Clinical Evaluation of Free-Breathing 3D Delayed Enhancement Imaging for Myocardial Viability Assessment: Comparison with Routine Breath-Hold 2D Imaging

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INTRODUCTION Delayed enhancement MRI (DE-MRI) of the myocardium has been established as a diagnostic imaging standard for myocardial viability assessment (1). DE-MRI is commonly performed using a breath-hold 2D (2DBH) sequence (2). Breath-holding limits the spatial resolution, requires patient cooperation, and may introduce slice misregistration due to inconsistent breath-holding levels. A rapid free-breathing navigator-gated 3D (3DNAV) DE-MRI sequence was developed to address these problems (3). This sequence combines 3D partial k-space acquisition with the efficient phase-ordered automatic window selection (PAWS) navigator gating algorithm to reduce scan time. Preliminary results demonstrated improved infarct SNR and CNR and reduced scan time compared to routine 2DBH imaging. The objective of this study was to prospectively compare 3DNAV imaging with 2DBH imaging in patients with confirmed prior myocardial infarction (MI).

MATERIALS AND METHODS 23 patients (16 men, 7 women, mean age = 59 ± 14 years, age range = 34-83 years) with history of MI based on elevated cardiac enzymes were imaged with both 2DBH and 3DNAV sequences at 1.5T (GE Excite). DE-MRI was initiated 10 min after contrast injection (0.2 mmol/kg) with the following typical imaging parameters: 1) 2DBH: TR/TE/FA/rBW = 7.0 ms/3.4 ms/20°/±15.63 kHz, FOV = 36x27 cm^2, 256x192 matrix, slice = 6 mm/4 mm skip, 24 views per segment, 2RR, 2) 3DNAV: TR/TE/FA/rBW = 4.8 ms/1.5 ms/20°/±62.5 kHz, FOV = 36x27 cm^2, 256x256 matrix, slice = 5 mm, 36 views per segment, 1RR, gating window = 4 mm. 2DBH and 3DNAV images were read by a Level III AHA certified physician in two separate sessions two weeks apart to minimize recall bias. The transmural extent of MI was scored visually using a 17-segment model (4) with a 5-point scale (0=no infarction; 1=1-25% of wall thickness; 2=26-50%; 3=51-75%; 4=76-100%). Global infarct size as a percentage of left ventricular (LV) myocardium was calculated by summing the regional scores (5). Qualitative image quality based on infarct SNR, CNR, and motion artifacts was also evaluated using a 5-point scale (0=non-diagnostic; 1=poor; 2=fair; 3=good; 4=excellent).

RESULTS Myocardial hyperenhancement was observed in all patients. Infarct size comparison between 2DBH and 3DNAV techniques was possible in only 22 of the 23 patients due to excessive motion artifact on 2DBH images in one patient who was unable to follow breathing instructions (Fig.1). Fig.2 shows an example of concordant 2DBH and 3DNAV images depicting very similar transmural infarction of the anteroseptal wall. Note that 3DNAV imaging provided contiguous LV coverage without gap and improved SNR. Compared to 2DBH imaging, 3DNAV imaging provided significantly better image quality (3.0 ± 0.9 for 3DNAV vs 2.5 ± 0.8 for 2DBH, P = 0.01) in 33% less scan time (318 ± 139 sec for 3DNAV vs 472 ± 114 sec for 2DBH, P = 0.002). 2DBH and 3DNAV imaging identified 90 and 91 involved segments and 22 and 24 transmural segments, respectively. Fig.3 demonstrates the strong correlation between the infarct volumes measured from 2DBH and 3DNAV images (regression slope = 0.91, $R^2 = 0.86$, $P < 0.001$). The Bland-Altman plot (Fig.4) shows narrow limits of agreement between the two techniques, but reveals a slight underestimation of 1.4% LV obtained with 3DNAV imaging compared to that obtained with 2DBH imaging.

CONCLUSION In a patient cohort with confirmed MI, free-breathing 3DNAV DE-MRI improves image quality, provides contiguous LV coverage in less scan time, and yields comparable infarct size measurements compared to conventional breath-hold 2D imaging.

REFERENCES 1. Kim RJ et al. New Engl J Med 2000;343:1445-1453. 2. Simonetti OP et al. Radiology 2001;218:215-223. 3. Nguyen TD et al. ISMRM 2007;p3577. 4. Cerqueira MD et al. Circulation 2002;105:539-542. 5. Wagner A et al. Lancet 2003;361:374-379.

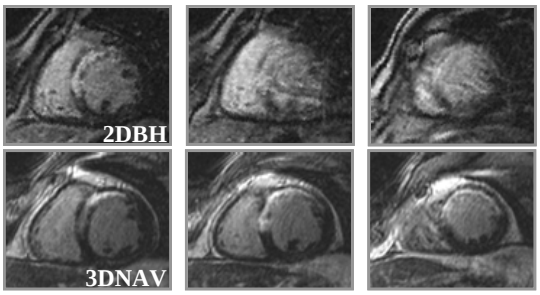

Fig.1. In an uncooperative patient, 2DBH images show excessive motion artifact. 3DNAV images provide a clear depiction of transmural infarction of the mid anteroseptum and subendocardial infarction of the distal lateral wall.

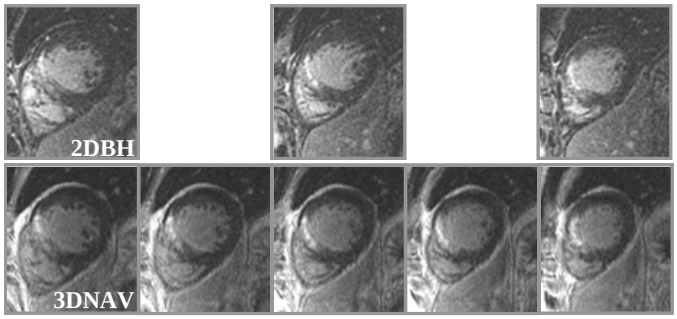

Fig.2. Concordant 2DBH and 3DNAV images demonstrating transmural infarction of the anteroseptal wall. Note that there is a 4 mm gap between 2DBH images and no gap between 3DNAV images.

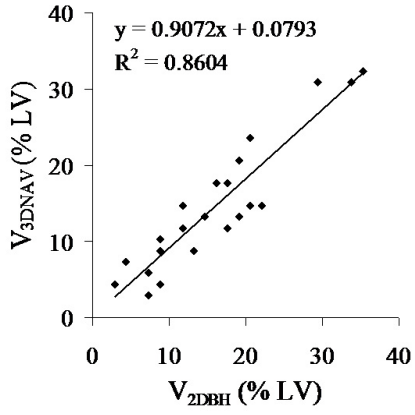

Fig.3. Scatter plot of infarct sizes measured from 2DBH and 3DNAV images (N=22).

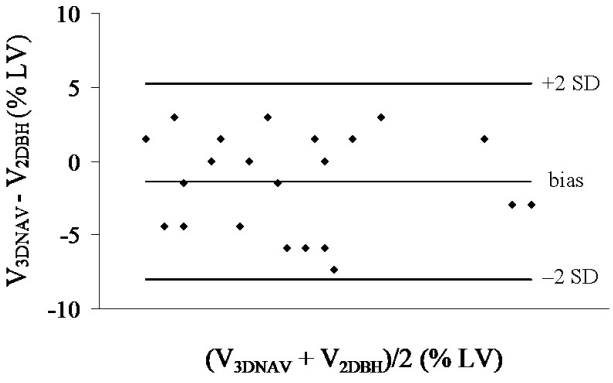

Fig.4. Bland-Altman plot of the difference vs the average of infarct sizes measured with 2DBH and 3DNAV DE-MRI.