COMPLETE ASSESSMENT OF LV AND RV FUNCTION AND VOLUME IN A SINGLE BREATHOLD USING REAL-TIME, SPIRAL, STEADY-STATE FREE PRECESSION

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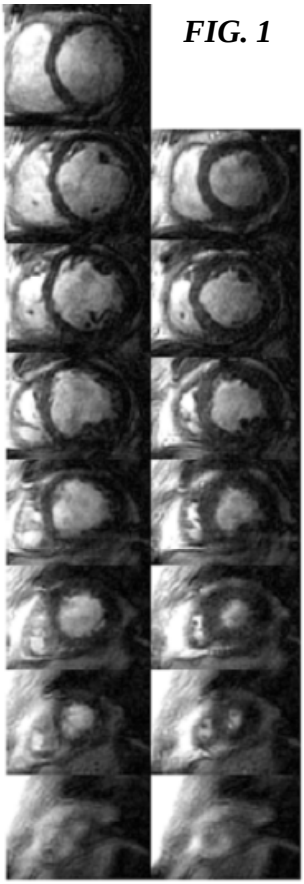
Background & Purpose: Accurate, reproducible quantitation of LV and RV volumes and function is important for the care of heart failure patients. However, existing MR techniques are clinically cumbersome in the heart failure population given the need for long acquisition times, requirement for multiple patient breath-holds, and sensitivity to arrhythmias. Rapid, accurate, and respiration immune assessment of LV and RV function and volume is required. A novel, real-time, steady-state free precession (SSFP) technique using a triggered, single breath-hold strategy was compared with the standard gated, multiple-breath hold, segmented k-space SSFP strategy for the assessment of LV and RV function in heart failure patients.

Methods: Twenty heart failure patients (mean age 59 ± 17 yrs, 13 men and 7 women) underwent scanning with the standard, multiple-breath-hold, gated, segmented k-space strategy in the conventional short-axis orientation from base to apex. On the same day, a real-time, spiral, steady state free precession (SSFP) technique using a single breath-hold, triggered strategy was used to scan these patients in the same orientation. The sequence characteristics were: TR 5.9 ms, 20 interleaves, FOV 20 cm, 1.8 x 1.8 mm resolution, 10 mm slice thickness, 0 mm inter-slice gap. Images were acquired with a temporal resolution of 118 ms and reconstructed to 24 fps using a sliding window technique. As SSFP is highly sensitive to off-resonance, a slider was added to the real-time user interface to enable adjustments in RF phase cycling. Phase cycling was adjusted to optimize image quality. The exact position of the basal slice obtained on the standard sequence was localized in real-time with fine adjustments made during the breath-hold. After the requested breath-hold, the sequence was switched to a "triggered" mode where each slice was acquired and automatically advanced based on a cardiac trigger. The trigger delay was adjusted to ensure adequate delineation of the end-diastolic and end-systolic phases of the cardiac cycle. All acquisition was performed during continuous scanning. The total number of slices was adjusted based on the size of the heart. Generally, 8-12 slices could be obtained in a breath-hold lasting 8-12 RR intervals. LV and RV end-systolic and end-diastolic volumes and LV mass were calculated and compared between the two techniques using Bland-Altman analysis. In addition, patients (n=3) and normals (n=2) underwent scanning with both a free breathing and single-breath hold strategy (each twice) using our real-time, spiral SSFP sequence to compare the reproducibility of the two breathing strategies.

Results: Image quality using the real-time strategy allowed precise endocardium-blood delineation in all patients (see Fig. 1). In addition, data acquisition was only 9 +/- 2 seconds versus 312 +/- 41 seconds for the standard, segmented k-space technique. The new real-time strategy was highly concordant with the gold standard technique in the assessment of LVEDV (r=1.04), LVESV (r=0.92), RVESV (r=0.99), RVEDV (r=1.16), and LV mass (r=1.19). The mean bias (95% CI) for each parameter were as follows: LVEDV: 10.6 cc (3.8,17.4 cc), LVESV: -0.8 cc (-5.3,3.7 cc), RVEDV: 3.7 cc (-5.6,13.2 cc), RVESV: -3.1 cc (-11.1,4.9 cc), LV mass: 26 gms (12.4, 39.8 gms). LV and RV parameters, as assessed by the single breath-hold strategy, were more reproducible compared with the free-breathing strategy (inter-study variability 9% versus 18%).

Conclusions: Real-time, spiral SSFP allows rapid and accurate quantitation of RV and LV function in a single-breath hold in patients with heart failure. This technique provides a clinically robust, rapid modality to accurately assess cardiac function in heart failure patients using Cardiac MRI.

FIG. 1



End-diastole End-svstole

References:

1) Meyer, CH, Pauly HM, Nayak, KS, et al., Real-time spiral SSFP cardiac imaging. In: *Proc., ISMRM, 9th Annual Meeting, Glasgow, April 2001*, p. 442.
2) Nayak, K, Hu, BS, Triggered real-time MRI and cardiac applications. *Magn. Reson. Med.* 2003; 49:188-192.
3) Kerr ABS, Li KCP, Handy, CJ, et al., Real-time interactive MRI on a conventional scanner. *Magn Reson. Med*. 1997; 38:355-367.