Pre-Operative Computed Tomography Coronary Angiography to Detect Significant Coronary Artery Disease in Patients Referred for Cardiac Valve Surgery

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OBJECTIVES
We studied the diagnostic performance of 64-slice computed tomography coronary angiography (CTCA) to rule out or detect significant coronary stenosis in patients referred for valve surgery.

BACKGROUND
Invasive conventional coronary angiography (CCA) is recommended in most patients scheduled for valve surgery.

METHODS
During a 6-month period, 145 patients were prospectively identified from a consecutive patient population scheduled for valve surgery. Thirty-five patients were excluded because of CTCA criteria: irregular heart rhythm (n = 26), impaired renal function (n = 5), and known contrast allergy (n = 4). General exclusion criteria were: hospitalization in community hospital (n = 4), no need for CCA (n = 4), previous coronary artery bypass surgery (n = 1), or percutaneous coronary intervention (n = 4). Of the remaining 97 patients, 27 denied written informed consent. Thus, the study population comprised 70 patients (49 male, 21 female; mean age 63 ± 11 years).

RESULTS
Prevalence of significant coronary artery disease, defined as having at least 1 ≥50% stenosis per patient, was 25.7%. Beta-blockers were administered in 71%, and 64% received lorazepam. The mean heart rate dropped from 72.5 ± 12.4 to 59.5 ± 7.5 beats/min. The mean scan time was 12.8 ± 1.3 s. On a per-patient analysis, the sensitivity, specificity, and positive and negative predictive values were: 100% (18 of 18; 95% confidence interval [CI] 78 to 100), 92% (48 of 52; 95% CI 81 to 98), 82% (18 of 22; 95% CI 59 to 94), and 100% (48 of 48; 95% CI 91 to 100), respectively.

CONCLUSIONS
The diagnostic accuracy of 64-slice CTCA for ruling out the presence of significant coronary stenoses in patients undergoing valve surgery is excellent and allows CTCA implementation as a gatekeeper for invasive CCA in these patients. (J Am Coll Cardiol 2006;48:1658 – 65)

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Pre-operative detection of obstructive coronary artery disease (CAD) with conventional coronary angiography (CCA) is recommended in most patients scheduled for valve surgery (1).

Although CCA is considered a safe procedure, it still carries a small but relevant risk for major (death, stroke, or vascular dissection) and minor (inguinal hematoma) complications (2). Furthermore, the catheterization procedure is rather expensive, as its invasive nature involves admission to a hospital or day-care facility and requires surveillance by an experienced team. A non-invasive, patient-friendly pre-operative work-up for these patients would be desirable.

The newest-generation 64-slice computed tomography (CT) scanner with improved spatial and temporal resolution shows excellent diagnostic accuracy to detect significant coronary artery lesions (3–6). In this study, we evaluated the clinical value of computed tomography coronary angiography (CTCA) in patients scheduled for elective valve surgery.

METHODS

Study population. During a 6-month period, we screened 145 consecutive patients scheduled for valve surgery. Patients were contacted before their final pre-operative appointment requesting them to conduct an additional CTCA. Thirty-five patients were excluded because of CTCA criteria and 13 patients because of general criteria (Table 1). Of the remaining 97 patients, 27 denied written informed consent. Thus, the study population comprised 70 patients (49 male, 21 female; mean age 63 ± 11 years). The institutional review board of the Erasmus Medical Center Rotterdam approved the study, and all 70 subjects gave written informed consent.

Patient preparation. Patients with an aortic stenosis and a good left ventricular function (LVF) with a heart rate exceeding 65 beats/min were given 50 mg metoprolol and 1 mg lorazepam 60 min before the CT scan. If the LVF was impaired, beta-blockers were withheld and only lorazepam...
material in the ascending aorta reached a pre-defined coronary arteries, and the scan was started once the contrast was used to synchronize the arrival of contrast in the antecubital vein at 5 ml/s. A bolus-tracking technique (Iomeron, Bracco, Milan, Italy) was injected intravenously in respective X-ray tube modulation was calculated as 1.3 to 1.7 mSv (for men and women, respectively) (9). The radiation exposure of calcium scoring (including prospective X-ray tube modulation) was not used. Calcium scoring parameters (similar unless indicated) were a tube current of 150 mAs, voltage, 120 kV; tube current, 900 mAs. Prospective X-ray tube modulation was used. The radiation exposure for CTCA with this scan protocol was calculated as 15.2 to 21.4 mSv (for men and women, respectively) using dedicated software (WinDose, Institute of Medical Physics, Erlangen, Germany), which is in line with previously reported X-ray radiation exposure (7,8). The radiation exposure of calcium scoring (including prospective X-ray tube modulation) was calculated as 1.3 to 1.7 mSv (for men and women, respectively) (9).

A bolus of 100 ml of contrast material (400 mgI/ml; Iomeron, Bracco, Milan, Italy) was injected intravenously in an antecubital vein at 5 ml/s. A bolus-tracking technique was used to synchronize the arrival of contrast in the coronary arteries, and the scan was started once the contrast material in the ascending aorta reached a pre-defined threshold of +100 Hounsfield units.

**Scan protocol.** All scans were performed with a 64-slice CT scanner having a temporal resolution of 330 ms and a spatial resolution of 0.4 mm³ (Sensation 64, Siemens, Forchheim, Germany). Angiographic scan parameters were: number of slices per rotation, 32 × 2; individual detector width, 0.6 mm; table feed, 3.8 mm per rotation; tube voltage, 120 kV; tube current, 900 mAs. Prospective X-ray tube modulation was not used. Calcium scoring parameters (similar unless indicated) were a tube current of 150 mAs, and prospective X-ray tube modulation was used. The radiation exposure for CTCA with this scan protocol was calculated as 15.2 to 21.4 mSv (for men and women, respectively) using dedicated software (WinDose, Institute of Medical Physics, Erlangen, Germany), which is in line with previously reported X-ray radiation exposure (7,8). The radiation exposure of calcium scoring (including prospective X-ray tube modulation) was calculated as 1.3 to 1.7 mSv (for men and women, respectively) (9).

A bolus of 100 ml of contrast material (400 mgI/ml; Iomeron, Bracco, Milan, Italy) was injected intravenously in an antecubital vein at 5 ml/s. A bolus-tracking technique was used to synchronize the arrival of contrast in the coronary arteries, and the scan was started once the contrast material in the ascending aorta reached a pre-defined threshold of +100 Hounsfield units.

**Image reconstruction.** The post-processing technique to acquire the best possible image quality is previously described by Mollet et al. (6). In short, images are obtained during a half X-ray tube rotation, resulting in an effective temporal resolution of 165 ms. Images were reconstructed with electrocardiographic (ECG) gating to obtain nearly motion-free image quality. Optimal data sets were reconstructed in the mid- to end-diastolic phase. If non-diagnostic image quality was obtained, additional datasets were reconstructed in the end-systolic phase.

**Quantitative coronary angiography (QCA).** All scans were carried out within 2 months after CCA. One experienced cardiologist, unaware of the results of CTCA, identified and analyzed all coronary segments, using a 17-segment modified American Heart Association (AHA) classification (10).

All segments, regardless of size, were included for comparison with CTCA. Segments were classified as normal (smooth parallel or tapering borders), as having non-significant disease (wall irregularities or <50% stenosis), or as having significant stenosis (stenosis ≥50%). Stenoses were evaluated in 2 orthogonal views, and were classified as significant if the mean lumen diameter reduction exceeded 50% as measured by validated QCA algorithm (CAAS, Pie Medical, Maastricht, the Netherlands).

**CT image evaluation.** One observer analyzed total calcium scores of all patients with dedicated software, and results were expressed as Agatston score (11). Two experienced observers, a radiologist and a cardiologist, unaware of the results of CCA, evaluated the CTCA datasets on an offline workstation (Leonardo, Siemens, Forchheim, Germany). The axial slices were initially evaluated for the presence of significant segmental disease, and additionally (curved) multi-planar reformatted reconstructions were used. Segments distal to a chronic total occlusion were excluded because of poor distal filling by collaterals. Inter-observer disagreements were resolved by consensus in a joint session.

**Statistical analysis.** The diagnostic performance of CTCA for the detection of significant stenoses in the coronary arteries with QCA as the standard of reference is presented as sensitivity, specificity, positive and negative predictive values with the corresponding 95% confidence intervals (CIs). Positive (Sensitivity/[1-Specificity]) and negative ([1-Sensitivity]/Specificity) likelihood ratios are given. The likelihood ratio incorporates both the sensitivity and specificity of a test and provides a direct estimate of how much a test result will change the odds of having a disease. Post-test odds can be calculated by multiplying the pre-test odds by the likelihood ratios.

Comparison between CTCA and QCA was performed on 3 levels: patient–by–patient, vessel–by–vessel, and segment–by–segment analysis. Furthermore, the relation of angina pectoris to angiographically significant CAD was analyzed.

A subanalysis was performed for patients with aortic stenosis compared to other valve pathology and patients

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**Table 1. Patient Inclusion**

| Patient population after CTCA exclusion criteria | 110 |
| Hospitalization in community hospital | 4 |
| Percutaneous coronary intervention | 4 |
| Coronary artery bypass graft | 1 |
| No conventional angiogram | 4 |

| Patient population after general exclusion criteria | 97 |
| Refusal of informed consent | 27 |

CTCA = computed tomography coronary angiogram.
with or without angina pectoris. An unpaired 2-sided Student t test was performed to reveal possible differences in age, calcium score, and heart rate during the CTCA between both groups. A p value <0.05 was considered statistically significant.

An additional sensitivity analysis was done to investigate the effect of nesting; repeated assessments (segment by segment and vessel by vessel) within the same patient were made that were not independent observations. Interobserver and intraobserver variability for the detection of significant coronary stenosis was determined by \( \chi^2 \)-statistics.

**RESULTS**

Patient demographics are shown in Table 2. One patient had combined valve pathology: aortic stenosis and mitral regurgitation. Beta-blockers were administered in 71% of patients, and 64% received lorazepam. The mean heart rate in these patients dropped within 60 min from 73 ± 12 to 60 ± 8 beats/min. The mean scan time was 12.8 ± 1.3 s.

Initially all datasets were reconstructed in the mid- to end-diastolic phase. In 30% of the cases (21 of 70), additional higher-quality reconstructions from data of the end-systolic phase were used.

### Table 2. Patient Demographics (n = 70)

| Age (yrs)* | 63 ± 11 (35–80) |
| Aortic stenosis (yrs)* | 68 ± 8 (44–80) |
| Other valve pathology (yrs)* | 59 ± 11 (35–80) |
| Males | 49/70 (70) |

### Symptoms

- Angina pectoris: 21 (30)
- No angina pectoris: 49 (70)
- Previous MI: 5 (7)

### Risk factors

- Hypertension: 33 (47)
- Hypercholesterolemia: 29 (41)
- Diabetes mellitus: 2 (3)
- Smoker: 15 (21)
- Ex-smoker: 4 (6)
- Family history of CAD: 26 (37)
- Obese (body mass index ≥30 kg/m²): 11 (16)
- Calcium score, median†: 214.4
- Aortic stenosis, median†: 391.9
- Other valve pathology, median†: 116.6

### Valve operation

- Aortic valve stenosis: 31 (44)
- Mitral valve insufficiency: 24 (34)
- Aortic valve insufficiency: 9 (13)
- Mitral valve stenosis: 2 (3)
- Pulmonary valve insufficiency: 2 (3)
- Congenital aortic stenosis: 2 (3)
- Tricuspid valve insufficiency: 1 (1)
- Tricuspid valve stenosis: 1 (1)
- Reoperation: 6 (9)

### Conventional angiography

- Absence of coronary disease: 17 (24)
- Non-significant disease: 35 (50)
- Single-vessel disease: 11 (16)
- Multivessel disease: 7 (10)

### Table 3. Diagnostic Performance and Predictive Value of 64-Slice CTCA for the Detection of ≥50% Stenosis on QCA

<table>
<thead>
<tr>
<th>Prevalence of Disease, %</th>
<th>n</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Kappa</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
<th>LR⁺</th>
<th>LR⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient-based analysis</td>
<td>25.7</td>
<td>70</td>
<td>48</td>
<td>8</td>
<td>48</td>
<td>0</td>
<td>0.86</td>
<td>100 (78–100)</td>
<td>92 (81–98)</td>
<td>92 (81–98)</td>
<td>99 (97–100)</td>
<td>30.00</td>
</tr>
<tr>
<td>Vessel-based analysis</td>
<td>9.3</td>
<td>280</td>
<td>26</td>
<td>8</td>
<td>246</td>
<td>0</td>
<td>0.89</td>
<td>100 (66–100)</td>
<td>97 (94–99)</td>
<td>97 (94–99)</td>
<td>99 (97–100)</td>
<td>31.75</td>
</tr>
<tr>
<td>RCA</td>
<td>14.3</td>
<td>70</td>
<td>10</td>
<td>2</td>
<td>58</td>
<td>0</td>
<td>0.89</td>
<td>100 (66–100)</td>
<td>97 (94–99)</td>
<td>97 (94–99)</td>
<td>99 (97–100)</td>
<td>30.00</td>
</tr>
<tr>
<td>LM</td>
<td>14.3</td>
<td>70</td>
<td>10</td>
<td>2</td>
<td>58</td>
<td>0</td>
<td>0.89</td>
<td>100 (66–100)</td>
<td>97 (94–99)</td>
<td>97 (94–99)</td>
<td>99 (97–100)</td>
<td>30.00</td>
</tr>
<tr>
<td>Cx</td>
<td>8.6</td>
<td>70</td>
<td>6</td>
<td>3</td>
<td>64</td>
<td>0</td>
<td>1.00</td>
<td>100 (52–100)</td>
<td>100 (93–100)</td>
<td>100 (52–100)</td>
<td>100 (93–100)</td>
<td>100.00</td>
</tr>
<tr>
<td>Segment-based analysis</td>
<td>3.6</td>
<td>1003</td>
<td>34</td>
<td>49</td>
<td>949</td>
<td>18</td>
<td>0.76</td>
<td>94 (80–99)</td>
<td>98 (97–99)</td>
<td>65 (51–78)</td>
<td>100 (99–100)</td>
<td>50.74</td>
</tr>
<tr>
<td>Patient-based sub-analysis</td>
<td>38.1</td>
<td>21</td>
<td>8</td>
<td>12</td>
<td>12</td>
<td>0</td>
<td>0.90</td>
<td>100 (60–100)</td>
<td>92 (62–100)</td>
<td>92 (62–100)</td>
<td>99 (97–100)</td>
<td>30.00</td>
</tr>
<tr>
<td>AP</td>
<td>20.4</td>
<td>41</td>
<td>9</td>
<td>3</td>
<td>32</td>
<td>0</td>
<td>0.93</td>
<td>100 (66–100)</td>
<td>93 (66–100)</td>
<td>93 (66–100)</td>
<td>99 (97–100)</td>
<td>31.75</td>
</tr>
<tr>
<td>No AP</td>
<td>29.0</td>
<td>40</td>
<td>19</td>
<td>3</td>
<td>27</td>
<td>0</td>
<td>0.79</td>
<td>100 (60–100)</td>
<td>98 (80–100)</td>
<td>98 (80–100)</td>
<td>100 (99–100)</td>
<td>31.75</td>
</tr>
<tr>
<td>No AS</td>
<td>23.1</td>
<td>39</td>
<td>9</td>
<td>3</td>
<td>32</td>
<td>0</td>
<td>0.93</td>
<td>100 (60–100)</td>
<td>98 (63–100)</td>
<td>98 (63–100)</td>
<td>100 (99–100)</td>
<td>31.75</td>
</tr>
</tbody>
</table>

According to the 17-segment modified American Heart Association classification, 1,003 segments and 280 vessels visualized with conventional angiography were included for segment and vessel analysis, respectively. For patient-based analysis 70 patients were included, which were divided according to symptoms of AP. Sub-analysis for AS (n = 31) and other valve pathology is described. Values in parentheses represent 95% CIs.

**Abbreviations:** AP = angina pectoris; AS = aortic stenosis; CI = confidence interval; Cx = circumflex coronary artery; FN = false negative; FP = false positive; LR⁺ = positive likelihood ratio; LR⁻ = negative likelihood ratio; other abbreviations as in Table 1.
Diagnostic performance of 64-slice CT coronary angiography: patient-by-patient analysis. The diagnostic performance of CTCA for detecting significant stenoses on a patient-based analysis is detailed in Table 3. Computed tomography coronary angiography documented absence of significant disease in 48 patients, for an overall specificity per patient of 92% (Fig. 1). The severity of a stenosis was overestimated in 4 patients who were misclassified as having significant CAD. The CTCA correctly identified significant disease in all patients (18 of 70, prevalence 25.7%) with at least 1 significant stenosis, resulting in a sensitivity per patient of 100% (Fig. 2). An accurate determination of the presence or absence of significant CAD was made in 66 of 70 patients (94%). In 3 of 11 patients with single-vessel disease, another stenosis was detected with CTCA. The severity of these stenoses was overestimated, which resulted in incorrect classification as multivessel disease. Agreement between CTCA and QCA on a per-patient level was very good (κ value, 0.86); agreement between both techniques for classifying patients as having no, single-vessel, or multivessel disease was good (κ value, 0.78).

Diagnostic performance of 64-slice CT coronary angiography: vessel-by-vessel analysis. The mean total per-vessel calcium scores for the left anterior descending coronary artery (LAD), right coronary artery (RCA), and circumflex coronary artery were 96.72, 47.89, and 40.22, respectively. The diagnostic performance of CTCA for detecting significant stenoses is detailed in Table 3. All vessels with significant disease, as classified by QCA, were detected with CTCA. Of a total of 280 vessels, the severity of the stenoses in these 8 vessels, 6 in the LAD and 2 in the RCA, were overestimated and scored as false positives. Agreement between CTCA and QCA on a per-vessel level was very good (κ value, 0.85).
Diagnostic performance of 64-slice CT coronary angiography: segment-by-segment analysis. A total of 1,003 segments were included for comparison with QCA. Inter- and intraobserver variability for detection of a significant stenosis per segment had a $\kappa$ value of 0.71 and 0.74, respectively. The diagnostic performance of CTCA for detecting significant stenoses is detailed in Table 3. Two significant stenoses were detected by CTCA, but the severity of the stenosis was underestimated. Both lesions were adjacent to a correctly detected stenosis. Eighteen non-significant stenoses were detected with CT, and the severity of the stenoses was overestimated, resulting in false positive scores. Conventional coronary angiography revealed 5 wall irregularities and 13 non-significant stenoses, whereas the majority (83.3%, 15 of 18) of these segments were calcified.

The presence of coronary calcium induced overestimation of the severity of these stenoses with the CT scan (Table 4). Agreement between CTCA and QCA on a per-segment level was good ($\kappa$ value, 0.76).

To exclude the possible confounding effect of nesting, random selection of a single segment per patient was done,
and the diagnostic accuracy for detecting significant artery disease resulted in a sensitivity of 100% (5 of 5; 95% CI 46 to 100), a specificity of 98% (63 of 64; 95% CI 90 to 100), a positive predictive value of 83% (5 of 6; 95% CI 36 to 99), and a negative predictive value of 100% (63 of 63; 95% CI 93 to 100).

**Sub-analysis for patients with aortic stenosis versus other valve pathology.** The sub-analysis comprised 31 patients with aortic stenosis and 39 with other valve pathology. The diagnostic performance of CTCA for detecting significant stenoses on a patient-based analysis in patients with and without aortic stenosis is detailed in Table 3. The average age (68 vs. 59 years; \( p < 0.0004 \)) and calcium score (391.9 vs. 116.6; \( p < 0.02 \)) of patients with aortic stenosis were significantly higher than in patients not having aortic stenosis (Table 2). The heart rate during CTCA for both groups was the same (both 60 beats/min).

**The relation of angina pectoris to significant CAD.** The discordance between angina pectoris and the presence of significant CAD is displayed in Figure 3. Twenty-one patients had angina pectoris; 8 of these had significant obstructive disease. Moreover, 10 patients of 49 without angina pectoris did have significant stenoses. The diagnostic accuracy for angina pectoris was calculated, and the sensitivity, specificity, and positive and negative predictive values were 44% (8 of 18; 95% CI 22 to 67), 75% (39 of 52; 95% CI 61 to 86), 38% (8 of 21; 95% CI 19 to 61), and 80% (39 of 49; 95% CI 65 to 89), respectively.

**DISCUSSION**

The presence of concomitant obstructive CAD in patients undergoing cardiac valvular surgery worsens prognosis (12–14). Various studies have shown that combined valve and bypass surgery of significant CAD reduced early and late mortality (13,15). Because aortic stenosis and CAD share common risk factors and occur with advancing age, and because mitral regurgitation is often the consequence of CAD, concomitant, significant CAD is found in approximately one-third of these patients (16–19). Angina pectoris is present in 25% to 35% of patients with valvular heart disease. Angina pectoris is a poor predictor of obstructive CAD in patients with valvular disease because angina pectoris can have multiple causes, such as left ventricular enlargement, increased wall stress, or wall thickening with subendocardial ischemia (17,20). This was also shown in our study, and the low sensitivity of 44% and specificity of 75% are in keeping with the results observed in earlier reports. The value of non-invasive ECG stress testing to detect concomitant CAD is limited because of the presence of left ventricular hypertrophy and left bundle branch block in patients with valvular disease. Resting or exercise-induced wall motion abnormalities and myocardial perfu-

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**Table 4. Influence of Coronary Calcifications on Diagnostic Accuracy of 64-Slice CTCA on a Segment-Based Analysis**

<table>
<thead>
<tr>
<th>Calcium Score</th>
<th>( n ) (Patients)</th>
<th>( n ) (Segments)</th>
<th>Agatston Score, Mean (±SD)</th>
<th>TP</th>
<th>TN</th>
<th>FP</th>
<th>FN</th>
<th>Kappa</th>
<th>Sensitivity, %</th>
<th>Specificity, %</th>
<th>PPV, %</th>
<th>NPV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–10</td>
<td>23</td>
<td>338</td>
<td>0.3 ± 0.9</td>
<td>0</td>
<td>338</td>
<td>0</td>
<td>0</td>
<td>—</td>
<td>100 (99–100)</td>
<td>—</td>
<td>100 (99–100)</td>
<td></td>
</tr>
<tr>
<td>11–400</td>
<td>33</td>
<td>465</td>
<td>184 ± 131</td>
<td>15</td>
<td>443</td>
<td>7</td>
<td>0</td>
<td>0.80</td>
<td>98 (97–99)</td>
<td>68 (45–85)</td>
<td>100 (99–100)</td>
<td></td>
</tr>
<tr>
<td>401–1,000</td>
<td>10</td>
<td>146</td>
<td>675 ± 23</td>
<td>16</td>
<td>124</td>
<td>5</td>
<td>1</td>
<td>0.82</td>
<td>94 (69–100)</td>
<td>96 (91–99)</td>
<td>76 (52–91)</td>
<td>99 (95–100)</td>
</tr>
<tr>
<td>&gt;1,000</td>
<td>4</td>
<td>54</td>
<td>1,394 ± 2,73</td>
<td>3</td>
<td>44</td>
<td>6</td>
<td>1</td>
<td>0.40</td>
<td>75 (22–99)</td>
<td>88 (75–95)</td>
<td>33 (9–69)</td>
<td>98 (87–100)</td>
</tr>
</tbody>
</table>

Values in parentheses represent 95% CIs.
Abbreviations as in Tables 1 and 3.
sion abnormalities, as seen with stress echo and nuclear tests, lack sufficient accuracy for reliable detection of concomitant CAD (21–24).

Because of the poor predictive value of angina pectoris and the lack of accuracy of non-invasive tests, the following guideline is recommended by the American College of Cardiology/AHA committee: pre-operative CCA is indicated in symptomatic patients and/or those with left ventricular dysfunction in men ≥35 years, pre-menopausal women ≥35 years with risk factors for CAD, and post-menopausal women (1).

Non-invasive coronary angiography using 4- and 16-slice CT is a relatively recent development. The early results were promising but lacked sufficient robustness to be useful in clinical practice, but the diagnostic performance of 64-slice CT scanners to detect coronary stenoses is very good in patients who have a high prevalence (more than 70%) of CAD. In these patients the negative predictive value of 64-slice CT scanners is very high, allowing one to exclude the presence of significant CAD (3–6). However, there is little information about the diagnostic performance of CTCA in patients with a low or intermediate prevalence of CAD.

In our study, the prevalence of concomitant CAD was 25.7%. We found that significant coronary stenoses were detected using a 64-slice CT scanner with a sensitivity of 100% and a specificity of 92% compared with CCA. A negative CT scan was correct in 92% (48 of 52) patients in ruling out significant disease, and all patients (18 of 18) with significant CAD were correctly diagnosed. The stenosis severity was overestimated in 4 patients using CTCA. Given the high reliability of CTCA, this would mean that CCA could have been avoided in 69% (48 of 70) of patients; in 26% (18 of 70) a CCA was performed to confirm the CTCA diagnosis, and in 6% (4 of 70) an unnecessary CCA would have been performed on the basis of CTCA outcome.

Coronary calcium. The presence of calcium causes problems in the correct interpretation of the CTCA. Calcium creates blooming artifacts, which obscure the visualization of the underlying non-calcified plaque or lumen. Calcium tends to overestimate the severity of adjacent lesions, either because of the blooming effect itself or because, in the case of doubt or fear of “missing” a significant stenosis, a “defensive” scoring is exercised. This has led to an ongoing debate as to whether a CTCA should be aborted when the calcium score exceeds a certain threshold. A generally accepted cutoff value is lacking, and proposed thresholds are arbitrarily chosen. Usually a chosen cutoff level is derived from the total calcium score. The total calcium score is somewhat misleading, because calcium distributed along the entire coronary tree would make the interpretation of a CTCA examination relatively easy, whereas a single heavily calcified plaque would make interpretation doubtful.

Recently, Gilard et al. (25) reported good accuracy of a 16-slice scanner in 55 patients referred for elective aortic valve surgery who had a mean calcium score of 609 ± 860. They used the Agatston score of ≥1,000 as a cutoff point by showing that patients with this score had a higher frequency of non-interpretable segments. In our subgroup of patients with aortic stenosis we also found, not unexpectedly, a higher calcium score. In this subgroup, the diagnostic accuracy of CTCA was lower because the extensive calcifications negatively influenced grading of stenoses and resulted in overestimation of the stenosis severity.

What would be the role of CTCA in patients referred for CCA before cardiac valve surgery? We do recommend to first obtaining a calcium score in all patients without atrial fibrillation, persistent irregular heart rhythm, or renal dysfunction. If the calcium score is ≥1,000, we would advise not to proceed with CTCA. If lower, patients may be advised to undergo CTCA. Patients with a scan negative for significant CAD can directly be referred for cardiac valve surgery. In case of doubt, and in the presence of significant CAD, a confirmative CCA is required to either confirm or refute the presence of significant CAD.

Heart rate reduction in patients with heart rates >65 beats/min is part of the protocol used with current 64-slice CT scanners to increase image quality. Next-generation dual-source CT scanners will allow scanning at higher heart rates because of the improved temporal resolution of 83 ms, thereby avoiding the use of heart-rate reduction with beta-blockers (26,27). Especially, patients with severe aortic stenosis would benefit, since the administration of beta-blockers is limited. The radiation exposure can be decreased with the ultrafast dual-source CT scanner during higher heart rates and use of X-ray tube modulation compared to 64-slice CT scanning.

Study limitations. The presence of atrial fibrillation, which occurs frequently with mitral valve disease, precludes the use of CTCA and was indeed a significant reason for exclusion in our study. Only patients scheduled for elective valve surgery were screened, and patients in acute settings with hemodynamic compromise were not studied. Since most patients were referred from community hospitals for valve surgery, the pre-operative diagnostic work-up, including the CCA, was performed in many study patients. This may have created a bias, although the CT scoring was done blinded to the coronary angiogram. The rather high radiation exposure from CTCA as compared to CCA is of concern (7,8). The radiation exposure can be reduced by 50% with use of prospective X-ray tube current modulation (28). However, this limits the possibility of reconstructing valuable datasets during the end-systolic phase (29). In our study, we found that in 30% of the patients, end-systolic phase reconstructions were useful and were of higher image quality than the mid- to end-diastolic–phase reconstructed images.

Conclusions. The diagnostic accuracy of 64-slice CTCA for ruling out the presence of significant coronary lesions in patients undergoing elective valve surgery is excellent and...
allows CTCA implementation as a gatekeeper in these patients.

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