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Temporal interpolation of real-time cine images for ventricular function assessment

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Background

In uncooperative patients or in presence of arrhythmia, real-time free-breathing cine MR approaches may offer an alternative to well-established segmented data acquisition strategies [1,2]. Segmented acquisition strategies collect data throughout a number of heartbeats and typically a fixed number of cardiac phases are reconstructed for each slice representing an average RR interval. In real-time cine imaging, the number of reconstructed phases may be different for each slice due to heart rate variations. However, it is desirable to reconstruct a predefined number of cardiac phases per slice to facilitate functional analysis and processing. In this work, we present an image reconstruction approach that retrospectively interpolates real-time cine images to calculate a predefined number of cardiac phases per heartbeat and slice. Ejection fraction is compared between segmented cine images and interpolated real-time cine images in healthy volunteers.

Methods

Segmented breath-hold and real-time free-breathing cine images were acquired in four healthy volunteers on a clinical 3T MR scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany). Acquisition parameters for each volunteer are represented in Table 1. FOVs for real-time studies were kept as small as possible to improve spatial resolution. T-PAT factor 3 was used to improve temporal resolution. The linear interpolation module was fully integrated into the reconstruction pipeline of the scanner. During imaging, heart rate was continuously monitored and real-time images were linearly interpolated to a fixed number of cardiac phases for each heartbeat and for each slice (Figure 1). 20 cardiac phases were calculated per heartbeat by interpolation during real-time acquisitions to achieve 50 ms nominal temporal resolution. Subsequently, interpolated real-time images were analyzed to evaluate LV function (syngo Argus 4D ventricular function, Siemens Healthcare, Erlangen, Germany) and compared with results based on segmented images.

Results

Interpolated real-time images were loaded to Argus and endo-cardial borders were detected prior to analysis. EF measurements (see Table 2) from interpolated real-time

Table 1

Data acquisition parameters for healthy volunteers				
	Segmented	**Real-Time (RT)**	**RT Interpolated**	
Temporal Resolution (ms)	39 to 41	78 to 114	42 to 55	
Spatial Resolution (mm)	1.5 × 1.5 × 6	2.8 × 2.3 × 6	2.8 × 2.3 × 6	
Comparison of ejection fraction values between segmented and interpolated real-time data sets (Seg: segmented, RT: real-time).				
	Volunteer 1 Seg./RT	Volunteer 2 Seg./RT	Volunteer 3 Seg./RT	Volunteer 4 Seg./RT
EF (%)	57/57	65/64	65/64	68/65

[1]Siemens Healthcare USA, Inc., Chicago, Illinois, USA

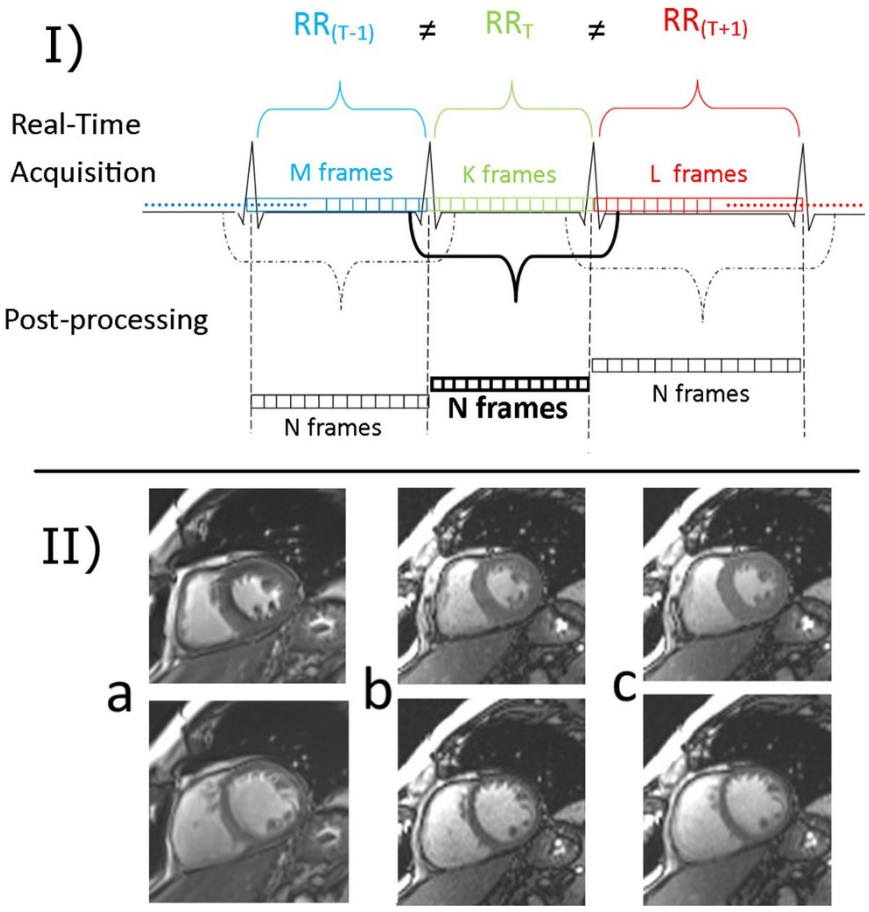

Figure 1 I. Interpolation of RT cine images. Real-time acquired images during a heartbeat are interpolated to a fixed number of frames. The linear interpolation algorithm uses frames before and after the QRS peak to estimate first and last phase. II. End-systolic (upper images) and end-diastolic (bottom images) cardiac phases for a) segmented, b) non-interpolated real-time, and c) interpolated real-time images. Please note that interpolation introduces a slight blur to the images.

and segmented images were found to be in good agreement. End-systolic and end-diastolic phases for segmented, non-interpolated real-time, and interpolated real-time images are given in Figure 2. Interpolation increased the SNR, but introduced slight blurriness. The level of blurring was low and thus it did not affect the functional evaluation.

Conclusions

In this feasibility study we presented initial evidence that interpolated real-time cine images may be used to facilitate cardiac functional analysis using well-established post-processing software. The current implemented algorithm will be extended to take arrhythmia events into account.

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