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Centric reordered echo planar imaging (EPI) for phase contrast MRI

Yiu-Cho Chung*[1], Yu Ding[2] and Orlando Simonetti[2]

Address: [1]Siemens Healthcare, Columbus, OH, USA and [2]The Ohio State University, Columbus, OH, USA

* Corresponding author

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Introduction

Limited temporal resolution underestimates peak velocities assessed by phase contrast MRI (PC-MRI) [1]. Segmented EPI with partial Fourier as previously proposed [2] has relatively long TE, and is prone to chemical-shift artifact. We propose centric reordered water-excitation EPI for PC-MRI with short TE and fat suppression. It improves temporal resolution by twofold while halving scan time compared with turboFLASH.

Purpose

Design a centric reordered EPI sequence for PC-MRI, and compare it with turboFLASH in healthy volunteers.

Methods

Sequences

The prospective triggered EPI sequence used centric reordering [3], fast, flow-compensated water excitation [4] and TSENSE [5]. Concomitant gradient effects were corrected [6]. The sequence was implemented on a 1.5 T scanner (MAGNETOM Avanto, Siemens Healthcare, Germany) and its performance was compared to turboFLASH (imaging parameters in Table 1). The TR/TE/flip angle were 12.4 ms/2.4 ms (effective)/15°-25° for EPI, and 5 ms/1.9 ms/25° for turboFLASH. EPI echo spacing = 690 μs. In both cases, venc = 150-200 cm/s, pixel ~2.3 × 2 mm^2, slice = 6-8 mm.

Imaging/Analysis

For each (n = 8) healthy volunteers in this IRB approved study, an imaging plane perpendicular to the ascending aorta was prescribed. Aortic flow was imaged twice using each of the two sequences. Argus (Siemens Healthcare, Germany) was used to find the peak velocity (PV) and flow volume (FV). PVs from EPI were obtained using 5-pixel spatial averaging to account for bandwidth related SNR differences between EPI and turboFLASH. PV and FV

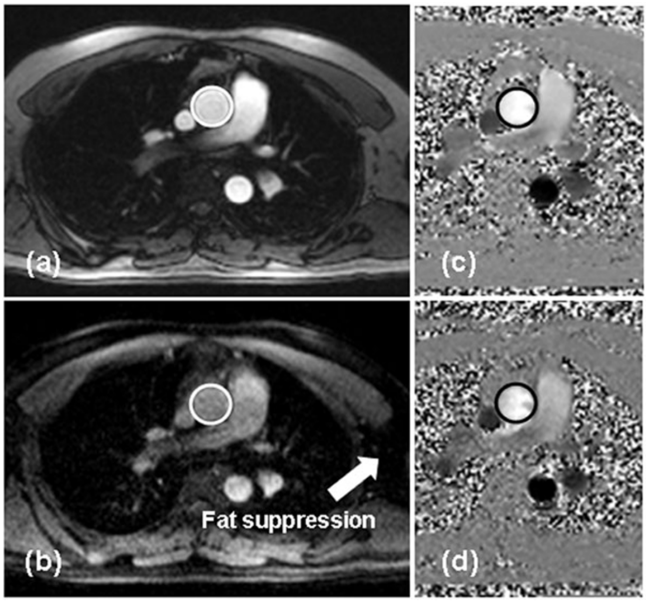

Figure 1
Magnitude images from turboflash, 5 segments (a) and EPI, 9 echoes (b). The circle marked the aortic flow. (c) and (d) show the corresponding phase images.

Table 1: Imaging parameters used in the study.

	PAT	Bandwidth per pixel	k-space traversal	Image Matrix	Temporal resolution	Scan time
EPI	TSENSE rate 2	2005 Hz	9 echoes/RF pulse	134 × 192	25 ms	8 beats
Turboflash	iPAT rate 2, 24 extra lines	500 Hz	5 seg.	125 × 192	50 ms	15 beats

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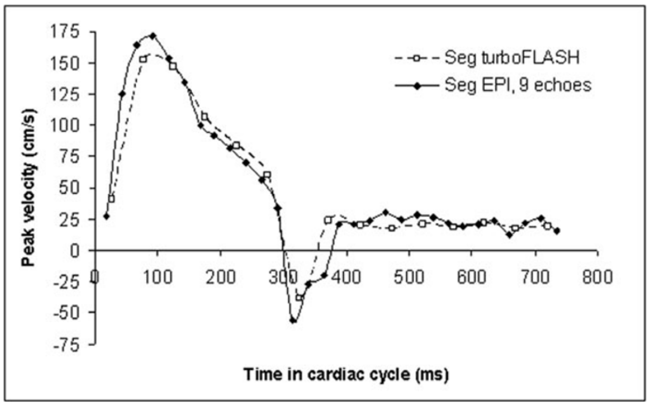

Figure 2
The peak-velocity versus time curve of the aortic flow from one volunteer. The peak velocity and backflow were better sampled by EPI.

rom each volunteer were averaged for one sided and two sided t-tests respectively

Results

All EPI images had good image quality. EPI related distortion or fat-water shift artifact was not observed (Fig. 1). The FV between the two techniques differ by 0.5% ($p = 0.66$). PVs from EPI were higher than those from turboFLASH by 7% ($p < 0.01$,), due most likely to improved temporal resolution (e.g., Fig. 2).

Conclusion

Centric reordered EPI provided short TE and reduced sensitivity to turbulence and minimized T2* effects. Fat suppression improved image quality. The volunteer study results suggested that the high temporal resolution of EPI improves peak velocity sampling, and the shortened scan time makes the technique clinically attractive.

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