3D, Free Breathing Late Gadolinium Enhanced Myocardial Imaging with Retrospective TI Selection and Isotropic Resolution

Steven Kecskemeti[1], Kevin Johnson[1], Mark Schiebler[1], Chris Francois[1], and Orhan Unal[1]
[1]*University of Wisconsin, Madison, Wisconsin, United States*

Introduction: Contrast enhanced MRI can differentiate scar from healthy tissue using late gadolinium enhancement (LGE) [1]. LGE is generally performed using breath held 2D inversion recovery (IR) with an inversion time (TI) chosen to null healthy myocardium. The optimal TI varies considerably based on dosing, time since administration, and agent utilized [2]. Thus TI scout scans must be performed prior to imaging and the operator must heuristically increase the TI between subsequent slices to achieve optimal myocardium nulling. 3D LGE has recently been proposed utilizing a single breath-hold which mitigates these errors [3]; however most patients undergoing LGE are unable to breath hold for such a scan. Radial k-space acquisitions sample the center of k-space each TR, which has a T1 averaging effect in the central parts of k-space, thereby permitting longer scans and the use of respiratory gating. Sampling the center of k-space each TR also permits several TIs to be reconstructed from each acquisition as shown in 2D [4]. In this work, we investigate a free breathing, 3D radial acquisition with retrospective TI selection and isotropic spatial resolution for LGE imaging.

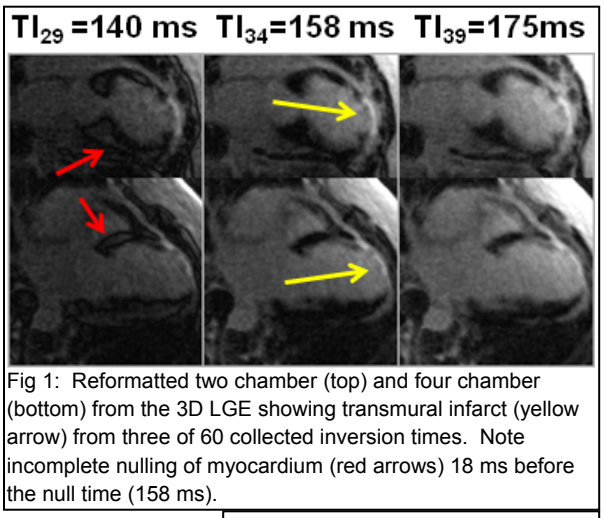

Fig 1: Reformatted two chamber (top) and four chamber (bottom) from the 3D LGE showing transmural infarct (yellow arrow) from three of 60 collected inversion times. Note incomplete nulling of myocardium (red arrows) 18 ms before the null time (158 ms).

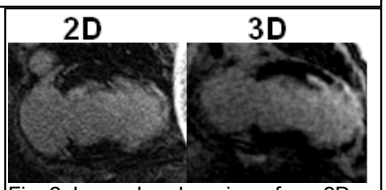

Fig. 2: Long chamber views from 2D LGE and approximate slice from reformatted 3D LGE from same patient as in Fig. 1.

Acquisition and Reconstruction: Imaging is performed using a 3D spoiled gradient echo (SPGR) IR sequence with 3D radial k-space sampling [5]. Data acquisition is centered about a predicted TI for normal myocardial nulling. Using an interleaved, bit-reversed projection ordering, sliding window reconstruction can be performed around any inversion time that occurs during the data acquisition window. Respiratory motion is mitigated by utilizing a modified diminishing variance algorithm (DVA) with 50% efficiency [6].

Methods: Using a HIPPA compliant and IRB approved protocol, 1 normal volunteer and 9 patients were scanned with a multi-slice 2D Cartesian LGE and a 3D radial LGE exam. Five exams were performed at 3T and five at 1.5T. The 2D LGE imaging began approximately 9 minutes after administration of 0.15 mmol/kg of Gd (Multihance, Bracco Diagnostics Inc.) and had a mean and median duration both equal to 17min 08s. Parameters for the 2D acquisition were FOV: 37x37 cm, RES: 1.4x2.3 mm, slice thick: 8 mm, tip=20°, BW=31.25 kHz, TR/TE=6.4/1.6 ms, NEX=2, 24-32 views per segment, 1-2 RR between inversions, scan time (9-17 s). Axial 3D LGE acquisition was performed with FOV=48x48x18 cm, 2 mm isotropic resolution, flip=15°, BW=62.5k Hz, TR/TE=3.6/0.7 ms, scan time 9 min, data acquisition window=216 ms. Radial view sharing of ±15 views was used to reconstruct 60 images with different TIs. LV image quality was assessed on 17 segments defined according to the American Heart Association [8]. Each segment was scored by consensus of two experienced radiologists based on myocardial nulling : '1' incomplete / not diagnostic quality, '2' some / diagnostically useful, '3' good, '4' excellent, and presence or absence of infarct.

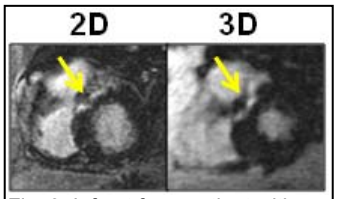

Fig. 3: Infarct from patient with hypertrophic cardiomyopathy. Shown are 2D LGE and approximate corresponding slice from reformatted 3D LGE.

Results: Myocardium nulling was not significantly different (3.3±0.8 for 2D vs. 3.1±0.3 for 3D). Of the total 170 (10 x 17) segments, the 3D radial acquisition had only 3 segments with incomplete nulling while the 2D acquisition had 29 with incomplete nulling. One or more images from 6 of the 9 patients had respiratory motion artifacts for the 2D Cartesian acquisition, resulting in motion corrupted images or the appearance of incomplete nulling (etching). The respiratory gated 3D radial acquisition did not display respiratory induced artifact. Both methods detected the presence of infarct in the same 15 segments and thrombus in one segment.

Discussion and Conclusions: The free breathing 3D radial LGE technique is a promising alternative for the assessment of myocardial viability when patients have difficulty sustaining breath-holds for 2D Cartesian acquisitions. The respiratory gated 3D radial exam, which has the ability to retrospectively choose the TI and reformat to arbitrary orientations without loss of spatial resolution simplifies the entire exam, is shorter to acquire, and reduces patient discomfort when compared with the current clinically-used 2D LGE method.

Acknowledgements: This work was supported in part by National Institutes of Health Grant R01 HL086975.

References: **[1]** Judd et.al. Circulation 1995;92(7);1902-1910 **[2]** Sharma JMRI 2006;23;323-330 **[3]** Foo et al. Radiology 2004; 230:845-851 **[4]** Peters et al MRM 2006; 55:1150-1156 **[5]** Barger et al MRM 2002; 48:297-305 **[6]** Sachs MRM 1995 34:412-422 **[7]** Roemer et al MRM 1990; 16:192-225 **[8]** Circulation 2002; 105:539-542