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Contrast-enhanced whole-heart coronary magnetic resonance angiography (MRA) in less than 5 minutes using radial EPI

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Introduction

Whole-heart coronary MRA is challenging due to the long data acquisition time on the order of 8-12 minutes. Interleaved EPI using Cartesian k-space sampling has been reported for reducing the scan time of whole-heart coronary MRA [1]; however, this method suffers from an increased sensitivity to motion artifacts [2]. The purpose of this work was to optimize a radial EPI [3] technique for contrast-enhanced whole-heart coronary MRA, with the goal of combining the scan efficiency of EPI with the motion insensitivity of radial sampling.

Methods

Sequence design

A stack-of-stars radial trajectory was used for 3D imaging. Fig. 1 shows the Radial EPI pulse sequence. Adjacent projections were sampled in each TR. Combining all the projections during gridding leads to phase cancellation and corresponding signal loss in the images. We used a novel self-calibrating phase correction technique to compensate for this effect. K-space was split into n undersampled sections, each acquired at a particular TE. A low resolution fully sampled image was reconstructed at each TE. Off-resonance phase was estimated from this low resolution image and eliminated from the corresponding high resolution image. The multiple high resolution undersampled images (one for each TE) were then combined by complex summation to give the final image. Trajectory measurement [4] was used for correction of gradient delays and variable density sampling was used in the kz direction [5] for reduction of streaking artifacts.

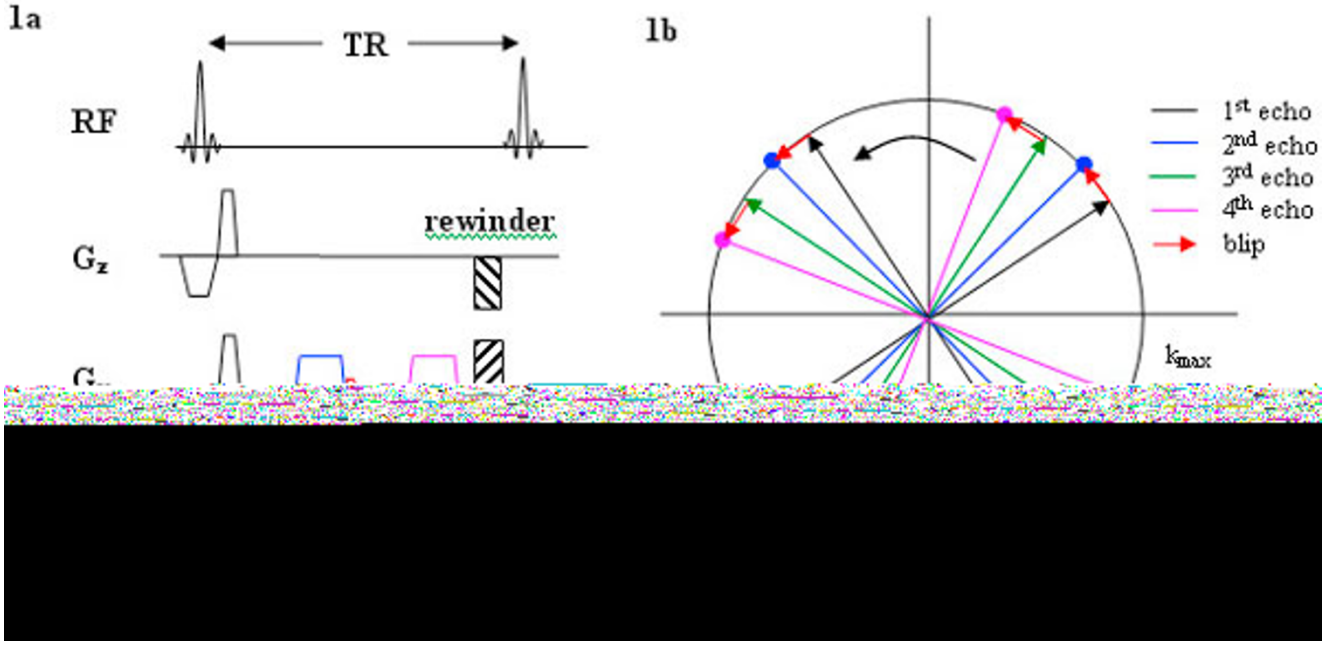

Figure 1
Radial EPI pulse sequence (1a) and reordering scheme (1b).

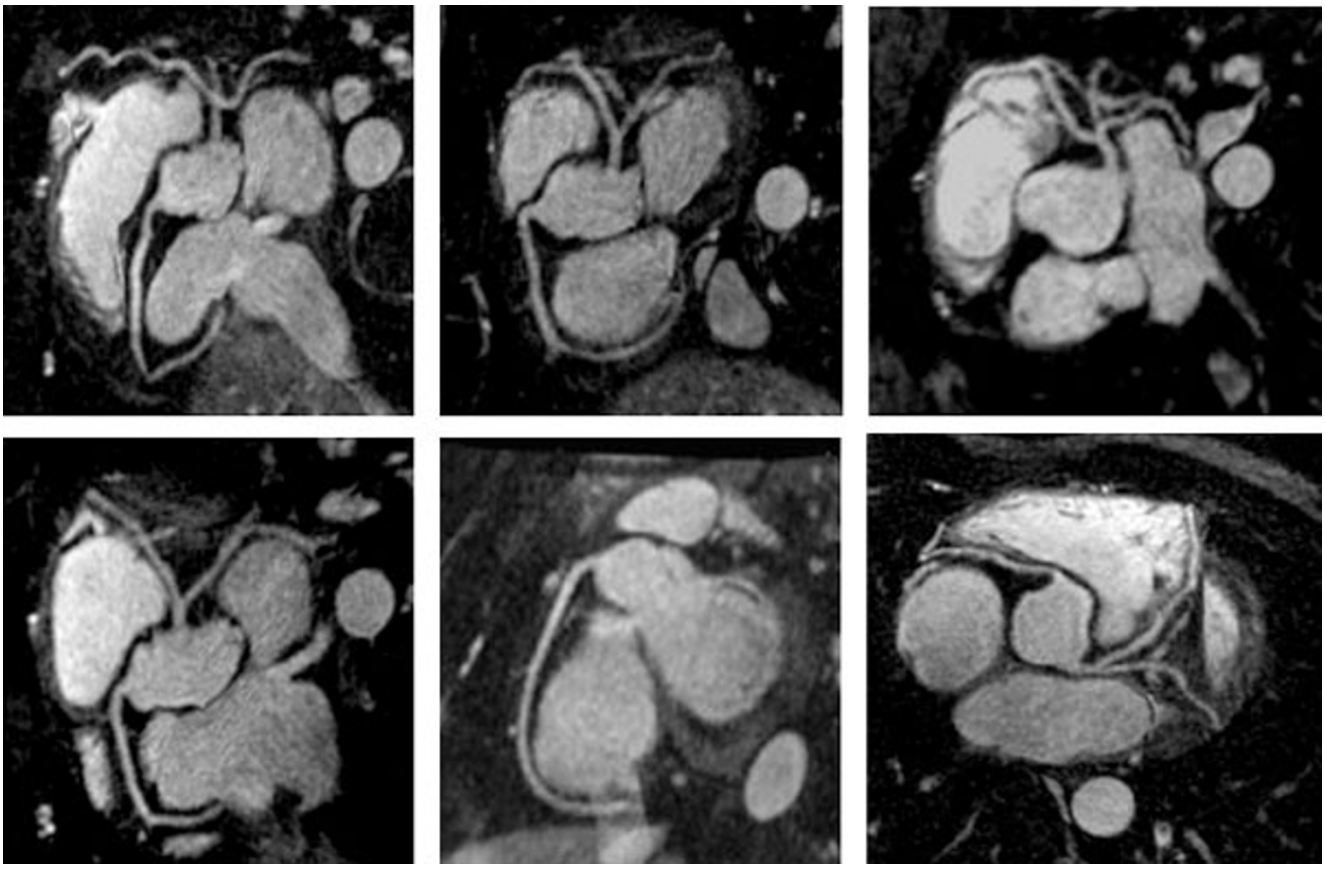

Figure 2
Reforammted coronary artery images using the contrast-enhanced whole-heart Radial EPI technique.

Table 1:

Sequence (n = 6)	Imaging time (mins)	Navigator efficiency (%)	SNR	CNR	RCA length	LAD length
Radial EPI	4.9 ± 0.7	49.0 ± 8.0	27.0 ± 4.0	14.0 ± 1.3	9.3 ± 1.7	9.3 ± 2.3

Volunteer imaging

6 volunteers were scanned on a 3 T Trio scanner (Siemens Medical Solutions). Scan parameters were: 4 projections in each TR, TR = 8.2 ms, flip angle = 30, readout bandwidth = 977 Hz/pixel, number of radial views = 288 or 144 depending on the kz value, partial Fourier of 5/6 in the kz direction, inversion-recovery preparation with TI = 200 ms, matrix: 256 × 256 × 60, voxel size: 1 × 1 × 2 mm^3. 0.2 mmol/kg of Gd-DTPA was injected at 0.3 cc/sec.

Results

The average imaging time for contrast-enhanced whole-heart imaging was 4.9 minutes. Fig. 2 shows reformatted coronary artery images using the radial EPI technique. Excellent depiction of all the coronary arteries is seen. Quantitative evaluation of the radial EPI technique is shown in Table 1.

Conclusion

A radial EPI sequence was developed for contrast-enhanced whole-heart coronary MRA in a scan time under 5 minutes.

References

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4. *MRM* **39:**999–04.
5. *ISMRM* 2007, # 307.