The Year in Cardiology

The Year in Cardiology 2012: imaging, computed tomography, and cardiovascular magnetic resonance

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The year of 2012 has seen many significant publications in cardiac imaging, particularly in the modalities of cardiovascular magnetic resonance (CMR) and cardiac computed tomography (CT). This article will review in brief some of the most important studies with a particular emphasis on the new evidence base for perfusion imaging both by cardiovascular magnetic resonance and computed tomography.

Keywords
Non-invasive cardiac imaging • Coronary computed tomography • Cardiac magnetic resonance • Myocardial perfusion scintigraphy

Introduction

The year of 2012 has seen many significant publications in cardiac imaging, particularly in the modalities of cardiovascular magnetic resonance (CMR) and cardiac computed tomography (CT). This article will highlight a small selection of the most important studies relating to cardiac cross-sectional imaging. There will be a focus on studies that reinforce the evidence base for current practice, such as stress perfusion imaging, and those that support new developments in clinical practice.

Perfusion imaging

Arguably the most important study to impact upon cardiac imaging this year is not primarily an imaging paper at all!—FAME II.1 Although invasive pressure wire assessment was utilized to demonstrate myocardial ischaemia, and subsequently improved patient outcomes from revascularization, the results can reasonably be extrapolated to other non-invasive functional ischaemic tests. FAME II adds significant weight to the growing body of evidence that revascularization should be driven by myocardial ischaemia rather than angiographic appearances and will inevitably increase the demand for any imaging modality that can reliably demonstrate ischaemia. The choice of which functional ischaemic test to use remains subject to local availability and expertise but the evidence base is increasing for each modality.

Cardiovascular magnetic resonance

The two largest studies so far comparing the performance of CMR with single-photon emission computed tomography (SPECT) against a reference standard of invasive coronary angiography (CA) have been published this year. The first, CE-MARC,2 recruited 752 patients with suspected angina pectoris to a single-UK centre. A multiparametric CMR protocol was performed including adenosine stress perfusion, late gadolinium enhancement, and a whole heart coronary angiogram. The SPECT was performed with cardiac gating and a standard 2 day stress/rest protocol using 99mTc tetrofosmin. The second, MR-IMPACT II,3 was a multicentre study enrolling 533 patients to 33 centres in Europe and the USA. A multiparametric CMR protocol was performed including adenosine stress perfusion, late gadolinium enhancement, and a whole heart coronary angiogram. The SPECT was performed with cardiac gating and a standard 2 day stress/rest protocol using 99mTc tetrofosmin. The second, MR-IMPACT II,3 was a multicentre study enrolling 533 patients to 33 centres in Europe and the USA. A similar CMR protocol was used across the centres but excluding the whole heart coronary angiogram. The SPECT protocols were more varied, according to the institutions clinical routine, and included both gated and un-gated acquisitions as well as adenosine/physical stress protocols. The results of CE-MARC and MR-IMPACT II are shown in Table 1. Cardiovascular magnetic

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resonance demonstrated significantly higher sensitivity than SPECT in both studies but failed to show significant superiority in specificity (indeed showed a significant inferiority of CMR vs. SPECT in MR-IMPACT II). Taken together these trials promote the role of CMR as a safe alternative to SPECT avoiding the additional radiation exposure integral to the latter, a position further supported by the results of a meta-analysis of PET, CMR, and SPECT by Jaarsma et al.4

Looking to the future of stress CMR, Jogiya et al.5 published the results of three-dimensional (3D) perfusion technique at 3 Tesla. Fifty-three patients referred for angiography were recruited to the study comparing the 3D CMR sequence to pressure wire-derived fractional flow reserve (FFR). Cardiovascular magnetic resonance showed a sensitivity, specificity, and diagnostic accuracy of 91, 90, and 91%, respectively, on a patient basis and 79, 92, and 88% by coronary territory, offering hope of further improvements in diagnostic accuracy as new techniques and higher field strengths are rolled out into clinical practice.

### Computed tomography

The high spatial and temporal resolution of current multislice CT devices have established CT CA as a robust and accurate clinical tool for the non-invasive evaluation of coronary arteries. More recently, CT has been advocated as a possible alternative to assess myocardial perfusion in research protocols: The preliminary results of the CORE-320 study were presented at the 2012 ESC meeting by Dr. Lima (http://spo.escardio.org/SessionDetails.aspx?id=299167). This trial compared the addition of a CT perfusion (CTP) sequence to a CT coronary angiogram (CTA) acquisition, with a ‘standard model’ of invasive CA and SPECT MPI in 381 patients. Adding CTP significantly increased the diagnostic accuracy of CTA to define flow limiting coronary disease (AUC: 0.87 vs. 0.81, P < 0.001) and at a lower radiation dose than the invasive angiogram and MPI combined.

An alternative approach to assessing the functional significance of a coronary stenosis with CT is CT-based fractional flow reserve (FFR<sub>CT</sub>). This novel method employs computational fluid dynamics to calculate pressure gradients across coronary lesions on standard CT coronary angiograms. In the multicentric DeFACTO study,6 the authors compared FFR<sub>CT</sub> with the gold standard of invasive FFR in 252 patients. Use of FFR<sub>CT</sub> in conjunction with CTA improved diagnostic accuracy and discrimination of functionally significant stenosis over CTA alone (AUC: 0.81 vs. 0.68 respectively, P < 0.001). Although the pre-specified primary outcome of per-patient diagnostic accuracy was not met the study demonstrates potential as an alternative to the direct evaluation of myocardial perfusion with CT.

Evidence for the use of cardiac CT in the emergency department has taken a further step forward with the publication of two large trials, ACRIN-PA7 and ROMICAT II.8 Collectively, these studies recruited 2370 low-intermediate risk patients presenting with possible acute coronary syndromes to emergency departments in the USA and compared traditional care with a protocol including an early CT. The results, Figure 1, show a significant reduction in the length of stay and increased rate of discharge from the emergency department in the CT group without any adverse clinical outcome. While these findings are encouraging it remains to be seen whether these data can be reproduced in Europe where care pathways may be different.

### Table 1  Comparison of cardiovascular magnetic resonance and single-photon emission computed tomography results from CE-MARC and MR-IMPACT II

<table>
<thead>
<tr>
<th>Study</th>
<th>Functional test</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE-MARC&lt;sup&gt;2&lt;/sup&gt;</td>
<td>CMR</td>
<td>86.5</td>
<td>83.4</td>
<td>77.2</td>
<td>90.5</td>
</tr>
<tr>
<td></td>
<td>SPECT</td>
<td>66.5</td>
<td>82.6</td>
<td>71.4</td>
<td>79.1</td>
</tr>
<tr>
<td>MR-IMPACT II&lt;sup&gt;3&lt;/sup&gt;</td>
<td>CMR</td>
<td>75</td>
<td>59</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>SPECT</td>
<td>59</td>
<td>72</td>
<td>73</td>
<td>60</td>
</tr>
</tbody>
</table>

### Figure 1  Results from ROMICAT II and ACRIN-PA.

### Table 2  Low-dose cadmium zinc telluride single-photon emission computed tomography results in obese and non-obese patients

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Radiation dose (mSv)</th>
<th>BMI (kg/m&lt;sup&gt;2&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duval et al.&lt;sup&gt;9&lt;/sup&gt;</td>
<td>89</td>
<td>66</td>
<td>5.8</td>
<td>25</td>
</tr>
<tr>
<td>Gimelli et al.&lt;sup&gt;10&lt;/sup&gt;</td>
<td>92</td>
<td>67</td>
<td>5.1 (male)</td>
<td>39</td>
</tr>
</tbody>
</table>
The main change in the world of nuclear cardiology has been the introduction of a new generation of gamma cameras using cadmium zinc telluride (CZT) detector technology with improved sensitivity and spatial resolution compared with conventional systems. The ability of these new detectors to deliver improved image quality, faster, and with a lower radiation dose has been the subject of much investigation. Two studies illustrate the significant advances made with low-dose stress imaging; Duval et al. studied 71 patients with weights of <200 lbs, while Gimelli et al. studied 148 obese patients. The results, Table 2, show well maintained sensitivity and specificity in both groups with a reduction in radiation dose of >50% compared with standard protocols.

A further area of research in nuclear cardiology is the potential of ‘hybrid imaging’ with CT to impact upon clinical management by providing both functional and anatomical information at the same time. Fiechter et al. investigated the efficacy of a combined CZT gamma camera and 64-slice CT scanner to influence clinical practice.

Sixty-two patients were classified as having matched defects, if they had a coronary stenosis with a matching perfusion defect (Figure 2), or unmatched if they did not. Ninety one per cent of those with matched findings (21 patients) were eventually revascularized compared with 8% in the unmatched group. Despite the potential for selection bias highlighted by the authors, the findings are an important step to larger randomized studies of hybrid imaging.

**Figure 2** Hybrid single-photon emission computed tomography/computed tomography image. A left anterior descending artery stenosis is demonstrated (white arrowhead) on computed tomography (A multiplanar and B curved multiplanar reconstruction) and invasive coronary angiogram (D). A hybrid single-photon emission computed tomography/computed tomography image at stress (C) shows the associated area of myocardial ischaemia in pink compared with the rest study (E) which is normal. Image courtesy of Dr M. Fiechter and Prof. P. A. Kaufmann with kind permission from Springer Science and Business Media.

**Nuclear cardiology**

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**Conclusion**

2012 has witnessed a number of important publications underpinning the role of new and established functional imaging techniques in ischaemic heart disease. CE-MARC and MR-IMPACT II in particular should support an increasing role for stress perfusion CMR. Likewise the case for a role for coronary CT in the emergency department is getting still stronger in light of ACRIN-PA and ROMICAT II. In addition, there have been significant advances in newer clinical applications such as hybrid cardiac imaging and perfusion CT. Roll on 2013!
Conflict of interest: none declared.

References


