Quantification of Left Ventricular Twist during Free-breathing with SPAtial Modulation of Magnetization (SPAMM) and Fourier Analysis of STimulated Echoes (FAST)

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INTRODUCTION – Left Ventricular (LV) twist is an imaging biomarker for global LV dysfunction, which is often measured from breath-held tagged cardiac MRI. LV twist is defined as the difference in rotation between the apex and base of the heart. The ***objective*** of this study was to determine if significant differences exist in LV twist measurements acquired during breath-holding (BH), free-breathing with averaging (AVG), and respiratory bellows gated free-breathing (BEL). We ***hypothesized*** that BH peak twist measures would not be significantly different between BH and free-breathing (AVG or BEL) derived images.

METHODS – LV twist measurements were acquired in healthy volunteers (N=10) during BH, AVG, and BEL conditions. LV short-axis tagged images were acquired on a Siemens 3T scanner to improve tag contrast through mid-diastole. Images were analyzed with Fourier Analysis of STimulated echoes (FAST), a recently validated novel method for the semi-automatic rapid quantification of LV twist in the Fourier domain (1). The FAST algorithm was used to measure LV systolic and diastolic twist parameters with ~3 minutes of user interaction. Peak LV twist was reported as mean±SD. Conventional breath-held images (without averaging) were considered the 'gold-standard'.

RESULTS – Figure 1 represents typical images derived from BH, AVG, and BEL. Mean peak LV twist measurements were 12.9±2.8° (BH), 11.8±3.2° (AVG), and 10.0±3.8° (BEL). Figure 2 demonstrates the mean LV twist values from the three acquisition methods. Bland-Altman analysis resulted in a bias with 95% confidence intervals of 0.3° [-0.5°, 2.8°] for BH versus AVG, 1.5° [0.7°, 3.2°] for AVG versus BEL, and 2.2° [1.0°, 4.3°] for BH versus BEL. A paired t-test with Bonferroni post-hoc correction showed a significant difference for peak LV twist between BH and BEL ($p=0.007$), AVG and BEL ($p=0.0153$), but not BH and AVG ($p>0.1$). Linear regression analysis yielded AVG=0.9*BH ($r=0.8$), BEL=0.9*AVG ($r=0.8$), and BEL=0.8*BH ($r=0.7$). Peak LV twist values were greater for BH compared to BEL for every subject. Peak twist values were greater for BH compared to AVG in 5 of 10 volunteers.

Discussion – These results are similar to the work of Zhong *et al.,* who observed a decrease in the magnitude of strain when comparing navigator gated 3D cine DENSE data with breath-held 2D cine DENSE data – a difference that likely arises from the different loading conditions(2). Note that linear regression of peak LV twist values for BEL and BH produced the lowest slope (m=0.8). The peak twist data derived from AVG fell in between the BH and BEL derived values. This is likely due to averaging of the tagged images over different phases of the respiratory cycle. This may also account for the significant peak LV twist differences observed between the two free-breathing methods, as bellows gating performs imaging only during expiration.

CONCLUSION – BEL estimates of LV twist were significantly lower than BH, which likely reflects the different hemodynamic loading conditions during the acquisitions. Since BH depth and consistency can be variable during clinical studies, BEL estimates may be a more consistent and accurate estimate of resting LV twist and may be a better biomarker of LV dysfunction in patient populations with limited breath-hold capabilities. This study is relevant to clinical practice and future research because it demonstrates differences in LV twist measured under breath-held and free-breathing conditions using tagged MR images.

REFERENCES – 1. Reyhan, J Magn Reson Imaging 2012; 35:587-593. 2. Zhong, Magn Reson Med 2010; 64:1089-1097.

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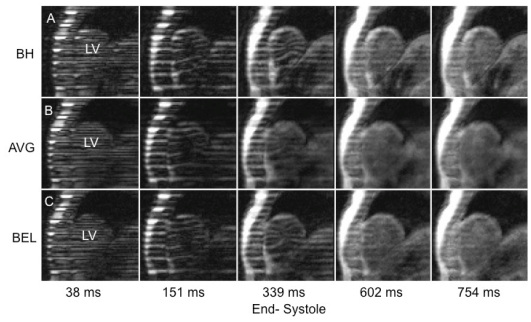

Figure 1. BH, AVG, BEL Tagged Images

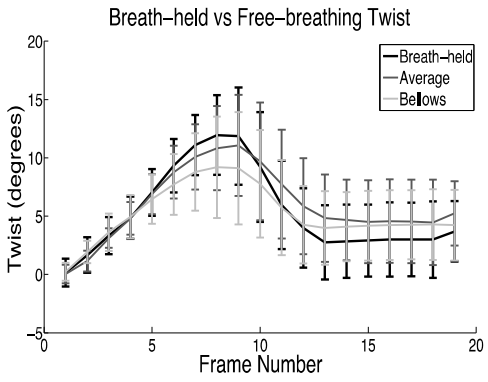

Figure 2. LV Twist from BH, AVG, BEL