Ventricular-Function Assessment with Online Post-Processing of Real-time Free-Breathing Radial GRAPPA images

Haris Saybasili[1], Gary McNeal[1], Michaela Schmidt[2], Peter Kellman[3], Mark Griswold[4], Michael Zenge[2], and Nicole Seiberlich[5]

[1]*Siemens Healthcare USA, Inc., Chicago, Illinois, United States,* [2]*Siemens AG Healthcare Sector, Erlangen, Germany,* [3]*National Heart Lung and Blood Institute, National Institutes of Health, Bethesda, Maryland, United States,* [4]*Radiology, Case Western Reserve University, Cleveland, Ohio, United States,* [5]*Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio, United States*

TARGET AUDIENCE: Cardiovascular MRI, Radiologists, Cardiologists

PURPOSE: High spatial and temporal resolution real-time cardiac imaging can be performed using through-time radial GRAPPA [1]. Such a free-breathing real-time imaging approach may be attractive for uncooperative patients or patients with arrhythmia where well-established segmented cine imaging often results in poor image quality [2]. However, the use of images acquired in real-time to evaluate cardiac function is challenging as different number of phases are often acquired for each slice due to heart-rate variations. In this work, we present an approach that employs heart beat information and retrospectively reconstructs a pre-determined number of cardiac phases per slice by performing a temporal interpolation of real-time free-breathing cardiac cine images generated using through-time radial GRAPPA. Global cardiac function parameters can then be derived using these interpolated real-time cine images. Initial results from four healthy volunteers were compared with clinical gold-standard segmented cine images.

METHODS: A prototype image reconstruction approach was implemented that i) extracts heart beat information during real-time free-breathing data acquisition, and ii) generates a predefined number of phases per slice for each heart beat using temporal interpolation of real-time images. Image data is collected and buffered until the conclusion of the current heartbeat, and a predetermined number of images that are equidistantly spaced in time are generated by temporally interpolating real-time images using the RR interval information (Figure 1). In this work, the prototype interpolation module was combined with real-time images collected using the through-time radial GRAPPA data acquisition and image reconstruction strategy. Both gold-standard segmented TrueFISP cine images and free-breathing real-time images were acquired in four healthy volunteers using a clinical 3T MR scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). For radial GRAPPA images, spatial resolution was 1.3x1.3x6 mm^3 and the temporal resolution was 51 ms. For segmented cine acquisitions, spatial resolution was 1.5x1.5x6 mm^3, and the temporal resolution was 41 ms. The through-time radial GRAPPA reconstruction was performed using 26 calibration frames and a segment size of 8x4; 16 projections were acquired with each real-time frame, and 256 projections were reconstructed (R=16). 25 phases per heart beat and per slice were generated from the real-time images using the post-processing module. Finally, post-processed real-time images were analyzed to evaluate LV function (*syngo* Argus, Siemens Healthcare, Erlangen, Germany). Calculated cardiac function parameters were compared with results obtained from segmented cine images.

RESULTS: Cardiac parameters calculated from the standard segmented cine images and the processed real-time images are presented in Figure 2. Values derived from the real-time images were in accordance with segmented cine results: overall differences were 1.5% for end diastolic volume (EDV) and 2% for end systolic volume (ESV), and stroke volume (SV). Example end diastolic and end systolic short-axis images are presented in Figure 3.

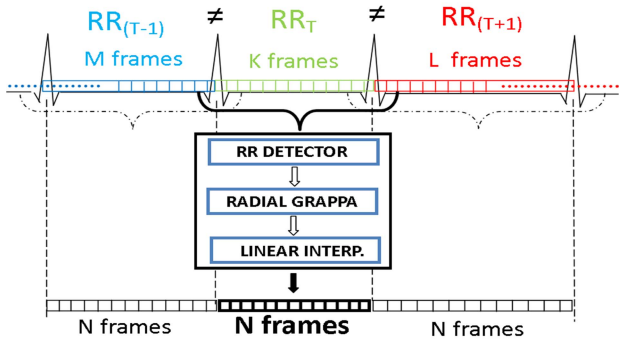

FIG 1 Real-time free-breathing data were acquired and fed to the reconstruction pipeline. A heartbeat detection approach analyzed the imaging data headers to determine the RR interval. Radial Grappa images were reconstructed and a subsequent temporal interpolation step was used to generate a predetermined number of cardiac phases for each heartbeat.

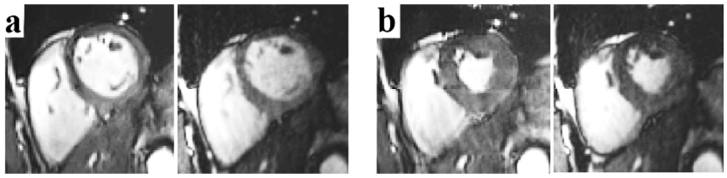

FIG 3. Short axis end diastolic (a) and end systolic images (b)**.** *Left:* Segmented cine images. *Right:* processed real-time free-breathing radial GRAPPA images.

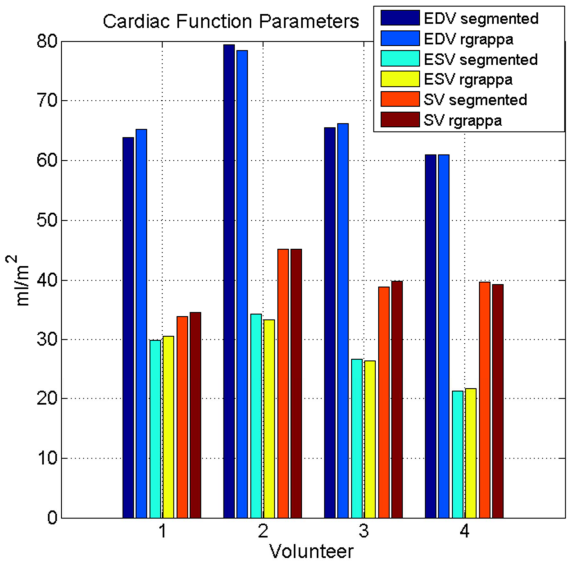

FIG 2. Comparison of cardiac function parameters from 4 healthy volunteers calculated by segmented cine and real-time free-breathing through-time radial GRAPPA (rgrappa) images with the described post-processing. There is excellent agreement in the measures of volumes.

CONCLUSION: In this study, we presented an approach that facilitates cardiac function assessment using real-time images reconstructed using through-time radial GRAPPA. By generating a predefined number of cardiac phases per slice and per heart beat using temporal interpolation from the real-time images, cardiac functional parameters could be assessed and compared with values from gold-standard cine imaging. Our initial results suggest that cardiac parameters calculated from post-processed real-time images are in agreement with parameters obtained from segmented cine acquisition, and indicate that real-time imaging could be used for clinical evaluations in patients with compromised cardiac function.

REFERENCES: **[1]** Seiberlich et al. Magn Reson Med. 2010; 65:492-505. **[2]** Carr JC et al. Radiology 2001; 219:828-834.

FUNDING: Case Western Reserve University/Cleveland Clinic CTSA UL1 RR024989 and NIH/NIBIB R00EB011527.