Multi-band Multi-echo EPI (M2-EPI) for Dynamic Susceptibility Contrast (DSC) Perfusion Imaging: A feasibility Study

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Target Audience: Researchers interested in fast imaging in fMRI and DSC perfusion imaging

Introduction:

Dynamic susceptibility contrast (DSC) imaging with bolus injection of contrast injection provides important cerebral perfusion measures, such as cerebral blood flow (CBF), cerebral blood volume (CBV), Time to peak of tissue response function (Tmax), among others. It has been shown to be useful in the assessment of brain tumors and treatment triage of acute stroke patients[1]**.** However, conventional single-band single-echo EPI is limited in its sensitivity to contrast agent leakage due to breakdown of blood brain barrier (BBB) [2], clipping of arterial input function (AIF), and limited slice coverage for scans with sub-second temporal resolution. In this paper, we developed a novel multi-band multi-echo EPI (M2-EPI) that could overcome these limitations. The feasibility of this sequence in DSC perfusion imaging was studied in a phantom and patients with both 12-channel and 32-channel head coils.

Method:

The M2-EPI sequence was developed on the Siemens IDEA pulse sequence development platform, and scans were performed at 3T (Tim Trio VB17, Siemens Healthcare, Erlangen). Figure 1 shows pulse diagram of the core part of the sequence. Multiband excitation pulse was implemented by modulating sinc function with exponential function. This was followed by multiple repetitions of EPI readout trains. Blipped-CAIPI was implemented to create slices shifts to minimize the multiband g-factor[3]. In-plane GRAPPA parallel imaging was implemented and calibration data was acquired following initial dummy scans, which was then followed by the acquisition of multiband calibration data. The following parameter was used for all the scans: TR=800ms, TE=18/41/65ms, FOV=240mm, Matrix = 100x100, Slice thickness/gap = 4/1mm, multiband-factor = 3, GRAPPA factor = 3. For scans with 32-channel coil, CAIPI slice shift was 1/6 of the FOV; and a slice shift of 1/9 FOV was used for the scan with 12-channel coil since there is only very little variation of coil sensitivity in B0 direction of this coil. Perfusion maps were generated using Perfusion Mismatch Analyzer (PMA, ASIST-Japan), including CBF and CBV maps among others.

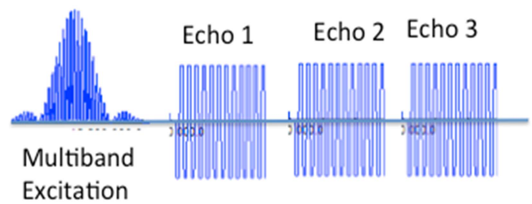

Figure 1. Multiband excitation pulse was implemented by modulating sinc function with exponential function, which is followed by repetitions of EPI readout trains

Results:

Figure 2. shows images from a phantom scanned with 32 channel head coil, a patients with bolus injection of Multihance at 4ml/s scanned with 32-channel head coil, and a patient scanned with 12 channel head coil injected at 4ml/s of Multihance. No obvious image aliasing can be observed with images acquired with 32 channel while images acquired with 12-channel head coil showed degenerated images quality with significant image aliasing. For patient scan with 32 channel, CBF and CBV can be successfully generated with no obvious artifacts (Figure 3).

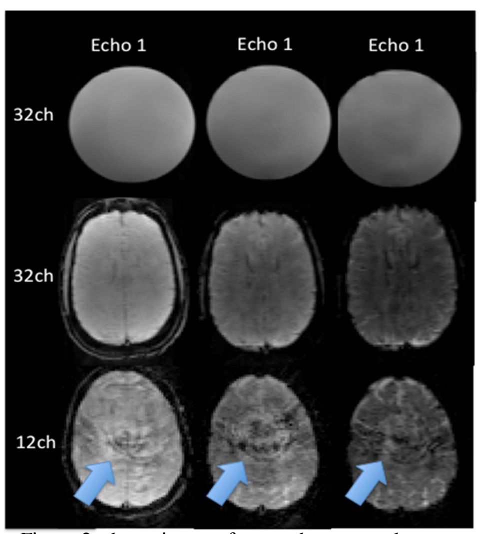

Figure 2. shows images from a phantom and a patient scanned with 32 channel head coil (first and second row respectively) as well as from a patient scanned with 12 channel coil head coil (third row). No obvious visual image artifacts can be observed from images acquired with 32ch coil, while severe aliasing artifacts are observed when 12-channel coil was used.

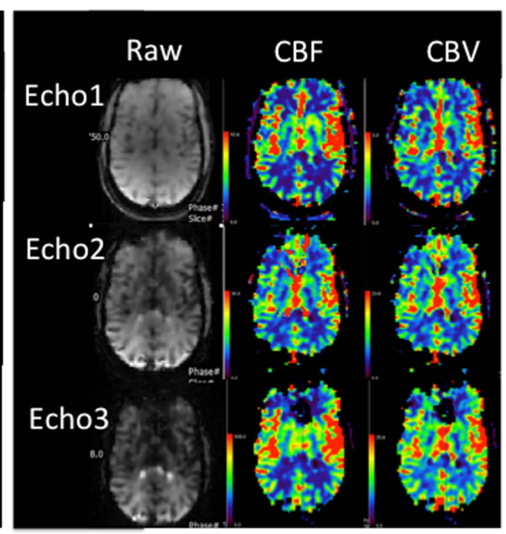

Figure 3. DSC images and the derived CBF and CBV images from a scan performed with a 32-channel coil.

Discussions & Conclusions:

A multi-band multi-echo EPI (M2-EPI) is successfully developed that achieves a total of 9 factor of acceleration (3 for in-plane and 3 for slice direction). The sequence performs the best with the use of a 32-channel coil with respect to a 12-channel coil. The sequence provides high temporal resolution of 800ms with whole brain coverage. The high temporal resolution could improve the accuracy of DSC perfusion quantification, while the multiple echoes could allow more accurate quantification of perfusion parameters in the case of BBB breakdown and capacity for permeability quantification. Further study is underway to evaluate the advantage of this method in patients with neurological diseases including brain tumors.

References: ***1.*** Albers GW, et al. Ann Neurology. 2006. 60:508-17. ***2.*** Newbould R. et al. MRM. 2007; 58:70-81. ***3***. Setsompop K. et al. Neuroimage. 2012;569-80.