Integrating Multidetector Computed Tomography Into Clinical Practice

Computed Tomography Scanning Shows its Metal*

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Selective coronary angiography (1) opened the era of in vivo visualization of the coronary arteries. It allowed new insights into the pathophysiology of coronary syndromes and made it possible to perform myocardial revascularization using bypass surgery and percutaneous coronary intervention (PCI). Almost 50 years later, advances in technology have opened another new era, this time an era of noninvasive cardiac imaging. Specifically, multidetector computed tomography (MDCT) is capable of providing high-quality almost-instant noninvasive coronary angiography, with high diagnostic accuracy for the assessment of coronary stenoses (2–10) and the identification and characterization of coronary plaques (11,12).

Until recently, MDCT has been of limited value in the assessment and follow-up of the revascularized patient. In the post-PCI patient, blooming artifact from the metallic stent produces a “napkin-ring appearance” on MDCT (Fig. 1) and may obscure some 30% of the stent luminal dimension, making the diagnosis of in-stent restenosis quite difficult (13). Indeed, stented segments—the most important part of the coronary tree requiring assessment in the post-PCI patient—were simply omitted in most reports validating the cardiac use of MDCT. In the post-bypass patient, a relatively large volume of contrast medium and longer breath hold time are necessary to image the area from clavicle to diaphragm and to include the origin of internal mammary arteries as well as proximal and distal graft anastomoses and distal native segments. The blooming artifact introduced by metal clips may again prevent accurate definition of graft segments, whereas beam hardening can produce dark areas adjacent to clips that may simulate stenoses, especially at points of anastomosis. In both the bypass patient and the stent patient, native vessel calcification may be extensive, thus further reducing diagnostic accuracy.

New-generation MDCT scanners have allowed us to begin to examine patients with implanted coronary stents (14) and to assess patients with coronary bypass grafts (15). In this issue of the Journal, 2 papers describe the role of 64-slice MDCT scanning in revascularized patients. Ehara et al. (16) report the use of MDCT for diagnosing in-stent restenosis. Using 2 dataset reconstructions based on a soft and a sharp image formulation, the investigators produced high-definition images of stents and of contrast-poor regions at sites of intimal proliferation partially obscuring the arterial lumen. Sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) for assessable stents (compared with invasive angiography) were 91%, 93%, 77%, and 98%. Two lesions were missed by MDCT, and 6 were overestimated to be in-stent restenosis. Although these data move us one step further in the assessment of stented segments, the stents in their study were relatively large (60% were ≥3.5 mm) and therefore more easily assessed, there was no patient with a “stent in stent” for previous restenosis, patients with renal failure (often with more calcified arteries) were necessarily excluded, and 12% of stents that were considered nonassessable and analyzed as restenosis in a secondary analysis would have to be taken into account in the real-world clinical setting. The binary restenosis rate of 19% in stented segments (majority were bare stents) would be lower with drug-eluting stents (DES), and the rather low 77% PPV for assessable segments was lower still for DES patients. On the other hand, the real clinical utility of MDCT may be the ability to rule out restenosis in the post-PCI patient; this certainly is feasible given the high NPV, which should be even higher in the presence of a lower rate of restenosis.

In a complementary paper, Meyer et al. (17) report the high accuracy of 64-slice MDCT for assessing coronary bypass grafts in an unselected symptomatic patient population. On a per-patient analysis in the 97% evaluable patients, MDCT diagnosed graft stenosis with high sensitivity (100%), specificity of 92%, PPV of 93%, and NPV of 100%, but including the nonevaluable patients for an intention-to-diagnose analysis, the resulting values were lower, and this would be the case in real-world patients. Good results were obtained for both arterial and venous grafts, albeit with lower sensitivity (93% vs. 99%) and lower PPV (86% vs. 96%) for arterial grafts, which are usually of smaller caliber. In 9 grafts, image quality was insufficient because of motion artifact (8 grafts) or numerous metallic clips (1 patient). What the investigators did not study, however, were the...
proximal and distal native segments, which may have clinical relevance as a cause of symptoms, especially in patients in whom bypass conduits are abnormal or occluded. Feasibility of assessment of the distal anastomosis has been variously reported for 74% (18) to 94% and 99% of grafts (15,19). Distal to the anastomosis, the coronary vessel may be relatively small and more difficult to assess. Feasibility of native vessel PCI after graft occlusion may depend on the distinction between high-grade and chronic total occlusion of the proximal vessel, a differentiation that may be difficult with MDCT.

What then is the current role of MDCT in the post-revascularization patient? Should every patient undergo MDCT angiography routinely after revascularization? Should this be repeated at regular intervals? Should we study only symptomatic patients and/or those with abnormal exercise or radionuclide imaging test results? Although only the last of these strategies seems to be appropriate at the present time, an increasing number of patients now undergo MDCT and the physician needs to integrate the findings into the overall clinical picture. When possible, MDCT findings should be compared with previous invasively obtained information. We have used MDCT in post-revascularization patients presenting to the emergency department, where MDCT-based patient triage allowed us to avoid hospital admission in a number of cases and to adjust clinical decision making regarding need for a repeat invasive strategy (20). In patients with an equivocal or nondiagnostic treadmill test result, MDCT allowed us to refine the selection of patients who require invasive angiography (21). Also, MDCT is useful in post-bypass patients scheduled for repeat invasive angiography, when prior information regarding graft patency or occlusion allows a shorter invasive procedure, particularly in patients with a complex surgical history. The MDCT images transmitted to the monitoring screens of the invasive laboratory already assist in interventional planning in a number of medical centers.

Where Are We Heading?
The MDCT technology is advancing rapidly, and dual-source (22) and other new technologies, such as 256-slice scanning (23), promise to simplify the test quite remarkably while improving diagnostic accuracy. Novel computer processing aims at automatic analysis of the coronary vasculature and coronary plaques. Other noninvasive modalities, such as magnetic resonance imaging (MRI), allow for high-quality images of cardiac anatomy and vascular plaque (24) and real-time MRI has been suggested as a guide for cardiac interventional procedures (25). The world of cardiac imaging is still evolving, but it is clear that the possibilities regarding diagnosis and management in the post-revascularization patient have improved considerably, and we are ready to integrate the new noninvasive imaging modalities into clinical practice.

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