STAR-TFE Sequence for arterial spin labeling in abdominal organs at 3T

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Introduction: Signal targeting with alternating radiofrequency and echo-planar imaging (STAR-EPI) is a well established pulse sequence for arterial spin labeling (ASL) perfusion in the brain (1). Applications of ASL perfusion in abdominal organs have shown promise for identifying and monitoring the flow to known and new suspicious lesions (2,3). Although STAR-EPI can achieve the highest temporal resolution, many problems arise with STAR-EPI for abdominal ASL, such as image distortion, low spatial resolution, susceptibility artifact, Nyquist ghost, and large chemical shift. In this study, we proposed a turbo field echo (TFE) based acquisition with STAR labeling (STAR-TFE) for abdominal ASL. Compared to STAR-EPI, the image quality was significantly improved at 3T with fewer artifacts. The temporal resolution of 0.4ms was achieved to compensate the respiratory motion. STAR-TFE should be promising for perfusion studies in abdominal organs such as kidney and lumbar spine bone marrow.

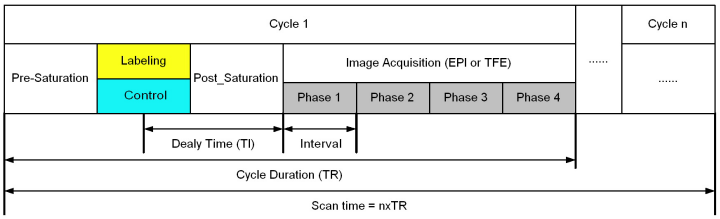

Fig.1. Diagram of the STAR-EPI and STAR-TFE sequence

Methods: The proposed STAR-TFE sequence was implemented and applied for lower lumbar vertebral bone marrow ASL in four healthy volunteers on a 3T Philips Achieva MRI scanner. The imaged slice (FOV=36cm) was located axially at the lumbar spine vertebrae L3 with an 8mm thickness. The labeling region was located 20mm superior to the imaged slice with a 130mm thickness. In each cycle, the imaged slice was saturated by a series of four RF pulses to eliminate signals from static tissues first. A hyperbolic secant pulse was then used for labeling. After labeling, the imaged slice was post-saturated again by a single RF pulse. Five startup dummy-scans were used to initialize the steady-state in TFE acquisition. Thirteen phases of labeling and control images were acquired in an interleave mode. Thirty cycles were repeated to average the signal (Fig. 1). To minimize the scan time and phase interval, partial Fourier acquisition and parallel imaging were employed. The delay time (TI) after labeling was 300ms and the shortest interval was 415ms. The matrix size for STAR-TFE and STAR-EPI were 144x144 and 96x96 respectively. All images were acquired under free-breathing condition without motion compensation.

Results: Figure 2 shows the averaged phase-one label and control images acquired by STAR-EPI (a, b) and STAR-TFE (c, d), respectively. The image quality for STAR-EPI suffers from severe chemical shift, ghost artifact, respiration artifact and low spatial resolution. In contrast, the image quality has been improved significantly using STAR-TFE to remove most of artifacts even under free-breathing. The corresponding subtracted phase-one perfusion images acquired by STAR-EPI (a) and STAR-TFE (b) are shown in Fig. 3. No reliable and consistent perfusion parameters could be retrieved from the STAR-EPI data due to the poor perfusion images. In contrast, the arrival time and the bolus duration was measured as 150ms and 1s, respectively, from the STAR-TFE data. The perfusion rate estimated ranged from 0.02ml/ml.s to 0.04ml/ml.s for four subjects.

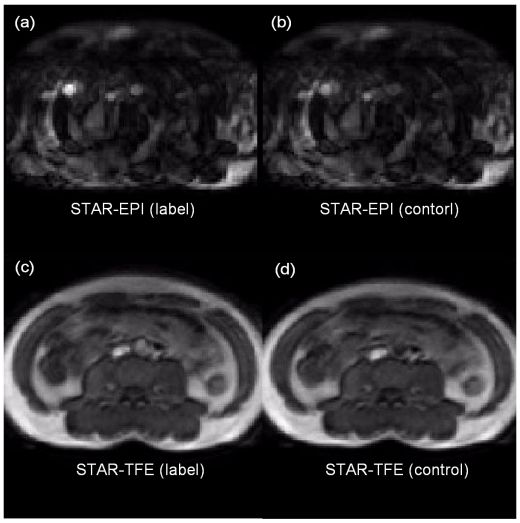

Fig.2. Averaged phase-one label and control images acquired by STAR-EPI and STAR-TFE, respectively.

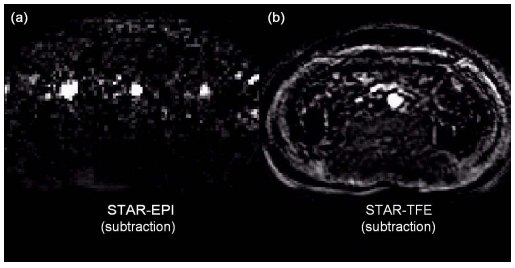

Fig.3. Subtracteded phase-one perfusion images acquired by STAR-EPI and STAR-TFE, respectively.

Discussion: No fat suppression is required for STAR-TFE to remove the chemical shift artifact for STAR-EPI. The minimal phase intervals with STAR-TFE are 415ms and 530ms for matrix sizes of 144x144 and 192x192, respectively, by using a SENSE factor of 2 and a partial Fourier factor of 0.6, longer than the corresponding 77ms and 124ms with STAR-EPI. It is a necessary trade-off for better image quality. Compared to other acquisitions, TFE acquisition can achieve comparable temporal resolution as HASTE (4), but with lower SAR, and eliminate the dark banding artifact for bSSFP acquisition (3).

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References: [1] Alsop DC et al, Radiology, 208:410-16(1998); [2] Karger N et al, MRI 18:641-647(1995); [3] Martirosian P et al, MRM 51:353-361(2004); [4] Chen Q et al, MRM 38:404-408(1997)