Role of Multi-Detector CT Angiography in Assesmente of Athrosclerotic Coronary Artery Disease

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ABSTRACT

Background: Imaging has a critical role in the diagnosis and evaluation of cardiac diseases, beginning with chest radiography and fluoroscopy and progressing to coronary angiography, echocardiography, nuclear medicine and recently multidetector computed tomography (MDCT) as well as magnetic resonance (MR) imaging

Objective: To highlight the role of Multi-detector CT in the evaluation of coronary artery disease and its importance of being noninvasive diagnostic technique.

Methods: A cross sectional study for 20 patients. Patients were asked to fast 6 hours prior to the examination and the patients with heart rates above 65 beats per minute were given cardio-selective beta-blocker and for heart rate above 75 (up to 85) beat/min, the best systole phase was used for reconstructing our images

Results: for Evaluation of native coronary arteries, the CTCA showed significant lesions (occlusion or >60 % stenosis) in the native arteries of 13 patients and insignificant lesions in 7 patients.

Evaluation of CABG (8 arterial grafts); for (LIMA) graft, 83% were patented, and 17% were narrowed and 100 % of (radial graft) were patent. For Venous Grafts the study included 10 venous grafts; 70 % were patent, 20% were narrowed and 10 % were totally occluded.

Conclusion: The multi-slice CTCA is now a clinically reliable noninvasive tool that allows the evaluation of the native coronary arteries, the bypass grafts, coronary stents.

Key words: Coronary artery disease (CAD), multidetector computed tomography (MDCT)

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INTRODUCTION

Coronary artery disease (CAD) and other acquired and congenital cardiac diseases are major medical and socioeconomic problems [(1)]. Historically, imaging has had a critical role in the diagnosis and evaluation of cardiac disease, beginning with chest radiography and fluoroscopy and progressing to coronary angiography, echocardiography, nuclear medicine and recently multidetector computed tomography (MDCT) as well as magnetic resonance (MR) imaging**)** [(2)].

Conventional invasive coronary angiography is currently the diagnostic criterion standard for clinical evaluation of known or suspected coronary artery disease (CAD) [(3)]. The risk of adverse events is small, but serious and potentially life-threatening sequelae may occur, including arrhythmia, stroke, coronary artery dissection, and access site bleeding Furthermore, catheterization induces some discomfort and mandates routine follow-up care [.(4)]. Therefore, conventional invasive diagnostic angiography should be restricted to stringent clinical indications [(5)]. This situation constitutes the basis of the demand for a reliable non-invasive replacement) [(6)] **.**

Contrast-enhanced computed tomographic angiography or CTA is a non-invasive imaging test that requires the use of intravenously administered contrast material and high-resolution, high-speed CT machinery to obtain detailed volumetric images of blood vessels. 7CTA can be applied to image blood vessels throughout the body [(8)].

MDCT scanners generate thousands of submillimeter slices. More and thinner slices translate into better images of large coronary arteries, which measure about 4 millimeters [. (9)]. In addition, scan time drops to a reasonable 6 to 8 seconds, which is a feasible breath hold for most patients [(10)] .The brief scan time reduces the chance of an arrhythmia or the patient releasing his breath and produces clearer images.[11] In addition; improved temporal resolution limits blurred images and artifacts **[(12)]** .

Appropriate patient preparation, detailed technical and technological knowledge with regard to recognition of typical imaging artefacts and the adequate choice of post processing techniques to detect stenosis and plaque are prerequisites to achieve diagnostic image quality[(13)] .A growing number of studies have suggested that MDCT angiography is highly accurate for the exclusion of significant coronary artery stenosis (> 50% luminal narrowing), with negative predictive values of 97%–100%, in comparison with invasive selective coronary angiograph [14] .

The non-invasive characterization and quantification of atherosclerotic plaque burden have important implications for the prevention of CAD progression and/or its complications [15]. CT techniques also provide an overall assessment of cardiac anatomy beyond coronary imaging, paralleling morphologic capabilities of cardiac MR imagin [16].

The objective of this study was to highlight the role of Multidetector CT in the evaluation of coronary artery disease and its importance of being noninvasive diagnostic technique.

METHODS

This study was carried on 20 patients referred for a retrospectively ECG-triggered Dual-Source CT (DSCT) coronary angiogram (Somatom Definition, Siemens Medical Systems) (128 slices) in a private center within the period of 6 months.

The patient's age was ranged between 45 and 72 years old. They were 13 males and 7 females. The average heart rate was 65 beats/min.

- Patients were asked to fast 6 hours prior to the examination. The heart rate was evaluated before the examination.
- Patients with heart rates above 65 beats per minute were given cardio-selective beta-blocker; 100mg of atenolol orally 1 hour before the study to obtain a stable low heart rate, provided that contra-indications to B-blockers are excluded e.g. asthma.
- For heart rate above 75 (up to 85) beat/min, the best systole phase was used for reconstructing our images.

Scan Protocol:

All CT angiographic examinations were performed using ECG gated multislice CT coronary angiography Dual-source 64 [SEMENS SOMATOM DEFINITION (128)], acquisition of thin section of 0.6mm. The tube current (mA) was estimated automatically through software called care dose 4D which estimate the m A according to the scout of the patient. And 120-140 kV. Scanning Adirection; cranio-caudal. Mean scan time was 12-14 seconds ± 1.5, and total time for the examination was less than 10-15 minutes, and a gantry rotation time of 0.33 s for both tubes. ECG pulsing window was set at 40 – 70% of the RR interval and was used for all patients. The pitch was automatically adapted to the heart rate.

Image Reconstruction;

For patient with heart rate more than75 up to 85 beat/min the images of the best systolic phase were used for reconstruction.

RESULTS

This study included 20 patients, 13 males & 7 females. The ages of them ranged between 45-72 years, 8 patients with no history of prior coronary intervention, 3 patients with previous coronary stenting, 9 patients with history of CABG.

Out of them; 7 had positive family history for coronary artery disease, 6 had diabetes mellitus, 8 had hypertension, and 3 were smokers. The total number of examined segments was 260 considering13 segments in each of the examined 20 coronary systems according to the model suggested by the American Heart Association (AHA). Fig (1)

The "non-assessable" segments:

The total number of excluded segments being "non-assessable" was (**9**) equivalent to **3.4 %** regarding all examined coronary segments 5(56%) of them seen at distal LCX, 3 (33%) distal LAD and 1(11%) at second diagonal branch. Among the 20 patients; the CTCA showed significant lesions (occlusion or >60 % stenosis) in the native arteries of 13 patients and insignificant lesions in 7 patients.

The 13 patients with significant lesions were distributed in the following table.

Distribution of the diseased vessels:

CTCA revealed a total number of 24 significant stenotic lesions distributed over coronary segments 12(50%) of them seen at LAD, 7(29%) a t RCA, and 5(21%) at LCX artery. Fig (3) Evaluation of CABG The total number of examined patients with previous CABG surgery is 9 having a total number of 18 conduits with an average of 2 conduits per patient. Arterial Grafts Dual-Source multidetector CT angiography demonstrated that arterial For the LIMA grafts, 5 of them (83%) were patent, 1 (17%) was narrowed. Fig. (4). There were 2 free arterial grafts (radial graft) in this study connected to OM and CX arteries both of them were (100 %) patent. Fig (5) Venous Grafts

This study included 10 venous grafts. 7 of them (70. %) were seen patent, 2 (20%) were seen narrowed and 1 (10 %) were totally occluded. Fig (6)

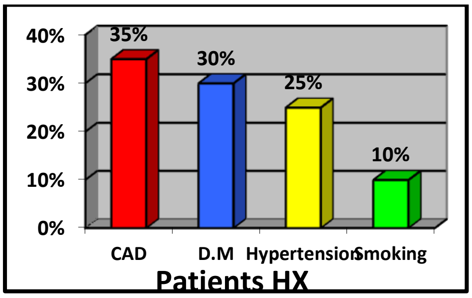

Fig. (1): Showing percentage of LIMA status.

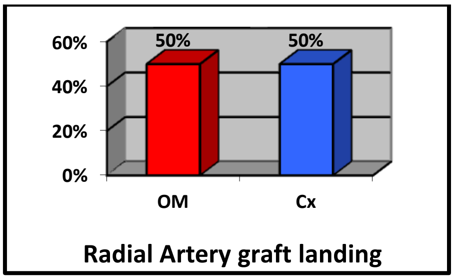

Fig. (2): Radial graft status.

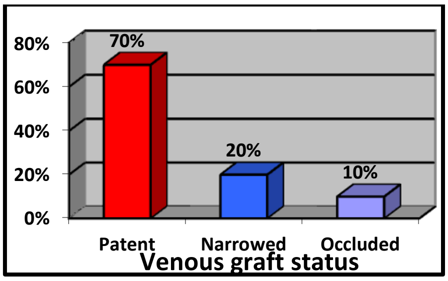

Fig. (3): The status of venous grafts.

DISCUSSION

Multi-slice computed tomography (MSCT) has been going through a dramatic evolution of technology in the past years. The increased spatial and temporal resolutions directly translate into improved image quality and more versatile applications. Indeed, entirely new areas of

grafts may be in situ (LIMA), or free (Radial). This study included 8 arterial grafts, 6 of them were in situ grafts (LIMA) and 2 of them were free grafts (radial).

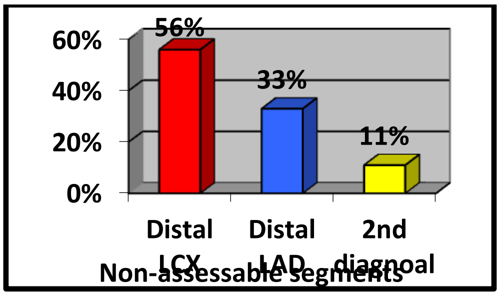

Fig. (4): Patients history regarding CAD, diabetes mellitus (D.M), hypertension and smoking.

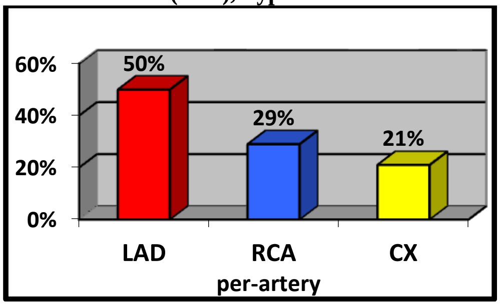

Fig. (5): Distribution of the non-assessable “excluded” segments.

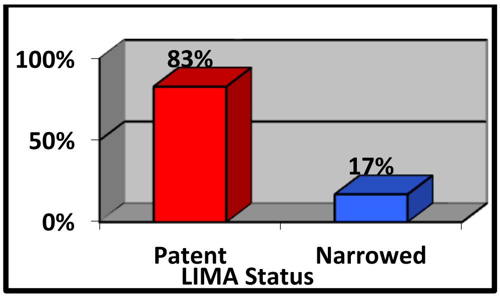

Fig. (6): *T*he Results for the CTCA on a "per-artery" basis

clinical application have emerged, one of the most prominent being the recent advent of cardiac computed tomography. Specially CT angiography of the coronary arteries has received tremendous interest and is currently entering the clinical field. In fact, it has the potential to greatly alter the way in which many patients with coronary artery disease will be worked up [17] .

MSCT raised high expectations because of its superb resolution of images, providing a highly defined anatomical detail, and, as a consequence, obtaining truly readable images of the coronary arteries .[18]

MSCT is a relatively simple procedure that does not require arterial access or hospital admission. After optional pre-medication, i.e., a β-receptor blocker, the scan is performed in ± 20 s after intravenous injection of contrast medium. The entire procedure does not require more than 15 min. Images can be reconstructed during different cardiac phases, which allows retrospective selection of the phase with the least motion artifacts. Compared to catheter-based coronary angiography; CT-coronary angiography has some advantages; such as vessel-wall visualization, quantification and characterization of atherosclerotic plaque material, evaluation of course and relations of coronary artery anomalies and the functional analysis [19]

Highly attenuating materials such as calcium and coronary stents struts cause beam hardening (blooming) artifacts, this can interfere with accurate interpretation of the lumen diameter [20]

Role of MSCT in evaluation of native coronary arteries

In our study we examined 260 coronary segments. , only 9 segments were excluded and considered as non assessable (equivalent to 3.4%). Most of these segments were at the distal segments or the coronary branches and this is referred to their markedly small calibre and their marked blurring by the cardiac and respiratory motion artefacts.

The improved spatial and temporal resolution of 64-slice CT increased image quality and facilitated the assessment of CAD with increased diagnostic accuracy .The shortened scanning time allowed a decreased breath-hold time, better exploitation of the contrast medium with lesser enhancement of adjacent structures, and a lower dose of contrast medium, although image degradation in patients with higher heart rates was still observed.

Coronary artery anomalies easily detected on CTCA .

Evaluation of atherosclerotic coronary plaque

Since acute coronary disease events such as unstable angina, myocardial infarction and cardiac death are caused by plaque rupture, it is a crucial concept to use imaging methods that permit detection, quantification, and possibly also characterization of coronary atherosclerotic plaques. Assessment of coronary atherosclerotic plaque burden through quantification of coronary calcification has shown to be of high predictive value concerning the occurrence of future coronary events in asymptomatic individual .[21]

Since, however, calcium constitutes only one component of plaque and non-calcified structures, such as a large necrotic/lipid core and thin fibrous cap, are usually considered to indicate high propensity towards plaque rupture, there is growing interest in the use of imaging to visualize and analyze non-calcified coronary atherosclerotic plaque components . [22]

CONCLUSION

The multi-slice CTCA is now a clinically reliable non invasive tool that allows the evaluation of the native coronary arteries, the bypass grafts, coronary stents with results very close to those obtained from conventional angiography and without the hazards that may associate the coronary catheterization.

However some limitations remain and need to be solved in the future including the beam hardening artifacts cause by the high attenuation materials (calcifications, stent struts and metallic clips) and the cardiac motions artifacts at high or irregular cardiac rhythm.

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