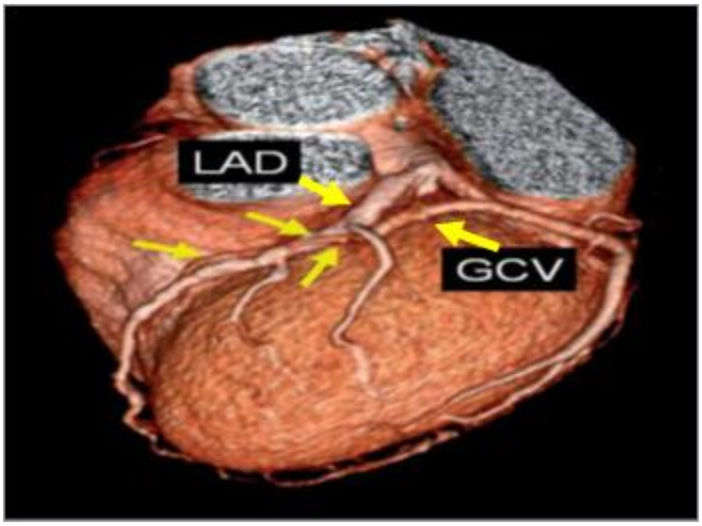

Figure 4: Relationship between the left anterior descending (LAD) and the great cardiac vein (GCV), showing vessel crossing at their middle course (yellow arrows). ***(Leta-Petracca, 2006)***

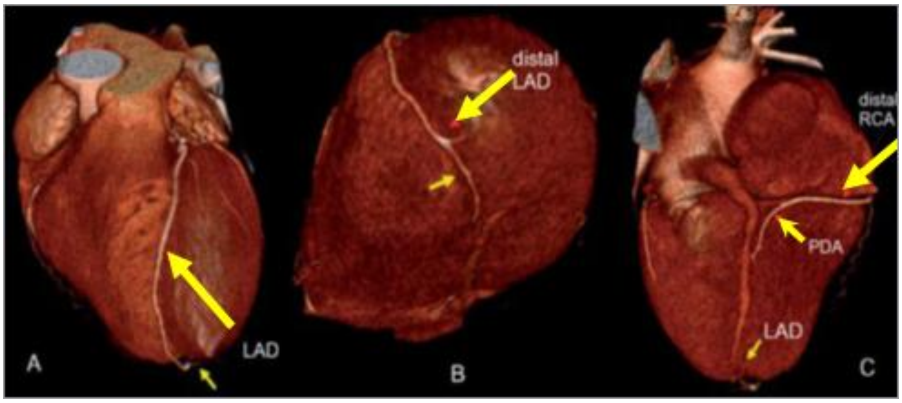

Figure 5: Recurrent course of the distal segment of the left anterior descending (LAD) artery reaching the interventricular posterior groove. A: anterior view; B: apical view; C: posterior view. PDA: posterior descending artery. ***(Leta-Petracca, 2006)***

The LAD gives some branches along its course:

- *Left conal artery* (Figure 1): with an origin in the proximal LAD, it communicates with the right conal artery, with which it constitutes the "arterial ring of Vieussens," along with the *vasa vasorum* of the aorta and pulmonary artery.
- *Right anterior ventricular branches*: usually irrelevant in number and diameter, as the right ventricle is almost exclusively irrigated through the right coronary artery.
- *Left anterior ventricular branches (Diagonal arteries)* (Figure 6): Variable in number, these branches distribute diagonally over the anterior aspect of the left ventricle .The origin of the first diagonal artery (Figure 2) is used as the anatomical point dividing the middle and distal segments of the LAD. Frequently, one of

these diagonal arteries is particularly large and follows a course parallel to the LAD (Figure 9), from which it can be distiguished by the lack of septal branches and the presence of secondary small diagonal branches.

- – <u>*Anterior septal branches*</u>: variable in number, these branches arise orthogonally from the LAD and distribute into the anterior two thirds of the interventricular septum. The first septal branch is usually a well developed vessel , its origin being considered as the reference point dividing the proximal and middle portions of the LAD. ***(O'Brien et al., 2007)***

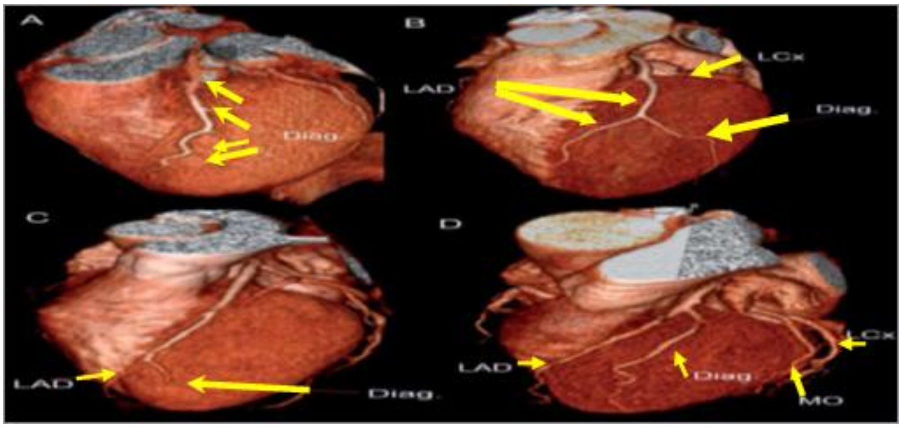

Figure 6: Normal anatomical variants of diagonal (Diag) branches. A: Multiple small brief branches; B: Single branch emerging from the middle left anterior descending (LAD); C: Single branch emerging from the distal LAD; D: Large vessel coursing parallel to the LAD; LCx: left circumflex; MO: marginal obtuse branch. ***(Leta-Petracca, 2006)***

Left circumflex (LCx) artery:

LCx artery is also a large vessel, similar in diameter to the LAD. The proximal portion of the vessel lies beneath the left atrial appendage and, from there; its course follows the anterior aspect of the left atrioventricular groove, ending at the obtuse margin of the heart (Figure 7). In some cases, the vessel extends to the posterior aspect of the left atrioventricular groove, usually below the coronary venous sinus, ending proximally to the region of the *crux cordis*. Finally, in cases of anatomical dominance of the left coronary system; the LCx goes beyond this region and gives the PDA. ***(Standring et al., 2005)***

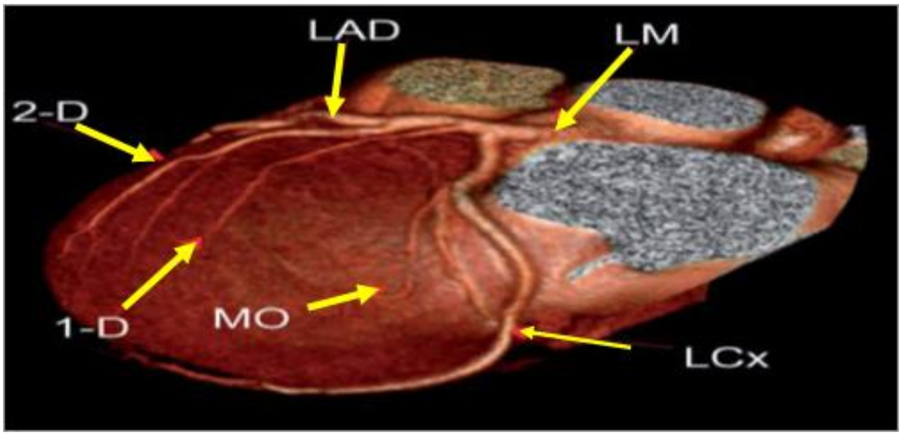

Figure 7: Left circumflex (LCx) artery ending at the (left) obtuse margin of the heart. LAD: left anterior descending; LM: left main; MO: marginal obtuse; 1D and 2D: first and second diagonal branch. ***(Leta-Petracca, 2006)***

LCx gives origin to different branches during its course:

- *Anterior or anterolateral ventricular branches (Figure 8)*: when present, these small vessels arise proximally and course parallel to the first diagonal artery. When this artery is absent, it is substituted by these branches.
- *Sinusal or sinoatrial branch (Figure 8):* although usually arising from the right artery, the sinusal branch emerges from the proximal segment of the LCx in 30–35% of individuals, courses around the left atrium, and reaches the sinus node region at the superior vena cava drainage.
- *Atrial arteries:* these small vessels are usually located beneath the base of the left atrial appendage or at the posterior aspect of the left atrium.
- *Obtuse marginal branches* (Figure 9): usually one or two, their origin is used as a reference dividing the proximal and distal segments of the LCx. Coursing along the left margin of the heart until they reach the apex, where they can communicate with vessels from the LAD.
- *Posterior ventricular branches: although* the posterior wall of the left ventricle is mostly irrigated by branches from the right PDA, when this vessel is absent, a variable number of these posterior ventricular branches, together with a number of interventricular branches of the LCx are responsible for the blood supply to this region.

- *Atrioventricular nodal branch*: it arises from the LCx in up to 20% of subjects, particularly in cases of left dominance. ***(Standring et al., 2005)***

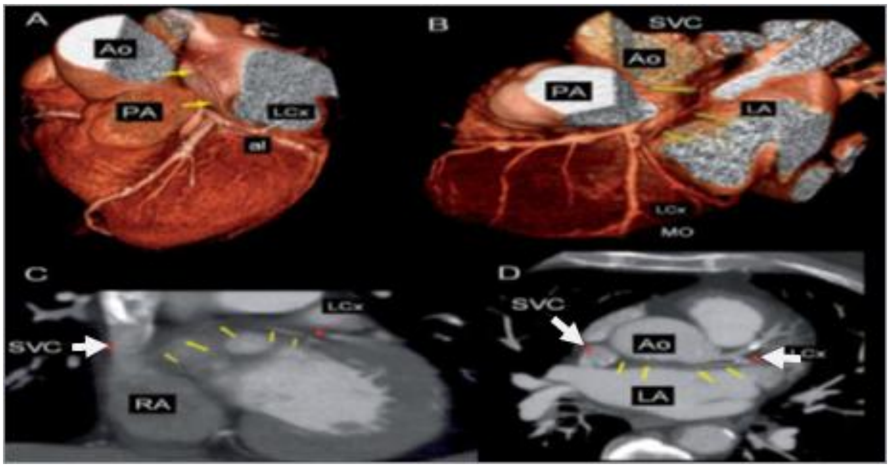

Figure 8: Left circumflex (LCx) artery. A: Anterior view showing an anterolateral (al) branch (green arrow) and a sinus branch (yellow arrows); B: Cranial view also displaying the sinus branch (yellow arrows); C: MPR on an oblique view with volume render, and; D: Axial slice with MIP, both showing the sinus branch of the LCx and its course towards the region of the superior vena cava (SVC); Ao: aorta; LA: left atrium; MO: marginal obtuse branch; PA: pulmonary artery; RA: right atrium. ***(Leta-Petracca, 2006)***

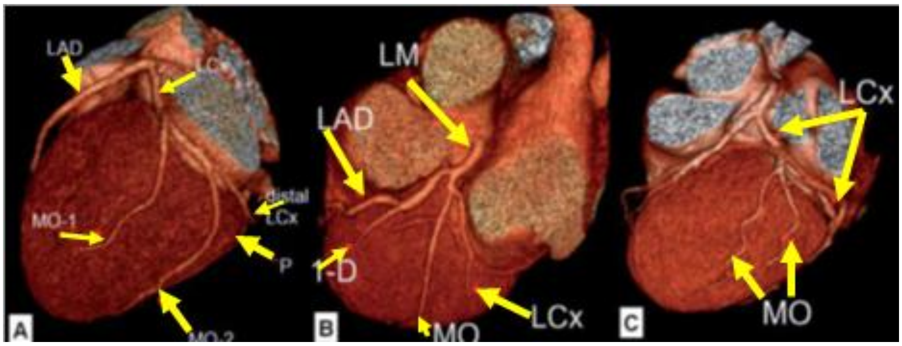

Figure 9: Anatomy of marginal obtuse (MO) branches. A: Two MO branches are seen (1 and 2) and, also, a posterior branch irrigating the posterior aspect of the left ventricle; B: Occasionally, only a single MO branch is present which arises early from the left circumflex

(LCx) and is frequently larger than the LCx itself; C: Bifurcated MO branch; LAD: left anterior descending; LM: left main; 1D: first diagonal. ***(Leta-Petracca, 2006)***

Right coronary artery (RCA):

The RCA supplies the right atria and ventricle and, when dominant, also for a variable extension of the posterior aspect of the left ventricle. The proximal segment of the RCA courses closely to the right atrial appendage and is then located on the anterior aspect of the right atrioventricular groove, where it is embedded in adipose tissue (Figure 10).

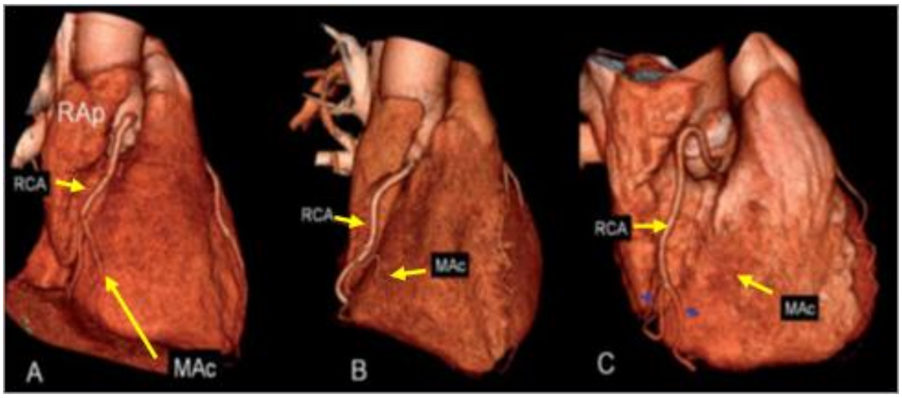

Figure 10: Anatomy of the right coronary artery (RCA). A: Proximal and middle segments of the vessel coursing in close relationship with the right atrial appendage (RAp) and giving origin to the marginal acute branch (MAc); B: Example of a tortuous MAc; C: Early bifurcation of the RCA at its middle segment (blue arrows). ***(Leta-Petracca, 2006)***

At its medial segment, the RCA rounds the right acute margin of the heart and through the posterior aspect of the right atrioventricular groove; it reaches the region of the *crux cordis* (the region where both posterior