Non-invasive computed tomographic coronary angiography: the end of the beginning

Axel Schmermund* and Raimund Erbel

Department of Cardiology, University Clinic Essen, Germany

Online publish-ahead-of-print 11 May 2005

This editorial refers to ‘Accuracy of MSCT coronary angiography with 64-slice technology: first experience’ by S. Leschka et al., on page 1482

One of the favourite questions in cardiologists’ meetings involving modern imaging modalities concerns the future of cardiac multidetector computed tomography (MDCT) vs. magnetic resonance tomography (CMRT)—which one of the two techniques will win the race and will be the modality of the future? Obviously, future technical developments are difficult to foresee. The current status is that CMRT, using no radiation and non-toxic amounts of contrast media, is preferred for the diagnostic workup of the myocardium (including cardiac chamber volumes, regional and global contractility, right ventricular regional function, scar tissue, and perhaps perfusion). MDCT, using radiation and increasingly smaller amounts of toxic contrast media, is preferred for imaging of the coronary arteries. Given the technical fundamentals, it is highly unlikely that MDCT will ever assume a more prominent role in any other aspect of cardiac function and morphology, that is, any aspect but the coronary arteries. Over the past few years, we have seen a spectacular development of image quality obtained by using MDCT for visualizing the coronary arteries. Of course, usually, only the best images are shown. However, it is justified to assume that with the continuous improvement of the top-quality images, the average-quality ‘everyday’ images are also improving. This assumption is substantiated by an analysis of published data on the diagnostic accuracy of MDCT for detecting high-grade coronary stenosis. Table 1 presents an overview of recent publications using 16-slice MDCT with different tube rotation times.

There is a clear tendency for a reduced proportion of coronary segments whose image quality precludes evaluation. This had been a major criticism with earlier generations of CT machines (electron-beam CT and 4-slice MDCT). With the dissemination and further development of 16-slice MDCT, investigators have become more and more ambitious in including even small (~1.5 mm) distal arterial segments and side branches. Probably, the introduction of a lighter-weight high-power X-ray tube last year, which lends itself to rotation times <400 ms has accelerated this process. Several independent groups have published comparable results regarding the detection of coronary stenoses. Within this spectrum, we believe much of the remaining variability is due to differences in patient selection, patient preparation, and image analysis. For optimal results, it is indispensable to select patients who can reach a reasonably low heart rate, hold their breath and follow the instructions, and have no previous stent implantation or massive coronary calcification. Obviously, CT technology and protocols may also be important. The vast majority of published data were obtained using machines from one vendor (Siemens Medical).

Because of a radiation exposure estimated to measure ~10 mSv, the examination should only be performed in the expectation of diagnostic images. We believe it is necessary to liberally give beta-blockers to lower the heart rate to ≤60 b.p.m. We also believe vasodilatory nitrates should be administered prior to the examination (in analogy to invasive coronary angiography). Finally, image analysis requires a dedicated workstation and considerable experience. It is useful to remember that threedimensional reconstructions will only use the information inherent in the source images. Smoothing algorithms can mask a circumscribed stenosis. Wonderful three-dimensional images notwithstanding the source images provide for diagnostic quality.

The report by Leschka et al. is the first to have utilized a new generation of 64-slice CT machines. All coronary segments ≥1.5 mm were included in the analysis, although the authors did not give additional beta-blockers. The mean heart rate was 66 b.p.m. No nitrates were administered. The authors used a 64-slice CT machine with 32 detector rows and a technology employing an oscillating electron beam to produce two parallel X-ray beams (‘z-spot technology’). The tube rotation time was 370 ms. As it happens in this technology-driven setting, the actual CT machines of this type currently have an even faster rotation time of 330 ms. The study did not aim to evaluate certain indications for non-invasive angiography but rather tested the approach in consecutive patients referred because of suspected coronary artery disease or prior to coronary
bypass surgery. Accordingly, 47 of the 67 patients (70%) had at least one high-grade coronary stenosis, and almost half of the patients (n = 33) had coronary three-vessel disease. On a coronary segmental level, invasive coronary angiography revealed a total of 176 stenoses. Non-invasive MDCT angiography correctly detected 165 of the 176 stenoses. On a per-segment basis, overall sensitivity was 94% and specificity was 97%. Most of the stenoses which were missed (n = 33) had coronary three-vessel disease. Non-invasive MDCT angiography correctly detected 165 of the 176 stenoses. On a per-segment basis, overall sensitivity was 94% and specificity was 97%. Most of the stenoses which were missed (n = 8) were located in severely calcified segments. Motion artefacts were responsible for three false-negative findings and were, as is typical, mostly observed in the mid right coronary artery. Further heart rate reduction might have even improved this outcome. Most of the 24 false-positive findings were related to severe calcification. Of note, no lesion in the left main or proximal left anterior descending coronary artery was missed, and the false-positive findings also mainly concerned distal arteries or side branches. Finally, on a per-patient basis, all patients with at least one significant stenosis were correctly identified, and no patient without significant stenosis was incorrectly classified as having significant disease by MDCT.11 From a clinical perspective, diagnostic quality thus appeared to be very useful. The results need to be interpreted with caution, because only 20 patients had no high-grade stenoses, and it is unclear whether the current cohort is at all representative of patients examined at other centres. Nevertheless, given the progressively more favourable results published by several groups (Table 1), the current report fits the picture and confirms our impression that specialized centres increasingly use non-invasive CT angiography for clinical indications.

Is it justified at this time to perform non-invasive CT angiography for detection of coronary stenoses outside of clinical studies? We believe it is, if used in a knowledgeable fashion, with up-to-date technology, and with very careful patient selection.12 It needs to be always kept in mind that only patients in whom invasive coronary angiography is contemplated can benefit from non-invasive CT coronary angiography. There must be a reasonable suspicion of high-grade coronary stenoses. The test makes no sense if used in asymptomatic patients with no signs of (exercise-induced) myocardial ischaemia. In contrast, if there is a high degree of suspicion, the test also does not make sense. The patient should go straight to the catheterization laboratory if it is judged probable that revascularization will be necessary. However, every invasive cardiologist is confronted with patients who have a relatively low probability of significant coronary artery stenoses but are referred for 'rule-out’ coronary angiography. Examples include patients with no cardiovascular risk factors who have findings suspicious for exercise-induced ischaemia or patients with atypical symptoms who cannot undergo stress testing for various reasons. Additionally, it can be very difficult to exclude an important stenosis on clinical grounds in some patients, for example, in women with hypertensive heart disease who have angina (sometimes typical) and ECG-changes. Such patients with some suspicion of significant coronary artery disease, but a low-to-moderate pre-test probability, might be good candidates for non-invasive MDCT coronary angiography. Table 2 lists evolving indications for non-invasive MDCT coronary angiography. The diagnostic quality of this method is rapidly improving. The current article by Leschka et al.11 is only the latest demonstration of this tendency.

Indeed, there is a very dynamic development of CT technology, which in our view strengthens the position of this method and portends an enormous potential for future applications. Already at this time, it has overcome the most ardent limitations it had during the first few years, namely, problems with temporal and spatial resolution. In addition, only 60–80 mL of iodinated contrast media is needed. Unfortunately, the issue of the relatively high radiation dose remains. However, if used in well-selected patients, we believe the method has a valuable diagnostic yield.

### Table 1 Reports on the diagnostic performance of 16-slice (and–see Leschka et al.11 64-slice) MDCT

<table>
<thead>
<tr>
<th>First author (reference)</th>
<th>Year of publication</th>
<th>Tube rotation time (ms)</th>
<th>Number of patients</th>
<th>Mode of analysis</th>
<th>Vessel size (mm)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Not evaluable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nieman1</td>
<td>2002</td>
<td>420</td>
<td>59</td>
<td>Per-artery</td>
<td>2.0</td>
<td>95</td>
<td>86</td>
<td>7</td>
</tr>
<tr>
<td>Ropers2</td>
<td>2003</td>
<td>420</td>
<td>77</td>
<td>Per-artery</td>
<td>1.5</td>
<td>93</td>
<td>92</td>
<td>12</td>
</tr>
<tr>
<td>Martuscelli3</td>
<td>2004</td>
<td>500</td>
<td>64</td>
<td>Per-artery</td>
<td>1.5</td>
<td>89</td>
<td>98</td>
<td>16</td>
</tr>
<tr>
<td>Mollet4</td>
<td>2004</td>
<td>420</td>
<td>128</td>
<td>Per-segment</td>
<td>2.0</td>
<td>92</td>
<td>95</td>
<td>—</td>
</tr>
<tr>
<td>Hoffmann5</td>
<td>2004</td>
<td>420</td>
<td>33</td>
<td>Per-segment</td>
<td>Proximal and mid segments</td>
<td>89</td>
<td>95</td>
<td>—</td>
</tr>
<tr>
<td>Kuettner6</td>
<td>2005</td>
<td>370</td>
<td>72</td>
<td>Per-segment</td>
<td>All segments</td>
<td>82</td>
<td>98</td>
<td>7</td>
</tr>
<tr>
<td>Mollet7</td>
<td>2005</td>
<td>370</td>
<td>51</td>
<td>Per-artery</td>
<td>2.0</td>
<td>95</td>
<td>98</td>
<td>—</td>
</tr>
<tr>
<td>Morgan-Hughes8</td>
<td>2005</td>
<td>500</td>
<td>57</td>
<td>Per-segment</td>
<td>All segments</td>
<td>83</td>
<td>97</td>
<td>—</td>
</tr>
<tr>
<td>Achenbach9</td>
<td>2005</td>
<td>370</td>
<td>50</td>
<td>Per-segment</td>
<td>1.5</td>
<td>93</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>Leschka11</td>
<td>2005</td>
<td>370</td>
<td>67</td>
<td>Per-segment</td>
<td>1.5</td>
<td>94</td>
<td>97</td>
<td>—</td>
</tr>
</tbody>
</table>

### Table 2 Evolving indications for non-invasive MDCT coronary angiography

- Patients with suspected congenital or acquired coronary anomalies, in particular anomalous coronary origin and coronary course in relation to the great vessels
- Asymptomatic high-risk patients or patients with atypical or stable angina who have inconclusive exercise stress test results
- cannot undergo exercise stress testing
- need to undergo major noncardiac surgery
- Patients in whom invasive coronary angiography was unable to selectively find a major coronary artery or bypass graft
Thus, it has reached the end of the beginning and finds itself at the threshold of clinical application.

References