

POSTER PRESENTATION

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# The influence of static and RF field heterogeneity on T1rho cardiovascular MRI

Qiao Han<sup>1\*</sup>, Yuchi Han<sup>1</sup>, Robert C Gorman<sup>2</sup>, Walter R Witschey<sup>2</sup>

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## Background

Spin lock or T1rho MRI methods may be very useful for assessing myocardial disease. Recently, we reported that there is significant low field relaxation dispersion in myocardial and fibrotic scar tissue during *in vivo* T1rho MRI, contributing to contrast enhancement compared to spin echo (T2) MRI. However, we also observed that differences in magnetic field susceptibility between the heart and lung organs and poor RF penetration and field homogeneity in large patients and at 3 T contribute to T1rho quantification errors. Our goal was to determine the influence of static ( $B_0$ ) and RF ( $B_1$ ) heterogeneity on *in vivo* myocardial T1rho quantification.

## Methods

We performed simulations and experiments to explore how  $B_0$  and  $B_1$  field heterogeneity influences T1rho MRI. Tilted rotating frame (TRF) Bloch simulations were performed for a rotary-echo spin lock, varying field heterogeneity and spin lock duration (TSL = 2-50 ms,  $B_1$  = 60-140% nominal spin lock, and  $\Delta B_0$  = -2-2 ppm at 1.5 T) with random Gaussian noise ( $\sigma$  = 1-20% of initial magnetization). Phantom experiments were performed using a homogeneous H<sub>2</sub>O cylinder (MnCl<sub>2</sub> = 0.016%). *In vivo* experiments were performed in Yorkshire swine (n = 5). Simulated phantom and *in vivo* images were derived from  $B_0$  and  $B_1$  maps using the TRF Bloch simulations and were correlated with experimental images at the same spin lock duration.

## Results

We investigated the effect of field heterogeneity on measured T1rho relaxation times in simulations, phantom experiments and *in vivo*. T1rho artifacts were

characterized by banding artifacts resulting from incomplete longitudinal restoration of the T1rho-prepared magnetization, leading to RF field heterogeneity and rotation about the effective field during the spin lock pulse. These artifacts were most prominent at the LV posterolateral wall where significant static field heterogeneity ( $\pm 200$  Hz) could result in nutation about an effective field oriented away from the idealized spin lock axis. *In vivo* results correlated well with simulations and phantoms experiments. Measured T1rho relaxation times in the three identical compartments were constant in the homogeneous  $B_0$  field and in the 50 mT/m field gradient in which the  $B_0$  field was less than 50 Hz off-resonance. Noticeable variations were observed at 100 Hz off-resonance (100 mT/m gradient). The  $B_0$  field *in vivo* is much less homogeneous than that for the phantom; therefore the T1rho images show much more complex patterns (Figure 1C). Mean  $B_0$  and  $B_1$  field over the left ventricle in the short axis view of the pig heart *in vivo* are in ranged -85.14 to 34.7 Hz and 244.30 to 361.87 Hz respectively with 95% confidence interval.

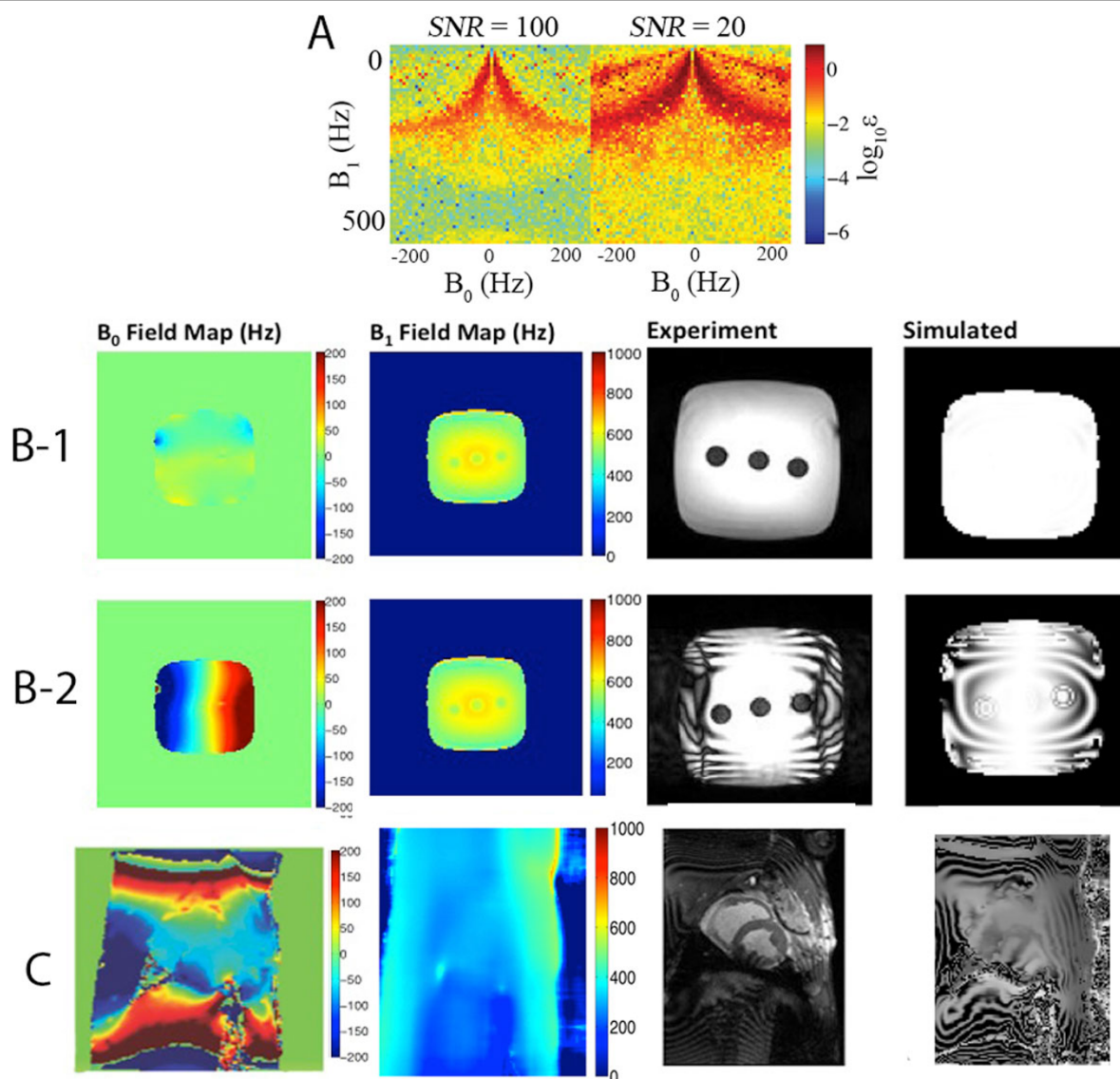
## Conclusions

Spin lock artifacts were the result of static field heterogeneity predominantly confined to the left ventricular posterolateral wall. Static field heterogeneity should be reduced to less than 10% of the spin lock field amplitude to minimize T1rho quantification errors.

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<sup>1</sup>Cardiology, University of Pennsylvania, Philadelphia, Pennsylvania, USA  
Full list of author information is available at the end of the article



**Figure 1** The effect of field heterogeneity on T1rho relaxation times in the phantom and in vivo. (A) Tilted rotating frame (TRF) Bloch simulations with random Gaussian noise. For the continuous wave 'rotary echo' spin lock pulse, measurement error was less than 1% for spin lock amplitudes greater than 400 Hz with minimal  $B_0$  field heterogeneity. Between  $\omega_1 = 200$ -400 Hz, this error could rise to 10%. (B)  $B_0$  and  $B_1$  field maps, experimental and simulated T1rho images in the phantom with no field gradient (1) and with 100 mT/m gradient (2). (C)  $B_0$  and  $B_1$  field maps, experimental and simulated T1rho images in vivo.

**Table 1**

		Phantom			in vivo		
	Gradient	Tube 1	Tube 2	Tube 3		Mean	Range
$B_0$ (Hz)	No gradient	$16.89 \pm 0.96$	$14.25 \pm 0.80$	$8.68 \pm 3.75$	$B_0$ (Hz)	-25.21	-85.14 - 34.7
	50 mT/s	$-43.86 \pm 5.58$	$14.18 \pm 5.04$	$77.97 \pm 7.63$			
	100 mT/s	$-103.43 \pm 10.73$	$14.97 \pm 10.21$	$148.84 \pm 12.65$			
$B_1$ (Hz)	All gradient levels	$546.38 \pm 6.96$	$14.24 \pm 0.80$	$541.50 \pm 4.21$	$B_1$ (Hz)	303.01	244.29-361.87
T1Rho (ms)	No gradient	$47.28 \pm 2.92$	$47.25 \pm 2.97$	$44.99 \pm 3.06$	T1Rho-Septum (ms)	55.55	50.13-60.97
	50 mT/s	$43.02 \pm 3.34$	$48.57 \pm 2.92$	$45.57 \pm 3.25$	T1Rho-Anterior (ms)	55.27	46.29-64.24
	100 mT/s	$59.40 \pm 8.88$	$42.50 \pm 4.02$	$63.26 \pm 7.12$	T1Rho-Posterolateral (ms)	60.60	45.64-75.57

**Authors' details**

<sup>1</sup>Cardiology, University of Pennsylvania, Philadelphia, Pennsylvania, USA.

<sup>2</sup>Surgery, University of Pennsylvania, Philadelphia, Pennsylvania, USA.

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