Evaluation of Coronary Artery Lumen Diameter With 16-Slice Multidetector-Row Computed Tomography

Kozo Sato, MD*; Yutaka Tanami, MD*; Shen Yun, PhD**; Kosuke Sasaki, MS**

Background When using 16-slice multidetector-row computed tomography (MDCT) to detect coronary artery stenosis, coronary arteries measuring 1.5 mm or larger in lumen diameter are usually evaluated. The purpose of this study was to investigate the frequency of the visualized lumen in each coronary artery segment measuring more than 1.5 mm in diameter.

Methods and Results Electrocardiographic-gated 16-slice MDCT was used to scan 20 patients after administration of nitroglycerin. The luminal diameter of each coronary artery segment was measured on cross-sectional images using a caliper method. The frequency of the visualized lumen of each coronary artery segment measuring larger than 1.5 mm in diameter was as follows: #1: 100%, #2: 100%, #3: 100%, #4PD: 85%, #4AV: 80%, #5: 100%, #6: 100%, #7: 100%, #8: 90%, #9: 85%, #10: 40%, #11: 100%, #12: 65%, #13: 100%, #14: 80%. Averaged lumen diameter ± standard deviation (mm) larger than 1.5 mm in all patients was calculated as follows: #1: 3.8±0.70, #2: 3.5±0.69, #3: 3.2±0.82, #4PD: 4.2±1.04, #6: 3.4±0.79, #7: 2.9±0.62, #11: 2.9±0.69, #13: 2.6±0.57.

Conclusion Luminal diameter larger than 1.5 mm of each coronary artery segment can be assessed in most cases by 16-slice MDCT.

Key Words: Coronary artery; Lumen diameter; Multidetector-row computed tomography

Multidetector-row computed tomography (MDCT) has recently been introduced as a non-invasive method of evaluating the coronary arteries, and has been used successfully in the clinical field.9–10 Coronary arteries measuring 1.5 mm or larger in lumen diameter are usually evaluated in studies of coronary artery stenosis. The purpose of this study was to investigate the frequency of the visualized lumen in each coronary artery segment measuring more than 1.5 mm in diameter.

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We used 16-slice MDCT (Light Speed ultra16: GE Healthcare, WI, USA) and after obtaining an unenhanced scan of the whole heart, sublingual nitroglycerin (0.3 mg) was administered.

In the main scanning, contrast material and saline chaser of 20 ml was injected at a rate of 3 ml/s. An enhancement curve was drawn by placing the region of interest on the ascending aorta at the coronary ostium level to indicate the time needed to reach the peak of maximum enhancement for the test bolus. The time to peak enhancement for the test bolus injection plus 2 s was the delay applied for the main scanning.

In the main scanning, contrast material and saline chaser of 20 ml was injected at a rate of 3 ml/s. The contrast material volume was 3 (injection rate) x scanning time. The main scanning parameters were: tube voltage of 120 kV, tube current of 350–380 mA, gantry speed of 0.5 s/rotation, detector collimation of 16×0.625 mm, and a pitch of 0.275–0.3, scanning direction cranio-caudal. The field of view reconstructed axial image was 200 mm with a 512×512 matrix, and the kernel used was standard.

The raw data of the main scanning were reconstructed using half reconstruction for the patients with a heart rate less than 60 beats/min, and the multisector reconstruction for the patients with a heart rate of more than 60 beats/min respectively. For the selection of the optimal cardiac phase,
each axial image of every 5% in the cardiac phase was reconstructed at 3 different levels (ostium of the right coronary artery, the acute marginal bifurcation, and the obtuse marginal bifurcation), which have been reported to show marked movement compared with other areas. The image of the mid-diastolic phase was judged by visual inspection to be the most excellent in all the present patients.

Measurement of Coronary Artery Lumen Diameter

The reconstructed data were transferred to the workstation system (Advantage Workstation ver.4.2; GE Healthcare, WI) for post-processing. Curved multiplanar reformations (MPR) and cross-sectional images of all coronary artery segments according to the American Heart Association Committee Report were automatically reconstructed on this workstation. When central axis of curved MPR did not choose the center of lumen, the correction was manually performed. One specialist of image-processing (M.Y) measured the diameter of origin of each coronary artery segment twice with the fixed window width of 700 Hounsfield units (HU) and window level of 250 HU (WW/WL), which are previously reported. When there were multiple branches classified into one segment, we measured the diameter of the largest branch. Ramus Medianus was

<table>
<thead>
<tr>
<th>Frequency of each segment 1.5 mm</th>
<th>Average lumen diameter</th>
<th>Standard deviation of lumen diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCA #1</td>
<td>100%</td>
<td>3.8 mm</td>
</tr>
<tr>
<td>RCA #2</td>
<td>100%</td>
<td>3.5 mm</td>
</tr>
<tr>
<td>RCA #3</td>
<td>100%</td>
<td>3.2 mm</td>
</tr>
<tr>
<td>RCA #4PD</td>
<td>85%</td>
<td>–</td>
</tr>
<tr>
<td>RCA #4AV</td>
<td>80%</td>
<td>–</td>
</tr>
<tr>
<td>LMT #5</td>
<td>100%</td>
<td>4.2 mm</td>
</tr>
<tr>
<td>LAD #6</td>
<td>100%</td>
<td>3.4 mm</td>
</tr>
<tr>
<td>LAD #7</td>
<td>100%</td>
<td>2.9 mm</td>
</tr>
<tr>
<td>LAD #8</td>
<td>90%</td>
<td>–</td>
</tr>
<tr>
<td>LAD #9</td>
<td>85%</td>
<td>–</td>
</tr>
<tr>
<td>LAD #10</td>
<td>40%</td>
<td>–</td>
</tr>
<tr>
<td>LCX #11</td>
<td>100%</td>
<td>2.9 mm</td>
</tr>
<tr>
<td>LCX #12</td>
<td>65%</td>
<td>–</td>
</tr>
<tr>
<td>LCX #13</td>
<td>100%</td>
<td>2.6 mm</td>
</tr>
<tr>
<td>LCX #14</td>
<td>80%</td>
<td>–</td>
</tr>
</tbody>
</table>

RCA, right coronary artery; PD, posterior descending; AV, atrioventricular; LMT, left main trunk; LAD, left anterior descending; LCX, left circumflex.
regarded as segment of #12, #1, 2, 3, 5, 6, 7, 8, 11 and 13 were defined as major segments and, #4PD, 4AV, 9, 10, 12 and 14 were defined as side branches. The frequency of the visualized lumen measuring larger than 1.5 mm in diameter at each coronary artery segment were calculated. The averaged lumen measuring larger than 1.5 mm in diameter was calculated in all patients.

Results

Fig 1 shows the intra-observer variability for measurement of coronary artery lumen diameter in 20 patients and Table 1 shows the frequency of the visualized lumen diameter measuring more than 1.5 mm, as well as the averaged diameter of each coronary artery segment.

The lumen diameter of all major segments, except for #8, was larger than 1.5 mm in every patient in a balanced distribution. The lumen diameter of all side branches, except for #10, was larger than 1.5 mm in more than 50% of the patients.

Discussion

In the present study we measured the lumen diameters of each coronary artery segment in 20 patients. It is difficult to determine the minimum lumen diameter that MDCT can theoretically evaluate and in this study the detector collimation was 0.625 mm. However, the spatial resolution depends on the helical pitch and reconstruction algorithm, so we adopted 1.5 mm as the minimum lumen diameter, because it is the most commonly used.10 MDCT enables noninvasive evaluation of the coronary artery, but it must be image processed segment by segment on MDCT, whereas on conventional coronary angiography (CAG) many coronary artery segments are demonstrated in one series. In the present study, the major segments, except for #8, could be assessed in every patient, and side branches, except for #10, could be assessed in more than 50% of patients, which is important knowledge about the image-processing of coronary CT angiography.

To our knowledge, this is the first study to evaluate the lumen diameter of coronary artery using 16-slice MDCT. Dodge et al. reported the averaged lumen diameter on CAG19-20 According to their study, the lumen diameter in the proximal portion of the major segments of men and women was 4.0 mm and 3.4 mm in #1, 3.5 mm and 3.3 mm in #2, 3.2 mm and 2.8 mm in #3, 4.5 mm and 4.0 mm in #5, 3.7 and 3.3 mm in #6, 2.9 and 2.8 mm in #7, 3.4 and 2.9 mm in #11, and 2.8 and 3.1 mm in #13, respectively. These data are comparable to the averaged lumen diameter on MDCT in our study.

Study Limitations

First, the patients in our study did not undergo CAG and were judged to have normal coronary arteries based on the MDCT findings. However, the negative predictive value of coronary CT angiography is reported to be very high.6,9,10,17,18 although MDCT is considered reliable for the diagnosis of normal coronary artery. Thus, CAG is rarely performed in patients with normal coronary arteries diagnosed by MDCT. Second, the diameter of the coronary artery will vary according to its anatomic distribution. In our study the lumen diameter was evaluated in the patients with a balanced distribution, because right-dominance was apparent in only 1 patient and left-dominance in none. The anatomic distribution, such as right- or left dominance, must be evaluated. Third, the total number of patients was small and so further study with a larger population is needed.

In conclusion, MDCT was able to determine that all major segments, except for #8, were larger than 1.5 mm in diameter in every patient with a balanced distribution. A lumen measuring larger than 1.5 mm in diameter was visualized in all side branches, except for #10, in more than 50% of the patients.

References


