News and Views from the Literature

Noninvasive Imaging

Multislice Computed Tomography Versus Myocardial Perfusion Imaging

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Relationship Between Noninvasive Coronary Angiography With Multi-slice Computed Tomography and Myocardial Perfusion Imaging

Schuijf JD, Wijns W, Jukema JW, et al.

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Noninvasive attempts to identify coronary artery disease (CAD) continue to evolve. This study from the Netherlands and Belgium of 114 patients who had chest pain with no history of CAD compared multislice computed tomography (MSCT) with myocardial perfusion imaging (MPI).[1]

All patients underwent single-photon emission computed tomography (SPECT) MPI with either Tc-99m tetrofosmin or Tc-99m sestamibi using either bicycle exercise or some pharmacologic stress (dipyridamole, adenosine, or dobutamine). The study results were considered abnormal if either a fixed or a reversible defect was observed. All patients had noninvasive coronary angiography with MSCT using either a 16-slice scanner (in 28 patients) or a 64-slice scanner (in 86 patients). A "significant" lesion by MSCT was considered one with more than 50% diameter narrowing. The study is "real world" in that multiple imaging technologies are being compared, but the different studies and equipment do complicate the analysis. About half of the patients (58) had conventional coronary angiography for comparison.

The results were not all that unexpected. As shown in Figure 1A, when the MSCT was normal, the perfusion study was also normal in 90% of the cases. This finding is consistent with many studies confirming the extraordinarily high negative predictive value of MSCT.[2] When the MSCT coronary angiogram is normal, you can pretty much count on the patient not having epicardial coronary disease.

The issue gets clouded when the MSCT is abnormal. In the study by Schuijf and colleagues,[1] when the MSCT was abnormal, the perfusion study was abnormal in only 45% of cases (Figure 1B). When the MSCT found nonobstructive disease, the perfusion study was abnormal in 39% of patients (Figure 1C). When the MSCT found

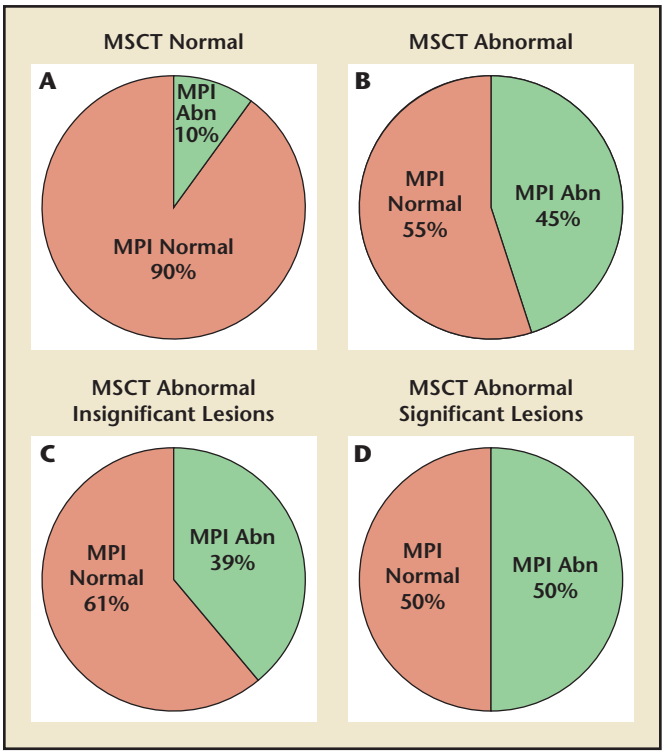

Figure 1. *Relation between multislice computed tomography (MSCT) and myocardial perfusion imaging (MPI).* **(A)** *The 90% of MSCT patients with normal images had a normal MPI.* **(B)** *Only 55% of patients with an abnormal (Abn) MSCT had an abnormal MPI.* **(C)** *When the MSCT suggested insignificant epicardial coronary disease, the MPI was abnormal in 39%.* **(D)** *When the MSCT suggested significant disease, the MPI was abnormal in half. Data from Schuijf JD et al.*[1]

significant obstructive disease, the perfusion study was positive in only half of patients (Figure 1D).

Why the discrepancy? First off, it is obvious that the presence of coronary lesions angiographically does not imply that the lesions have hemodynamic significance. This has been shown repeatedly when invasive coronary angiography has been compared with myocardial perfusion studies or coronary fractional flow reserve. The well-known problems with angiographic estimation of disease due to geometric issues and diffuse disease in the "normal" reference segment, as well as other factors such as collateral flow, all contribute to this observation. So our "gold standard" is not all that shiny.

Second, how accurate is MSCT when compared with invasive coronary angiography? In this study, only 58 patients underwent both procedures. When the MSCT was normal (n = 9) or suggested insignificant disease (n = 16), the invasive angiogram confirmed the findings. However, when the MSCT suggested significant disease, the catheterization angiography revealed insignificant disease in 6 out of 33 (18%) and significant disease in 27 out of 33 (82%). Other larger studies have revealed sensitivities from 83% to 99% with specificities of 93% to 98% for MSCT when the 2 methods have been compared.[3] One additional problem the authors did not describe was how many coronary segments were not evaluated due to technical issues, such as cardiac motion, inadequate opacification, calcium within the vessel wall, too rapid heart rate, and cardiac arrhythmias. In most laboratories, about 5% to 10% of the coronary segments are unable to be evaluated due to these artifacts. The impact on the present study is unknown.

Third, just how good is the perfusion study in defining significant epicardial CAD? Perfusion studies are subject to many sources of artifacts, including those due to motion, attenuation, reconstruction errors, "hot liver," and Compton scatter. For SPECT technetium myocardial perfusion studies, the sensitivity is generally reported at about 85%, with a specificity of around 80% for defining CAD. In the study under review, both fixed and reversible lesions were considered abnormal, so transient plaque rupture may have been associated with infarction, and the lesion could appear nonobstructive at this point. In addition, data suggest that myocardial perfusion may be abnormal in some patients in the absence of significant stenoses in the epicardial coronary arteries even without infarction, perhaps because of endothelial dysfunction or impaired smooth muscle relaxation, or both, at the microcirculatory level.[4]

In what area is MSCT now headed? Technologically, the CT scanners have evolved from 4 to 8, 16, 32, 40, and now 64 slices per rotation. The gantry speeds have increased to allow better temporal resolution, and the thickness of the slices (collimation) has decreased to improve spatial resolution. Other improvements have reduced image noise as well. With 64-slice scanners, the entire study can now be performed in 6 to 12 seconds. Newer developments include scanning up to 256 slices at a time or using 2 x-ray tubes at a time—the latter approach should further reduce motion artifact.

Although the hope remains that MSCT will be able to replace conventional coronary angiography, there are important unresolved issues. Spatial resolution remains a particular problem. For most 64-slice scanners, the voxel imaged is roughly a box that measures 0.4 mm × 0.4 mm × 0.6 mm, and this resolution still does not approach cardiac catheterization image systems, where it is 0.1 mm or so. There is also an issue with detector "memory" after radiation exposure that makes it difficult to separate objects that are close together because of the "afterglow." These factors are all improving, but most clinicians think that MSCT is not yet quite up to snuff.[5]

Electron beam computed tomography (CT) and MSCT made their initial impact by allowing clinicians to identify and quantify coronary calcium. In fact, calcium scoring remains a major focus for cardiac CT. As outlined in the recent scientific statement from the American College of Cardiology and the American Heart Association,[2] a negative calcium score makes an atherosclerotic plaque unlikely and carries a low risk (0.1% per year) of a cardiovascular event in the next 5 years. A positive test confirms atherosclerotic plaque, and a high calcium score (an Agatston score $>$ 100) is consistent with high risk ($>$ 2% per year). Although all that calcium is important for determining an overall calcium score, it is a problem when one is trying to image the coronary lumen and sort out which lesions are "significant."

The focus now is turning to whether it is possible to detect the "soft" or the vulnerable plaque, because it is clear that the unstable plaque is often the guilty party when acute coronary events occur. Although there are encouraging studies that suggest MSCT might be useful in this regard,[6] the questions surrounding spatial resolution and temporal resolution still remain unresolved. In addition, the low-density resolution problem (the finite afterglow in the detector mentioned above) decreases detection of unstable plaque.[5]

There are other everyday challenges to MSCT technology. There are still few studies showing that both coronary artery bypass grafts and the native coronaries can be imaged at the same time, so the application of MSCT in patients who have had bypass remains uncertain. Coronary stents present yet another challenge due to the artifact created by the metal; although some studies have claimed that in-stent stenosis can be accurately quantified,[7] it is still unclear whether results would be reliable.

The study by Schuijf and colleagues[1] compared the angiographic coronary anatomy with radionuclide myocardial perfusion, but wouldn't it be nice to get both epicardial coronary anatomy and myocardial perfusion with one study? One possible approach was recently presented by George and colleagues.[8] In an animal model, the authors found that adenosine-augmented differential myocardial perfusion could be semi-quantitated using a first-pass contrast signal density.

In summary, MSCT continues to evolve. With each new technological leap, the studies become closer and closer to enabling cardiologists to identify coronary anatomy in a noninvasive manner. Studies such as those by Schuijf and colleagues[1] continue to add valuable information regarding the practical application of this exciting technology. We still have much to learn, however. ■

References

1. Schuijf JD, Wijns W, Jukema JW, et al. Relationship between noninvasive coronary angiography with multi-slice computed tomography and myocardial perfusion imaging. *J Am Coll Cardiol*. 2006;48:2508-2514.
2. Budoff MJ, Achenbach S, Blumenthal RS, et al. Assessment of coronary artery disease by cardiac computed tomography. A scientific statement from the AHA committee on cardiovascular imaging and intervention, council on cardiovascular radiology and intervention and committee on cardiac imaging, council on clinical cardiology. *Circulation*. 2006;114: 1761-1791.
3. Achenbach S. Computed tomography coronary angiography. *J Am Coll Cardiol*. 2006;48:1919-1928.
4. Wang L, Jerosh-Herold M, Jacobs DR, et al. Coronary artery calcification and myocardial perfusion in asymptomatic adults. The MESA (Multi-Ethnic Study of Atherosclerosis). *J Am Coll Cardiol*. 2006;48:1018-1026.
5. Rumberger JA. The promise of quantitative computed tomography coronary angiography and noninvasive segmental coronary plaque quantification. Pushing the edge. *J Am Coll Cardiol*. 2006;47:678-680.
6. Leber AW, Becker A, Knez A, et al. Accuracy of 64-slice computed tomography to classify and quantify plaque volumes in the proximal coronary system. A comparative study using intravascular ultrasound. *J Am Coll Cardiol*. 2006;47:672-677.
7. Gaspar T, Halon DA, Lewis BS, et al. Diagnosis of coronary in-stent restenosis with multidetector row spiral computed tomography. *J Am Coll Cardiol*. 2005;46:1573-1579.
8. George RT, Silva C, Corderio MAS, et al. Multidetector computed tomography myocardial perfusion imaging during adenosine stress. *J Am Coll Cardiol*. 2006;48:153-160.