Improved detection of papillary muscle infarction by high-resolution 3D free breathing delayed enhancement CMR

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INTRODUCTION Papillary muscle infarction (PMI) is a serious consequence of acute myocardial infarction (AMI) that can impede mitral valve function and contribute to heart failure symptoms. Delayed enhancement cardiac magnetic resonance (DE-CMR) is well-established as a highly accurate imaging technique to identify infarcted myocardium within the left ventricular (LV) wall (1,2). As DE-CMR enables detection of myocyte necrosis, it provides a non-invasive means of identifying PMI. However, the breath-held 2D sequence that is routinely used for DE-CMR is suboptimal for detection of small infarcts such as PMI as it is limited by spatial resolution and includes slice gaps when breath-holding level is inconsistent. A rapid free-breathing navigator 3D DE-CMR sequence has been developed to provide higher spatial resolution and contiguous LV coverage without gaps for myocardial imaging (3). The objective of this study was to prospectively compare free-breathing 3D with breath-held 2D DE-CMR for PMI detection in a diverse cohort of patients presenting with AMI.

MATERIALS AND METHODS DE-CMR was performed between September 2006 and July 2009 as part of a standardized, institutional review board approved research protocol of post-AMI patients. CMR was performed 26±11 days following AMI. In accordance with the established protocol, 2D and 3D DE-CMR were attempted in all patients. 2D used a standard inversion recovery pulse sequence with segmented k-space acquisition and breath-holds during image acquisition (typical 2D imaging parameters: TR/TE/FA/rBW = 7.0 ms/3.4 ms/20°/±15.63 kHz, matrix = 256x192, slice = 6 mm/4 mm skip, 24 views per segment). 3D used a free-breathing inversion recovery sequence (3) that combines partial k-space acquisition with the efficient phase-ordered automatic window selection (PAWS) navigator gating algorithm (4) to reduce scan time (typical 3D imaging parameters: TR/TE/FA/rBW = 4.8 ms/1.5 ms/20°/±62.5 kHz, matrix = 256x256, slice = 5 mm, 36 views per segment). 2D and 3D were independently interpreted for presence of PMI, defined as hyperenhanced myocardium within the papillary muscle apparatus. PMI was also graded for papillary location (anterolateral or posteromedial) and size (partial or complete hyperenhancement of affected papillary muscle). All interpretations were performed by an experienced physician blinded to patient identifiers and results of the other DE-CMR imaging approach.

RESULTS The study population was comprised of 109 patients presenting with initial AMI (57±13yo, 82% male, LVEF 51±11%, infarct related artery: 61% left anterior descending, 30% right coronary, 9% left circumflex artery). 25% (n=27) had PMI as determined by either 2D or 3D DE-CMR. PMI was more likely to involve the posteromedial (66%) than the anterolateral papillary muscle (33%; p=0.02), and hyperenhancement in the affected papillary muscle was more often partial (74%) than complete (26%; p<0.001). Both 2D and 3D DE-CMR were successfully acquired in 80% of all patients, with navigator 3D failure in 18% and intolerance to breath-held 2D in 2%. Among subjects with both 2D and 3D DE-CMR, PMI prevalence was higher by 3D than 2D DE-CMR (21% vs. 16%, p<0.001). 3D DE-CMR detected PMI in all patients (14/14) with positive 2D. In these patients, 3D scan time was 291±166 sec and navigator efficiency was 37±19%. All of the 7 patients with PMI detected by 3D but missed by 2D DE-CMR had partial PMI (admixed infarcted and viable papillary myocardium) (**Figure 1**). Matched ROI comparisons yielded higher SNR and CNR (both p<0.001) for 3D vs. 2D PMI (**Figure 2**). 3D yielded a 1.4 fold improvement in spatial resolution vs. 2D DE-CMR (mean voxel size: 11.1±3.2 vs. 15.9±3.4 mm^3).

CONCLUSION Among a diverse cohort of post-AMI patients, free-breathing 3D DE-CMR provided improved detection of PMI compared to breath-held 2D DE-CMR. Improvement PMI detection by 3D DE-CMR was associated with higher spatial resolution, contiguous LV coverage without gap between imaging slices, as well as increased SNR and CNR.

REFERENCES 1. Kim RJ et al. New Engl J Med 2000;343:1445-53. 2. Simonetti OP et al. Radiology 2001;218:215-23. 3. Nguyen TD et al. JMRI 2008;27:802. 4. Jhooti et al. MRM 2000;43:470-80.

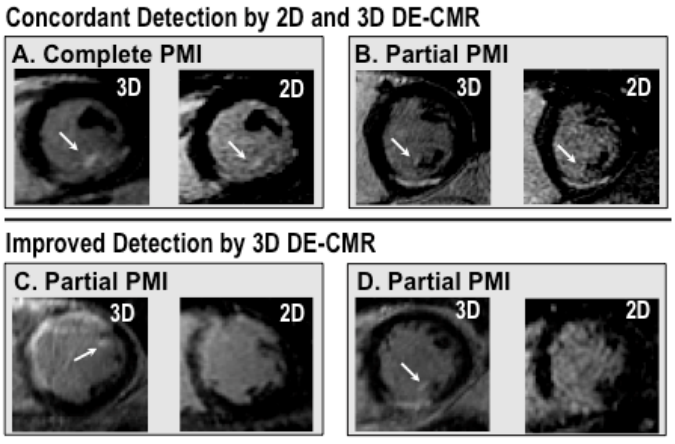

Figure 1. A, B: Complete PMI (A) and partial PMI (B) concordantly detected by 2D and 3D DE-CMR. **C, D**: Partial PMI detected by 3D but not 2D DE-CMR. Note the misregistration between 2D and 3D, which may explain PMI detection by 3D (C). Partial PMI detected by 3D but not 2D despite near identical image positions (D).

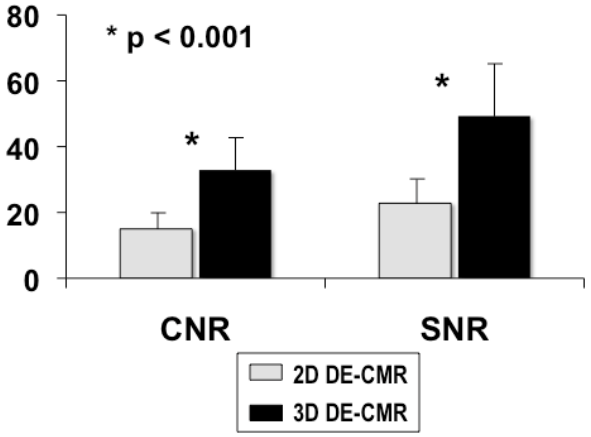

Figure 2. PMI detection by 3D DE-CMR was associated with higher contrast to noise ratio (CNR) and signal to noise ratio (SNR) as compared to 2D DE-CMR (p<0.001). Comparisons based on matched ROI analysis among 14 patients with concordant PMI detection by 2D and 3D DE-CMR.