Multi-slice Excitation with MRI Tagging for Single Breath hold Estimates of Left Ventricular Rotational Mechanics

Zhe Wang[1,2], Ziwu Zhou[1,2], Yi Wang[3], Peng Hu[1,2], and Daniel B. Ennis[1,2]

[1]*Radiological Science, University of California, Los Angeles, CA, United States,* [2]*Bioengineering, University of California, Los Angeles, CA, United States,* [3]*Neurology, University of California, Los Angeles, CA, United States*

TARGET AUDIENCE – MR physicists and clinicians

PURPOSE – Quantitative measurements of left ventricular (LV) rotational mechanics can be estimated using myocardial tagging[(1)] and may provide early insight to LV dysfunction before changes to LV ejection fraction are apparent. LV peak twist (peak rotational angle difference between the LV apex and the LV base) is a commonly used parameter for evaluating LV rotational mechanics. Current clinical protocols for measuring LV twist require two separate breath holds to acquire tagged images at the LV apex and LV base, which subjects estimates of LV twist to breath hold differences. The recent development of multi-slice excitation using Controlled Aliasing in Parallel Imaging Results in High Acceleration (CAIPIRINHA) [(2)] permits acquiring these two slices in a single scan. Our **objective** was to implement CAIPIRINHA into a tagging sequence and compare the results to two breath-hold LV twist results.

METHODS – A SPoiled GRadient (SPGR) echo tagging sequence, which uses non-selective RF pulses to generate grid tag patterns throughout the heart, was modified to support CAIPIRINHA. The tagging preparation pulses were followed by a combination of two imaging RF pulses (RF_1 and RF_2) with a frequency offset of f. RF_1+RF_2 was used to acquire the odd k-space lines, while RF_1-RF_2 was used to acquire the even k-space lines. This results in an aliased image combining both excited slices. The frequency difference between the two pulses was calculated by $\Delta f = \gamma \cdot G_z \cdot \Delta z$, where γ is the gyromagetic ratio, z is distance between the two slices and G_z is the amplitude of the slice selection gradient. The sequence was evaluated in an IRB approved study after obtaining consent in five (N=5) healthy human subjects with the following parameters: 350x350mm FOV, 6mm slice thickness, TE/TR=4.5/5.3ms, 12° flip angle, 160x160 acquisition matrix, 250 Hz/pixel bandwidth, 8 phase encode lines per segment on a 1.5T scanner (Siemens Avanto). The acquisition duration was adjusted to acquire images through mid-diastole (~750ms). Images were reconstructed using a Matlab (Mathworks, Natick, MA, USA) toolbox[(3)]. Images were also acquired with conventional grid tags for basal and apical slices. LV twist measurements were calculated using the FAST method [(4)]. Results were compared using linear regression and Bland-Altman analysis.

RESULTS – Figure 1 shows the LV tagged images before and after CAIPIRINHA reconstruction and the conventional grid tagged images acquired using separate breath-hold scans. The reconstructed CAIPIRINHA tagged images showed good separation in all subjects with slightly higher noise. Figure 2 shows the mean LV twist results from five healthy volunteers using the conventional grid tagged method (blue curve) and the CAIPIRINHA grid tagged method (red curve). The blue curve is slightly shifted to avoid overlap between the two curves. Linear regression of all twist values showed a high correlation between the two techniques (R=0.99). Bland-Altman analysis of peak LV twist comparing the two methods had a bias of 0.21° and 95% confidence intervals of [-0.47°, 0.89°]. There was no significant difference in peak LV twist (P<0.001).

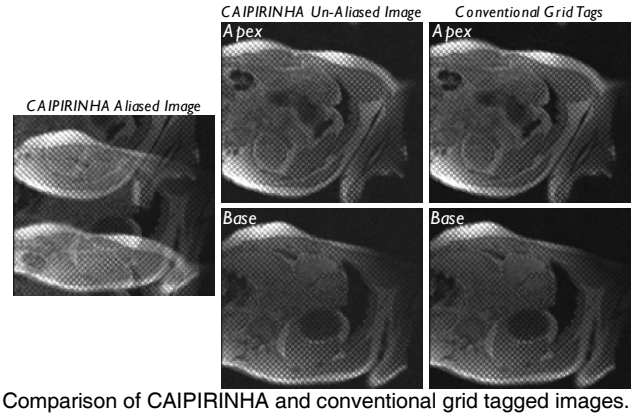

Figure 1. Comparison of CAIPIRINHA and conventional grid tagged images.

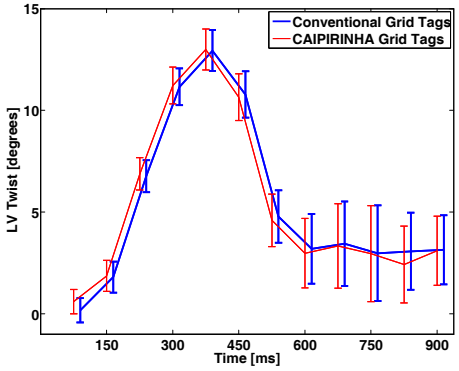

Figure 2. Comparison of LV twist estimates.

DISCUSSION – CAIPIRINHA and cardiac tagging are complementary techniques because the tagging pulses are non-selective. This analysis shows high agreement between the two methods indicating that CAIPIRINHA and cardiac tagging can be combined for single breath hold acquisitions of multiple short axis imaging planes and used to rapidly measure LV twist with the FAST technique.

CONCLUSION – The application of CAIPIRINHA to a LV tagging sequence can achieve similar estimates of peak LV twist in a single breath hold, which simplifies the exam and avoids measurement differences that may arise from data acquired in different breath holds.

REFERENCES: [1] Zerhouni EA, *et al.* Radiology 1988;169(1):59-63. [2] Felix A.B. *et al.* MRM 53:684-691 2005. [3] Setsompop, K. *et al.* MRM 67, 1210-1224. [4] Reyhan M. et al. JMRI 2012 35:587-593.