High Field (3.0T) CBF Imaging using Spin-echo EPI and Parallel Imaging

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Introduction

Perfusion weighted MR imaging with dynamic susceptibility contrast (DSC) typically uses echo planar imaging (EPI) such as gradient echo EPI (GE-EPI) or spin echo EPI (SE-EPI). In clinical use, GE-EPI is preferable due to full coverage of brain because sequence running time in single slice of GE-EPI is shorter than that of SE-EPI within a same repetition time (TR). The large overall susceptibility contrast sensitivity of GE-EPI sequence requires smaller injections of contrast than that of SE-EPI for the same signal to noise (SNR) [1]. On the other hand, GE-EPI suffers from inhomogeneity of external magnetic field (B_0) which causes image distortion near maxillary sinus, low sensitivity at the base of the brain, and blurring near large cortical branches of the middle cerebral artery. We present a technique for perfusion SE-EPI with parallel image technique in 3.0 T which gives higher SNR with same dose of contrast in 1.5 T, whole brain coverage and higher sampling rate. We compare with perfusion GE- and SE-EPI in DSC analysis in 3.0 T.

Method

Parallel imaging technique has been developed to improve spatial and temporal resolution. GRAPPA (GeneRalized Auto-calibrating Partially Parallel Acquisition) technique obtains the fraction line in k-space, and missing line information is reconstructed by coil calibration [2].

We scanned 7 volunteers with conventional perfusion GE-EPI (TR/TE = 1.29s/47ms, FOV = 220×220 mm, resolution 128×128, bandwidth 1260Hz, partial Fourier 7/8, slice thickness = 5 mm, 11 slices, 50 phases, total scan time = 1 min 10 secs) and SE-EPI (TR/TE = 1.37s/59ms, FOV = 220×220 mm, resolution 128×128, bandwidth 1260Hz, slice thickness = 5 mm, 11 slices, 50 phases, GRAPPA : acceleration factor = 2, reference line of phasing encoding line = 24, total scan time = 1 min 18 secs) with 8 channels head coil in 3.0 T scanner (Trio, Siemens Medical Systems, Erlangen, Germany). 0.1 mmol/kg Gadolinium contrast (Magnevist, Berlex, Princeton, NJ) was injected by automatic power injector (Spectris, Medrad, Indiana, PA) with 60% of single dose (0.12ml/kg) with 2 ml/sec flow rate in GE-EPI and with a single dose (0.2ml/kg) with 2 ml/sec flow rate in SE-EPI. Time gap between GE-EPI and SE-EPI was approximately 30 minutes, and the order of GE-EPI and SE-EPI was chosen randomly. 20 ml of saline was followed for washout of contrast with 2 ml/sec flow rate after each contrast injection.

Singular value decomposition (SVD) technique was used in data analysis [3]. User determined arterial input function (AIF) was chosen.

$$C_m(t) = F \cdot AIF(t) \otimes R(t)$$

where $C_m(t)$ is concentration time curve in tissue, F is cerebral blood flow and R(t) is residue function. Relative CBF (rCBF) images were obtained by normalization – divided by average CBF values of brain in each slice.

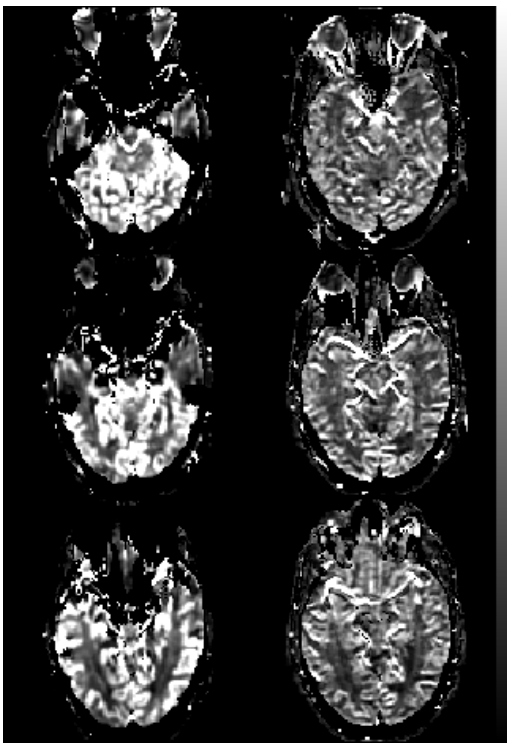

Figure 1 : Whole brain rCBF maps at 3.0T (Left) GE-EPI and (Right) from SE-EPI. Three images in each column have same position with corresponding images in other columns. Large image distortion is shown (arrows) from GE-EPI by inhomogeneity of B_0

Results

Figure 1 shows GE-EPI images are distorted by inhomogeneity of B_0 field. the distortion in GE-EPI images become severe closer to maxillary sinus, which causes susceptibility artifacts. From figure 2-a), SE-EPI images shows rCBF values in microvascular region-white matter (WM) without the overwhelming signal from large vessels in gray matter (GM). rCBF values distribution in figure 2-b) represents GE-EPI shows large high rCBF values in (GM) and SE-EPI shows high microvascular sensitivity in WM

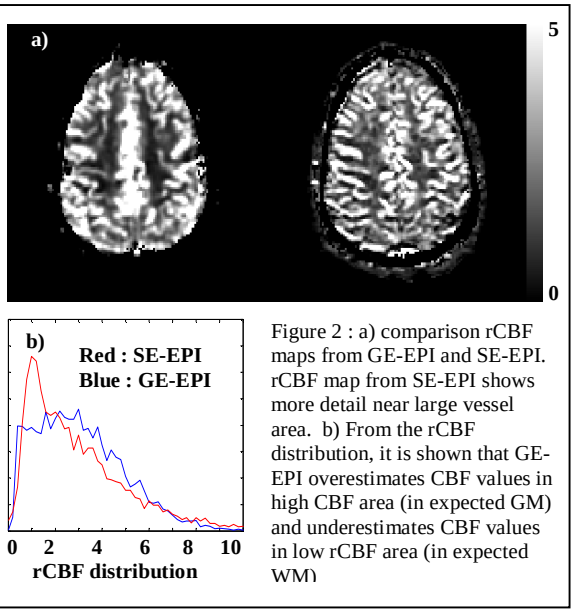

Figure 2 : a) comparison rCBF maps from GE-EPI and SE-EPI. rCBF map from SE-EPI shows more detail near large vessel area. b) From the rCBF distribution, it is shown that GE-EPI overestimates CBF values in high CBF area (in expected GM) and underestimates CBF values in low rCBF area (in expected WM)

Conclusion

We present perfusion SE-EPI with parallel imaging technique (GRAPPA) in 3.0 T. High B0 field compensates the loss of SNR using SE-EPI, and makes relatively small contrast injection (single dose -0.2ml/kg) possible, which is important in clinical use. Parallel imaging techniques take a benefit of whole brain coverage (11 slices) with small TR (1.37 sec).

Reference

1. Weisskoff, R.M., et al., Magn Reson Med, 1994. **31**(6): p. 601-10.
2. Griswold, M.A., et al., Magn Reson Med, 2002. **47**(6): p. 1202-10.
3. Ostergaard, L., et al., Magn Reson Med, 1996. **36**(5): p. 715-25.