Magnetic resonance imaging versus computed tomography for the detection of coronary stenosis: do we really have to focus on "stenoses"?

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See article on page 1381

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Over the past few years, technical advances have led to a significant improvement of non-invasive cardiac imaging by multislice computed tomography (MSCT) and magnetic resonance imaging (MRI). The publication of impressive examples of possible image quality in scientific journals, as well as in the lay press, have resulted in a high interest in these new technologies.

Patients desire a well-tolerated alternative to invasive procedures, and doctors require a reliable and cost-effective alternative modality to conventional coronary angiography.

However, up to now only selected patients have been eligible for non-invasive coronary imaging using MSCT and MRI—with some similarities and some differences between the two technologies. For a better understanding of which patients might benefit from cardiac CT or cardiac MRI, some principal considerations are essential.

MULTISLICE COMPUTED TOMOGRAPHY

The principle of non-invasive cardiac imaging with CT is based on a rotating x-ray tube with currently 64, or even more, slices. The whole heart is covered within one single breath hold after administration of iodinated contrast media. Simultaneous acquisition of an ECG permits the beating heart to be "frozen" in different heart phases. Visualisation of the coronary arteries is performed by post-processing of the acquired dataset, normally in the mid-diastolic phase of the heart cycle. In contrast with the first scanner types with four slices, up-to-date scanners permit detection of coronary lesions within the whole coronary tree, including bypass graft vessels—with an overall brilliant diagnostic accuracy, at least in selected patients.^{1,2} Besides assessment of the coronary arteries, additional information can be obtained—for example, reliable information about the global left and right ventricular function from one single scan.^{3,4} Even information about cardiac valve morphology and function can be easily achieved.⁵ Recent studies have demonstrated the ability of MSCT to detect perfusion defects and non-viable myocardium.⁶ Additional studies focused on the detection of pulmonary vein stenosis⁷ or myocardial bridging.⁸

CARDIAC MRI

In contrast with MSCT, cardiac imaging with MRI is not associated with radiation exposure. Even the application of contrast media can be avoided, depending on the clinical question. However, the clinical application of MRI is sometimes limited owing to general contraindications for MRI scanning, such as implanted pacemakers. Owing to the quite long examination period, severe claustrophobia is a more common problem in MRI than in MSCT.

Although quantification of left and right ventricular function, assessment of shunt volumes and ventricular diameters as well as evaluation of valve function and myocardial viability—to name just a few well-established indications for cardiac MRI—has become an integral part of the care of cardiology patients, the visualisation of the coronary arteries with MRI, and especially the quantification and detection of coronary stenosis, has been a continuing challenge for the past few years.

Imaging of the coronary arteries is possible by two different approaches. Either each coronary artery is imaged separately using a "targeted" volume specific for each coronary artery, or a three-dimensional volume of the heart is imaged with axial slices ("whole heart" technique) at almost isotropic spatial resolution. The "whole heart" approach is to some extent comparable with MSCT as the coronary arteries are reconstructed offline using the data of the three-dimensional volume dataset.

Applying the "whole heart" approach, coronary vessel visualisation of the total coronary artery tree has become possible and coronary lesions can be detected with an overall good sensitivity and specificity.⁹ However, the diagnostic accuracy of MSCT cannot be determined at present, mostly because MRI has insufficient spatial resolution. For a more adequate evaluation of the coronary arteries specific software tools for post-processing of the three-dimensional datasets have been introduced, enabling, for example, the visualisation of more than one coronary vessel within one two-dimensional representation.¹⁰

Although coronary artery imaging is possible without application of contrast media, there are efforts to improve the signal within the coronary artery.¹¹ Beside the application of "standard"

Abbreviations: MSCT, multislice computed tomography; MRI, magnetic resonance imaging

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contrast agents (eg, Gd-DTPA), the application of a special gadolinium-based paramagnetic blood pool agent has been shown to be better in this situation. With this intravascular contrast agent, a significant increase of contrast-to-noise-ratio as well as signal-to-noise-ratio can be achieved.¹² This is also reflected in an increase of the visualised vessel length and the number of side branches.

HOW TO DETECT CORONARY STENOSES?

Visualisation of the coronary arteries and coronary lesions is only one possible method of detecting obstructive coronary artery disease. Only a few studies are available comparing MSCT and MRI for the detection of significant coronary lesions. In a meta-analysis published by Schuijff *et al*, MSCT proved to be more accurate than MRI for detection of coronary lesions.¹³ A comparison of sensitivities and specificities showed significantly higher values for MSCT, with a weighted average of 85% and 95% as compared with MRI (weighted average 72% and 87%, respectively).

In a single-centre trial enrolling 108 patients with suspected coronary artery disease, Dewey *et al* reported a significantly better diagnostic performance of MSCT in direct comparison with MRI, although only the proximal parts of the coronary arteries were evaluated by MRI¹⁴ and the whole coronary tree was evaluated by MSCT.

Nevertheless, most studies have focused on the detection of diameter stenoses of at least 50%. However, the presence of a 50% stenosis does not necessarily mean that this is a haemodynamically relevant obstruction of the coronary artery.

For this reason it would be useful to find alternative approaches for the detection of coronary artery disease by MRI—namely, stress perfusion imaging. A study in this issue of the journal by Merkle and colleagues examined 228 patients with an adenosine stress perfusion scan and compared the results with those for invasive coronary angiography (*see article on page 1381*).¹⁵ Up to now, this is the largest cohort ever described.

The analysis was performed with regard to the presence of stenoses of >50% and >70%. The sensitivity, specificity and accuracy of adenosine first pass perfusion imaging to detect coronary artery stenoses of >50% was 93%, 85.7% and 91.2% and for the detection of relevant stenoses (>70%) 96.1%, 72.0% and 88.2%, respectively.

At first glance, the results are not really impressive, as cardiac CT studies produced a much higher accuracy. However, having a closer look at the data, there are couple of interesting points. First, the aim of the study was to test MRI in clinical routine. In contrast with most previous trials, there were only a fistful of exclusion criteria beside general contraindications for MRI. Patients with atrial fibrillation were not excluded from the analysis. Moreover, patients with suspected coronary artery disease, as well as patients with suspicion of progressing disease were included in the study, leading to a very diversified study cohort. On the other hand, distribution of coronary artery disease was quite homogeneous, making the results reliable for patients without coronary artery disease or with one-, two- or three-vessel disease.

Interestingly, only 6.1% of the study population developed transient atrioventricular block III and no additional severe adverse side effects were seen, like bronchospasm or ventricular arrhythmias, indicating the safety of the method.

ADENOSINE STRESS PERFUSION IN PATIENTS WITH SUSPECTED CORONARY ARTERY DISEASE

In this subgroup the high negative predictive value of 100% fits well with MSCT data. Thus, both modalities proved to be useful to rule out significant coronary artery disease. However, the

remarkably high number of patients with false positive MRI results (leading to a positive predictive value of only 59.1%) raises the question, of whether “false positive” results are probably the effect of endothelial dysfunction in the absence of obstructive coronary artery disease—and might be correlated with the patients’ symptoms. An intracoronary pressure measurement with a pressure wire in these patients might help to answer this question, but it was not measured in this study.

ADENOSINE STRESS PERFUSION IN PATIENTS WITH KNOWN CORONARY ARTERY DISEASE

In contrast with patients with suspected coronary artery disease, in this cohort a high positive predictive value and a lower negative predictive value were observed. Consequently, patients with perfusion defects should undergo invasive angiography. Nevertheless, the low negative predictive value means, that some patients with relevant stenosis are missed by MRI.

COST EFFECTIVENESS

In times when financial resources for healthcare are restricted, cost effectiveness has a more and more important role, especially for competing diagnostic tools. Some interesting data were recently published about the cost effectiveness of MRI and MSCT and invasive angiography in the care of patients with suspected coronary artery disease.¹⁶ Interestingly, MSCT proved to be the most cost-effective tool in patients with a likelihood for coronary artery disease of up to 50%. At a pretest likelihood of 60%, invasive angiography and MSCT were equally effective, while the invasive procedure was most effective in patients with a pretest likelihood of at least 70%. Although MRI could not compete in this setting, we should always keep in mind that the most cost-effective resource we have, remains the doctor’s skills.

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REFERENCES

- 1 Mollet NR, Cademartiri F, van Mieghem CA, *et al*. High-resolution spiral computed tomography coronary angiography in patients referred for diagnostic conventional coronary angiography. *Circulation* 2005;**112**:2318–23.
- 2 Pache G, Saueressig U, Frydrychowicz A, *et al*. Initial experience with 64-slice cardiac CT: non-invasive visualization of coronary artery bypass grafts. *Eur Heart J* 2006;**27**:976–80.
- 3 Dogan H, Kroft LJ, Bax JJ, *et al*. MSCT assessment of right ventricular systolic function. *AJR Am J Roentgenol* 2006;**186**:S366–70.
- 4 Heuschmid M, Rothfuss JK, Schroeder S, *et al*. Assessment of left ventricular myocardial function using 16-slice multidetector-row computed tomography: comparison with magnetic resonance imaging and echocardiography. *Eur Radiol* 2006;**16**:551–9.
- 5 Feuchtnner GM, Dichtl W, Friedrich GJ, *et al*. Multislice computed tomography for detection of patients with aortic valve stenosis and quantification of severity. *J Am Coll Cardiol* 2006;**47**:1410–7.
- 6 Gerber BL, Belge B, Legros GJ, *et al*. Characterization of acute and chronic myocardial infarcts by multidetector computed tomography: comparison with contrast-enhanced magnetic resonance. *Circulation* 2006;**113**:823–33.
- 7 Burgstahler C, Trabold T, Kuettner A, *et al*. Visualization of pulmonary vein stenosis after radio frequency ablation using multi-slice computed tomography: initial clinical experience in 33 patients. *Int J Cardiol* 2005;**102**:287–91.
- 8 Kantarci M, Duran C, Durur I, *et al*. Detection of myocardial bridging with ECG-gated MSCT and multiplanar reconstruction. *AJR Am J Roentgenol* 2006;**186**:S391–4.
- 9 Jahnke C, Paetsch I, Nehrke K, *et al*. Rapid and complete coronary arterial tree visualization with magnetic resonance imaging: feasibility and diagnostic performance. *Eur Heart J* 2005;**26**:2313–9.
- 10 Etienne A, Botnar RM, Van Muiswinkel AM, *et al*. “Soap-bubble” visualization and quantitative analysis of 3D coronary magnetic resonance angiograms. *Magn Reson Med* 2002;**48**:658–66.

- 11 Lorenz CH, Johansson LO. Contrast-enhanced coronary MRA. *J Magn Reson Imaging* 1999;**10**:703–8.
- 12 Paetsch I, Huber ME, Bornstedt A, et al. Improved three-dimensional free-breathing coronary magnetic resonance angiography using gadoletic acid (B-22956) for intravascular contrast enhancement. *J Magn Reson Imaging* 2004;**20**:288–93.
- 13 Schuijff JD, Bax JJ, Shaw LJ, et al. Meta-analysis of comparative diagnostic performance of magnetic resonance imaging and multislice computed tomography for noninvasive coronary angiography. *Am Heart J* 2006;**151**:404–11.
- 14 Dewey M, Teige F, Schnapauff D, et al. Noninvasive detection of coronary artery stenoses with multislice computed tomography or magnetic resonance imaging. *Ann Intern Med* 2006;**145**:407–15.
- 15 Merkle N, Wöhrle J, Grebe O, et al. Assessment of myocardial perfusion for detection of coronary artery stenoses by steady-state, free-precession magnetic resonance first-pass imaging. *Heart* 2007;**93**:1381–5.
- 16 Dewey M, Hamm B. Cost effectiveness of coronary angiography and calcium scoring using CT and stress MRI for diagnosis of coronary artery disease. *Eur Radiol* 2007;**17**:1301–9.

IMAGES IN CARDIOLOGY

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The changing faces of aortic dissection: an unusual presentation mimicking pulmonary embolism

A 71-year-old man was admitted owing to an episode of retrosternal chest pain. Based on ECG findings and minimal troponin elevation, the patient was initially treated as having an acute coronary syndrome, with subsequent clinical improvement. On the second day of hospitalisation, he complained of progressively worsening dyspnoea, and pulmonary embolism was clinically suspected.

Pulmonary perfusion scintigraphy showed the total absence of perfusion in the right lung, consistent with massive pulmonary embolism in the right pulmonary artery (panels A and B). To obtain a definite diagnosis, chest computed tomography was carried out, which, unexpectedly, disclosed a type II dissecting aneurysm of the ascending aorta. Around the proximal segment of the ascending aorta a haematoma had accumulated (panels C–F), compressing the right pulmonary artery, almost occluding its patency and limiting the perfusion of the reciprocal lung.

An emergency operation was carried out, with repair of the ascending aorta and recanalisation of the right pulmonary artery. However, the patient died on the seventh postoperative day owing to post-operative acute renal failure and sepsis.

Clinical symptoms of aortic dissection vary widely from symptoms resulting from its rupture to those due to compression of surrounding organs. A clinical presentation mimicking pulmonary embolism is extremely rare. Moreover, the finding of a large unilateral segmental perfusion defect upon lung scanning does not always secure the diagnosis of pulmonary embolism. Instead, other causes of pulmonary artery obstruction should be excluded. In such cases, CT scanning may be extremely valuable in establishing the correct diagnosis and suggesting further treatment.

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