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EDITORIAL COMMENT

Is CT the Better Angiogram?

Coronary Interventions and CT Imaging*

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Periprocedural myocardial infarction is a potential problem of percutaneous coronary intervention. Even after seemingly uncomplicated, straightforward elective coronary interventions, elevation of cardiac enzymes can be observed and occur in approximately one-third of cases (1). Such enzyme elevations have been shown to be associated with myocardial injury, for example, by magnetic resonance studies (2,3). Both for troponin elevation (1) and for detectable myocardial scar following elective percutaneous intervention (4), substantial prognostic implications have been demonstrated; in a meta-analysis of more than 15,000 patients, Nienhuis et al. (1) found post-interventional troponin release to be associated with a 35% increase in mortality.

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Such ischemic complications after percutaneous coronary intervention can be caused by a number of mechanisms. They include abrupt closure of the intervention site, side branch occlusion, and distal embolization of plaque material or thrombus (5,6), and predicting such complications would be of value. Angiographic parameters can be predictive of periprocedural infarction, such as the SYNTAX score, which incorporates the presence of branching vessels, ostial stenosis, vessel tortuosity, lesion length, degree of calcification, and presence of thrombus (7). Also, the volume of atherosclerotic plaque (as quantified by intravascular ultrasound before the intervention [8]) as well as the type of plaque in the treated segment (9,10) are associated with periprocedural infarction. Prior knowledge of the risk of such potential complications may influence the choice of revascularization methods or may prompt initiation of specific measures to lower the rate of this complication, such as the use of embolization protection devices (15) or pre-treatment with statins (11–13). Even a single dose of statins may have a beneficial effect (14).

In this issue of *iJACC*, Uetani et al. (16) present an intriguing study which demonstrates that coronary computed tomography (CT) angiography may help predict periprocedural infarction in patients undergoing elective coronary revascularization by percutaneous stent placement. In a large study of planned elective intervention of single lesions, the authors employed 64-slice CT coronary angiography to quantify plaque volume in the target lesion before the intervention, as well as to quantify the volume of plaque components with low (<50 Hounsfield units), intermediate, and high (>500 Hounsfield units) CT attenuation. After coronary intervention, troponin elevation occurred in one-third of patients. In multivariate analyses, the volume of atherosclerotic plaque with low CT attenuation was independently associated with periprocedural infarction. The association was striking—in patients with troponin increase, the average volume of low-density plaque was twice as high as in patients without troponin elevation. Plaque with low CT attenuation is assumed to be lipid-rich, more likely to embolize during stent placement, lead to downstream ischemia, and at least partially explain the observed findings.

The atherosclerotic plaque at the target lesion is only 1 component that may lead to ischemic complications. In everyday practice, vessel dissection, side branch occlusion, and other mechanisms may also be involved and were not assessed in this

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report. Also, angiographic parameters, such as the degree of calcification and lesion length, were found to be different between patients with and without periprocedural infarction in the present study. It should be noted that the rate of direct stent placement was relatively low, which may have an effect on the overall rate of distal embolization (17,18).

Plaque quantification and characterization by CT is by no means trivial. Only in datasets of pristine image quality can measurements of plaque size and quantification of various plaque components be performed. Uetani et al. (16) had to exclude 11 datasets because image quality was not good enough for analysis. It can be assumed that in Japanese patients, the average body weight was considerably lower than in a typical Western patient with coronary artery disease and may have direct implications for image noise and the ability to characterize plaque by CT. All the same, several recent trials have demonstrated a stunning ability of CT angiography to analyze coronary atherosclerotic plaque in selected patients. So far, the main focus had been the association with the future risk of cardiovascular events (19–21), and credit goes to Uetani et al. (16) for bringing our attention to the ability of CT to predict periprocedural myocardial infarction.

CT imaging of the coronary arteries offers potentially important information to interventional cardiologists in several ways. The 3-dimensional nature of CT angiography data sets allows an accurate assessment of geometry, and their cross-sectional nature allows combining of imaging of the coronary lumen and, image quality permitting, of the coronary artery wall. For example, these properties have been used for the spatially correct measurement of branching angles—important information for treatment of bifurcation lesions (22,23). Clinically, it has been shown that CT angiography, by depicting the degree of calcification and the length of the occluded segment, is helpful to predict the success of percutaneous treatment of chronic total coronary artery occlusions, one of the major challenges in interventional cardiology (24,25). Wertman et al. (26) demonstrated that CT characteristics were able to predict the complexity of interventional revascularization procedures, including contrast use and fluoroscopy time. A recent report described the ability to perform coronary interventions without even angiography, using magnetic navigation and a previously acquired coronary CT angiogram (27). Uetani et al. (16), with their contribution in this issue of *iJACC*, add to this body of knowledge. CT imaging may be considered in the preparation of complex revascularization procedures, and if a CT scan has been performed as part of the diagnostic workup in a patient with chest pain, interventionalists should be aware of the information available from the CT data set if percutaneous treatment is planned.

Currently, the temporal and spatial resolution of CT imaging is lower than that of the invasive, catheter-based coronary angiogram. However, the 3-dimensional, cross-sectional nature of CT has the inherent ability to deliver more information than a projectional technique such as fluoroscopic angiography. The technical development of CT imaging continues at an astounding pace, and although many problems remain to be solved there is a good reason to believe that CT angiogram will become a better coronary angiogram in the future.

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REFERENCES

1. Nienhuis MB, Ottervanger JP, Bilo HJG, Dikkeschei BD, Zijlstra F. Prognostic value of troponin after elective percutaneous coronary intervention: a meta-analysis. Cathet Cardiovasc Interv 2008;71:318–24.
2. Selvanayagam JB, Porto I, Channon K, et al. Troponin elevation after percutaneous coronary intervention directly represents the extent of irreversible myocardial injury. Circulation 2005;111:1027–32.
3. Ricciardi MJ, Wu E, Davidson CJ, et al. Visualization of discrete microinfarction after percutaneous coronary intervention associated with mild creatine kinase-MB elevation. Circulation 2001;103:2780–3.
4. Rahimi K, Banning AP, Cheng AS, et al. Prognostic value of coronary revascularisation related myocardial injury: a cardiac magnetic resonance imaging study. Heart 2009 Aug 16 [E-pub ahead of print].
5. Porto I, Selvanayagam JB, Van Gaal WJ, et al. Plaque volume and occurrence and location of periprocedural myocardial necrosis after percutaneous coronary intervention: insights from delayed-enhancement magnetic resonance imaging, thrombolysis in myocardial infarction myocardial perfusion grade analysis, and intravascular ultrasound. Circulation 2006;114:662–9.
6. Bates ER. Ischemic complications after percutaneous transluminal coronary angioplasty. Am J Med 2000;108:309–16.
7. van Gaal WJ, Ponnuthurai FA, Selvanayagam J, et al. The Syntax score predicts periprocedural myocardial necrosis during percutaneous coronary intervention. Int J Cardiol 2009;135:60–5.

8. Mehran R, Dangas G, Mintz GS, et al. Atherosclerotic plaque burden and CK-MB enzyme elevation after coronary interventions: intravascular ultrasound study of 2256 patients. Circulation 2000;101:604–10.
9. Uetani T, Amano T, Ando H, et al. The correlation between lipid volume in the target lesion, measured by integrated backscatter intravascular ultrasound, and post-procedural myocardial infarction in patients with elective stent implantation. Eur Heart J 2008; 29:1714–20.
10. Ito S, Saio M, Suzuki T. Advanced atherosclerotic plaque as a potential cause of no-reflow in elective percutaneous coronary intervention: intravascular ultrasound and histological findings. J Invasive Cardiol 2004;16:669–72.
11. Patti G, Pasceri V, Colonna G, et al. Atorvastatin pretreatment improves outcomes in patients with acute coronary syndromes undergoing early percutaneous coronary intervention: results of the ARMYDA-ACS randomized trial. J Am Coll Cardiol 2007;49:1272–8.
12. Ebrahimi R, Saleh J, Toggart E, et al. Effect of preprocedural statin use on procedural myocardial infarction and major cardiac adverse events in percutaneous coronary intervention: a meta-analysis. J Invasive Cardiol 2008;20: 292–5.
13. Mood GR, Bavry AA, Roukoz H, Bhatt DL. Meta-analysis of the role of statin therapy in reducing myocardial infarction following elective percutaneous coronary intervention. Am J Cardiol 2007;100:919–23.
14. Briguori C, Visconti G, Focaccio A, et al. Novel Approaches for Preventing or Limiting Events (Naples) II trial impact of a single high loading dose of atorvastatin on periprocedural myocardial infarction. J Am Coll Cardiol 2009 Aug 3 [E-pub ahead of print].
15. Angelini A, Rubartelli P, Mistrorigo F, et al. Distal protection with a filter device during coronary stenting in patients with stable and unstable angina. Circulation 2004;110:515–21.
16. Uetani T, Amano T, Kunimura A, et al. The association between plaque characterization by CT angiography and post-procedural myocardial infarction in patients with elective stent implantation. J Am Coll Cardiol Img 2010;3:19–28.
17. Nageh T, Thomas MR, Sherwood RA, Harris BM, Jewitt DE, Wainwright RJ. Direct stenting may limit myocardial injury during percutaneous coronary intervention. J Invasive Cardiol 2003;15:115–8.
18. Barbato E, Marco J, Wijns W. Direct stenting. Eur Heart J 2003;24:394–403.
19. Choi EK, Choi SI, Rivera JJ, et al. Coronary computed tomography angiography as a screening tool for the detection of occult coronary artery disease in asymptomatic individuals. J Am Coll Cardiol 2008;52:357–65.
20. Motoyama S, Sarai M, Harigaya H, et al. Computed tomographic angiography characteristics of atherosclerotic plaques subsequently resulting in acute coronary syndrome. J Am Coll Cardiol 2009;54:49–57.
21. Hadamitzky M, Freissmuth B, Meyer T, et al. Prognostic value of coronary computed tomographic angiography for prediction of cardiac events in patients with suspected coronary artery disease. J Am Coll Cardiol Img 2009;2:404–11.
22. Shaw LJ, Berman DS, Hendel RC, Borges Neto S, Min JK, Callister TQ. Prognosis by coronary computed tomographic angiography: matched comparison with myocardial perfusion single photon-emission computed tomography. J Cardiovasc Comput Tomogr 2008;2:93–101.
23. Pflederer T, Ludwig J, Ropers D, Daniel WG, Achenbach S. Measurement of coronary artery bifurcation angles by multidetector computed tomography. Invest Radiol 2006;41: 793–8.
24. Mollet NR, Hoye A, Lemos PA, et al. Value of preprocedure multislice computed tomographic coronary angiography to predict the outcome of percutaneous recanalization of chronic total occlusions. Am J Cardiol 2005; 95:240–3.
25. Soon KH, Cox N, Wong A, et al. CT coronary angiography predicts the outcome of percutaneous coronary intervention of chronic total occlusion. J Interv Cardiol 2007;20:359–66.
26. Wertman BM, Cheng VY, Kar S, et al. Characterization of complex coronary artery stenosis morphology by coronary computed tomographic angiography. J Am Coll Cardiol Img 2009;2:950–8.
27. Ramcharitar S, Pugliese F, Schultz C, et al. Integration of multislice computed tomography with magnetic navigation facilitates percutaneous coronary interventions without additional contrast agents. J Am Coll Cardiol 2009;53:741–6.

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