Coronary CT Angiography Findings In Comparison with Digital Conventional Angiography

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Abstract

Background: Multislice computed tomography (MDCT) is a promising noninvasive method of detecting coronary artery disease (CAD). Aim of study was to assess the diagnostic accuracy of the 64 slice computed tomography (CT) scant in detecting CAD with reference to conventional coronary angiography. **Methods:** It was a cross sectional comparative study conducted in Al-Najaf Cardiac Center. Forty five patients were included in the study that underwent MDCT and digital coronary angiogram between January and July 2012. **Results:** Over all sensitivity 91.75%, specificity 90.25%, positive predictive value 95.5% and negative predictive value was 83.33%. **Conclusion:** coronary CTA is a sensitive and specific diagnostic method for the assessment of coronary artery stenosis. MDCT can serve as an excellent screening procedure which will reduce the load on invasive conventional procedure, because of its high spatial resolution and ability to image the arterial lumen and wall.

Key words: Coronary CT Angiography, Digital Conventional Angiography

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Introduction

Despite worldwide efforts to investigate and control cardiovascular risk factors, coronary artery disease (CAD) remains currently the primary cause of death worldwide, in particular among Western nations [1]. Approximately, one in five deaths is currently related to cardiac disease in Europe and the US. Nearly 500,000 deaths caused by CAD are reported every year in the US and over 600,000 in Europe [2]. The lifetime risk of developing CAD after 40 years of age is 49% for men and 32% for women [3]. In Sweden, although the age standardized mortality of myocardial infarction (MI) an acute manifestation of CAD decreased from 1987 to 2004 by an average of 3.5% per year, and the age standardized MI incidence from 1987 to 2000 decreased by 1-2% per year [4]. CAD is still the most common cause of death and the case fatality of MI is still high. During 2008, about 17,000 out of 91,000 (18%) total deaths were caused by CAD-related ischemic cardiac disease [5].

The development of Coronary CTA

Since its introduction by G. Hounsfield in 1972, the CT scan has become a reliable and widely used non-invasive imaging modality for various diagnostic usages. The first attempts to image the heart were in the very early days of CT, in the 1970s. However, due to the rapid motion of the heart and relatively long acquisition times (more than 10 seconds per slice) of early equipment, only large pathological lesions such as tumors along the surface of the heart could be detected [6].

In the early 1980s, Electron beam computed tomography (EBCT), so-called “Ultrafast CT”, was introduced [7]. With non-mechanical control and movement of the X-ray source, a fixed detector system and ECG-correlated sequential scanning, EBCT enabled extremely short image acquisition times that could virtually freeze cardiac motion. However, the limited application spectrum of EBCT in general purpose use, the high cost of acquisition, and very limited industry support has restricted distribution of the technology. Although the concept of coronary calcium evaluation has been established since 1989 [8], and noninvasive coronary angiographic imaging with EBCT has been reported since 1995 [9]. A new developed “step and shot” protocol for the MDCT has successfully reduced the mean radiation dose to 2.1±0.6mSv (range 1.1–3.0 mSV) [10,11].

Advantages of Coronary CTA

Coronary CTA provides a quick and non-invasive diagnostic technique for CAD. The technological advances that have occurred in CT have been directed towards non-invasive coronary angiography. Many clinical studies have proved that the ability of modern coronary CTA to detect significant CAD (stenosis with more than 50% diameter reduction) is very close to CA. Although, it might not be able to totally replace coronary angiography (CA) for diagnosis and assessment of CAD, its high sensitivity for patient based detection of CAD and high negative predictive value suggest its ability to rule out significant CAD. There are several widely recognized advantages that make coronary CTA preferable to invasive CA for a selected patient spectrum [12,13]. Aim of study was to assess the diagnostic accuracy of the 64 slice computed tomography (CT) scant in detecting CAD with reference to conventional coronary angiography.

Methods

Study Design and Patient Profile

It was a cross sectional comparative study conducted in Al-Najaf Cardiac Center. Total 45 patients were included in the study that underwent MDCT and digital coronary angiogram between January and July 2012. The mean (±SD) age of the patients was 51.44 (±10.6) years with a range 31 to 75 years, 28 was male (62%) and 17 female (38%). All patients underwent coronary calcium scoring and MDCT first, followed by standard digital invasive conventional coronary angiography (CA).

MDCT Data Acquisition

A 64 slice Multi-row Detector was used (Aquilion, Toshiba Medical Systems), that provides true isotropic images. Acquiring isotropic volume data sets allows the resolution of axial images (X-Y plane) to be identical to that of the sagittal and coronal images (Z Plane), thus improving spatial resolution. A scout scan without contrast was used to measure coronary calcium scores using the Agatston equivalent scores for MDCT. The collimation was set at 16, providing 0.5 mm slices; the table feed was at 15mm/rotation, with a gantry rotation of 400 msec. The tube current was at 350 mAs, with 120kV Sure Start. A protocol developed by the manufacturer, detects the contrast enhancement in the region of interest (ROI), over the ascending aorta. It optimizes contrast use, while enhancing peak timing, and improving reproducibility. Patients with allergy to contrast media and those with impaired renal function and a creatinin value > 2.0 mg/dl were excluded from the study.

Metoprolol 50-100 mg was administered orally to patients with heart rates >60 bpm on arrival, one hour prior to procedure. Intravenous Metoprolol, with 5 mg increments up to 15 mg, was given only as needed to lower heart rates below 60 bpm. The patients signed an informed consent. For automatic initiation of the scan and deployment of the Sure Start, a threshold of 100 Hounsfield Units (HU) is entered. The scanning area extends from the carina to the diaphragm. Data sets acquisition starts while the patients hold their breath for 20-30 seconds (single breath hold). A double barrel injector (Medrad, Inc.) is used to inject 80-100 cc of non-ionic contrast media, Iohexol 350, at a rate of 5 ml/sec, followed by 50 cc of saline flush at the same rate. Multiple image data sets are reconstructed during the mid-to-end diastolic phase, during which coronary artery displacement is relatively small, with reconstruction window positions starting at 50%, 60%, 70%, 80% and 90% of the cardiac cycle (later diastole).

CTA Interpretation

The images obtained by the scanner were ECG gated. Retrospective reconstruction, from 50% to 90% of the preceding RR interval, was utilized to obtain multiple data sets. These sets then forwarded to a separate workstation, "the Vitrea", to load and visually determine the best quality data set, most suitable for interpretation. Processing with 3D Volume Rendering provides a good overview of the myocardium and vessels condition, and is not just an impressive artistic rendering. The Vessel Probe allows expansion throughout the artery, providing three-dimensional views of the vessel, including cross sections proximal and distal to the point of interest.

The standard two dimensional Maximal Intensity Projections (MIP) views with isotropic axial, coronal and sagittal images were also utilized, for precise assessment of the plaques and degree of obstruction. Further enhancement of vessel analysis is provided by the ability to obtain curved and double oblique Multi-Planar Reformatting (MPR) images. The final diagnosis was based on the findings, after reviewing of all these images. Curved multiplanar reformats (curved MPR's) are tomographic images which are helpful to evaluate the individual coronary arteries. Plaques, stenosis and other pathology are optimally depicted on these images. The straightened MPR technique allows for 360 degree rotation of the vessel, this may be especially useful for identification of small eccentric plaques.

Determination of Coronary Stenosis

The percentage stenosis is determined automatically, by producing MPR images perpendicular to the maximum stenosis, as well as more normal appearing vessel proximal to and distal to the focal narrowing. The main coronary arteries were evaluated for degree of stenosis. Lesions are scoring in five groups according to degree of stenosis based on both CT and conventional angiography as: Normal= o stenosis, Mild=25-50% stenosis, Moderate=50-75% stenosis, Severe=75-95% stenosis or Occluded=>95%stenosis.

Digital Coronary Angiography

Digital conventional coronary angiography (CA) was performed in the usual fashion, and considered as the standard for comparison. The attending physician and the interventionist, based on the clinical data and the CA findings, made the final therapeutic decisions.

Statistical Analysis

Data analysis, Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) was calculated for MDCT using conventional CA as the gold standard. SPSS version 17.0 for windows statistical software was used for all data entry and statistical analysis. Statistical analyses for sensitivity & specificity, and their associated confidence intervals were performed by an independent statistician. The proposal of this study was approved by the ethics committee of medicine college Al-kufa University.

Results

The CT of the left main stem evaluation overestimated the disease severity classifying 7 of 34 angiographically which showed the normal left main stems having mild disease. In the LMA the majority of cases (13) showed mild in MDCT. In the LAD cases, 12 cases showed severe in CA while 16 showed mild in MDC. The LCX showed mild in the CA (15) and MDCT (16) cases. The RCA showed high rate of CA and MDCT of both mild and severe status (Table 1). The over all of the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for MDCT in comparison with conventional CA as the gold standard showed the sensitivity 91.75%, specificity 90.25%, positive predictive value 95.5%, and negative predictive value 83.33% (Table 2).

Table (1): number of patients according to severity of stenosis as estimated by CA and MDCT for left main artery (LMA), left anterior descending artery (LAD), Left Circumflex Artery (LCx) and Right Coronary Artery (RCA)

Degree of stenosis	LMA		LAD		LCx		RCA	
	CA	MDCT	CA	MDCT	CA	MDCT	CA	MDCT
Normal	34	27	11	8	15	14	18	17
Mild	6	13	11	16	15	16	11	12
Moderate	0	0	5	3	1	1	3	1
Severe	3	3	12	12	8	8	9	11
Occluded	2	2	6	6	6	6	4	4
Total	45	45	45	45	45	45	45	45

Table (2): The accuracy (sensitivity & specificity) of MDCT in comparison to conventional coronary angiography for each main coronary artery

Artery	Sensitivity	Specificity
LM	81%	92%
LAD	93%	80%
LCX	97%	94%
RCA	96%	95%
Total	91.75%	90.25%

Discussion

The CT angiogram using dual X-ray source MDCT with high temporal resolution to rule out coronary stenosis showed important results of MDCT sensitivity specificity, positive predictive value, and negative predictive value. The results of this study were in consistent with previous studies [14-16].

Another study on 72 patients of MDCT showed the per patient sensitivity 97%, specificity 79%; positive predictive value 86%, negative predictive value 96% [15] . Selcoki *et al* [16] found the per patient sensitivity 95.1%, specificity 83.3%; positive predictive value 96.7%, negative predictive value 76.9%. They conducted a study on 73 patients and examined by 64-slice CT. Raff *et a l* [17] found that per patient specificity, sensitivity, and positive and negative predictive values for the presence of significant stenosis were 95%, 90%, 93%, and 93%, respectively. They studied 70 consecutive patients undergoing elective invasive coronary angiography to evaluate the diagnostic accuracy of multislice computed tomography (MDCT) coronary angiography using a 64-slice scanner.

Another compared diagnostic performance of MDCT and CA using 16-and 64-detector CT systems showed that at experienced centers and with dedicated data acquisition and analysis, sensitivities ranging from 83% to 99%, specificities ranging from 93% to 99%, and negative predictive values ranging from 95% to 100% can be achieved for the detection of relevant coronary artery stenosis [11]. Non-invasive of CA is an invasive procedure that might cause some complications for the patients. Although, the risk of severe complications such as death is relatively low, around 0.1-0.2% [18], the combined risk of all major complications such as MI, stroke, renal failure, or major bleeding is around 2% [19].

Time and cost-efficient of diagnostic strategies involving the 64-slice CT will still require invasive CA for CT test positives to identify CT false positives, several studies have proved the cost efficiency of coronary CT for rapid disposition of the low risk population in an emergency department [20,21]. Unlike conventional of CA, coronary CTA is a three-dimensional modality and is not limited to any particular two-dimensional projections/slice orientation. This allows assessment of structures in any desired plane or angle, and offers volumetric information on vessel stenosis and other structures such as cardiac chambers [22]. The physicians can closely investigate the composition of plaques and perform quantitative measurements of the extraordinary contrast resolution of CTA [23].

Triple rule out for chest pain diagnosis besides the coronary arteries, specially designed coronary CTA protocols with a wider field of view (FOV) can simultaneously visualize the pulmonary and systemic arteries of the chest, thereby excluding two other important causes of chest pain: pulmonary embolism and aortic dissection. This is known as a “triple rule out” study [24]. Four-dimensional modality for function analysis of image reconstruction in coronary CTA has been optimized for coronary artery visualization. However, with ECG gated spiral acquisition, image data are available for any phase of the cardiac cycle, which makes coronary CTA a 4D modality that can give accurate information about the cardiac muscle and valve function, and it can do so in a fashion that is less operator-dependent than echocardiography [22].

In comparison with invasive CA and other non-invasive cardiac imaging techniques, coronary CTA has some inherent limitations that physicians should consider when requesting this examination. These disadvantages have restricted the usage of coronary CTA to selected patients who have atypical symptoms and are of intermediate risk for coronary artery disease [25]. These limitations are radiation exposure which is a major drawback of CTA. The average background radiation one experiences in a year is about 3 mSV, and the estimated radiation dose from a chest X-ray is 0.04 mSV, while the radiation of a coronary CTA examination currently is 2.1±0.6mSv (range 1.1–3.0 mSV) [10,26]. Previous **s**tudies have indicated that temporal resolutions of 35 ms are needed to obtain motion-free images from a beating heart [27]. A modern 64-slice CT can achieve a temporal resolution of 175-200 ms, and cranio-caudal (z-axis) coverage of 40 mm. This makes coronary CTA highly dependent on the ECG-gating technique that calibrates images from different parts of the heart to the same phase of the cardiac cycle. Thus, coronary CTA is difficult to use with patients with tachycardia and arrhythmia, where the images can suffer from registration artifacts and blurring [28].

Coronary CTA requires iodinated contrast and often additional medication such as beta-blockers [29]. Although, the risk of these drugs is minimal, and CTA exams are usually performed in a hospital under the close supervision of medical staff, it does limit the usage of this technique among patients with renal insufficiency [30]. The degree of luminal narrowing may be difficult and even impossible to quantify if heavy calcification presents, due to the blooming artifacts. One study shows that the area of calcified plaque measured with the MDCT was severely overestimated compared to the histopathologic examination [31]. The evaluation of chest pain with no previous known disease in patients who are able to exercise and no previous tests (intermediate risk) unable to exercise or ECG uninterruptable. Equivocal or uninterpretable stress test results and normal ECG exercise test but ongoing symptoms. Evaluation of acute chest pain in emergency patients with normal ECG and cardiac enzymes may in low-to-intermediate pretest probability of CAD [32]. The limitations of this study was the small sample size ,as the study was carried out in a short period of time, because we include the patients doing both tests (MDCT and CA) at the same center. In conclusion, coronary CTA is a sensitive & specific diagnostic method for the assessment of coronary artery stenosis. MDCT can serve as an excellent screening procedure which will reduce the load on invasive conventional procedure, because of its high spatial resolution and ability to image the arterial lumen and wall.

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