Direct Comparison of Whole-Heart Navigator-Gated Magnetic Resonance Coronary Angiography and 40- and 64-Slice Multidetector Row Computed Tomography to Detect the Coronary Artery Stenosis in Patients Scheduled for Conventional Coronary Angiography

Anne-Catherine Pouleur, MD; Jean-Benoît le Polain de Waroux, MD; Joëlle Kefer, MD; Agnès Pasquet, MD; Jean-Louis Vanoverschelde, MD; Bernhard L. Gerber, MD

Background—Both whole-heart magnetic resonance coronary angiography (WH-MRCA) and multidetector computed tomography (MDCT) have been proposed for the noninvasive identification of the coronary stenosis. The authors sought to directly compare the diagnostic accuracy of these noninvasive imaging techniques using the invasive quantitative coronary angiography as a reference standard.

Methods and Results—Seventy-seven consecutive patients (56 men, 61 ± 14 years) prospectively underwent WH-MRCA and 40- or 64-slice MDCT before the quantitative coronary angiography. Diagnostic accuracy of WH-MRCA and MDCT for the visual identification of 50% diameter stenosis in segments of ≥1.5 mm size was compared using the quantitative coronary angiography as a reference. According to the quantitative coronary angiography, 49 of 992 coronary segments ≥1.5 mm diameter had ≥50% diameter stenosis. MDCT had a higher success rate (100% versus 88%, *P* < 0.001) and enabled identification of more segments (963 versus 726, *P* < 0.001) than did WH-MRCA. On a per-segment basis, WH-MRCA had similar sensitivity (47/49 or 96% versus 48/49 or 98%, *P* = 0.9) but significantly lower specificity (644/943 or 68% versus 863/943 or 92%, *P* < 0.001) and accuracy (691/992 or 70% versus 911/992 or 92%, *P* < 0.001) for the detection of ≥50% diameter stenosis than did MDCT. On a per-patient basis, the sensitivity was similar (17/17 or 100% versus 16/17 or 94%, *P* = 0.9), but specificity (43/60 or 72% versus 53/60 or 88%, *P* = 0.024) and diagnostic accuracy (60/77 or 78%, versus 69/77 or 90%, *P* = 0.044) of WH-MRCA for the detection of ≥50% diameter stenosis were significantly lower than of MDCT.

Conclusions—Because of the higher success rate and higher number of interpretable segments, 40- or 64-slice MDCT performs better than WH-MRCA. (Circ Cardiovasc Imaging. 2008;1:114-121.)

Key Words: contrast media ■ coronary disease ■ magnetic resonance imaging ■ tomography, computed

Both multidetector computed tomography (MDCT) and magnetic resonance coronary imaging (MRCA) have been proposed for the direct noninvasive visualization of the coronary artery disease (CAD). So far, only few studies have directly compared the diagnostic accuracy of these 2 techniques. In 2 initial studies, we compared early 4- and 16-slice MDCT technique with navigator-gated MRCA with localized acquisition of coronary arteries. In this work, excluding nonevaluable segments, both tests had similar high diagnostic accuracy. In contrast, in another study comparing a 16-slice MDCT with breath-hold or navigator-gated MRCA—and performed on an intention to diagnose basis, thus considering absent and nonevaluable studies and segments as false-positives or -negatives—16-slice MDCT was superior to MRCA.

Since then, the field of noninvasive coronary imaging techniques has seen a further spectacular development. The latest generation of 64-slice MDCT scanners has even higher spatial and temporal resolution, which results in a significantly better image quality. As a result, it was reported that this technique has >90% sensitivity and specificity for detecting the CAD on per-segment and per-vessel basis. Regarding MRCA, the most recent improvement was the advent of whole-heart MRCA (WH-MRCA). With this approach, instead of localizing each coronary artery individually on thin slices, a single large axial prescription encompassing the entire heart is acquired. This 3D image stack is

© 2008 American Heart Association, Inc.

Circ Cardiovasc Imaging is available at http://circimaging.ahajournals.org DOI: 10.1161/CIRCIMAGING.107.756304

114
then similar to MDCT postprocessed using multiplane curved reformatting to visualize the coronary arteries. This approach substantially simplified and shortened the localization and prescription phase of the MRCA. It also allows a better visualization of twisting coronary segments, especially of small branch vessels. Several recent studies reported that WH-MRCA might have diagnostic accuracies rivaling those of MDCT16–19; however, direct comparison of WH-MRCA and MDCT has not been performed yet.

Therefore, the aim of this prospective study was to perform a head-to-head comparison of the diagnostic accuracy of the currently most advanced noninvasive state-of-the-art techniques for the detection of CAD, ie, WH-MRCA imaging versus 40- or 64-slice MDCT using conventional invasive coronary angiography as a reference standard. We, therefore, analyzed accuracy not only in the successfully completed and interpretable examinations but also on an “intention to diagnose,” ie, considering failed and uninterpretable examinations as if they had disease and thus positive (true or false).

**Methods**

**Study Design**

Consecutive patients referred to our institution for conventional diagnostic x-ray coronary angiography were prospectively considered for inclusion into this study. Only those patients who were in sinus rhythm and who had no prior revascularization procedure (no stent or bypass operation) were considered for inclusion into the study. Exclusion criteria were hemodynamic instability, constant arrhythmia (atrial fibrillation or more than 5 premature bpm), decompensated heart failure (New York Heart Association IV class), renal insufficiency (serum creatinine levels >1.4 mg/dL), known allergy to iodated contrast agents, or any contraindication to MRI (cerebral aneurysm clips, pacemaker, or severe claustrophobia). The study protocol was approved by the local Ethics Committee, and patients were included after giving written informed consent to study.

**Patient Population**

Between February 2005 and April 2006, 105 consecutive patients were prospectively screened for possible inclusion into this study. Twenty-one patients were excluded based on the exclusion criteria, and 7 refused to participate in the study (Figure 1). Thus, the final study group consisted of 77 patients (56 men; mean age, 61±14 years) (Table 1). Indications for cardiac catheterization in this population were as follows: typical angina and positive stress test in 14 patients, atypical chest pain or dyspnea and positive stress test in 5 patients, and chest pain and negative stress test in 4 patients. Forty-five patients were referred to evaluate coronary anatomy before noncoronary cardiac surgery or during evaluation of idiopathic cardiomyopathy. Pretest probability of CAD was computed based on history and risk factors.20,21 Patients underwent WH-MRCA and MDCT in random order on the same day. Both tests were performed at a median of 1 day (range, 0 to 30 days) before conventional coronary angiography.

**Whole-Heart MRCA**

WH-MRCA was performed on a 1.5-T system (Intera CV, Release 1.1, Philips Medical Systems) using a 5-element cardiac coil as previously described.16 After 3-plane survey images, a high-resolution transaxial cine balanced turbo field-echo scan (repetition time, 2.7 ms; echo time, 1.3 ms; flip angle, 60°; field of view, 380 mm; acquisition matrix, 256×256; cardiac phases, 50; echoplanar imaging factor, 1; turbo factor, 7) was acquired to visually determine the resting period of the right coronary artery. WH-MRCA images were acquired using a vectocardiogram-triggered, free-breathing navigator-gated multislice 3D segmented axial balanced turbo field-echo sequence with T2 preparation. Imaging parameters were as follows: flip angle, 90°; repetition time, 5.2 ms; echo time, 2.6 ms; field of view, 256 mm; and acquisition matrix, 256×256×160, resulting in an acquired voxel dimension of 1×1×1.5 mm³, which was reconstructed to 0.5×0.5×1.5 mm³. Images were acquired with a trigger delay and duration (15 to 25 lines in K-space acquired per heart beat, resulting in a temporal

![Figure 1. Study protocol.](image-url)
resolution varying between 75 and 125 ms) corresponding to the individually determined resting period of the right coronary artery. Images were navigator gated for respiratory motion by a navigator placed on the right diaphragmatic dome with a window of 5 mm and continuous drift correction. Image acquisition was interrupted if it lasted >30 minutes or if navigator efficiency was 0%.

Multidetector Row Coronary CT

MDCT was performed on a 40-slice (n = 56) or 64 (n = 21) system (Brilliance, Philips Medical Systems) as previously described.23 The onset of the coronary scan was timed by a bolus-tracking technique after an 80- to 120-mL injection (depending on length of scan) of nonionic contrast (400 mg I/mL, Iomeron, Bracco, Milan, Italy) at a rate of 4 mL/s, followed by a 60-mL saline bolus chaser. Tube rotation speed was 420 ms, detector collimation 40 or 64 × 0.66 mm, pitch 0.20 to 0.24, tube voltage 120 kV, and effective tube current 600/800 mAs. Images were reconstructed using a retrospective multisegment ECG gating algorithm using 1 to 4 cardiac cycles for reconstruction, with subsegment reconstruction angles varying between 45° and 180° and temporal resolution varying between 52 and 210 ms, depending on the patient’s heart rate. Spatial resolution was 0.6 mm³. Reconstruction image matrix was 512 × 512 pixels; field of view was 280 mm; and section thickness was 0.67 mm, with an increment of 0.33 mm. A medium hard kernel was used. In each patient, data sets were reconstructed at 75% as well as at every 10% of the cardiac cycle. ECG dose modulation was not used. The average radiation exposure was 14 ± 2 mSv (range, 9 to 18 mSv) as calculated from computed tomography dose index (CTDI) vol (40 mGy) and dose length product (DLP) (805 ± 134 mGy/cm) estimates. The data set containing the fewest motion artifacts was selected for surface projection and for quantitative analysis.

Coronary Angiography

Quantitative coronary angiography (QCA) served as the index test. Selective biplane coronary angiograms in multiple orthogonal projections were evaluated blindly by a single reviewer (J.K.) unaware of the MDCT and MRI results. The standard 16-segment American Heart Association classification system was used.23 QCA was performed on all coronary segments in 2 orthogonal views by a QCA using the Cardiovascular Angiographic Analysis System II software (QCA, Pie Medical Equipment, Switzerland) after catheter-based image calibration and automated vessel contour detection. All segments were measured, and only segments with a reference diameter >1.5 mm were evaluated. Segments with smaller diameter and segments distal to a proximal occlusion were considered to be absent. All visible stenoses were quantitatively evaluated. Diameter stenosis was computed by measuring a reference vessel and a minimal lumen diameter of the stenosis. Diameter stenosis >50% was considered significant.

MDCT and WH-MRCA Data Analysis

WH-MRCA and MDCT data sets were transferred to dedicated workstations (ViewForum 6.0 equipped with a prototype coronary visualization software and Brilliance Extended Workspace versus 1.06, respectively, both by Philips Medical Systems) for subsequent analysis. All patient information was removed, and images were interpreted visually by consensus of 2 blinded readers (A.C.P. and B.G.) unaware of the results of coronary angiography. To avoid interpretation bias, WH-MRCA and MDCT images were read at least 30 days apart. The MDCT data set containing the fewest motion artifacts was selected for interpretation. Image quality of MDCT and WH-MRCA images was graded independently by both readers on a 4-point ordinal Likert scale, where 1 = poor (nondiagnostic), 2 = moderate (diagnostic with poor visibility of the anatomic details of the coronary arteries), 3 = good (good visibility of the anatomic details of the coronary arteries), and 4 = excellent (excellent visibility and differentiation of the anatomic details of the coronary arteries). Contrast-to-noise ratio (CNR) was evaluated in nondiseased proximal coronary segments (proximal left main, midleft anterior descending, left circumflex, and right coronary artery) and computed as the difference in mean signal intensity between the vessel lumen and the adjacent tissue, divided by the standard deviation of the background noise in the proximal aorta.2 Interpretation of MDCT and WH-MRCA was done using curved planar reformations in various directions as well as maximum intensity projections on a curved surface (globe view). Using the same 16-segment AHA model as for QCA, both readers first determined by consensus reading which segments were visualized and then visually categorized the severity of diameter stenosis as being <50% or ≥50%. The reasons for false-positive and false-negative interpretations were investigated a posteriori by consensus reading.

Statistical Analysis

Continuous values are reported as mean ± standard deviation. Sample size was estimated using PASS 2005 for Windows (NCSS Co, Kaysville, Utah) for correlated proportions. We aimed at demonstrating a difference of 10% in the diagnostic accuracy between WH-MRCA (85%) and MDCT (95%) for an estimated prevalence of 40% CAD on per-vessel basis. This prevalence was based on a prevalence in a prior work.2 Using these computations, we estimated that at least 200 vessels, ie, 50 patients, were sufficient to demonstrate such significance at a power of >80% for an α level of 0.05.

Statistical analysis was performed using NCSS 2005 for Windows (NCSS Co) and SPSS 12.05 for Windows (SPSS Inc, Chicago, Ill) software. The diagnostic performance of WH-MRCA and MDCT for the visual detection of significant coronary artery stenosis was assessed for the consensus reading of the 2 reviewers using QCA as the standard of reference and is presented as sensitivity (probability that the test is positive when given to a group of patients with CAD), specificity (probability that the test will be negative among patients who do not have CAD), positive and negative predictive values, and accuracy (ability of the test to correctly identify all sick and well people). Sensitivity, specificity, and diagnostic accuracy of WH-MRCA and MDCT on per-segment, per-vessel, and per-patient basis were compared using McNemar’s χ² test. Analysis was performed by comparing tests on “intention to diagnose” basis (both failed studies and uninterpretable segments were considered as false or true positives, respectively).24 A vessel was considered diseased if it was presented at least 1 segment with a coronary stenosis ≥50%, and a patient was considered as having CAD if he or she had at least 1 vessel with a ≥50% stenosis. Tests were 2-sided, and P < 0.05 was considered as statistically significant. For the visual analysis and the image quality grading, the interobserver agreement was evaluated on segmented basis using the kappa statistic. Authors had full access to the data and take responsibility for its integrity. All authors have read and agreed to the manuscript as written.

Results

Study Protocol

The baseline characteristics of the study population are summarized in Table 1. Acquisition of WH-MRCA failed in 9 patients (12%) because of the poor navigator performance owing to the irregular breathing pattern or drift of the diaphragm position. In contrast, all 77 patients successfully completed MDCT. The duration of the complete WH-MRCA examination (including localization and plane prescription) was 20 ± 4 minutes (range, 15 to 27 minutes), whereas the comprehensive MDCT acquisition lasted 6 ± 2 minutes (range, 5 to 10 minutes). Forty-two (54%) patients received chronic β-blocker therapy before MDCT imaging. Mean heart rate during WH-MRCA (69 ± 15 bpm; range, 48 to 115 bpm) was similar to that during MDCT (68 ± 14 bpm; range, 45 to 120; P = 0.43; NS). Magnetic resonance angiograms were acquired during diastole in 53 patients (average heart rate, 65 ± 12 bpm; trigger delay, 605 ± 133 ms) and during
systole in 15 patients (average heart rate, 82±15 bpm; trigger delay, 268±38 ms). The optimal reconstruction window for MDCT was found at 75% of the cardiac cycle in 58 patients, at 50% of the cardiac cycle in 9 patients, and at 40% of the cardiac cycle in 10 patients. In 5 patients, more than 1 reconstruction window was used for a complete evaluation of the coronary tree.

Quantitative Coronary Angiography
According to QCA, 240 coronary segments were either anatomically absent or had <1.5 mm diameter. Details of the anatomy of the remaining 992 coronary segments with a reference luminal diameter ≥1.5 mm are shown in Table 2. Four patients had a single-vessel disease, 6 had a 2-vessel disease, 7 had a 3-vessel disease, and 60 were considered to be free of any significant CAD (Table 1).

Visualization of Coronary Arteries and Image Quality by WH-MRCA and MDCT
Typical sets of WH-MRCA, MDCT, and conventional angiographic images of the proximal coronary arteries are shown in Figure 2. Two hundred sixty-six of 992 coronary segments (27%) with a reference luminal diameter ≥1.5 mm by QCA were not available for evaluation by WH-MRCA; 119 of these segments belonged to the 9 patients in whom WH-MRCA acquisition failed. The remaining 147 segments were not visualized during interpretation. Most (113 or 77%) of these segments were small (diagonal, marginal, or posterolateral) branch vessels. In contrast, only 29 of the 992 coronary segments (3%, P<0.001 versus MDCT) with a reference luminal diameter ≥1.5 mm could not be visualized by MDCT (Table 2). Reproducibility of each technique was assessed in 15 randomly selected patients. The concordance between the readers was 83% (κ=0.83) for MDCT and 71% (κ=0.71) for WH-MRCA. MDCT had significantly higher contrast-to-noise ratio in all vessels (left main 9±3 versus 5±2; midleft anterior descending artery, 9±4 versus 4±2; midleft circumflex, 9±3 versus 5±2; and midright coronary artery, 10±3 versus 4±2; all comparisons P<0.001) than did WH-MRCA. Also, subjectively graded image quality of segments imaged by MDCT (3.7±0.6) was judged to be higher than that of WH-MRCA (2.5±1.6, P<0.001). Interobserver agreement for image quality grading was high for both techniques (κ=0.85 for MDCT and 0.81 for WH-MRCA).

Diagnostic Accuracy for Identification of CAD by WH-MRCA and MDCT
Diagnostic accuracies were calculated on per-segment (Figure 3), per-vessel (Figure 4), and per-patient (Figure 5) basis. On per-segment basis, sensitivity of both tests was equally high. In contrast, WH-MRCA had significantly lower specificity and diagnostic accuracy for detection of coronary stenosis than did MDCT. This was also true on a per-vessel basis.

For analysis on a per-patient basis, MDCT had a sensitivity of 94% (16/17), a specificity of 88% (53/60), and an accuracy of 90% (69/77), to correctly identify patients with CAD. WH-MRCA had an equally high sensitivity (17/17 or 100%, P=0.99 versus MDCT), lower specificity (43/60 or 72%, P=0.024 versus MDCT), and lower accuracy (60/77 or of 78%, P=0.044 versus MDCT) than MDCT.

Both WH-MRCA and MDCT had high negative predictive values on per-vessel, per-segment, and per-patient basis. Positive predictive values for both tests were, however, low on per-segment basis.

Table 2. Details of Evaluation of Segments by QCA, WH-MRCA, and MDCT

<table>
<thead>
<tr>
<th></th>
<th>QCA</th>
<th>WH-MRCA</th>
<th>MDCT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Segments</td>
<td>No. Absent</td>
<td>No. Not</td>
</tr>
<tr>
<td></td>
<td>&gt;1.5 mm</td>
<td>(Acquisition</td>
<td>Evaluable</td>
</tr>
<tr>
<td>Left Main</td>
<td>77</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Proximal</td>
<td>77</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Mid</td>
<td>77</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Distal</td>
<td>73</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Diagonal branches</td>
<td>84</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Proximal</td>
<td>75</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Distal</td>
<td>62</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Marginal branches</td>
<td>125</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>RCA</td>
<td>76</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Mid</td>
<td>75</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Distal</td>
<td>70</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>PDA/PL</td>
<td>121</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>992</td>
<td>49</td>
<td>119</td>
</tr>
</tbody>
</table>

LAD indicates left anterior descending artery; LCx, left circumflex; RCA, right coronary artery; PDA/PL, posterior descending artery/posterolateral branch.
Reason for False Interpretations

Reasons for false-negative and false-positive readings were analyzed a posteriori (Table 3). The main reasons for false-positive readings by MDCT were severe vessel calcification and overestimation of the severity of a <50% luminal diameter stenosis according to QCA. The main reasons for false-positive readings by WH-MRCA were poor opacification of small vessels and motion artifact. There were only 2 false-negative readings in each technique, which were related to motion artifact or poor opacification of a distal vessel branch and a short (<10 mm) stenosis.

Discussion

Our study findings can be summarized as follows:

1. MDCT offers better visualization of the coronary arteries than does WH-MRCA, with a higher success rate and a shorter acquisition time.
2. Because of the higher success rate, MDCT has a superior diagnostic accuracy than does WH-MRCA on intention to diagnose base.

Figure 2. Typical examples of reformatted WH-MRCA (left), and MDCT (center), and corresponding QCA images (right) of the right and left coronary artery system. a. Normal right coronary artery. b. Normal left coronary artery. c. Double stenosis on the right coronary artery involving the proximal and distal right coronary artery (arrows).

Figure 3. Visual diagnostic accuracies of MDCT (white bar) and WH-MRCA (black bar) for the detection of >50% diameter stenosis on a per-segment basis (*P<0.05).

Figure 4. Visual diagnostic accuracies of MDCT (white bar) and WH-MRCA (black bar) for the detection of >50% diameter stenosis on a per-vessel basis (*P<0.05).
Technical Considerations and Image Quality of Noninvasive Coronary Imaging by WH-MRCA and MDCT

Noninvasive coronary imaging by WH-MRCA and MDCT differs in several important aspects. Differentiation of coronary arteries from neighboring tissue by MDCT requires an injection of an iodated contrast agent. In contrast, WH-MRCA is performed without any injection of the contrast media and relies on differences in tissue T2/T1 relaxation rates and on fat suppression and T2 prepulses to distinguish coronary blood, myocardium, and epicardial fat. An important advantage of MDCT is that the acquisition of the 3D volumetric data of the coronary arteries is much faster than using WH-MRCA. Indeed, by allowing simultaneous measurement of absorption profiles from 64 parallel detectors, MDCT scanning can be completed within a short breathhold lasting <10 seconds. In contrast WH-MRCA acquires the 3D volumetric data set line by line. Only 10 to 15 lines can be acquired per heart beat, and, thus, several hundred cardiac cycles are required to complete the data acquisition. This lengthy acquisition mode prevents breath-hold imaging and requires the use of free breathing respiratory navigator gating. Rejection of data during inspiration phase, especially in the setting of irregular breathing or low navigator performance, further increases scanning time for WH-MRCA. Previously, MDCT had higher temporal resolution than 4- and 16-slice MDCT, resulting in fewer motion artifacts. This was not the case in the present study, where the temporal resolution of 40- or 64-slice MDCT and WH-MRCA were approximately similar and where the motion artifacts on 40- or 64 slice MDCT images were infrequent. In contrast, the spatial resolution of MDCT is currently approximately 7 times higher (0.6×0.6×0.6 mm³) than that of WH-MRCA (1×1×1.5 mm³). Because of this higher spatial resolution and higher contrast-to-noise ratio, MDCT has superior image quality than does WH-MRCA. Also, its success rate was better than that of WH-MRCA, where navigator drift or failure prevented the acquisition of images in 12% of patients. This higher success rate and better image quality, thus, account for the higher number of visualized coronary segments by MDCT than by WH-MRCA.

Diagnostic Accuracy of MDCT and WH-MRCA

The present study evaluated the diagnostic accuracy of WH-MRCA and 40- or 64-slice MDCT in head-to-head comparison using QCA as a reference standard. Such direct comparison of the diagnostic accuracy of current state-of-art noninvasive coronary imaging techniques has not yet been determined. Our present study confirms previous work of others by demonstrating that 40- to 64-slice MDCT had >90% sensitivity and specificity for identification of significant CAD on per-segment and per-vessel basis. The diagnostic accuracy of 40- or 64-slice MDCT was significantly improved as compared with our previous studies using 4- and 16-slice MDCT. The diagnostic accuracy of WH-MRCA for the identification of CAD in the present study was similar to those reported by others. It was also better than our previous results, where we used MRCA with localized acquisition of coronary arteries. These findings illustrate the rapid pace of perfection of noninvasive coronary imaging techniques over recent years. Nevertheless, as compared with previous work, in the present study, the diagnostic accuracy of MDCT had become better than that of WH-MRCA. This illustrates the even more rapid evolution of MDCT over WH-MRCA.

The difference in diagnostic accuracy between WH-MRCA and MDCT is explained for the most part by the higher number of nonevaluable segments on WH-MRCA than on MDCT. This relates to the currently better image quality of MDCT over WH-MRCA. On the other hand, this also suggests that WH-MRCA has the potential to perform equally as MDCT if current limitations, such as navigator failure rate and low spatial resolution, can be overcome.

As in previous works addressing the value of MDCT and WH-MRCA in populations with intermediate prevalence of CAD, both techniques had a high negative predictive value but a low positive predictive value to rule out significant disease on a segmental basis. This indicates that both techniques still tend to overestimate the severity of coronary artery stenosis, probably as a result of a lower spatial and temporal resolution with respect to QCA.

Table 3. Reasons for False-Negative and False-Positive Readings on a Per-Vessel Basis

<table>
<thead>
<tr>
<th>Reason</th>
<th>WH-MRCA</th>
<th>MDCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>False-positive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy calcification</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Motion artifact</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Overestimation of a moderate stenosis</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Poor opacification or small branch</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>All</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>False-negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motion artifact</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Poor opacification of a distal branch</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>All</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Clinical Implications
Our study suggests that both MDCT and WH-MRCA can have clinical value for the noninvasive detection of CAD. Because of still imperfect diagnostic accuracy, neither technique is ready to fully replace the conventional coronary angiography at present. Nevertheless, both tests could be useful to better select patients who should not be referred to conventional x-ray angiography. Because both the tests had high negative predictive values, they might be particularly useful to avoid unnecessary normal coronary angiograms in patients without CAD. For example, they could be used to rule out CAD in patients with atypical chest pain, in those with resting ECG abnormalities, and in those unable to exercise. Given its shorter acquisition time, lower cost, higher success rate, and better image quality, 40- or 64-slice MDCT will likely be preferred over WH-MRCA in clinical practice. Yet, MDCT has the disadvantage of requiring contrast injection and of exposing patients to radiation. Moreover, WH-MRCA might overcome limitations of MDCT in patients with severe calcifications of coronary arteries. Therefore, despite lower performance, WH-MRCA could be a safe alternative in patients with contraindications to MDCT, as for instance in those with known allergy to contrast agents or in whom the risk of renal insufficiency after administration of contrast agents is high. Because of the risk of radiation, WH-MRCA might also be preferred for younger patients.

Study Limitations
The present study was a single-center trial, and interpretations were performed visually by 2 reviewers who had longstanding experience with both imaging techniques. The study findings may not reflect readings of other centers and of reviewers with different experience with both techniques. When compared with other studies, our patient population had a quite low prevalence of CAD. Nevertheless, this lower prevalence of disease may reflect more closely the situation encountered in general clinical practice than do studies performed in selected populations of highly symptomatic patients with high prevalence of CAD. Finally, this study was performed using 40- and 64-slice MDCT. More recently, dual source MDCT scanners with higher temporal resolution have been introduced. These systems could offer even higher diagnostic accuracies than the system used in the present work.

Conclusions
In this present large prospective, head-to-head comparison of noninvasive coronary imaging technique, MDCT was superior to WH-MRCA as it offered higher success rate, faster image acquisition with higher quality, and higher diagnostic accuracy on intention-to-diagnose basis than did WH-MRCA. The major limitation of WH-MRCA was related to longer acquisition duration and higher failure rate. MDCT would, thus, be the preferred technique for noninvasive coronary imaging. However, WH-MRCA could be a valuable alternative in patients with contraindications to MDCT.

Sources of Funding
This work was support by the Foundation Nationale de la Recherche Scientifique of the Belgian Government grant (FRSM 3.4557.02). Dr Pouleur received a postdoctoral fellowship by the Fondation de la Recherche Scientifique of the Belgian Government. Dr Le Polain de Waroux received a fellowship of the Damian Foundation.

Disclosures
None.

References
17. Kim YJ, Seo JS, Choi BW, Choe KO, Jang Y, Ko YG. Feasibility and diagnostic accuracy of whole-heart coronary MR angiography using free-


**CLINICAL PERSPECTIVE**

The field of noninvasive coronary imaging has seen a considerable development in recent years. Many studies have reported encouraging results regarding the diagnosis of coronary artery disease using multidetector coronary computed tomography (MDCT) angiography. Coronary imaging has also been reported feasible using magnetic resonance coronary angiography (MRCA); it was suggested that the most recent whole-heart MRCA may perform as well as MDCT. Therefore we performed a direct head-to-head comparison of the diagnostic accuracy of whole-heart MRCA and 40- to 64-slice MDCT for detecting coronary artery disease using invasive coronary angiography as the gold standard. Our present study is the first to perform such direct comparison of both state-of-the-art noninvasive coronary imaging techniques in the same patient population. It demonstrated that 40- to 64-slice MDCT allows better visualization of coronary arteries with higher success rate than does whole-heart MRCA. Both tests had similar high sensitivity and negative predictive value, making them especially useful to rule out significant stenosis in patients with intermediate or low probability of coronary disease. However, MDCT had higher specificity and overall diagnostic accuracy than whole-heart MRCA, suggesting that 40- to 64-slice MDCT should currently be the preferred noninvasive technique for coronary imaging. However, whole-heart MRCA could serve as an alternative to MDCT in specific clinical situations, especially because it does not expose patients to radiation and or iodinated contrast agents. To rival MDCT, however, it will need further improvement in reliability, image quality, and diagnostic accuracy.
Direct Comparison of Whole-Heart Navigator-Gated Magnetic Resonance Coronary Angiography and 40- and 64-Slice Multidetector Row Computed Tomography to Detect the Coronary Artery Stenosis in Patients Scheduled for Conventional Coronary Angiography
Anne-Catherine Pouleur, Jean-Benoît le Polain de Waroux, Joelle Kefer, Agnès Pasquet, Jean-Louis Vanoverschelde and Bernhard L. Gerber

Circ Cardiovasc Imaging. 2008;1:114-121; originally published online July 30, 2008; doi: 10.1161/CIRCIMAGING.107.756304
Circulation: Cardiovascular Imaging is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2008 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-9651. Online ISSN: 1942-0080

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circimaging.ahajournals.org/content/1/2/114

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Cardiovascular Imaging can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.
Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints
Subscriptions: Information about subscribing to Circulation: Cardiovascular Imaging is online at:
http://circimaging.ahajournals.org//subscriptions/