Optimization of Whole-Heart Cine MRI with a 128 Channel Receive Coil

H. Bhat[1], P. Hoecht[1], S. Zuehlsdorff[2], A. Mareyam[3], B. Keil[3], A. Potthast[4], M. Schmitt[4], L. L. Wald[3], M. Hamm[1], and D. E. Sosnovik[3]
[1]Siemens Medical Solutions USA Inc., Charlestown, MA, United States, [2]Siemens Medical Solutions USA Inc., Chicago, IL, United States, [3]Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Boston, MA, United States, [4]Siemens Healthcare, Erlangen, Germany

INTRODUCTION: The development of parallel acquisition techniques has allowed multi-slice cine imaging of the heart to be performed in fewer breath-holds. We have previously reported the development of a prototype 128 channel receive coil and MR system for cardiac MR at 3T [1]. Here we describe further optimization of the system and its supported sequences, in particular balanced SSFP. We show that with these optimizations cine MRI of the entire heart can be performed in 1-2 breath-holds without compromising temporal or spatial resolution.

METHODS: Imaging was performed on a commercial 3T scanner (MAGNETOM Trio a Tim System, Siemens Healthcare, Erlangen) modified to support 128 independent receive channels. Compared to our previous study [1]: 1) SAR was optimized with the 128 channel coil in the magnet allowing the use of higher flip angles (45-60° compared with 25-35°), and 2) retrospective ECG gating was used instead of prospective gating. 4 healthy male volunteers were imaged with three 2D multi-slice whole-heart cine protocols (A, B and C – Table 1). Protocol A was a segmented protocol with clinically typical spatial and temporal resolutions, protocol B was a real-time protocol which acquired the data for each slice in 1 heart-beat, and protocol C was a segmented cine protocol with high temporal resolution (13.55 ms). Common imaging parameters were: FOV = 400 x 320 mm^2, readout bandwidth = 930 Hz/pixel, TR = 2.7 msec, flip angle 45 to 60 degrees.

RESULTS: High quality images could be obtained with the segmented sequence using rate 6 acceleration (Fig 1). Fine details such as trabeculations were fully preserved, and the images were of similar diagnostic quality to the unaccelerated (No GRAPPA) images (Fig 1). Triplanar cines (3 slices in each cardiac axis) could be obtained with rate 6 GRAPPA acceleration in two breath-holds (Fig 2). Real-time imaging with TGRAPPA rate 5 allowed the entire heart (10 slices) to be imaged in a single breath-hold with good spatial and temporal resolution (Fig. 3). To evaluate the image quality in the GRAPPA rate 6 images, automated border detection of 7 mid ventricular slices (170 frames) was performed with a commercially available software package (Argus, Siemens Healthcare, Erlangen) (Fig. 4). Manual adjustment of the curves, indicating a loss of image sharpness, was required in only 2/170 of the endocardial borders and 0/170 of the epicardial curves.

CONCLUSION: We demonstrate here the feasibility of high quality 2D multi-slice whole-heart cine imaging with acceleration factors of upto 6 using a 128 channel receive coil. Optimization of the SAR limits and the use of retrospective ECG gating have significantly improved the quality of the accelerated images now obtainable with the 128 channel system. The results we obtain here with 1D acceleration bode well for the use of the coil in 3D imaging with acceleration in 2 dimensions.

DICLAIMER: The concepts and information presented in this paper are based on research and are not commercially available.

REFERENCES: [1] Schmitt et. al. Magn Reson Med. 2008: 59:1431-1439.

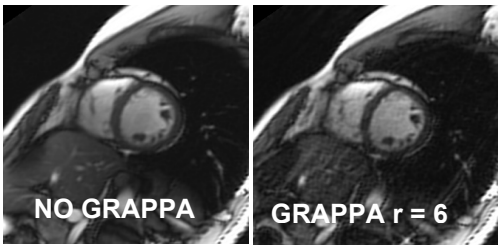

Fig 1: Segmented cine images comparing rate 6 GRAPPA acceleration with no acceleration.

Protocol	temporal resolution	spatial resolution	heart-beats/slice (including dummy heart-beat for steady state)	breath-holds to cover whole-heart
A: Segmented Cine **GRAPPA r = 6** 10 slices	40.65 msec	2.1 x 2.1 mm^2	4	2
B: Real-time Cine **TGRAPPA r = 5** 10 slices	58.52 msec	2.1 x 2.9 mm^2	2	1
C: Segmented Cine **GRAPPA r = 6** 10 slices	13.55 msec	2.1 x 2.1 mm^2	10	5

Table 1: Properties of the whole-heart cine protocols used in this study

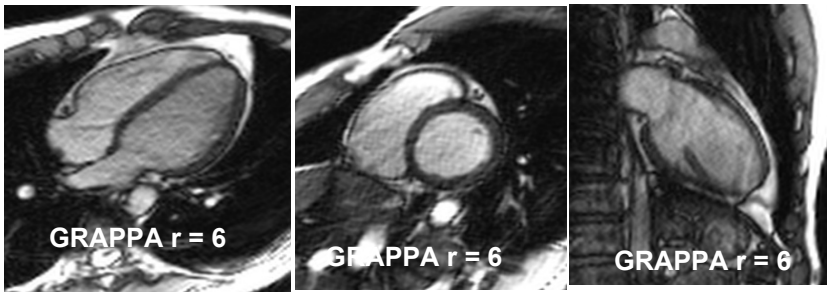

Fig 2: Segmented cine images acquired in multiple slice orientations (temporal res = 40.65 ms, spatial res = 2.1 x 2.1 mm^2, 9 slices).

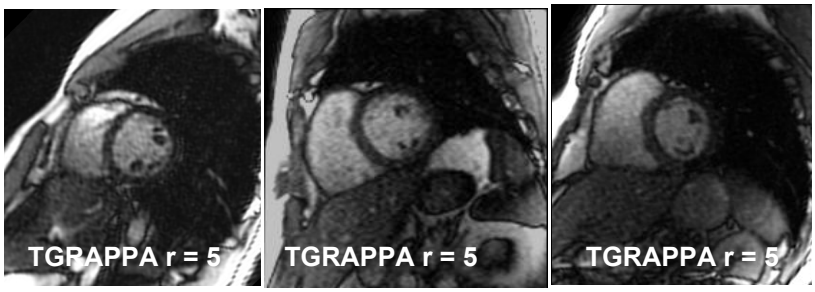

Fig 3: Real-time cine images in 3 volunteers (temporal res = 58.52 ms, spatial res = 2.1 x 2.9 mm^2, 10 slices). Each cine was acquired in a single heartbeat

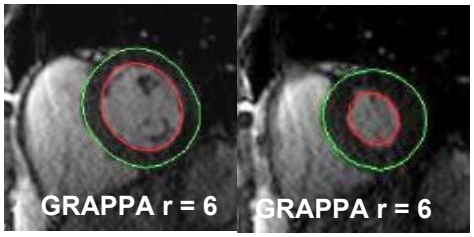

Fig 4: Automated epicardial and endocardial curves on a representative slice in end systolic and end diastolic phases. The images were acquired with a GRAPPA acceleration rate of 6.