Optimal Cutoff Value of Minimal Lumen Cross Sectional Area of Coronary Stents on 64-MDCT Coronary Angiography Compared with Intravascular Ultrasound

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Purpose

1. Coronary disease is increasingly treated by percutaneous coronary angioplasty. Invasive coronary angiography with or without IVUS is the gold standard for detection of in-stent restenosis (ISR). But, both coronary angiography and IVUS have limitations because of their invasiveness and association with potential risks of morbidity and mortality.

2. A noninvasive approach to evaluating these patients may be offered by 64-MDCT. But, there were a few studies that dealt with the diagnostic accuracy of ISR detection of 64-MDCT compared with IVUS which considered an accurate method for cross section area (CSA) of coronary artery.

3. In this poster we will evaluate the diagnostic performance of 64-MDCT to identify ISR in comparison with the IVUS. In addition, we will assess an optimal cutoff value of minimal lumen CSA on 64-MDCT coronary angiography compared with IVUS.
Methods and Materials

Patients

Between March 2008 and November 2008, 39 patients scheduled for follow up coronary angiography with IVUS and 64-MDCT after coronary stent implantation were consecutively investigated. Inclusion criteria for this study is male or non-pregnant female ≥18 years of age and those who had coronary artery disease treated by percutaneous coronary intervention with stent implantation and planned follow-up coronary angiography to evaluate ISR. We excluded patient with the followings: renal insufficiency (serum creatinine ≥2.0 mg/dL), contraindication to beta-blockers (3rd-degree AV block, decreased left ventricular function, asthma, or severe chronic obstructive pulmonary disease), previous allergic reaction to contrast, those who had an acute coronary syndrome at the time of scheduled angiography, atrial fibrillation, refusal of patient. All patients gave written informed consent to the study protocol, which was approved by the ethical committee.

64-MDCT Technique

The 64-MDCT scanner (Brilliance CT: Philips Healthcare Systems, Cleveland, Ohio, USA) was performed before conventional angiography. Patients with a heart rate > 65bpm received 100mg of metoprolol orally 1 hour before the scan. The MDCT scanner had the following scan parameters: detector collimation 64 x 0.625mm, table feed 19mm/sec (0.2 pitch), gantry rotation time 0.42 sec, tube voltage 120 kV, and tube current 400-500 mAs (depending on patient body mass).

Contrast medium (80mL, 370 mg I/mL) was injected IV at 5 mL/s followed by a 40 mL saline flush at 4 mL/s. The CT value of the area of interest in ascending aorta was monitored from the start of the injection. As soon as the CT value in the ascending aorta reached 110 H, scanning was initiated, and the imaging of the entire volume of the heart was acquired during one breath-hold with simultaneous recording of the ECG tracing.

Axial images (slice thickness, 0.9 mm; increment, 0.45 mm) were reconstructed using a multisector reconstruction algorithm. Using retrospective ECG gating, we routinely performed reconstructions at 75% of the R-R interval. If motion artifacts existed at these reconstruction, another, more optimal ECG phase was chosen to provide better image quality.

MDCT data analysis

An observer, unaware of the results of coronary angiography, assessed the MDCT data sets on both the original axial CT images and on curved multiplanar reconstruction. The stent was considered to be patent, when the distal run-off was present and contrast
medium could be detected within the stent. And ISR was considered to be present, when the vessel distal to the stent implantation site was not visualized or massive low density area in the stent lumen was detected visually as compared with the reference vessels (the sites proximal and distal to the stent). The vessels 5mm proximal and distal to the stent were evaluated. For comparison with IVUS, stent areas were measured in cross sectional image planes (Figure 1, 2). Lumen area stenosis (%) was the difference between the stent CSA and the minimal lumen CSA divided by the stent CSA. ISR was defined as #75% area stenosis in anywhere 5mm proximal and distal to the stent.

**IVUS analysis**

IVUS was performed with a 2.5F, 40-MHz or 2.9F, 20-MHz single-element mechanical transducer (Boston Scientific, Volcano corp). After intracoronary injection of nitrate, the IVUS catheter was positioned at least 1cm distal to the stent. IVUS images were recorded after initiation of pullback at 0.5mm/sec. Experienced observer, unaware of the results of MDCT reviewed and assessed IVUS image data. The following IVUS parameters were measure: (1) minimal lumen cross sectional area (CSA, mm$^2$), (2) minimal stent CSA (mm$^2$) at minimal lumen CSA, (3) minimal lumen diameter (mm), and (4) stent diameter (mm) at minimal lumen CSA were measured. And the area stenosis (%) was calculated (Figure 1, 2). The percent area stenosis were comparable to 64-MDCT determined in cross sections with maximal in-stent lumen narrowing. Binary ISR on IVUS was defined as maximum percentage of area stenosis #75% anywhere within the stent or within the 5mm proximal and distal to the stent.

**Statistical analysis**

Continuous variables are reported as means ± 1SD. Sensitivity, specificity, positive predictive value, and negative predictive value of MDCT for the detection of ISR using IVUS as the gold standard, were calculated. Correlations were determined by calculating the Pearson correlation coefficient. A value of p < 0.05 was considered statistically significant. All continuous variables including stent CSA, minimal lumen CSA and lumen area stenosis were evaluated using the paired T-test. Binary data of presence or absence of ISR were evaluated using McNemar test. Receiver operating characteristic (ROC) curves were calculated for minimal lumen CSA on 64-MDCT using IVUS (significant ISR defined as minimal lumen CSA < 4mm$^2$ on IVUS) as the gold standard.
Fig. 0: In-stent restenosis in stents placed at the proximal LAD artery of a 55-year-old man. (a) Five cross-sectional image and straightened multiplanar image of 64-MDCT shows eccentric located, low density with 43.8% CSA stenosis. Minimal CSA was 4.5mm². (b) Cross-sectional IVUS view of the proximal LAD showing 63.3% area stenosis with concentric location. Minimal CSA was 5.5mm².

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Fig. 0: In-stent restenosis in stents placed at the proximal LAD artery of a 70-year-old woman. (a) Three cross-sectional image and straightened multiplanar image of 64-MDCT shows low density with 100% CSA stenosis. Minimal CSA was 0mm². (b) Cross-sectional IVUS view of the proximal LAD showing 80.7% area stenosis. Minimal CSA was 1.86mm².

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Results

We evaluate 43 stents in 39 patients. Baseline clinical characteristics of the study population are summarized in Figure 1. The average time interval between stent implantation and MDCT coronary angiography was 708.87 ± 388.67; MDCT coronary angiography and follow up conventional coronary angiography was 20.72 ± 7.78. The site of stent implantation was: right coronary artery in 10(23.3%), left anterior descending coronary artery in 25(58.1%), left circumflex coronary artery in 7(16.3%), and ramus intermedius artery in 1(2.3%). Sensitivity, specificity, positive predictive value, and negative predictive value to detect ISR using 64-MDCT were 60%, 100%, 100%, and 95%, respectively (Figure 2). For the assessment of minimal lumen CSA and minimal stent CSA, 64-MDCT showed a good correlation with IVUS (r = 0.73 and 0.63, p < 0.0001) (Figure 3). But correlation of area stenosis (%) between 64-MDCT and IVUS was weak, with a correlation coefficient of 0.29. ROC analysis assesses whether minimal lumen CSA on 64-MDCT provide a good diagnostic accuracy to predict significant ISR. The area under the ROC curve was 0.82 (p < 0.0001) for per-stent analysis, indicating a high degree of agreement between 64-MDCT and IVUS for significant ISR (Figure 4). An optimal cutoff value of 6.2mm$^2$ on 64-MDCT would have yielded a sensitivity of 83.33% and a specificity of 72%.
### Demographic and Angiographic Characteristics of Patients (n=39)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Age (yrs), mean±SD</td>
<td>62.9±7.3</td>
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<tr>
<td>Male</td>
<td>24 (61.5%)</td>
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<tr>
<td>Single-vessel disease</td>
<td>76.9%</td>
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<tr>
<td>Multi-vessel disease</td>
<td>23.1%</td>
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<tr>
<td>Previous myocardial infarction</td>
<td>46.15%</td>
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<tr>
<td>Cardiac risk factor</td>
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<tr>
<td>Hypertension</td>
<td>53.8%</td>
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<tr>
<td>Diabetes mellitus</td>
<td>35.9%</td>
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<tr>
<td>Hypercholesterolemia</td>
<td>23.08%</td>
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<tr>
<td>Current smoking</td>
<td>38.5%</td>
</tr>
<tr>
<td>BMI (kg/m²), mean±SD</td>
<td>25.26±3.31</td>
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<tr>
<td>Serum creatine (mg/dL), mean±SD</td>
<td>0.94±0.27</td>
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<td>Stent location</td>
<td></td>
</tr>
<tr>
<td>RCA</td>
<td>23.3%</td>
</tr>
<tr>
<td>LAD</td>
<td>58.1%</td>
</tr>
<tr>
<td>LCX</td>
<td>16.3%</td>
</tr>
<tr>
<td>Ramus</td>
<td>2.3%</td>
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**Fig. 0:** Demographic and Angiographic Characteristics of Patients (n=39). BMI=body mass index, RCA=right coronary artery, LAD=left anterior descending artery, LCX=left circumflex artery.

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<tbody>
<tr>
<td>Sensitivity</td>
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<tr>
<td>Specificity</td>
<td>100%</td>
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<tr>
<td>Positive predictive value</td>
<td>100%</td>
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<tr>
<td>Negative predictive value</td>
<td>95%</td>
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<tr>
<td>Kappa value</td>
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**Fig. 0:** Diagnostic Accuracy of 64-MDCT to Detect In-Stent Restenosis.

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Fig. 0: Correlation of minimal CSA on MDCT with IVUS. Correlation coefficient is 0.73 (p>0.0001).

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Fig. 0: Receiver operator characteristic (ROC) curve analysis on a per stent comparing 64-MDCT vs IVUS. The area under the ROC curve was 0.82 (p < 0.0001)

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Conclusion

An optimal cutoff value of minimal lumen cross sectional area of coronary stents on 64 MDCT is 6.2mm$^2$. Coronary stents with 64-MDCT may be valuable as a noninvasive method of detecting significant ISR.
References

Personal Information

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