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Cardiac Imaging

Usefulness of a Comprehensive Cardiovascular Magnetic Resonance Imaging Assessment for Predicting Recovery of Left Ventricular Wall Motion in the Setting of Myocardial Stunning

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OBJECTIVES We sought to evaluate the usefulness of a comprehensive assessment of four cardiovascular magnetic resonance imaging (CMR)-derived myocardial viability indexes in the setting of myocardial stunning.

BACKGROUND Cardiovascular magnetic resonance imaging allows the simultaneous assessment of several viability indexes.

METHODS We studied 40 patients with a first ST-segment elevation myocardial infarction (MI) and an open infarct-related artery. At the first week, using CMR, wall motion (WM), and four viability indexes were determined: wall thickness, WM improvement with low-dose dobutamine, perfusion, and transmural extent of necrosis. We created a comprehensive score based on the presence and the relative power of these viability indexes for predicting normal WM at the sixth month.

RESULTS Of 153 dysfunctional segments at the first week, 59 (39%) exhibited normal WM at the sixth month. According to the odds ratio of viability indexes for predicting normal WM, we developed a five-level predictive score. The proportions of segments showing normal WM at sixth month were as follows; Level 1 (0 indexes): 0 of 13 (0%); Level 2 (normal thickness and/or perfusion): 14 of 82 (17%); Level 3 (dobutamine response): 5 of 11 (45%); Level 4 (non-transmural necrosis): 20 of 26 (77%); Level 5 (non-transmural necrosis and dobutamine response): 20 of 21 (95%), $p < 0.0001$ for the trend. These proportions were similar in a matched prospective validation group comprising 16 patients (0%, 18%, 62%, 77%, and 90% for levels 1 to 5, respectively, $p < 0.0001$ for the trend).

CONCLUSIONS A comprehensive analysis of the four more widely used CMR-derived viability indexes is useful for predicting late systolic function after myocardial infarction. (J Am Coll Cardiol 2005;46:1747–52) © 2005 by the American College of Cardiology Foundation

The analysis of residual myocardial viability in the infarcted area is of paramount importance when defining the outcome and management of patients after myocardial infarction (MI) (1,2). It has been demonstrated that, separately, wall thickness, contractile reserve, perfusion, and transmural extent of necrosis are useful tools for predicting late systolic recovery (3–8). However, the relative value of these indexes is different, and an integrated analysis might allow a more accurate prediction. This type of comprehensive assessment has proved its utility in other clinical scenarios (9–11).

Cardiovascular magnetic resonance (CMR) imaging permits, in a single session, a simultaneous state-of-the-art analysis of these parameters (6,7,12). Focusing on a single variable may dismiss relevant information easily obtainable by a complete evaluation of the CMR study. We aimed to evaluate the usefulness of a comprehensive assessment of these four widely used viability indexes for predicting late systolic function after MI in the setting of myocardial stunning.

METHODS

This study is a part of an ongoing protocol investigating several aspects of viability, perfusion, and remodeling after MI (3,6,13). We created a comprehensive score for predicting late systolic function by analyzing the results derived from the study group, which comprised the first 40 patients included in the study protocol. Afterwards, this score was tested in a matched prospective validation group, which comprised the next 16 patients included in this series. All 56 patients accomplished the inclusion criteria exposed in this report. The ethics committee of our institution approved the research protocol. Informed consent was obtained from all subjects.

Study group. We prospectively included 60 consecutive patients with a first ST-segment elevation MI treated with thrombolytic therapy within the first 6 h after the onset of

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Abbreviations and Acronyms

CMR = cardiovascular magnetic resonance imaging
IRA = infarct-related artery
MI = myocardial infarction
TIMI = Thrombolysis In Myocardial Infarction
TrueFISP = true fast imaging with steady state precession
WM = wall motion

chest pain. The inclusion criteria were: 1) stable clinical course without complications during the first six months; 2) single-vessel disease and a patent (Thrombolysis In Myocardial Infarction [TIMI] flow grade 3 and residual stenosis <50%) in the infarct-related artery (IRA) at the end of pre-discharge cardiac catheterization and at the sixth month; and 3) no contraindications to CMR. We excluded 20 patients because of multivessel disease (10 cases), TIMI flow grade <3 (2 cases), restenosis (5 cases), claustrophobia (2 cases), and re-infarction (1 case). Therefore, the final study group comprised 40 patients.

Cardiac catheterization. Cardiac catheterization was performed 4 ± 1 days after MI. A stent was placed in 33 patients (82%) in whom luminal narrowing in the IRA was >50%. At the end of the pre-discharge study, all patients showed TIMI flow grade 3 and residual stenosis <50%. Angiographic data were evaluated in a core laboratory (ICICOR, Valladolid, Spain). Cardiac catheterization was repeated 179 ± 8 days after MI, and TIMI flow grade 3 and residual stenosis <50% was confirmed in all cases.

CMR. We performed CMR (Sonata Magnetom, Siemens, Erlangen, Germany) at 7 ± 1 days (at least 48 h after cardiac catheterization) and 184 ± 11 days after MI according to our laboratory protocol (6). All images were acquired by a phased-array body surface coil during breath-holds and were electrocardiogram-triggered. Cine images (true fast imaging with steady-state precession [TrueFISP], repetition time/echo time: 3.2/1.6 ms; flip angle: 61°; matrix: 256 × 128; slice thickness: 6 mm; temporal resolution: 26 ms) were acquired in two-, three-, and four-chamber views and every 1 cm in short-axis views at rest and during intravenous infusion of low-dose (10 μg/kg/min) dobutamine.

After cine images, a minimum of three short-axis views (basal, midventricular, apical) and two long-axis views were performed for first-pass perfusion imaging (TrueFISP, inversion time: 110 ms, repetition time/echo time: 190/1 ms; flip angle: 49°; matrix: 128 × 72) after administering 0.1 mmol/kg of gadolinium-diethylenetriaminepentaacetic acid (Magnograf, Juste S.A.Q.F., Madrid, Spain) at a flow rate of 3 ml/s, and acquiring images every other beat in all slices during a period of 90 to 120 s.

Late enhancement imaging was performed 10 min after contrast injection using a segmented inversion recovery TrueFISP sequence (repetition time/echo time: 2.5/1.1 ms; slice thickness: 6 mm; flip angle: 50°; matrix: 195 × 192) and nullifying myocardial signal.

Analysis of CMR data. An experienced observer who was blinded to all patient data analyzed CMR studies by using customized software (Syngo, Siemens, Erlangen, Germany). Segment location was defined in cine-image sequences applying the 16-segment model (14). The same projections used in cine images were recalled for analyzing perfusion (in first-pass perfusion imaging) and the transmural extent of necrosis (in late enhancement imaging). Wall motion (WM), abnormal if wall thickening at rest (end-systolic thickness − end-diastolic thickness) was ≤2 mm (6,7,15), was quantified in cine images.

Four viability indexes were evaluated: 1) end-diastolic thickness (abnormal if ≤5.5 mm) (6,15), and 2) WM during low-dose dobutamine (abnormal if ≤2 mm) (6,7) were quantified in cine images. 3) Abnormal perfusion was defined qualitatively as regions showing hypoenhancement (compared with non-infarcted segments at the same slice) at the end of the 90- to 120-s acquisition period in first-pass perfusion imaging (6,12,16,17). Perfusion defects were confirmed both in short- and long-axis views to avoid artifacts. Finally, 4) transmural extent of necrosis was defined as ≥ 50% in late enhancement imaging (6,7,12,18). In the CMR study performed at the sixth month, WM was re-evaluated. Normal systolic function at the sixth month was considered in the case of WM >2 mm.

In a group of 15 patients (240 segments) not included in this study, we calculated intraobserver agreement with regard to the presence or not of the cut-off values applied. Intraobserver agreement on perfusion results was 94% (kappa = 0.86) versus 96% (kappa = 0.88) on late enhancement imaging and systolic function results (WM and wall thickness).

Statistical analysis. Continuous data were expressed as the mean ± standard deviation. Comparisons between groups were made using chi-square tests for discrete data. We analyzed separately the usefulness of the four viability indexes evaluated at the first week (1: wall thickness >5.5 mm; 2: WM during low-dose dobutamine >2 mm; 3: normal perfusion; 4: transmural extent of necrosis <50%) for predicting normal WM at the sixth month. We calculated sensitivity, specificity, and positive and negative predictive values of the four viability indexes evaluated.

A logistic regression model was applied including the four viability indexes to investigate the relative power of each variable for predicting late systolic function. According to the odds ratio magnitude, we constructed a five-level score. The percentage of segments with normal WM at the sixth month depending on the score level was determined. We used the chi-square test for trend for comparing percentages.

The utility of this score was tested in a matched prospective validation group that comprised the next 16 patients included in the ongoing study protocol (all of whom accomplished the inclusion criteria of the initial study