Clinical validation of multi-contrast delayed enhancement (MCDE) for wall motion and viability imaging

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Introduction: A cardiac MRI exam for patients with ischemic cardiomyopathy includes an assessment of cardiac function (wall motion) and viability. Wall motion imaging is typically acquired with a cine SSFP pulse sequence, and viability (or delayed enhancement) imaging is performed with an inversion-recovery gradient echo (IR-GRE) sequence. Both pulse sequences are 2D acquisitions which require repeated breath-holds to cover the entire left ventricle (LV). Multi-contrast delayed enhancement (MCDE) allows myocardial viability and wall motion to be assessed simultaneously by producing cardiac-phase-resolved images at multiple inversion times[1]. This study assessed the clinical accuracy and reproducibility of MCDE imaging for the evaluation of ejection fraction (EF), LV mass, LV end-diastolic volume (EDV) and infarct mass.

Methods: Forty-one patients with suspected myocardial infarction (MI) were studied. All patients underwent an assessment of cardiac function (with cine SSFP imaging) followed by viability imaging starting 10 minutes after administration of 0.2 mmol/kg Gd-DTPA with the IR-GRE and MCDE sequences (in a random order). The MCDE sequence uses a segmented SSFP acquisition following an inversion pulse; one inversion pulse is played out per heart beat, and twenty images are reconstructed each at a different cardiac phase and effective inversion time. The position of the inversion pulse is placed just prior to diastole to produce infarct-enhanced images in diastole and systolic images with normal SSFP contrast in systole (see Fig 1). MCDE can therefore be used to assess wall motion and viability in a single breath-hold. A short axis stack covering the entire LV was acquired with all three sequences (cine SSFP, IR-GRE and MCDE) at the same spatial resolution (1.5 x 1.5 x 8 mm). Manual endo and epicardial contours were drawn by two trained observers in a blinded fashion on the end-systolic and end-diastolic cine SSFP and MCDE images to calculate EF, LV mass, and LV EDV. Manual contours of enhanced MI were drawn on the IR-GRE and infarct-enhanced MCDE images to calculate the infarct mass.

Results: MCDE images in a 57-year old patient showing an antero-septal infarct as well as end-systolic and end-diastolic frames are compared to the conventional viability and wall motion images in Figure 1. Images from two patients were excluded from the final analysis as an incorrect placement of the inversion pulse prevented systolic frame identification. MI was detected in 24 patients, with associated wall motion abnormalities and a reduced EF. In one patient, a small subendocardial infero-lateral MI was detected on the MCDE images but not on the IR-GRE images (Fig 2); reduced wall motion was observed in the infero-lateral segment and the patient had an EF of 46%. This patient also had papillary muscle MI that was detected via MCDE but not with IR-GRE (Fig 2). MCDE showed excellent agreement with cine SSFP in the assessment of EF (bias = -2%) and LV mass (bias = 0.2 g), and clinically acceptable agreement for LV EDV (bias = -7 mL). Agreement was also excellent between MCDE and IR-GRE for the measurement of infarct mass (bias = 0.2 g). The inter-observer variability for the measurement of EF with MCDE imaging (mean difference = -2.0%) showed close agreement to the inter-observer variability with cine SSFP imaging (mean difference = -2.6%).

Discussion: This study shows that MCDE imaging can accurately and reproducibly assess EF, LV volume and mass, and infarct size, across a range of patients with both normal and abnormal myocardial architecture. With the inherent spatial registration provided by MCDE imaging, the relationship between the location and transmurality of infarcted tissue and the associated degree of any wall motion abnormality is easier to determine. The multi-contrast approach improves the visualization of the blood-infarct border[1], which led to the detection of a small subendocardial infarct in one patient via MCDE imaging that went undetected on the IR-GRE images. The MCDE sequence has also been shown to improve the detection of right ventricular infarcts[2] and papillary muscle infarcts[3].

Conclusions: MCDE demonstrates excellent clinical agreement conventional imaging for the assessment of cardiac function and viability. MCDE provides improved visualization of small infarcts and reduces the number of breath-holds required for a cardiac MRI exam.

References:

1. Detsky et al MRM 2007;58. 2. Yang et al ISMRM 2008 pp. 1009. 3. Yang et al Can J Cardiology 2008;24.

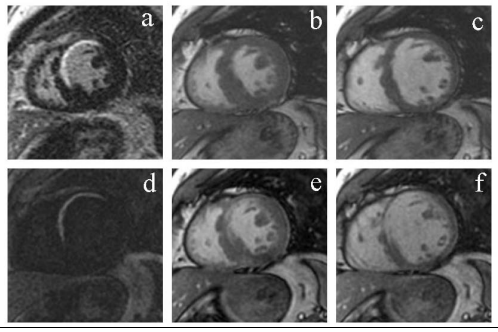

Fig 1. (a) IR-GRE viability image, (b-c) end-systolic and end-diastolic cine SSFP images, (d-f) three of 20 MCDE images showing (d) the antero-septal infarct, (e) end-systole and (f) end-diastole.

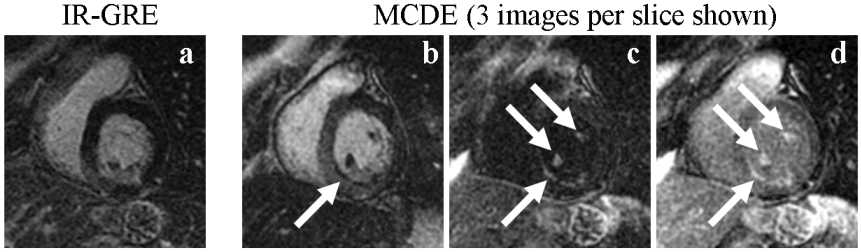

Fig 2. (a) IR-GRE image and (b-d) three MCDE images at early inversion times showing the small infero-lateral and papillary muscle infarct (arrows) not seen on the IR-GRE image.