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WORKSHOP PRESENTATION Open Access

Highly accelerated real-time T_2-weighted imaging with through-time radial GRAPPA and low-latency GPU reconstruction

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Background

T_2-weighted cardiac images are commonly used for edema detection [1-4]. However, neither black-blood TSE nor cine images can offer real-time edema monitoring, and are therefore not suitable for the guidance of cardiac ablation procedures. We proposed a radial T_2-weighted interrupted balanced SSFP (rT_2W-iSSFP), a real-time high temporal resolution sequence targeted at monitoring edema.

Methods

Sequence

rT_2W-iSSFP generates T_2-weighting with a series of 180° RF pulses. TE-effective for the radial sequence is defined as the time from the beginning of the train to the median imaging echo. rT_2W-iSSFP also incorporates through-time radial GRAPPA to achieve high temporal resolution with high degrees of acceleration (R = 8) [5], (Figure 1) which was implemented on a 48-core hybrid system with a GPU (Tesla C1060, NVIDIA), achieving 10-20 fps image acquisition with 20 ms latency reconstruction and image display [6].

Simulations

Bloch equation simulations were performed to evaluate the T_2-weighting and the image quality of rT_2W-iSSFP using a variant of the Shepp-Logan phantom containing 3 ellipsoids with different T_1s and T_2s to represent cerebrospinal fluid (CSF), liver, and myocardium (Figure 2a) [7,8]. T_2-weighted turbo spin echo (T_2W-TSE) was also simulated [3,9]. TE-effective was 60 ms for both T_2W-TSE and rT_2W-iSSFP.

Animal Model

Swine with acute injury ($N = 2$) were imaged on a 1.5T scanner (Avanto, Siemens, Germany). Free-breathing ECG-triggered single-shot rT_2W-iSSFP was acquired (TE-effective = 80 ms; TR = 3 ms; matrix = 192 × 192; 3 slices per heartbeats). ECG-triggered, breath-held T_2W-TSE (TE = 80 ms, resolution = 1 × 1 mm^2, matrix = 192 × 192) was used as a reference.

Results

The results from simulation of T_2W-TSE and rT_2W-iSSFP are shown in Figures 2b and 2c. The intensity difference between CSF and liver is similar in T_2W-TSE and rT_2W-iSSFP. Streaking artifacts are seen in Figure 2c, but these are not pronounced in in vivo images. Four-chamber views of swine heart from T_2W-TSE (breath-hold) and rT_2W-iSSFP (free-breathing) are shown in Figures 2d and 2e. Edema at the anteroseptal region due to acute myocardial infarction is depicted (the arrows in d).

Conclusions

rT_2W-iSSFP offers high temporal resolution T_2-weighted imaging with image quality sufficient for visualization of edema from acute injury. rT_2W-iSSFP can be applied to real-time monitoring of edema formation during cardiac interventions.

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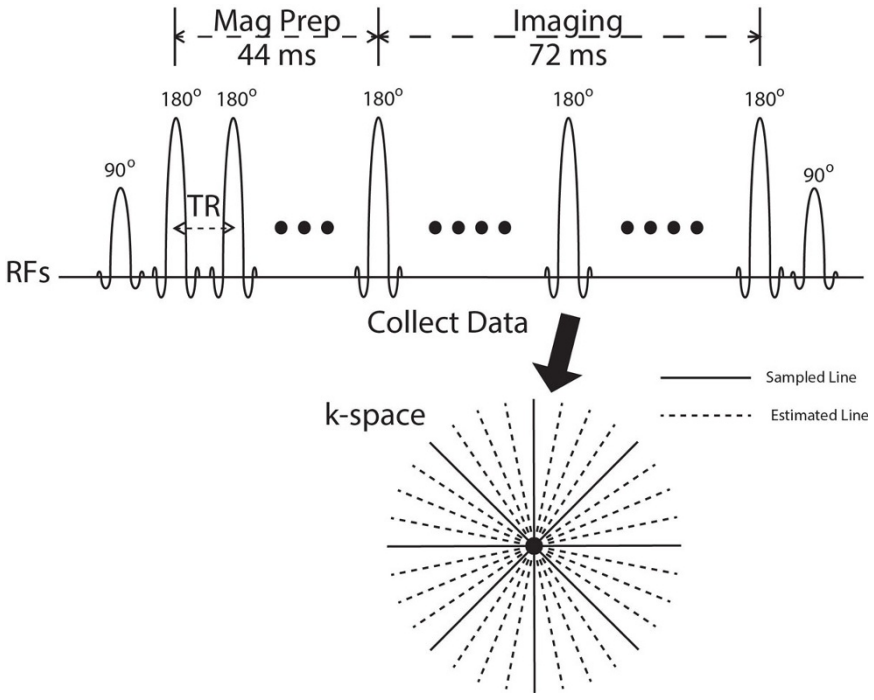

Figure 1 Illustration of the acquisition scheme, flip angles and k-space sampling pattern of rT_2W-iSSFP. Four-fold acceleration is shown in this example. Images were reconstructed using through-time radial GRAPPA with a low-latency implementation. Typically a 192 × 192 matrix and an acceleration rate of R = 8 is used.

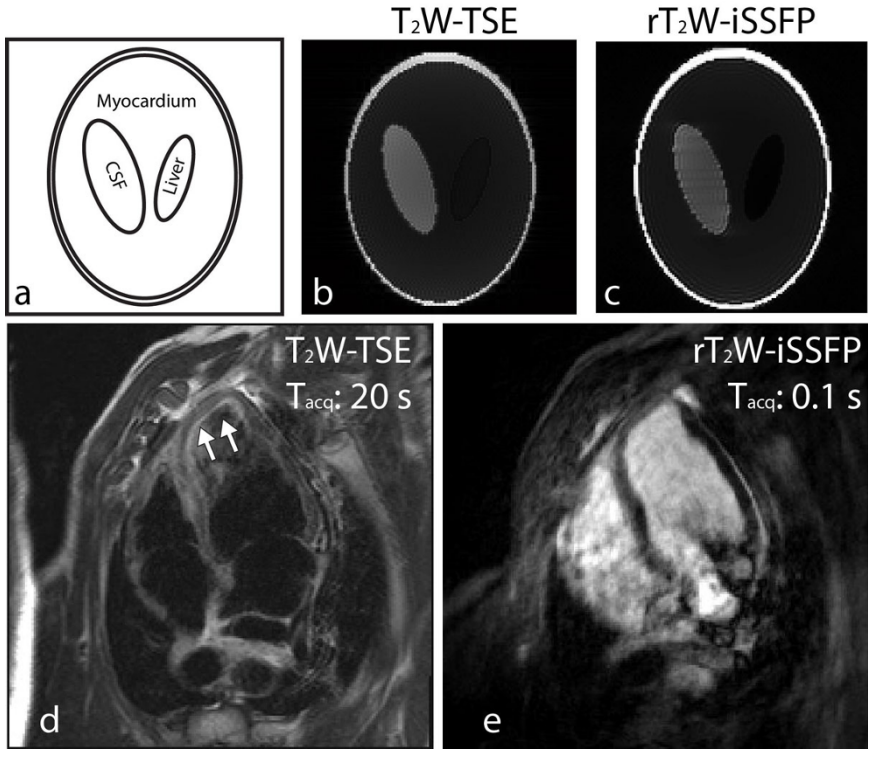

Figure 2 (a) Illustration of the Shepp-Logan phantom used for simulation. (b) T_2W-TSE and (c) r T_2W-iSSFP were simulated. Swine with acute injury was scanned by (d) breath-hold T_2W-TSE and (e) free-breathing r T_2W-iSSFP as well. The edema (the arrows in d) is depicted in both d and e. In both simulation and in-vivo imaging, T_2W-TSE was used as the reference of T_2-weighting. T_{acq} - acquisition time.

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