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# Performance of CMR Methods for Differentiating Acute From Chronic MI

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## ABSTRACT

**OBJECTIVES** The purpose of this study was to assess the performance of cardiac magnetic resonance (CMR) methods for discriminating acute from chronic myocardial infarction (MI).

**BACKGROUND** Although T2-weighted CMR is thought to be accurate in differentiating acute from chronic MI, few studies have reported on diagnostic accuracy, and these generally compared extremes in infarct age (e.g., <1 week old vs. more than 6 months old) and did not evaluate other CMR methods that could be informative.

**METHODS** A total of 221 CMR studies were performed at various time points after ST-segment elevation myocardial infarction in 117 consecutive patients without a history of MI or revascularization enrolled prospectively at 2 centers. Imaging markers of acute MI (<1 month) were T2 hyperintensity on double inversion recovery turbo spin echo (DIR-TSE) images, microvascular obstruction (MO) on delayed-enhancement CMR, and focally increased end-diastolic wall thickness (EDWT) on cine-CMR.

**RESULTS** The prevalence of T2-DIR-TSE hyperintensity decreased with infarct age but remained substantial up to 6 months post-MI. In contrast, the prevalence of both MO and increased EDWT dropped sharply after 1 month. T2-DIR-TSE sensitivity, specificity, and accuracy for identifying acute MI were 88%, 66%, and 77% compared with 73%, 97%, and 85%, respectively, for the combination of MO *or* increased EDWT. On multivariable analysis, persistence of T2-hyperintensity in intermediate-age infarcts (1 to 6 months old) was predicted by larger infarct size, diabetes, and better T2-DIR-TSE image quality score. For infarct size ≥10% of the left ventricle, a simple algorithm incorporating all CMR components allowed classification of infarct age into 3 categories (<1 month old, 1 to 6 months old, and ≥6 months old) with 80% (95% confidence interval: 73% to 87%) accuracy.

**CONCLUSIONS** T2-DIR-TSE hyperintensity is specific for infarcts <6 months old, whereas MO and increased EDWT are specific for infarcts <1 month old. Incorporating multiple CMR markers of acute MI and their varied longevity leads to a more precise assessment of infarct age. (J Am Coll Cardiol Img 2015;8:669–79) © 2015 by the American College of Cardiology Foundation.

It is vital to determine whether a myocardial infarction (MI) is recent or chronic because there are implications for patient management and prognosis. The determination, however, can be challenging because acute MI is often clinically unrecognized, and if testing is delayed 1 to 2 weeks, diagnostic electrocardiographic changes and elevated biomarkers have usually resolved (1).

T2-weighted cardiac magnetic resonance (CMR) can detect necrosis-associated myocardial edema, and recent expert reviews and consensus guidelines have touted this technique as an excellent method to

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**ABBREVIATIONS AND ACRONYMS**

**CI** = confidence interval

**CMR** = cardiac magnetic resonance

**CNR** = contrast-to-noise ratio

**DE-CMR** = delayed-enhancement cardiac magnetic resonance

**DIR-TSE** = double inversion recovery turbo spin echo

**EDWT** = end-diastolic wall thickness

**IRA** = infarct-related artery

**LV** = left ventricular

**MI** = myocardial infarction

**MO** = microvascular obstruction

**STEMI** = ST-segment elevation myocardial infarction

**TIMI** = Thrombolysis In Myocardial Infarction

distinguish acute from chronic MI (2–4). However, the time frame for detecting "acute" T2-weighted CMR changes is unclear, and, to date, only 3 studies have reported on diagnostic performance in 54, 50, and 46 patients, respectively (5–7). Moreover, these studies have the potential limitation of spectrum bias in that enrolled patients generally had extremes in infarct age (e.g., <1 week vs. more than 6 months). Hence, the diagnostic utility of T2-weighted CMR requires additional validation, especially in patients with intermediate-age infarcts.

Additionally, other CMR markers may be useful in discriminating acute from chronic MI, including the presence of microvascular obstruction (MO) on delayed-enhancement CMR and focally increased end-diastolic wall thickness (EDWT) on cine CMR. The utility of these methods in comparison with T2-weighted techniques has not been previously reported.

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The purpose of the present 2-center study was to examine the diagnostic performance of CMR methods in differentiating acute from chronic MI. Unlike previous reports, we: 1) included patients with intermediate-age infarcts (1 to 6 months old); 2) compared multiple CMR methods that could be informative; and 3) incorporated an assessment of image quality to help distinguish potentially artifactual from true findings.

## METHODS

**POPULATION.** We prospectively recruited 122 patients with a first-time ST-segment elevation myocardial infarction (STEMI) at 2 centers (Maastricht University Medical Center, Maastricht, the Netherlands; Duke Cardiovascular Magnetic Resonance Center, Durham, North Carolina). The diagnosis of STEMI required appropriate cardiac biomarkers with 12-lead electrocardiography showing ST-segment elevation (≥0.2 mV in 2 or more contiguous precordial leads or ≥0.1 mV in ≥2 contiguous limb leads) (1). Consecutive patients admitted for primary PCI who agreed to undergo CMR were enrolled. Patients with previous MI, revascularization, or CMR contraindications were excluded. CMR was performed for research, and results were not used for clinical decision making. Four patients did not complete CMR (hemodynamic instability or claustrophobia); 1 had recurrent MI before CMR and was excluded. No patient was excluded because of image quality. The final population consisted of 117 patients. Because of scheduling, 5 did not undergo scanning for 1 month. Hence, 112 underwent CMR <1 month after acute MI. Eighty-six and 23 patients underwent scans 1 to 6 months and ≥6 months post-AMI, respectively (total of 221 scans). In patients with multiple scans, there were no cardiac events between scans. The ethics board at both sites approved the study; all patients gave written informed consent.

Admission data including medications were recorded. Coronary angiograms were reviewed to assess infarct-related-artery (IRA) reperfusion. Thrombolysis In Myocardial Infarction (TIMI) flow grade (8) was scored as follows: 0 = absence of flow; 1 = faint flow with incomplete filling; 2 = delayed flow with complete filling; 3 = normal flow.

**CARDIAC MAGNETIC RESONANCE.** Scanners (1.5-T, Philips Intera, Best, the Netherlands or Siemens Avanto, Erlangen, Germany) with standard protocols were used. Cine images were acquired in multiple short-axis and 3 long-axis views using steady-state free precession (slice thickness, 6 mm; gap, 4 mm; in-plane resolution, ~1.7 × 1.4 mm). A short-axis stack of T2-weighted images encompassing the left ventricle and matched in location with cine images was obtained using a double inversion recovery turbo spin echo (DIR-TSE) sequence (repetition time, 2 R-R intervals; echo time, 100 ms [Philips], 80 ms [Siemens]; slice thickness, 8 mm; gap, 2 mm; in-plane resolution, ~1.9 × 1.4) with spectrally selective fat suppression and vendor-supplied coil-intensity correction. A conventional black-blood sequence was used so that findings could be placed in context with previous studies reporting diagnostic performance (5–7). Additionally, black-blood sequences are the most commonly used in clinical practice because they are commercially available from all magnetic resonance imaging scanner vendors. Delayed enhancement imaging was performed using a segmented inversion recovery sequence, 10 to 20 min after 0.15 to 0.20 mmol/kg gadolinium contrast (gadolinium-diethylenetriaminepentaacetic acid or gadoversetamide).

**IMAGE ANALYSIS.** Scans were interpreted in random order by consensus of 3 observers blinded to patient identity, clinical data, and CMR date. Three separate interpretations were performed, weeks apart: first, with only T2-DIR-TSE images available; second, with only cine-CMR and delayed-enhancement CMR DE-CMR images available; and third, with all components available. Standard quantitative assessments were performed to measure infarct size and left ventricular (LV) ejection fraction based on manual