Self-Gated Tissue Phase Mapping using Golden Angle Radial Sparse SENSE

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Introduction: Tissue Phase Mapping (TPM) allows analysis of global and regional LV motion and calculation of motion quantification parameters [1]. Due to the long scan time of high-resolution or volumetric TPM acquisitions, respiratory motion has to be considered. In this study, image-based self-gating (SG) [2] is compared to conventional pencil beam (RNAV) gating for TPM acquisitions. Additionally, the influence of the regularization strength λ in the radial SPARSE SENSE reconstruction [3] on the velocities is investigated.

Methods:

Acquisition: Two radial TPM acquisitions were compared in 10 healthy volunteers in 3 short axis slices: a prospectively triggered and conventionally RNAV gated acquisition (TPM_{ref}), and a retrospectively ECG-triggered self-gated golden angle TPM sequence (TPM_{SG}).

Reconstruction: For TPM_{SG}, image-based self-gating was performed. Data were reconstructed iteratively by k-t SPARSE SENSE [3], using regularization strengths of λ=0.1, 0.2 ,0.3, and 0.4. The low undersampling of R=2 in TPM_{ref} allowed reconstruction by gridding without iteration.

Analysis: Performance of TPM_{SG} was compared to TPM_{ref} regarding image quality by expert score and quantitative measures, and peak velocities as well as correlation of velocities, RMSE, and residual displacement Δr of velocities from 24 segments were analyzed.

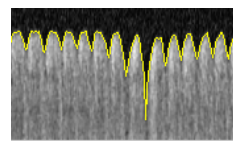

Figure 1: SG signal.

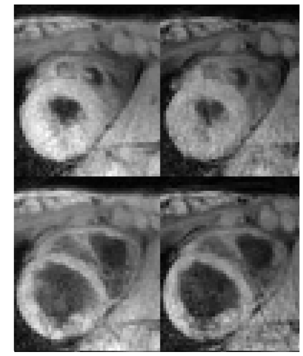

Figure 2: Images from TPM_{Ref} (left) and TPM_{SG} (right) in systole (top) and diastole (bottom).

Results and Discussion: Self-gating was successful in all cases. An exemplary SG signal is shown in Figure 1. Black-blood contrast was superior in TPM_{SG} (see Figure 2), since saturation slabs could be applied with full width without risk of interference with the RNAV measurement. Segmental velocities of TPM_{SG} are comparable to TPM_{Ref} (Figure 3), and show full coverage of the cardiac cycle. Quantitatively, image sharpness of TPM_{SG} was comparable, contrast improved, and SNR comparable or improved for λ>0.1. Velocity-to-noise ratio (VNR) was comparable to TPM_{Ref}. Peak velocities were reduced for strong regularization (λ>0.2), but comparable for moderate values of λ. Velocity correlation with TPM_{Ref} was > 0.81 and RMSE < 0.11 cm/s in all cases. The integral Δr over velocities over the cardiac cycle was significantly reduced due to the full coverage of the cardiac cycle in TPM_{SG}.

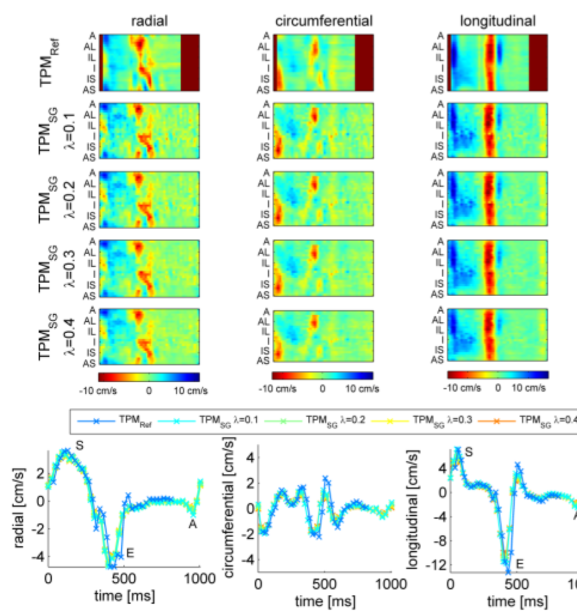

Figure 2: Segmental and global velocities.

Conclusion: The combination of k-t SPARSE SENSE with image-based self-gating allows measurement of velocities of the myocardium with full coverage of the cardiac cycle. The temporal regularization strength of λ=0.2 yields good artifact suppression while at the same time being low enough to avoid significant reduction of peak velocities.

References: [1] Lutz et al.: JCMR 2012;14(1):1–13. [2] Paul et al.: doi:10.1002/mrm.25102. [3] Wundrak et al.: ISMRM 2014, #4384.