DETECTION OF CORONARY ARTERY STENOSIS WITH MULTI-SLICE COMPUTED TOMOGRAPHY (MSCT) IN COMPARISION WITH CONVENTIONAL CORONARY ANGIOGRAPHY

Essay

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Ibraheem K. Kamel

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CAD	Coronary artery disease.
LAD	Left anterior descending artery.
LCA	Left coronary artery.
LMT	Left main trunk.
LAO	Left anterior oblique.
MDCT	Multi-Detectors Computed Tomography.
MI	Myocardial Infarction.
MIP	Maximum intensity projection.
MPR	Multi-planar reformates.
MRI	Magnetic resonance imaging.
MSCT	Multi-slice computed tomography.
PCI	Percutaneous coronary angiography.
PL	Postero-lateral branch
PDA	Posterior descending artery.
RAO	Right anterior oblique.
RCA	Right coronary artery.
SPECT	Single-photon emission computed tomography.
SSCT	Single slice computed tomography.
ST	Stent thrombosis.
SVG	Saphenous vein graft.
VR	Volume rendered.

Introduction

Coronary artery disease (CAD) remains a leading cause of death all over the word. The standard of reference for diagnosis of CAD is the conventional coronary angiography. The greatest advantage of conventional angiography is the perfect spatial resolution and the option of direct performance of interventions such as balloon dilatation or coronary stent placement. However, only one-third of all conventional coronary angiographic examinations are performed in conjunction with an interventional procedure, while the rest are performed only for diagnostic purposes. Thus, a reliable non-invasive tool for imaging of the coronary arteries and for early diagnosis of CAD is highly desirable ***(Flohr et al., 2004).***

Recent insights into the patho-physiology of atherosclerotic CAD suggest that coronary arterial wall structure has a crucial role in these disorders. Since coronary angiography depicts only the intra-luminal morphology but not the wall, much research effort has been focused on other imaging modalities. Multislice computed tomography (MSCT), unlike conventional angiography, enables assessment of the vessel wall abnormalities ***(Heuschmid, 2002).***

Computed tomography (CT) has evolved continuously since its introduction to medical imaging in the early 1970s. Over the years, all major aspects (e.g., spatial resolution and acquisition speed) have improved, through changes in both hardware and software. The latest stage in the development of CT is the introduction of MSCT ***(Flohr et al., 2005).***

MSCT was first introduced in 1992 with the advent of dual-slice scanners and was improved in 1998 by development of the quad-section technology and the recent increase in gantry speed from one to two revolutions per second. With this technique, the single detector bank of spiral CT scanners has been replaced by multiple detector banks that can acquire multiple slices simultaneously ***(Flohr et al., 2005).***

<u>Benefits of MSCT relative to single section helical CT include:</u>

- ♦ Improved spatial and temporal resolutions.
- ♦ Increased concentration of intra-vascular contrast material.
- ♦ Longer anatomic coverage.
- ♦ Decreased image noise.
- ♦ Efficient x-ray tube use. ***(Flohr et al., 2005).***

Until recently, CT applications for the assessment of CAD almost exclusively directed at the detection and quantification of coronary arterial calcium. In recent years, considerable interest has accordingly been directed at the beneficial use of high-spatial resolution contrast enhanced CT angiography for noninvasive evaluation of the coronary arterial tree. To date, the central rationale of this application has been the noninvasive detection and grading of coronary artery stenosis and follow up after coronary bypass surgery, with the ultimate goal of replacing diagnostic invasive conventional coronary angiography ***(Rodenwaldt, 2003).***

Challenges in evaluating the coronary arteries at CT are the small size of the vessels, their tortuous courses and fast continuous movement. Possible solutions are imaging on scanners with an increasing number of detector-rows, faster rotation speeds and reconstructing multiple sets of images obtained in different phases of the cardiac cycle (ECG-gating) from a volume acquisition ***(Pannu et al., 2003).***

Motion artifact is a major cause of diagnostic error in MSCT assessment of coronary artery stenosis. In which, the duration of the diastolic phase with little cardiac motion is inversely related to the heart rate, and hence, the heart rate plays an important role regarding the image quality during CT coronary angiography. The pre-examination heart rate was evaluated, those with rates above 65 bpm were given cardio-selective β–blocker orally 1 hour before the study to obtain a stable low heart rate, provided that contraindications to β–blocker are excluded. If heart rate was still above 65 bpm, the examination was postponed to another setting. Elevated heart rates, seen more prominently with arrhythmias, are a significant cause of motion artifact. The presence of atrial fibrillation usually serves as exclusion criteria in most MSCT analyses.***(Brodoefel et al., 2006)***.

More recently, studies using MSCT as **Pache et al.** ***(2006)*** and **Meyer et al.** ***(2007)*** included patients with atrial fibrillation and maintained excellent diagnostic accuracy, likely attributable to the increased temporal resolution associated with 64-slice technology ***(Khan et al., 2009)***.

With MSCT, some concern has been raised regarding the radiation dose administered to patients. The effective radiation dose using a 64-slice MSCT is approximately 6.5 mSv to 15 mSv ***(Wilson et al., 2007)***.

More recently, newer measures, including lower scan voltage and algorithms involving electrocardiogram-gated image acquisition, have been initiated to reduce the effective radiation dose associated with MSCT ***(Hausleiter et al, 2006)***.

Along with radiation, the administration of contrast required for MSCT can also lead to adverse events, most notably contrast-associated allergic reactions and contrast-induced nephropathy (CIN). The use of noniodinated contrast for radiological examinations is associated with severe allergic reactions in 0.2% to 0.7% of patients ***(Khan et al, 2009)***.

Recent studies have reported excellent diagnostic accuracy for 64-slice MSCT in detection of significant stenosis (86%-94% sensitivity and 93%-97% specificity. A high negative predictive value of 95%-97% suggests that 64-slice MSCT can reliably rule out the presence of hemo-dynamicaly significant CAD ***(Mollet et al., 2005).***

Our study was conducted to assess the diagnostic accuracy of 64-slice CT coronary angiography versus the invasive coronary angiography, which is the gold standard, in evaluating the coronary arteries, stents and bypass grafts.

Aim of the work

The aim of this work is to high-light the role of new generation of multi-slice CT (MSCT) as a non-invasive imaging tool for morphological assessment of the coronary arterial tree in cases with coronary stenosis.

Also, to show potentiality of MSCT in comparison with convential diagnostic coronary angiography in order to detect the presence of coronary artery stenosis.

Gross anatomy of the coronary arteries

The human heart normally has two coronary arteries named after the location of their main branches in the coronary sulcus. The right and left coronary arteries arise from the ascending aorta in its anterior and left posterior sinuses respectively (figures-1&2). Functionally, the coronaries are terminal arteries, which mean that their acute occlusion results in necrosis of their myocardial supply areas ***(Rodenwaldt, 2003).***

I- Left coronary Artery (LCA):

The LCA is larger in caliber, supplying a greater volume of myocardium. The initial stem than the left main trunk (LMT) extending between its osteum in the left posterior aortic sinus and its bifurcation varies in length from few millimeters to few centimeters. It lies between the pulmonary trunk and the left auricular appendages, reaching the left atrio-ventricular sulcus. The LMT divides into two main arteries:

(a)-The left anterior descending artery (LAD).

(b)-The left circumflex artery (LCx) ***(David, 2007).***

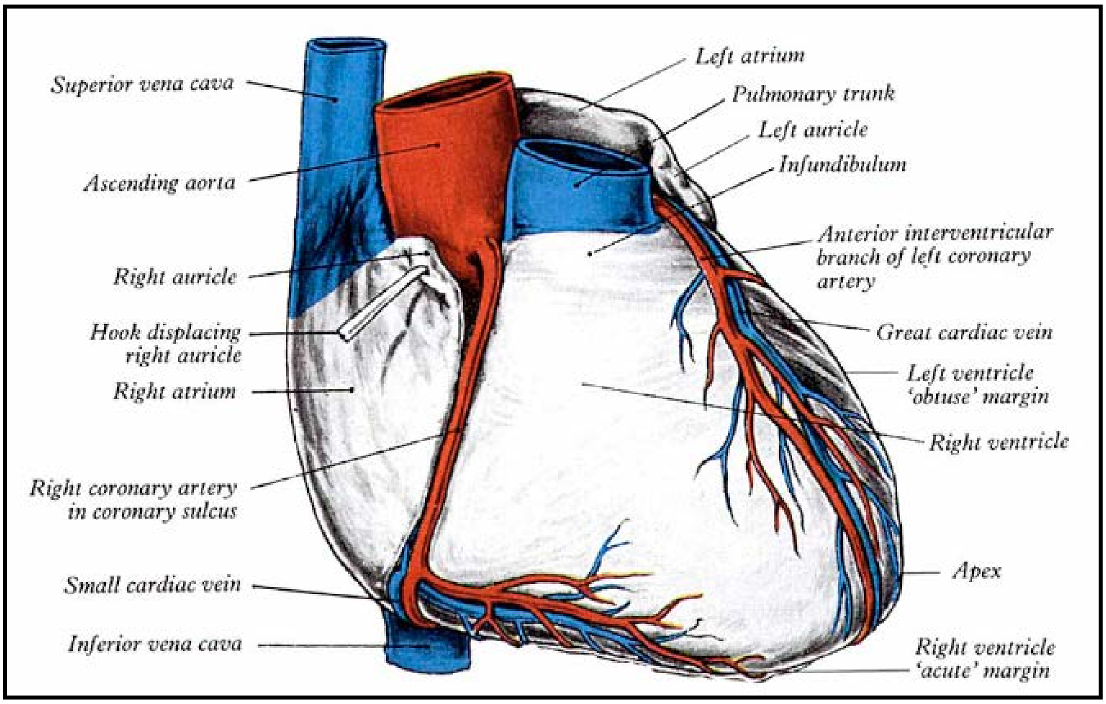

Figure-1: The anterior or sterno-costal surface of the heart ***(Quoted from: David, 2007).***

(a)- The left anterior descending artery (LAD):

Also, named as anterior inter-ventricular artery which considered as the direct continuation of the LMT. It descends obliquely forward and to the left in the anterior inter-ventricular sulcus. It reaches the apex and often turning around the apex into the posterior inter-ventricular sulcus, in which it traverses a third or half of its length to meet the terminal twigs of the posterior descending artery (PDA) (figures-2,3 &4). The LAD supplies right and left anterior ventricular surfaces and anterior septal rami. **The right ventricular remi** are few and small as the right ventricle being supplied almost totally by the RCA. From two to nine **largest left anterior ventricular remi (diagonal arteries)** arises at acute angles from LAD to cross diagonally the left ventricular anterior aspect, the large terminals may reach the left border of the heart. One is often large and may arise separately from the LMT which then ends by trifurcation. **The anterior septal remi** leave the LAD almost perpendicularly, passing down in the septum, of which they usually supply about the ventral two thirds ***(David, 2007).***

(b)- The left circumflex artery (LCX):

It is the second branch of **the left coronary artery.** It curves to the left in the atrio-ventricular sulcus, continuing around the left cardiac border into the posterior part of the sulcus and ending left to the crus. In about 90 % of cases, one or multiple large branches, known as the left **(obtuse)** marginal arteries, arise perpendicularly from the LCX to ramify over the lateral "obtuse" margin, supplying much of the adjacent wall of the left ventricle, usually down to the apex (figure-4)**.** Smaller anterior and posterior remi of the circumflex artery also supply the left ventricle. Atrial remi from the circumflex artery supply the left atrium ***(David, 2007).***

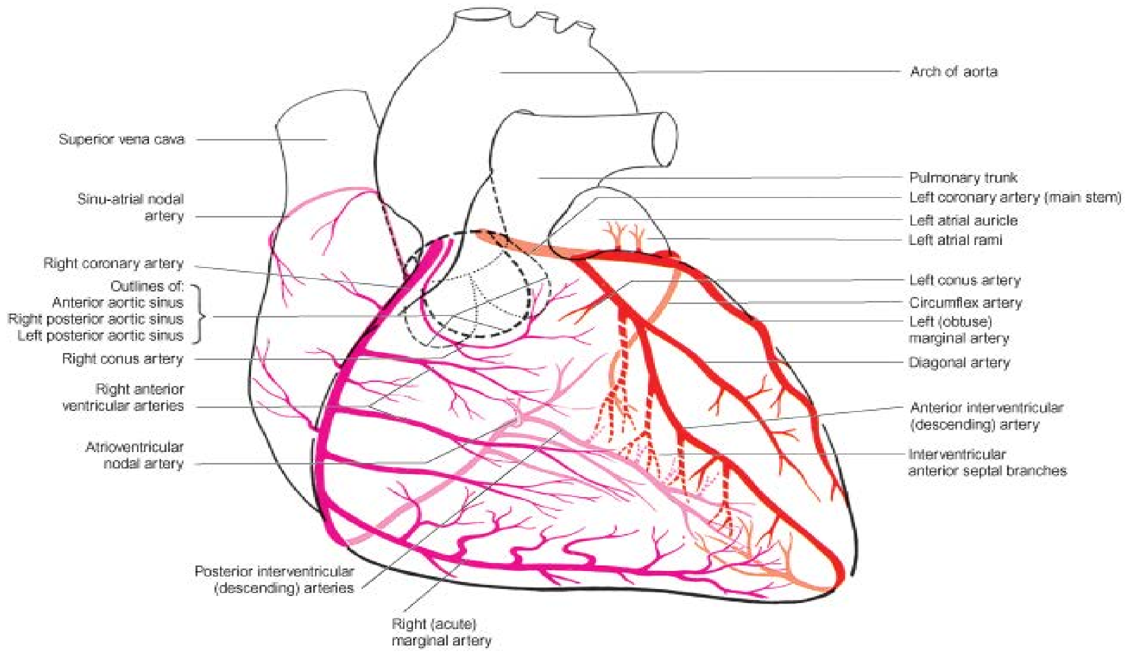

Figure-2: Anterior view of the most common arrangement of the coronary arterial system ***(Quoted from Shah, 2005).***

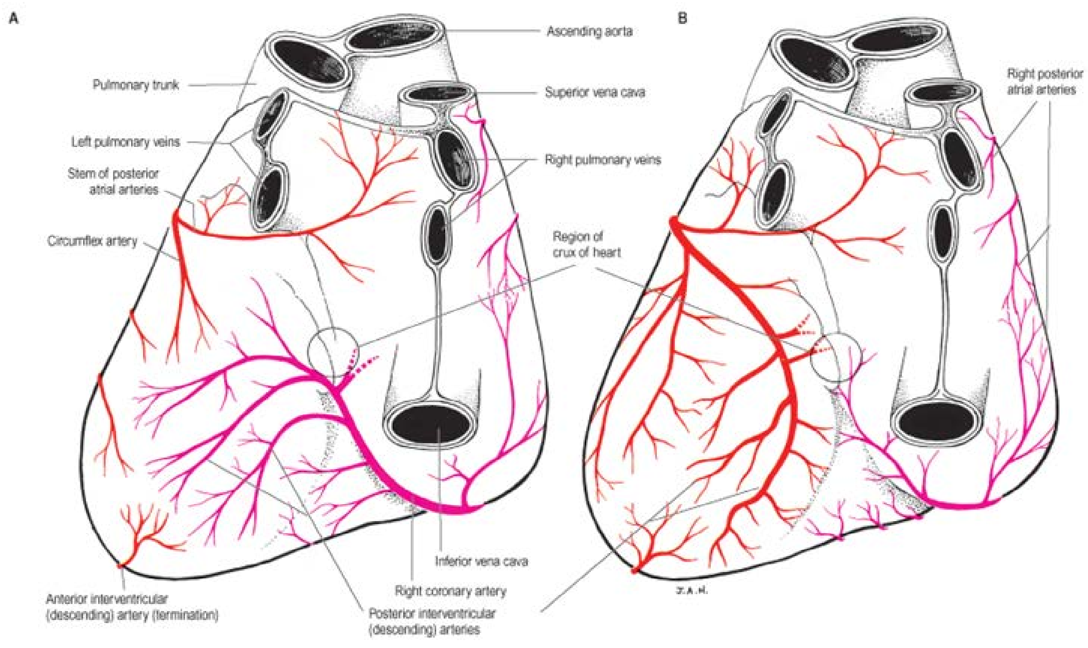

Figure-3: Postero-inferior view of the coronary arterial system. The right coronary arterial tree is shown in magenta, the left in full red. A. An example of the more normal distribution in right 'dominance'. B. A less common form of left 'dominance'. In these 'posterior' views, the diaphragmatic (inferior) surface of the ventricular part of the heart has been artificially displaced and foreshortening ignored to clarify the details of the so-called posterior (inferior) distribution of the coronary arteries ***(Quoted from: Shah, 2005).***