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Diagnostic Value of Contrast-Enhanced Magnetic Resonance Imaging and Single-Photon Emission Computed Tomography for Detection of Myocardial Necrosis Early After Acute Myocardial Infarction

Tareq Ibrahim, MD,* Hubertus P. Bülow, MD,† Thomas Hackl, MD,† Mira Hörnke, MD,† Stephan G. Nekolla, PHD,† Martin Breuer, MD,* Albert Schömig, MD,* Markus Schwaiger, MD, FACC†

München, Germany

Objectives This study sought to evaluate the diagnostic value of contrast-enhanced magnetic resonance imaging (CMR) and single-photon emission computed tomography (SPECT) for detection of myocardial necrosis after acute myocardial infarction (AMI).

Background Single-photon emission computed tomography is widely accepted in the clinical setting for detection and estimation of myocardial infarction. Contrast-enhanced magnetic resonance imaging offers technical advantages and is therefore a promising new method for identification of infarcted tissue.

Methods Seventy-eight patients with AMI were examined by CMR and SPECT 7 days after percutaneous coronary intervention. Contrast-enhanced magnetic resonance imaging and SPECT images were scored for presence and location of infarction using a 17-segment model. Results were compared with the peak troponin T level, electrocardiographic, and angiographic findings.

Results Acute myocardial infarction was detected significantly more often by CMR than SPECT (overall sensitivity: 97% vs. 87%; $p = 0.008$). Sensitivity of CMR was superior to SPECT in detecting small infarction as assessed by the peak troponin T level <3.0 ng/ml (92 vs. 69%; $p = 0.03$), and infarction in non-anterior location (98% vs. 84%; $p = 0.03$). Non–Q-wave infarctions were more likely to be detected by CMR (sensitivity 85% vs. 46%; $p = 0.06$). While CMR offered high sensitivity for detection of AMI irrespective of the infarct-related artery, SPECT was less sensitive, particularly within the left circumflex artery territory.

Conclusions Contrast-enhanced magnetic resonance imaging is superior to SPECT in detecting myocardial necrosis after reperfused AMI because CMR detects small infarcts that were missed by SPECT independent of the infarct location. Thus, CMR is attractive for accurate detection and assessment of the myocardial infarct region in patients early after AMI. (J Am Coll Cardiol 2007;49:208–16) © 2007 by the American College of Cardiology Foundation

Reperfusion therapy has significantly reduced mortality in patients with acute myocardial infarction (AMI) (1). However, use of mortality as an end point to demonstrate advantages of new reperfusion strategies requires large numbers of patients (2). Thus, there is growing interest in markers that can be used as surrogate for mortality in trials assessing the efficacy of reperfusion therapy. It has been shown, that the extent and degree of irreversible myocardial tissue injury after AMI are strong predictors of patient outcome, and interventions that reduce injury significantly improve prognosis (3). Nuclear imaging techniques such as single-photon emission computed tomography (SPECT) using ^{99m}Tc-sestamibi as a tracer are currently widely used in the clinical practice for the detection and estimation of myocardial infarction (MI) after reperfusion therapy and to predict outcome according to infarct size (2,4) or myocardial salvage (5). However, technical limitations of SPECT imaging such as a low spatial resolution may impair delineation of small infarcts in up to 25% of patients with AMI

From the *Deutsches Herzzentrum and 1. Medizinische Klinik Rechts der Isar, Technische Universität München, München, Germany; and †Nuklearmedizinische Klinik und Poliklinik, Technische Universität München, München, Germany. This work was supported, in part, by a grant from the Bayerische Forschungsstiftung (#372/99).

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(2,4). Because modern reperfusion therapies constantly improve and smaller infarcts are more frequently to be expected, this amount may even increase in the future. Furthermore, regional relative tracer inhomogenities resulting from soft tissue attenuation or scatter may compromise the diagnostic accuracy of SPECT imaging (6,7).

Findings from several studies have indicated that contrast-enhanced magnetic resonance imaging (CMR) enables the visualization of AMI and documentation of reperfusion with high spatial resolution (8–13). In a previous study, we have validated measures of CMR enhancement in patients with rather large AMI in comparison with quantitative SPECT imaging and shown a high correlation for estimation of infarct size (14). So far, there are only a few reports comparing the diagnostic value of CMR with that of SPECT in terms of infarct detection. In old MI, it has been recently shown that CMR can detect subendocardial infarcts that are missed by SPECT (15). Further data in patients with AMI suggest that CMR may be superior to SPECT for detecting small infarcts in the inferior wall (16). In this study, we sought to investigate the diagnostic value of CMR and SPECT for the detection of myocardial necrosis in patients early after AMI and reperfusion therapy.

Abbreviations and Acronyms

AMI = acute myocardial infarction
CE = contrast enhancement
CMR = contrast-enhanced magnetic resonance imaging
LAD = left anterior descending artery
LCX = left circumflex artery
LV = left ventricle
MI = myocardial infarction
RCA = right coronary artery
SPECT = single-photon emission computed tomography

Methods

Patients. During a 2-year period (March 2002 to March 2004), we consecutively enrolled 78 patients with AMI (onset of symptoms <48 h). Diagnosis of AMI was based on the presence of chest pain lasting at least 20 min associated with electrocardiographic (ECG) changes (ST-segment elevation or depression, pathologic Q waves, left bundle branch block of new onset) and elevation of troponin T activity (>0.1 ng/ml) (17). A total of 164 patients were screened for inclusion into the study. Patients were excluded for the following reasons: prior infarction (n = 17), death (n = 10), no scintigraphy (n = 21), claustrophobia (n = 12), reject consent (n = 16), pacemaker (n = 4), technical reason (n = 6). Patients from our previous study were all included (14). On the day of admission, all patients underwent coronary angiography with percutaneous coronary intervention (n = 75 stenting; n = 3 angioplasty) of the infarct-related artery. Contrast-enhanced magnetic resonance imaging and SPECT were performed in all patients median (25th, 75th percentiles), 7.0 (6.0, 8.0) days after infarction. The study protocol was reviewed and approved by the local ethics committee. Written informed consent was obtained before inclusion in the study.

Protocol. Contrast-enhanced magnetic resonance imaging was performed on a 1.5-T tomograph (Siemens Sonata, Erlangen, Germany) equipped with a dedicated cardiac phased-array surface coil. All images were obtained in repeated breath hold and were gated to the ECG. Contiguous short-axis slices and representative long-axis slices of the left ventricle (LV) were acquired 20 min after intravenous bolus injection of 0.2 mmol/kg gadolinium-diethlenetriamine pentaacetic acid (Gd-DTPA) (Magnevist, Schering AG, Berlin, Germany). Between March 2002 and April 2003, a segmented inversion-recovery TrueFISP-sequence was used (slice thickness 8 mm, repetition time (TR) 2.3 ms, echo time (TE) 1.4 ms, image matrix 256 × 256, flip angle 60°; n = 40 patients). Thereafter, CMR was performed using a 3-dimensional segmented inversion-recovery TurboFLASH-sequence (slice thickness 4 mm, TR 4.0 ms, TE 1.5 ms, image matrix 256 × 256, flip angle 30°; n = 38 patients). The inversion time was individually chosen to null normal myocardium.

Single-photon emission computed tomography imaging was performed after intravenous injection of 350 MBq technetium-99m-sestamibi using a camera system (MultiSPECT 3, Siemens AG, Erlangen, Germany) equipped with low-energy, parallel-hole collimators. Images were acquired ECG-gated in a 64 × 64 data matrix with an acquisition time of 40 s/projection. Summed data were reconstructed over 180° from 45° right anterior oblique to 45° left posterior oblique by use of a Butterworth filter and were realigned to generate short- and long-axis views.

Image analysis. Contrast-enhanced magnetic resonance imaging and SPECT were compared using a 17-segment model as previously recommended by the American Heart Association (18). Based on this model, representative short-axis slices of the basal (6 segments), mid-ventricular (6 segments), and apical (4 segments) region of the LV were analyzed. The apex was evaluated from long-axis slices. A total of 1,326 segments were assessed for both CMR and SPECT using semiquantitative scores.

For CMR, the presence or absence of contrast enhancement (CE) as well as the transmural extent of CE within each segment was defined visually and subjectively by 2 blinded observers by consensus according to the following scheme: 0 = no enhancement, 1 = 1% to 25%, 2 = 26% to 50%, 3 = 51% to 75%, 4 = 76% to 100% enhancement extent referred to the myocardial wall thickness (15). Single-photon emission computed tomography images were interpreted by an experienced nuclear cardiologist who was blinded to the clinical data and the CMR results. Segments were scored from 0 to 4: 0 = normal perfusion, 1 = mildly reduced, 2 = moderately reduced, 3 = severely reduced, 4 = absent tracer activity (19). For both modalities, a score of ≥1 in at least 1 segment was defined as abnormal. Regional assessment of CMR and SPECT was performed within 234 corresponding vascular territories. Segments were generally assigned to 1 of the 3 major coronary arteries