Abstract

Background: A non-invasive detection of in-stent restenosis (ISR) would result in an easier and safer way to conduct patient follow-up.

Objectives: This study sought to evaluate the diagnostic accuracy of 64-slice multislice computed tomography coronary angiography (MSCT) versus invasive coronary angiography (ICA) in follow-up of patients with previous coronary stent implantation.

Methods: The study population consists of 50 patients (with 118 stented lesions) presenting for follow-up after previous coronary stent (2.5mm diameter) implantation within at least a period of 6 months up to 1 year regardless the presence or absence of symptoms suggestive of instent restenosis. The diagnostic accuracy of MSCT compared with ICA was evaluated.

Results: By ICA, 21 (17%) ISR were diagnosed with a sensitivity, specificity, PPV and NPV of 85.714%, 94.845%, 78.261% and 96.842%. We found that 95 stents (80.5%) screened by MSCT were patent, 92 stents (77.9%) of this total number were seen patent by ICA. While 3 stents (2.5%) of those were seen non patent. Also, 97 stents (82%) of total number of patients taken in this study assessed by ICA were patent, 92 stents (77.9%) of this total number were seen patent by MSCT while 5 stents only (4.2%) were seen non patent by MSCT.

Conclusion: 64-MSCT coronary angiography is a very helpful test in excluding patients with coronary instent restenosis.

Key Words: Multi Slice Computed Tomography (MSCT) — Stent patency — Coronary angiography.

Introduction

STENT implantation is increasingly performed in the treatment of significant coronary artery disease and has significantly reduced the occurrence of restenosis as compared with balloon angioplasty [ii. Moreover, with the recent introduction of drug-eluting stents, the occurrence of in-stent restenosis has further decreased [2]. Nonetheless, a subset of patients still presents with recurrent chest pain with possible in-stent restenosis, and frequently evaluation with invasive coronary angiography is required. A noninvasive alternative approach to evaluating these patients may be offered by 64-slice multislice computed tomography (MSCT). In native coronary arteries, sensitivities and specificities of approximately 90% and 96% [3] for detection of coronary artery disease have been reported, with a substantial gain in diagnostic accuracy over 4- and 16-slice MSCT. Also the evaluation of coronary stents, which posed still considerable problems with 4- and 16-slice MSCT, may have improved with 64-slice MSCT. However, few data are currently available and the routine use of MSCT in patients with a history of stent implantation is at present not recommended [4]. The aim of the present study is to evaluate the diagnostic accuracy of coronary binary instent restenosis (ISR) with 64-slice MSCT compared with invasive coronary angiography (ICA).

Methods

Patient population: Between November 2010 and June 2011, 50 consecutive patients presenting for follow-up after previous coronary stent (2.5mm diameter) implantation were included in the study. The diagnoses of coronary artery disease were made by invasive coronary angiography and clinical findings. A pre-procedural blood sample was obtained for the assessment of troponin-I and TnT. The study was approved by the local ethics committee and all patients signed an informed consent form.

Correspondence to: Dr. Ramy R. Elias, The Department of Cardiology, Faculty of Medicine, Ain Shams University

Abbreviations and Acronyms:
ICA: Invasive Coronary Angiography.
CT: Computerised Tomography.
MSCT: Multislice Computed Tomography.
MPR: Multi-Planar Reformatations.
VRT: Volume Rendering Techniques.
MDCT: Multidetector Computed Tomography.
ROI: Region of Interest.
HU: Hounsfield Unit.
PPV: Positive Predictive Value.
NPV: Negative Predictive Value.
CTCA: Computed Tomography Coronary Angiography.
diameter) implantation within at least 6 months up to 1 year, underwent CTCA, regardless presence or absence of symptoms suggestive of instent restenosis. Exclusion criteria for CTCA examination were as follows: Renal insufficiency (serum creatinine > 1.5mg/d1), allergy to contrast media, atrial fibrillation or other rhythm irregularity, inability to perform breath hold and a coronary stent diameter < 2.5mm. An ICA was performed in all patients within the interval of 1 month of the CTCA examination.

Scan protocol of CTCA: History taking with emphasis on risk factors for CAD, time, size, site of stent implantation, bronchial asthma which contraindicate the use of Beta blockers and dye allergy. Then clinical examination with emphasis on blood Pressure that should be controlled, heart rate (Resting) should be adequate, both were recorded and Body Mass Index calculated by this equation weight/height (meters2), where <20kg considered non-obese while 20-40kg was considered obesity [5]. All patients were instructed to remain fasting for about 4 hours before doing the scan. Metformin was stopped 48hours before the scan. Patients were instructed as well to avoid coffee and tea drinks 24hrs before the study to minimize their effects on the patient's heart rate. Patient's with heart rate above 65bpm were given 100mg of Atenolol orally, half to one hour before the procedure. Those with heart rate 60-65bpm were given 50mg of Atenolol, half to one hour before the procedure, patients with heart rate less than 60bpm didn't receive any beta blockers. A second dose of Atenolol was given one hour after the initial one if the heart rate was not satisfactory (above 65bpm) up to a maximum 200mg. Some patients needed additional bolus or intravenous propranolol (1-2mg), those were typically patients who showed an increased heart rate on the CT topogram of the chest was done. On the topogram, the attempted scan volume was planned to start from just below the carina till the lower border of the cardiac silhouette (in a craniocaudal direction). ECG gated prospective sequential scans were done to evaluate the coronary calcification. Sequential scans were acquired at the diastolic intervals of the patient's ECG while the patient was holding a deep inspiration. A bolus of contrast media (10cc of iodinated or non iodinated dye was injected into antecubital vein (Daiichi Pharmaceutical Co., Ltd., Tokyo, Japan). Based on the calculated scan time e.g. for a 12sec scan a 70ml of contrast was administered. Flushing with 20 to 50ml saline. To reduce the incidence of adverse reaction, the sort of contrast media was selected for each patient considering previous usage. The proper amount of the contrast media and injection speed was determined according to patient's body weight, scan time, and heart rate. The start delay was automatically defined using bolus tracking software equipped in the scanner. The region of interest (ROI) viewed by the patient's ECG while the patient was holding a deep inspiration. A bolus of contrast media was injected into the antecubital vein, the scan was performed with the patient's ECG gated. The scan was performed between the tracheal bifurcation and diaphragm with the following parameters: collimation width 64 x 0.6mm, rotation time 330ms, tube voltage 120kV, effective tube current 800mA, table feed 11.5mm/rotation, and pitch 0.2. The scan was also acquired during a single deep breath hold. Higher doses were given to obese patients. ECG gated reconstruction were done in the diastolic phase (75% of the R-R interval).

Data acquisition and image reconstruction: A topogram of the chest was done. On the topogram, the attempted scan volume was planned to start from just below the carina till the lower border of the cardiac silhouette (in a craniocaudal direction). ECG gated prospective sequential scans were done to evaluate the coronary calcification. Sequential scans were acquired at the diastolic intervals of the patient's ECG while the patient was holding a deep inspiration. A bolus of contrast media (10cc of iodinated or non iodinated dye was injected into antecubital vein (Daiichi Pharmaceutical Co., Ltd., Tokyo, Japan). Based on the calculated scan time e.g. for a 12sec scan a 70ml of contrast was administered. Flushing with 20 to 50ml saline. To reduce the incidence of adverse reaction, the sort of contrast media was selected for each patient considering previous usage. The proper amount of the contrast media and injection speed was determined according to patient's body weight, scan time, and heart rate. The start delay was automatically defined using bolus tracking software equipped in the scanner. The region of interest (ROI) viewed by the patient's ECG while the patient was holding a deep inspiration. A bolus of contrast media was injected into the antecubital vein, the scan was performed with the patient's ECG gated. The scan was performed between the tracheal bifurcation and diaphragm with the following parameters: collimation width 64 x 0.6mm, rotation time 330ms, tube voltage 120kV, effective tube current 800mA, table feed 11.5mm/rotation, and pitch 0.2. The scan was also acquired during a single deep breath hold. Higher doses were given to obese patients. ECG gated reconstruction were done in the diastolic phase (75% of the R-R interval).

The whole coronary tree was reviewed for motion artifacts, if there were any other phases of reconstruction were done as systolic phase (40%). The datasets were reconstructed at a slice thickness of 0.6mm with 0.3mm increments. These datasets...
were then displayed and analysed using several modes of presentation: axial images, MPR (multi-planar reformations), oblique MPR, curved MPR, MIP (maximum intensity projection) as well as VRT (volume rendering techniques) formats [6]. Operator was blinded to angiographic and clinical findings but aware of previous cardiac history, evaluating the MSCT examinations using axial slices and multiplanar and curved reconstructions. The stent was judged to be occluded (significant ISR) when the lumen inside the stent was darker than the contrast-enhanced vessel before the stent and/or when no run-off could be visualized at the distal end of the stent [7]. Non occlusive (non significant ISR) was considered when the lumen inside the stent showed a darker rim (eccentric or concentric) between the stent and the enhanced vessel lumen with a lumen reduction <50% (as compared with other portions of the stent). In addition, the presence of reduced run-off distal to the stent was taken into consideration; if reduced distal run-off observed, this is to be suggestive of significant in-stent restenosis. The presence of distal run-off was not used as a criterion for the absence of significant in-stent restenosis, because collateral filling may occur (which cannot be detected adequately by CTCA) [8,9].

ICA procedure and analysis: The ICA was performed with standard techniques, and at least 2 different views were obtained for each main vessel. All stented segments (including the 5mm proximal and distal to stent edges) were evaluated by a skilled observer who was blinded to the results of CTCA. Segments with ISR were classified into 2 groups: significant ISR = WO%) reduction of lumen, non significant ISR = (<50%) reduction of vessel lumen with estimation of TIMI flow distal to stenosis.

Statistical analysis: Data were collected and tabulated. The statistics were done using SPSS version 13.0 statistical package. The current study included 50 patients; all of the patients had coronary CTA done followed by invasive coronary angiography within a time delay of 1-2 months as interval between both investigations. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for CTA to detect significant stenosis were calculated from chi-square test of contingency.

Results

Patient characteristics, scan condition, and stent parameters:

The studied population included 4 females (8%) and 46 males (92%). The mean age was 54.92±11.313 years. The mean BMI of the study population was 30.200±9.871 kg/m2. The heart rate of the subjects during the scan was 63.360±6.013bpm (Table 1).

Table (1): Patient characteristics and scan condition.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs</td>
<td>54.92±11.313</td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>139.1±15.276</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>83.000±12.975</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>46 (92%)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>42 (84%)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>36 (72%)</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>29 (58%)</td>
</tr>
<tr>
<td>Dyslipedemia, n (%)</td>
<td>39 (78%)</td>
</tr>
<tr>
<td>Family History of CAD, n (%)</td>
<td>18 (36%)</td>
</tr>
<tr>
<td>Mean heart rate during scan of &lt;65 beats/min, n (%)</td>
<td>33 (66%)</td>
</tr>
<tr>
<td>Obese patients, n (%)</td>
<td>46 (92%)</td>
</tr>
<tr>
<td>Patients with binary in stent restenosis on ICA, n (%)</td>
<td>21 (18%)</td>
</tr>
<tr>
<td>Use of beta blocker, n (%)</td>
<td>50 (100%)</td>
</tr>
<tr>
<td>Use of nitroglycerin, n (%)</td>
<td>10 (20%)</td>
</tr>
<tr>
<td>Scan time, sec</td>
<td>13.2±1.5</td>
</tr>
<tr>
<td>Total amount of contrast material, ml</td>
<td>73.5±10.6</td>
</tr>
</tbody>
</table>

Binary ISR diagnosis: CTCA compared with ICA:

Binary ISR was observed on ICA in 21 stented segments (17.80%) in 50 patients. The MSCT images quality was adequate in 115 stented segments (48 patients) of the 118 stented segments (50 patients). In these 115 assessable segments, 20 binary ISRs were diagnosed on ICA. Of these 20 binary ISRs diagnosed on ICA, 17 binary ISR were correctly detected by MSCT. Similarly among the 95 assessable lesions that had no ISR by ICA, 92 were correctly ruled out by MSCT. To estimate the overall accuracy, including the 3 unassessable stents (1 with ISR and 2 without ISR on ICA) that could not assessed by MSCT of total number of cases taken in this study. We assigned those segments as having binary ISR, because restenosis could not be excluded by MSCT. When including unassessable segments sensitivity, specificity, PPV and NPV were 85.7%, 94.8%, 78.2% and 96.8% respectively, with a diagnostic accuracy of 93% as shown in Fig. (1). When excluding =assessable segments, the sensitivity was 85%, specificity was 96.8%, PPV was 85% and NPV was 96.8%, with diagnostic accuracy of 94.78%. Failure to detect binary ISR by MSCT occurred in 3 lesions one missed in LAD, one in LCX and one in OM (false negative).
When assessing the accuracy of MSCT in evaluation of patency of stents implanted in LAD vessel in comparison to ICA, we found that 26 stents (83.87%) screened by MSCT were patent, 25 stents (80.65%) assessed by ICA were patent while 1 stent (3.2%) was non patent by ICA. Also, 26 stents (83.87%) assessed by ICA were patent, 25 stents (80.65%) of those screened by MSCT were patent, while only 1 stent (3.2%) screened by MSCT was non patent. In addition, 5 stents (16%) screened by MSCT were seen non patent, 1 stent only (3.2%) assessed by ICA was patent, while 4 stents (12.90%) assessed by ICA were non patent. Finally, 5 stents (16%) of total number of patients assessed by ICA were non patent, 1 stent (3.2%) screened by MSCT was patent, while the other 4 stents (12.90%) screened by MSCT were seen non patent. So, this would yield an overall sensitivity, specificity, PPV and NPV of 80%, 96%, 80% and 96% respectively with diagnostic accuracy of 93% (Tables 2, 3).

When assessing the accuracy of MSCT in evaluation of stent patency in relation to ICA in LCX vessel, we found that 21 stents (75%) of total number of patients screened by MSCT were seen patent, 20 stents (80.65%) assessed by ICA as patent while 1 stent (4.5%) assessed by ICA was non patent. Also, 23 stents (82%) of total number of patients taken in this study assessed by ICA were patent, 20 stents (71%) assessed by MSCT as patent while the other 4 stents (12.90%) assessed by MSCT were seen non patent. So, this would yield a sensitivity, specificity, PPV and NPV of 80%, 96%, 80% and 96% respectively with diagnostic accuracy of 93% (Tables 2, 3).

When assessing the accuracy of MSCT in evaluation of stent patency in relation to ICA in RCA vessel, we found that 18 stents (81%) of total number of patients screened by MSCT were seen patent, 18 stents (81%) assessed by ICA as patent. Also, 19 stents (86%) were assessed by ICA as patent, MSCT screened 18 stents (81%) as patent, while 1 stent (4.5%) screened by MSCT as non patent in this group of patients. In addition, only 3 stents (13.6%) assessed by ICA as non patent, while the MSCT screened the same number of stents as non patent. Four stents (14%) were seen non patent by MSCT, 1 stent (4.5%) only was assessed as patent by ICA while the remaining 3 stents (13.6) were assessed as non patent by ICA. So, this would yield sensitivity, specificity, PPV and NPV of 100%, 94%, 75% and 100% respectively with diagnostic accuracy of 95% (Tables 2, 3).
When assessing the accuracy of MSCT in relation to ICA in evaluation of stent patency in obtuse marginal vessel, we found that 15 stents (75%) were screened as patent by MSCT, those 15 stents (75%) assessed also by ICA as patent and vice versa. While 5 stents (25%) assessed by C.A. as non patent, MSCT screened the same 5 stents (25%) also as non patent and vice versa, with no results of patent stents. So, this would yield a sensitivity, specificity, PPV and NPV 100%, 100%, 100% and 100% respectively with diagnostic accuracy of 100% (Tables 2, 3).

In the assessment of accuracy of MSCT in relation to ICA in evaluation of stent patency in diagonal vessel, we found that 13 stents (86%) screened by MSCT as patent while ICA assessed 12 stents (80%) as patent, while 1 stent (6.6%) only was assessed as non patent by ICA. Also, 12 stents (80%) were assessed as patent by ICA and were seen patent by MSCT with no non patent results. In addition, 2 stents (13%) were seen non patent by MSCT and were assessed also as non patent by ICA Finally, 3 stents (20%) were assessed as non patent by ICA, 1 stent (6.6) only was seen patent by MSCT while the other 2 stents (13%) were seen as non patent by MSCT. So, this would yield an overall sensitivity, specificity, PPV and NPV of 66%, 100%, 100% and 92% respectively, with diagnostic accuracy of 93% (Tables 2, 3).

When assessing the accuracy of MSCT in evaluation of stent patency in relation to ICA in left main coronary artery, we found that there was only 1 case (100%) taken in this study screened by MSCT as patent stent while ICA assessed it patent also and vice versa. While no cases of positive findings (non patent) in LM taken in this study. Also, in assessment of accuracy of MSCT in evaluation of stent patency in graft to OM artery after bypass operation, we found that only 1 stent (100%) was screened by MSCT as patent while the same stent (100%) assessed by ICA as patent also. In addition, no cases with positive findings was taken in grafts furtherly (Tables 2, 3).

Unassessable segments: Among all 118 stented segments, 3 (2.54%) were evaluated as unassessable in 2 patients (2 in LCX in one patient, while the other one was in RCA of the other patient). Only one segments had binary ISR on ICA (in RCA). The diameter of these stents ranged between 2.5-3mm as an average. Reduction of image quality was caused by extensive imaging artifacts generated by metallic struts themselves, motion artifact, calcification, or low opacification. In addition, in all unassessable stents, the CT density of stented lumens were <300 HU, which indicates lower opacification [11, 12].

The 23 nonpatent stents by CTCA were 5 Cypher (Cordis), 7 Liberte (Boston scientific), 8 Skylor and 3 DuraFlex.

Table (3): Sensitivity, specificity, PPV, NPV and diagnostic accuracy among different parameters.

<table>
<thead>
<tr>
<th></th>
<th>Sens.</th>
<th>Spec.</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD</td>
<td>80</td>
<td>98</td>
<td>90</td>
<td>95</td>
<td>93.5</td>
</tr>
<tr>
<td>LCX</td>
<td>80</td>
<td>86.9</td>
<td>57</td>
<td>95</td>
<td>85.7</td>
</tr>
<tr>
<td>RCA</td>
<td>100</td>
<td>94</td>
<td>75</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>OM</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>D1</td>
<td>66</td>
<td>100</td>
<td>100</td>
<td>92</td>
<td>93</td>
</tr>
<tr>
<td>LM</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Graft .OM</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Non prox</td>
<td>91</td>
<td>90</td>
<td>84</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>Prox</td>
<td>77</td>
<td>96</td>
<td>70</td>
<td>97</td>
<td>94</td>
</tr>
<tr>
<td>Non obese</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Obese</td>
<td>85</td>
<td>94</td>
<td>78</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>HR (&gt;65)</td>
<td>100</td>
<td>95</td>
<td>80</td>
<td>100</td>
<td>96</td>
</tr>
<tr>
<td>HR (&lt;65)</td>
<td>82</td>
<td>94.5</td>
<td>77.7</td>
<td>95.8</td>
<td>92</td>
</tr>
</tbody>
</table>


Discussion

This study showed that the 64-multislice CT has a very high sensitivity and specificity for detecting significant instant restenosis (85%, 94% respectively), with a very good overall positive predictive value of 78% and a negative predictive value of 96%. These findings were revealed on stent bases analysis, by comparing the CT findings of each coronary stent with the invasive coronary angiography findings. These findings are consistent with several previously published reports [10, 11] which investigated the diagnostic accuracy of 64-multislice CT coronary angiography.

Most of the examined population (92%), in this study, had high pretest probability of having coronary instant restenosis based on their gender, age and symptoms of presentation. Whereas (6%) had intermediate pretest probability and only (2%) had low pretest probability of having coronary ISR. The current study revealed a good diagnostic accuracy of the MSCT coronary angiography (93%), while the characteristic findings in our study and almost all studies was the very high negative predictive value of the test which reached up to 99% in some studies [iii. In comparison to NPV of 96% in our study. Few studies addressed the effect of non patent coronary stents on the diagnostic accuracy of MSCT coronary angiography. The MSCT coronary angiography is basically a test that is
intended to rule out the presence of coronary stent patency rather than significant stenosis.

The failure to exclude the presence of significant coronary instent restenosis in a coronary artery would represent a positive finding. So, if these non patent stents are to be included in the statistical evaluation of the test accuracy, which is more close to the real world situation, they would be included as positive findings. This of course would increase the number of false positive stents evaluated by CT and would affect the diagnostic accuracy of the test, mainly affecting specificity and positive predictive value.

When including the non evaluable stents in the analysis of the current study, it was found that the sensitivity, specificity, positive predictive value and negative predictive value were 85.714%, 94.845%, 78.261%, 96.842% respectively. By looking at these figures, it was found that there is moderate increase in overall specificity 96.8% instead of 94%, with no significant change in sensitivity (85%) and a significant increase in positive predictive value of 85% instead of 78%, finally no change in negative predictive value of 96.8%, with mild increase in diagnostic accuracy of 94.7% instead of 93%. This finding is consistent with other studies [iii].

But only few studies included these non evaluable stents in their analysis. This explains the rather big range of differences in the positive predictive values in different studies. Generally, a high number of non evaluable stents due to, any cause would seriously affect the positive predictive value of the test. However, with the inclusion of only evaluable stents, as most studies did, the diagnostic accuracy of the test would be significantly higher.

However, the finding of interest is the persistently high NPV which was not influenced by including the non evaluable coronary stents in the analysis. This is of great value as this ensures the value of the MSCT as a rule out modality. This concept is consistent with the findings addressed by Gilard et al. [12], who performed a meta-analysis including 30 studies and reported the negative effect of these non evaluable coronary stents on the specificity and NPV of the test. Of course, this would necessitate an effort to minimize the number of non evaluable stents to the least possible.

In this study, the number of non evaluable coronary stents was 3 stents (2.54% of all stents). The variation of this number with other studies can be attributed to the difference in the scanning parameters in different studies, also not all studies reached adequate control of the heart rate during the scan.

Most of the non evaluable coronary stents were due to, motion artifacts, calcifications, thickened struts, small vessel calibre. Calcification was the second common cause for stent to be non evaluable. This would be due to heavy circumferential calcifications which would mask the coronary stent lumen preventing its adequate visualization. Also, thickened stent struts produce a (blooming effect) that affect evaluation of instent restenosis.

Moreover, we tried to get adequate heart rate control with beta-blocker administration if necessary, and with patient relaxation. Also, adequate examination explanation, rehearsal of breath-hold, and tools for body holding ensure better image quality, and consequently a better diagnostic accuracy. Examination preparation is particularly important in cases after stenting. The initial extra time spent for preparation or reconstruction allows saving a greater amount of time and energy for the analysis and interpretation of images with an adequate quality. One of the future challenges is to reduce the radiation doses, because it is currently higher than for ICA. On the other hand, the contrast media amount was similar to the amount used for ICA.

To improve stent visibility and to decrease artifact, specific reconstructions were performed. In addition to reconstruction with ordinary field of view, phase of cardiac cycle, and convolution kernel (B2Of or B30f, smooth or medium-smooth kernel), we made additional reconstructions stent by stent with another convolution kernel (B46f, Heart-View kernel) in limited field of view [12,13]. These reconstructions were repeated usually in a few different phases for each stent until a satisfactory image was obtained. A smooth kernel is suitable for delineating vessel lumen, vessel wall, and surrounding tissue, whereas a sharp kernel (Heart-View kernel) is good at visualizing objects located next to fine and high-density obstacles such as calcium deposit or stent. The same reconstruction protocols were performed for each stented segment by both observers, with an excellent reproducibility, as shown by the low inter-observer and intraobserver variability.

According to the pattern of ISR, we found in our study that 8 stents showed diffuse ISR while 15 stents showed focal ISR of total number of 23 ISR taken in our study. This is of course affecting the management of ISR and outcome of patients confirming other findings [14].
This study has some limitations; first the rather small number of patients included in this study prevented the adequate evaluation of confounding factors which would affect the study quality (as BMI and coronary calcification). Also, an important question, which is the accuracy of MSCT in evaluating left main disease, seems to need a larger number of patients. Also, the radiation exposure the patients were subjected to was not routinely calculated in this study. The impact of the radiation delivered during the MSCT in general and the coronary angiography in particular is gaining a major concern. To reach a clear recommendation regarding the value of this test in patients with suspected coronary instant restenosis, radiation exposure calculation should be an integral part for evaluation of the cost/benefit ratio.

Challenges in CTCA: Our analysis showed that CTCA had 5 false-positive segments. The main reasons for over-estimation is calcification, overlapping of stents, and motion artifact. Similarly, we had 3 (2.54%) unassessable segments. Although in most part this problem is caused by inadequate resolution, we have some room for improvement.

Former MSCT generations were unable to depict fine objects with a high CT density, such as calcium or metallic structures, which generate artifacts. The improved resolution of 64-MSCT allows us to overcome most of those limitations.

Conclusions: 64-MSCT coronary angiography is a very helpful test in diagnosing patients with coronary instant restenosis with sensitivity, specificity, PPV and NPV of 85.7%, 94.8%, 78.2% and 96.8% respectively. These values were reached when evaluating the MSCT results against invasive coronary angiography (per vessel analysis). These values were comparable to those found in a multitude of previous studies addressing the same issue. In particular, a high negative predictive value of 96% was observed, indicating that 64-slice MSCT may be most valuable as a noninvasive method of excluding in-stent restenosis.

This analysis included the non evaluable coronary stents which were considered as false positive stents. However, the test preserved its high NPV. This should be very valuable if the test is viewed as a rule out procedure, ruling out the presence of significant instant restenosis. This result is consistent with several other studies which have elucidated the high NPV of the MSCT coronary angiography.

We can reach to a conclusion from the study that the 64-slice CT coronary angiography is a robust test that can be used confidently to diagnose patients with coronary stents and more importantly to rule out significant coronary instant restenosis in patients with high likelihood of having significant ISR.

References
