Diagnostic Performance of Multislice CT Coronary Angiography in the Assessment of Significant Coronary Artery Disease

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Abstract- The use of noninvasive assessment tools such as multi-slice CT coronary angiography (MSCT-CA-CA) is recently considered mainly because it offers safety, patient convenience, and faster performance. The aim of the present study was to determine the ability of MSCT-CA-CA for the detection of significant stenoses in the coronary arteries, in comparison to conventional invasive coronary angiography (ICA). A total of 58 consecutive patients who were candidate for coronary angiography, with the diagnosis of acute coronary syndrome, from September 2006 to March 2006 were entered into the study. They underwent both coronary MSCT-CA-CA and ICA. The findings of each coronary segment were compared to MSCT-CA-CA in comparison with ICA. Based on artery analysis, sensitivity and specificity of MSCT-CA for the detection of involvement in RCA were 90.0% and 92.8%, in LAD were 71.8% and 92.9% and in LCX were 67.9% and 92.6%, respectively. On a per-segment basis, the sensitivity of MSCT-CA in the detection of injured segments ranged between 33.3% (for segment 11) and 100% (for segments 1, 2 and 12). Also, specificity ranged from 63.6% (for segment 15) and 98.1% (for segment 6). The presence of hypertension, hyperlipidemia, and smoking led to the reduction of the specificity and accuracy of MSCT-CA, whereas history of diabetes mellitus could increase the specificity and accuracy of this tool. MSCT-CA has high diagnostic performance in the assessment of significant coronary artery disease. Risk factors for coronary artery disease may influence this performance.

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Keywords: Coronary angiography; Coronary artery disease; Sensitivity and Specificity

Introduction

Catheter-based invasive coronary angiography (ICA) is the gold standard of reference technique for direct assessment of the severity of coronary stenosis. However, this applied tool can be associated with certain risks and complications. It should also be possible to more accurately determine the absence or presence of stenotic lesions and to rule out atherosclerotic changes at coronary bypass anastomoses (1). The use of noninvasive assessment tools was recently considered mainly because it offers safety, patient convenience, and faster performance (2,3). Some recent studies have shown that the multi-slice CT coronary angiography (MSCT-CA) in most vessels and segments of vessels is a sensitive and specific method. These studies have demonstrated highly accurate qualitative identification of significant coronary artery lesions (>50% stenosis) in vessels, with reported sensitivities and specificities ranging from 82% to 95% and 82% to 98%, respectively (4-7). The accuracy of this tool for significant stenosis can be determined based on pooled data from the

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studies, however, heterogeneity of methods and patient selection would reduce the accuracy of results of pooled data (8). The aim of the present study was to determine the ability of MSCT-CA for the detection of significant stenoses in the coronary arteries, in comparison to conventional invasive coronary angiography.

Materials and Methods

In a prospective study, a total of 58 consecutive patients who were candidate for coronary angiography with the diagnosis of acute coronary syndrome in Day hospital in Tehran between September 2006 and March 2006 were entered into the study. All patients underwent both coronary MSCT-CA and ICA. Patients with the history of previous adverse reaction to contrast media; renal functional impairment (serum creatinine >1.5 mg/dl); previous coronary artery bypass grafting or percutaneous coronary intervention, including placement of stent(s); and atrial fibrillation or frequent (>15 extrasystoles/min) extrasystoles were excluded (2). The study was approved by the ethical committee of Tehran University of Medical Sciences, and the patients provided written informed consent before participation in the study.

In patients with a heart rate >70 beats/min who were not administered beta-blocker before, an oral dose of atenolol 100 mg were administered one hour before scanning. Also, patients received sublingual nitroglycerin, one minute before scanning.

Scanning was performed using a 64-slice MSCT-CA scanner (Somatom Sensation 64, Siemens Medical Solutions, Forchheim, Germany) associated with synchronous electrocardiographic tracing of patients that was previously described in detail (2). First, non-contrast electrocardiography gated scanning for calcium score determination was carried out. In the coronary computed tomographic angiography phase, a bolus of 10 ml Visipaque contrast was injected into the antecubital vein, followed by a bolus of 10 ml saline solution chaser. Approximately 80 to 100 ml of contrast medium, according to the patient's body weight, was injected at a rate of 5 ml/s, followed by 40 ml of saline solution chaser through a dual-head injector.

Computed tomographic angiography parameters were collimation width 64×0.6 mm and tube potential voltage 120 kV. Also we collimation tube effective current 750 to 850 mA, tube rotation time 330 ms and table feed 3.8 mm/rotation, scanning time 8 to 13 seconds in an inspiratory breath hold. Then scan field from tracheal carina to the diaphragm have been performed. Interpretation of computed tomographic angiography images of each patient was made by consensus of 2 experienced observers, 1 radiologist and a cardiologist, who were unaware of the patient's ICA results. A 17-segment modified American Heart Association model of coronary artery nomenclature was used to assign major coronary arteries, including the left main coronary, left anterior descending, left circumflex, and right coronary arteries, as well as their branches (9). Then we evaluate reconstructed images of assessable segments along multiple longitudinal and transverse axes of coronary arteries. The severity of coronary artery stenosis was graded as a=normal (no stenosis), b=insignificant stenosis (<50% diameter decrease stenosis), c=significant stenosis (maximal luminal diameter decrease stenosis ≥50%), and d=total occlusion (no luminal flow shown). Negative results were considered either normal findings or the presence of insignificant stenoses, and positive results were regarded as ≥50% diameter decrease in stenoses, including total occlusion. In the case of multiple stenotic segments per artery, the vessel was classified according to the worst segment. When there was >1 stenosis ≥50%, the result was considered positive for the presence of significantly stenotic CAD (2). ICA in all patients was performed by an experienced cardiologist who was unaware of the patient's MSCT-CA results. The same 17- segment American Heart Association nomenclature was applied.

ICA was considered the standard of reference, and descriptive statistics including sensitivity, specificity; positive predictive value (PPV), and negative predictive value (NPV) of MSCT-CA in determining the presence or exclusion of significant coronary artery stenosis were calculated. Calculations were determined in per-segment, per-artery, and per-patient bases.

Results were reported as mean±standard deviation (SD) for quantitative variables and percentages for categorical variables. Above-mentioned descriptive statistics were calculated using chi-square test. All the statistical analyses were performed using SPSS version 13.0 for windows (SPSS Inc., Chicago, IL, USA).

Results

Demographic characteristics and clinical data are shown in Table 1. The mean age of patients was 58 years (ranged 43-78 years), and among them, 63.8% were men. Half of the patients had the history of hypertension and less than one-third of patients had the history of hyperlipidemia or diabetes mellitus. The average interval between MSCT-CA and ICA was 6.5 days (ranged 1 to 23 days). While scanning, mean heart rate was 63 beats/min (ranged 49 to 73).

Table 1. Demographic characteristics and clinical data (n=58)*.

Male gender	37 (63.8)
Age (year)	58.64±8.43
History of hypertension	29 (50.0)
History of diabetes mellitus	16 (27.6)
History of hyperlipidemia	16 (27.6)
Current cigarette smoking	25 (43.1)
Distance between ICA and MSCT-CA (day)	6.50±5.23
Calcium score (Agatston units)	37.49±7.91
Mean heart rate (beats/min)	63.12±5.14
Lowest heart rate (beats/min)	59.12±4.86
Highest heart rate (beats/min)	67.17±4.77

* Data are presented as mean±SD or number (%)

According to the ICA reports, among all 58 patients with assessable segments on ICA, 51 patients had significant coronary artery stenosis. Therefore, the prevalence of significant CAD was 87.9%. MSCT-CA correctly detected significant stenosis in 50 of 51 patients with stenosis in ICA reports with an overall sensitivity per patient of 98% (CI: 88.2-99.9%). Also in ICA, 7 cases lacked significant stenosis that all of them with results correctly diagnosed as negative using MSCT-CA, yielding some specificity of 100% (CI: 56.1-100%). Accuracy of the presence or absence of significant coronary disease using MSCT-CA was 98.3% (CI: 86.9-99.9%).

Results of descriptive statistics in the presence or absence of risk factors for CAD are shown in Table 2. These findings indicated that the presence of hypertension, hyperlipidemia and smoking lead to the reduction of the specificity and accuracy of MSCT-CA, whereas history of diabetes mellitus could increase the specificity and accuracy of this tool. Besides, these risk factors could not change the sensitivity of MSCT-CA. Also, accuracy of MSCT-CA decreased in males versus females and in heart rate <60 (beats/min) in comparison with higher heart rates.

Table 2. Descriptive statistics in the presence and absence of risk factors for coronary artery disease*.

Item	Sensitivity	Specificity	PPV	NPV	Accuracy
Gender					
Male	100	83.3	96.9	100	97.3
Female	100	100	100	100	100
Diabetes mellitus					
Positive	100	100	100	100	100
Negative	100	85.7	97.2	100	96.9
Hypertension					
Positive	100	80.0	96.0	100	96.6
Negative	100	100	100	100	100
Hyperlipidemia					
Positive	100	50.0	93.3	100	93.8
Negative	100	100	100	100	100
Cigarette smoking					
Positive	100	83.3	95.0	100	96.0
Negative	100	100	100	100	100
Mean heart rate					
<60 (beats/min)	100	50.0	90.9	100	91.7
60-70(beats/min)	100	100	100	100	100
>70(beats/min)	100	100	100	100	100

* Data are presented as percentages

Table 3. Descriptive statistics Based on coronary arteries involvement*.

Item	Sensitivity	Specificity	PPV	NPV	Accuracy
RCA	90.0	92.8	75.0	97.5	92.2
LAD	71.8	92.9	62.2	95.3	89.9
RCX	67.9	92.6	61.3	94.4	89.0

* Data are presented as percentages

Table 4. Descriptive statistics Based on segments injuries*.

Item	Sensitivity	Specificity	PPV	NPV	Accuracy
Segment 1	100	91.8	60.0	100	92.7
Segment 2	100	91.2	82.3	100	93.8
Segment 3	86.7	91.7	75.0	94.3	89.4
Segment 4	77.8	95.7	77.8	95.7	92.9
Segment 5	85.7	91.1	42.9	97.6	89.8
Segment 6	66.7	98.1	66.7	98.1	98.2
Segment 7	93.3	97.4	92.3	88.4	89.3
Segment 8	66.7	93.9	62.5	93.9	89.5
Segment 9	50.0	94.2	28.6	96.1	90.7
Segment 10	71.4	88.1	64.3	90.2	83.6
Segment 11	33.3	90.5	33.3	90.5	83.4
Segment 12	100	95.9	75.0	100	96.4
Segment 13	76.9	95.3	75.0	93.2	90.4
Segment 14	75.0	95.5	75.0	95.5	92.3
Segment 15	80.0	63.6	20.0	87.5	61.5
Segment 16	75.0	91.7	66.7	84.6	81.3
Segment 17	0.0	80.7	0.0	97.9	79.3

* Data are presented as percentages

Based on artery analysis, MSCT-CA had the highest and lowest sensitivity for the detection of involvement in RCA (90%, CI: 75.4-96.7%), RCX (67.9%, CI: 47.6-83.4%) respectively (Table 3). Also, MSCT-CA had the highest accuracy for the detection of RCA involvement (92.2%, CI: 86.5-98.7%), and the lowest accuracy for the detection of RCX involvement (89.0, CI: 72.1-94.4%).

On a per-segment basis, results of descriptive statistics on MSCT-CA were widely different so that the sensitivity of MSCT-CA in the detection of injured segments ranged between 33.3% (for segment 11) and 100% (for segments 1, 2 and 12). Also, specificity ranged from 63.6% (for segment 15) and 98.1% (for segment 6). On the basis of analysis, MSCT-CA had the highest and lowest accuracy for the detection of the injuries on segments 6 and 15, respectively (Table 4).

The accuracy of computed tomographic angiography for detecting significant stenosis was also examined according to coronary artery calcium score (based on equivalent Agatston units). In patients with a low calcium score (<10), sensitivity was 94.1%, specificity was 99.7%, PPV was 94.1%, and NPV was 99.7%. These figures were 100% for above four statistics analysis in the presence of Agatston units 10-100. When calcium score was higher than 100, sensitivity was 83.3%, specificity was 97.8% (6 of 10), and PPV and NPV were 71.4% and 98.9%, respectively. The accuracy of MSCT-CA in calcium scores <10, from 10 to 100 and >100 were 99.5%, 100% and 96.7% respectively.

Discussion

In most of the developed and developing countries, MSCT-CA is being used increasingly for contrast-enhanced imaging of the coronary arteries; however, different accuracy has been reported and this difference may be related to the skills of technicians and underlying medication protocols. In most of the studies, this imaging protocol has been produced sensitive and specific in most vessels and segments of vessels and accompanied by few false positives (8).

In the present study and based on artery analysis, MSCT-CA had the highest and lowest sensitivity for the detection of involvement in RCA, LAD and RCX was 90.0%, 71.8% and 67.9%, respectively, however, specificity of this procedure was more acceptable as 92.8%, 92.9% and 92.6%, respectively. Sensitivity for detection of significant stenosis in the RCA in Tier 1-3, studies was 90%, and specificity was 96%. Also, sensitivity for detection of significant stenosis in the LCX based on data from 13 Tier 1-3 studies was 88%, and specificity was 95%. Furthermore, in these studies, sensitivity and specificity for detection of significant stenosis in the LAD were 93% and 95%, respectively (9-15).

In a study has been done by Anders *et al.,* CT angiography permitted detection of bypass occlusion with 100% sensitivity and 98% specificity (1). Aviram *et al.*, reported the sensitivity, specificity, positive and negative predictive values were 86, 98, 83 and 98%, respectively (16).

Bordeleau *et al.*, showed that the sensitivity, specificity, and positive predictive value were, respectively, 80, 100, and 100%, for detecting more than 50% luminal stenoses, when optimally visualized segments were considered, in comparison to CCA (17). Previous studies found that not only MDCT had acceptable accuracy and predictive value in comparison with invasive angiography, but it can also reveal supplementary findings that invasive angiography was unable to visualize including anomalous vessel course, the course of vessels filling via collaterals, intramyocardial course of vessels and non-stenotic plaques (16).

On a per-segment basis, we also indicated that the sensitivity of MSCT-CA in the detection of injured segments ranged between 33.3% and 100% and specificity ranged from 63.6% to 98.1%. Therefore, in our study, these obtained analyses were different in all segments so that the sensitivity was higher than 90% only in the detection of injury in segments 1, 2 and 7 and the specificity was higher than 90% in the detection of injury 14 segments. Based on Tier 1-3 investigations, sensitivity for detection of significant stenosis in any segment was 90%, and specificity was 96%. However, in those studies, the average prevalence of coronary artery disease in Tier 1-3 studies was 12% of segments. They also showed that average coronary artery attenuation can be affect on sensitivity and specificity so that among patients with an average coronary artery attenuation of 388±46, both the sensitivity and specificity were higher than in those with an average coronary artery attenuation of 291 ± 33 HU and these differences were most marked in distal segments (18-21).

We also found that the presence of CAD risk factors could significantly influence the accuracy of MSCT-CA. In some studies, gender has been known as a main effective factor on the accuracy of MSCT-CA so that the sensitivity for detection of stenosis in small coronary branches has been lower in women than in men (22).

Although the effect of sex variable on accuracy and predictive value of MSCT-CA has been shown in some studies, but we did not find any study about the role of other CAD risk factors in the detection of MSCT-CA predictive value and, therefore, more studies for the demonstration of these relationships should be recommended.

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