Feasibility study of a novel acquisition technique of cardiac cine magnetic resonance imaging in patients with atrial fibrillation

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Background: For patients with arrhythmia, standard, segmented steady-state free precession sequence (CINE-SSFP) methods with high temporal and spatial resolution may result in poor image quality. Real-time cine sequences are robust against arrhythmias but suffer from poor spatial and temporal resolutions which prevented its routine application. We implemented a newly developed prototype sequence featuring sparse, incoherent sampling and iterative reconstruction [1]. This method promises to achieve high acceleration factors which enable triggered 2D real-time CINE MRI with significantly improved spatial and/or temporal resolution.

Purpose: To compare the prototype sequence as real-time version as well as multi-shot in very short BH with high temporal resolution compared to the standard segmented and real-time sequences.

Materials and Methods: CMR was performed at 3.0T system (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). The examinations included the following sequences: (1), standard segmented SSFP (iPAT3) (GRAPPA accel factor 3, temporal resolution, 45.6 ms; voxel size 1.6 x 1.6 x 8.0mm^3,8 heart beats per slice plus dummy cycle)；(2), standard real-time (TPAT3) (TGRAPPA accel factor 3, temporal resolution, 49.9 ms; voxel size 2.8×2.8×8.0mm^3, 1 heart beats per slice, dummy 0); (3), investigational prototype real-time (SPARSE11.5) (accel factor 11.5, temporal resolution, 41.7 ms; voxel size 2.0×2.0×8.0 mm^3 , 2 heart beats per slice plus dummy cycle); (4), investigational prototype, segmented, 3 shots, high temporal resolution (SPARSE9.3) (accel factor 9.3, **temporal resolution, 17 ms**; voxel size, 2.0×2.0×8.0mm^3, 4 heart beats per slice plus dummy cycle). Stacks of short-axis (SAX) cines were acquired covering both ventricles. The blood volume in the left ventricle was assessed to determine the end systolic volume (ESV), end diastolic volume (EDV), and ejection fraction (EF) for each sequence, and images were rated for the overall quality of specific image features (including CNR, artifacts, wall motion and edge sharpness) by two cardiac readers using 5-point score.

Result: CMR examinations of 11 patients (56±17 years, 5 male) with AF were completed successfully. The differences in EDV, ESV and EF between groups were not statistically significant (all p-values＞0.05). In overall, the image quality of prototype sequences was much better than the standard ones, and the SPARSE9.3 technique showed the best image quality (Table 1). The standard segmented iPAT3 sequence as well as the standard realtime sequence was rated as non-diagnostic. The images quality of the basal slice was inferior compared to the middle and apical slice due to flow artifacts (Fig. 1).

Discussion: Our results showed that there were no significant differences on EDV, ESV and EF between sequences, while the image quality of prototype sequences was much better than the standard ones. For patients with atria fibrillation whose heartbeat were irregular, and some of them couldn't hold breath as well as required, all of these would cause motion artifacts, which leads to significant difference in overall image quality. While the ejection fraction value was calculated from two images of the end of the systolic and diastolic at each slice, thus the differences between different sequences might be minor. However, it may also be related to our small sample size, which needs to be studied further. SPASE9.3 sequence has a very high temporal resolution, which could be applied to patients with high but regular heart beats..

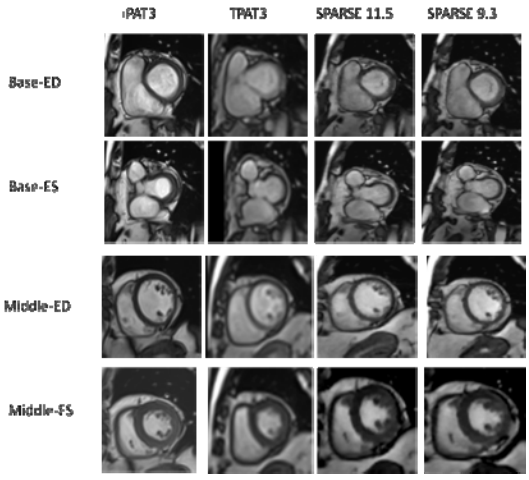

Fig 1. Visual comparison of the CMR images in a 64 year-old male patient (base and middle ventricular)

Conclusions: Our small sample research indicates that for patients with arrhythmia, the standard SSFP and real-time sequences could not fulfill the clinical requirements. With the application of CS cine sequence, we could acquire high-quality cardiac cine images which greatly reduce the scan time. In future, it could be applied in more clinical patients. **Reference:** [1] Liu, J. et al., Proc. ISMRM #178 (2012).

Table 1 Comparisons of EDV, ESV, EF and image quality

Sequence	EDV (mL)	ESV (mL)	EF (%)	Overall image quality (1-5 from poor to good)
Standard segmented SSFP (iPAT3)	117.9±24.2	44.5±13.3	61.8±9.7	3.7±0.5 (base); 3.9±0.7 (mild); 3.9±0.5 (apex)
Standard real-time (TPAT3)	122.5±18.3	45.8±10.1	62.4±7.1	3.4±0.5 (base); 3.5±0.5 (mild); 3.3±0.5 (apex)
CVsparse_rt_net 11.5 (SPARSE11.5)	125.0±14.4	48.5±9.9	60.1±8.1	4.1±0.6 (base); 4.5±0.5 (mild); 4.4±0.7 (apex)
CVsparse_net9.3 (SPARSE9.3)	123.3±14.9	45.9±10.2	61.1±7.7	4.2±0.4 (base); 4.7±0.4 (mild); 4.8±0.3 (apex)