

EDITORIAL COMMENT

# Myocardial Enhancement Defects on CT Angiograms



## Promising Prognosticator or Water Under the Bridge?\*

Koen Nieman, MD, PhD, Adriaan Coenen, MD

Over the past decade the value of cardiac computed tomography (CT) in the context of acute chest pain and suspected myocardial infarction has been intensively investigated. Coronary CT angiography has high sensitivity for the detection of coronary artery disease (CAD), and observational studies in chest pain cohorts have repeatedly demonstrated that the absence of CAD conveys a very low probability of acute coronary syndrome (ACS) and is associated with an excellent clinical outcome (1-3). Randomized controlled trials have confirmed that in patients with a low probability of ACS, cardiac CT is a safe and reliable diagnostic option with potential advantages in terms of efficiency and cost (4-6).

In addition, cardiac CT can identify myocardial infarction. On coronary CT angiograms, myocardial infarction is characterized by reduced contrast enhancement as a result of low perfusion. However, differentiation of acute myocardial infarction from chronic scar with fat tissue replacement can be difficult. Typically, fat tissue will have lower attenuation values than areas of reduced perfusion, and defects will often be visible on nonenhanced CT scans (calcium scans) as well (7). Infarct detection by CT angiography appears quite accurate in comparison to cardiac biomarkers or other imaging techniques (8,9), although total infarct size may be underestimated by CT compared with more established infarct imaging techniques (10). The prognostic value of infarct size has been investigated using various techniques but not yet with cardiac CT.

In this issue of *iJACC*, Kühl et al. (11) investigated the prognostic consequences of myocardial defects detected on coronary CT angiograms in patients with a non-ST-segment elevation myocardial infarction (NSTEMI). The study cohort of nearly 400 individuals was selected from a larger population of patients presenting to the emergency department with acute chest pain, for whom catheterization was considered necessary but not urgently required. Contrast-enhanced 64-detector cardiac CT was performed before invasive angiography, although imaging results were withheld from the treating physicians. In an elaborate analysis, the researchers applied various

SEE PAGE 684

parameters to characterize and quantify the presence, size, and transmural extent of enhancement defects of the myocardium. Of 376 evaluable patients, 62% showed abnormal myocardial enhancement, of which 11% had evidence of chronic myocardial scar. The combined endpoint of all-cause mortality and heart failure-related hospital admission at 4 years was reached by 15% of patients. After correction for several clinical parameters, ventricular function, and CAD severity, the attenuation ratio between the endocardial and epicardial myocardium and the segmental defect score, which combined the number of involved segments and the quantitative transmural severity, remained predictive of adverse outcome. Even after segments with evidence of old myocardial infarction on CT were removed, enhancement defects remained a significant predictor of clinical outcome.

The cohort is the largest of its kind, and the long follow-up permitted assessment of hard endpoints. Infarct size by various imaging techniques is associated with adverse outcome, although most prognostic data have been derived from cohorts with larger (ST-segment elevation) myocardial infarctions. In a study of patients with acute chest pain, rest perfusion defects by nuclear imaging were similarly associated with

\*Editorials published in *JACC: Cardiovascular Imaging* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Imaging* or the American College of Cardiology.

From the Departments of Cardiology and Radiology, Erasmus Medical Center, Rotterdam, the Netherlands. Dr. Nieman is supported by a grant from the Netherlands Heart Foundation; and has received institutional research support from Siemens Medical Solutions, Bayer Healthcare, and GE Healthcare. Dr. Coenen has reported that he has no relationships relevant to the contents of this paper to disclose.

outcome, but independent value over left ventricular ejection fraction could not be demonstrated (12). Contrary to these observations, in the present study, which included patients with NSTEMI at relatively low risk, the investigators demonstrated that myocardial enhancement defects provided incremental prognostic value over left ventricular ejection fraction.

A question that emerges from the presented results is whether the finding of prognostically relevant defects affects clinical management and therapeutic decisions in a meaningful way. Apart from the clinical context and individual patient characteristics, imaging can indeed provide various types of information that are relevant for management decisions. Myocardial contractility, inducible ischemia, and potential for functional recovery (viability) are all well-established parameters to guide revascularization decisions. Unfortunately, imaging of the myocardium during the arterial phase of enhancement, without induced hyperemia, will not provide these parameters in an optimal manner. As the investigators demonstrated, left ventricular function can be assessed using cardiac CT but is associated with more radiation exposure. Because of that, for routine coronary CT angiography, roentgen exposure is preferably limited to a brief period of the heart cycle. Enhancement defects on CT could represent either severe but reversible ischemia amenable to revascularization or permanently damaged myocardium, and it is not easy to distinguish between them. In case of myocardial infarction, the first-pass enhancement defects underestimate total infarct size, and the true transmural extent may be difficult to interpret, which would be important to assess myocardial viability in case of functional impairment. Not all chronic

infarctions show evident fat tissue replacement, whereas, on the other hand, its observation does not exclude the occurrence of a second ischemic insult.

In the setting of acute chest pain in the emergency department, the role of cardiac CT is momentarily limited to ruling out ACS in low- to intermediate-risk patients, generally without initial electrocardiographic or biochemical abnormalities. Although the incidence of false-negative first troponin assays has decreased substantially with the introduction of high-sensitivity assays, evidence of severe myocardial ischemia on CT could expedite the performance of invasive angiography and potentially improve outcome. The high sensitivity of new troponin assays comes at the expense of lower specificity and potential overdiagnosis of ACS in the emergency department. Even in this cohort of clinically established NSTEMI, 18% of patients did not have significant angiographic disease and 27% required no revascularization. Because high-sensitivity troponin assays appear to allow quick and reliable ruling out of ACS in many patients, the future role of cardiac CT could very well shift toward those patients with mildly elevated marker levels and avoid further (invasive) diagnostic procedures by excluding angiographic coronary disease. In this scenario, a comprehensive assessment of myocardial enhancement defects, as an expression of severe ischemia or impending myocardial infarction, could potentially play a valuable role.

**REPRINT REQUESTS AND CORRESPONDENCE:** Dr. Koen Nieman, Departments of Cardiology and Radiology, Erasmus Medical Center, Room Ca214, Bd 116, Dr. Molewaterplein 40, 3015 GC, Rotterdam, the Netherlands. E-mail: [k.nieman@erasmusmc.nl](mailto:k.nieman@erasmusmc.nl).

## REFERENCES

- Hollander JE, Chang AM, Shofer FS, et al. One-year outcomes following coronary computerized tomographic angiography for evaluation of emergency department patients with potential acute coronary syndrome. *Acad Emerg Med* 2009;16:693-8.
- Schlett CL, Banerji D, Siegel E, et al. Prognostic value of CT angiography for major adverse cardiac events in patients with acute chest pain from the emergency department: 2-year outcomes of the ROMICAT trial. *J Am Coll Cardiol Img* 2011;4:481-91.
- Dedic A, Ten Kate GJ, Neeffes LA, et al. Coronary CT angiography outperforms calcium imaging in the triage of acute coronary syndrome. *Int J Cardiol* 2013;167:1597-602.
- Goldstein JA, Chinnaiyan KM, Abidov A, et al. The CT-STAT (Coronary Computed Tomographic Angiography for Systematic Triage of Acute Chest Pain Patients to Treatment) trial. *J Am Coll Cardiol* 2011;58:1414-22.
- Hoffmann U, Truong QA, Schoenfeld DA, et al. Coronary CT angiography versus standard evaluation in acute chest pain. *N Engl J Med* 2012;367:299-308.
- Litt HI, Gatsonis C, Snyder B, et al. CT angiography for safe discharge of patients with possible acute coronary syndromes. *N Engl J Med* 2012;366:1393-403.
- Nieman K, Cury RC, Ferencik M, et al. Differentiation of recent and chronic myocardial infarction by cardiac computed tomography. *Am J Cardiol* 2006;98:303-8.
- Schepis T, Achenbach S, Marwan M, et al. Prevalence of first-pass myocardial perfusion defects detected by contrast-enhanced dual-source CT in patients with non-ST segment elevation acute coronary syndromes. *Eur Radiol* 2010;20:1607-14.
- Feuchtnner GM, Plank F, Pena C, et al. Evaluation of myocardial CT perfusion in patients presenting with acute chest pain to the emergency department: comparison with SPECT-myocardial perfusion imaging. *Heart* 2012;98:1510-7.
- Nieman K, Shapiro MD, Ferencik M, et al. Reperused myocardial infarction: contrast-enhanced 64-section CT in comparison to MR imaging. *Radiology* 2008;247:49-56.
- Kühl JT, Linde JJ, Køber L, Kelbæk H, Kofoed KF. The transmural extent and severity of myocardial hypoperfusion predicts long-term outcome in NSTEMI: an MDCT study. *J Am Coll Cardiol Img* 2015; 8:684-94.
- Kontos MC, Haney A, Ornato JP, Jesse RL, Tatum JL. Value of simultaneous functional assessment in association with acute rest perfusion imaging for predicting short- and long-term outcomes in emergency department patients with chest pain. *J Nucl Cardiol* 2008;15:774-82.

**KEY WORDS** computed tomography, myocardial infarction, perfusion, prognosis