Dynamic Angiography Imaging at 7T Using Variable Duration Pseudo-Continuous Arterial Spin Labeling

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INTRODUCTION

Arterial spin labeling (ASL) benefits twofold from higher magnetic fields: an increased equilibrium magnetization is available and the longitudinal relaxation time of the blood is prolonged. Pseudo-continuous arterial spin labeling (pCASL) [1] using a series of labeling pulses is capable of producing higher SNR when compared with pulsed ASL. pCASL has been employed in perfusion studies at various field strengths [3, 4] and in a dynamic angiography study at 3T [5]. In dynamic angiography, inflow of labeled blood to the target volume is imaged at various delay times (TI) between the end of labeling pulse(s) and the start of data acquisition [5-7]. With pCASL only inflow times larger than the total labeling pulse length can be sampled, and shorter labeling blocks are needed to image rapid bolus dynamics. But, short labeling blocks results in decreased SNR for longer delays [5]. In this study, we propose a variable duration pCASL for each inflow time (i.e. inflow phase) and utilize it in a dynamic angiography study at 7T. Results from a healthy volunteer are demonstrated.

MATERIAL & METHODS

For pCASL imaging, a whole bode 7 Tesla MRI system (Magnetom, Siemens, Erlangen, Germany) is used with a 24 channel receive and single channel transmit head coil (Nova Medical, Wilmington, VA). Global B_0 shimming and local B_1 calibration was performed prior to all scans. A pCASL pulse sequence was implemented which acquired a 40 mm thick slice with 0.82x0.82 mm^2 in-plane resolution using segmented TurboFlash readout (8 segments). The following imaging parameters were used: TR=11 ms, TE=3ms, 256x256 matrix, flip angle=5°, BW=270Hz/pixel. Labeling was performed by applying 512 μs Hanning pulses with 9.6 mT/m gradient amplitude, 1.08 ms pulse separation, 24° flip angle, 0.5 mT/m mean gradient during tag and zero gradient during control. A saturation pulse was applied 10 ms before labeling to suppress residual signal from static tissue. No delay time is used (TI=0) between labeling and acquisition, inflow effect was obtained by using the variable duration pCASL. This is done by changing the total number of individual pulses within the labeling block. 200 to 700 pulses with increments of 100 produces 216, 324, 432, 540, 648, 756 ms labeling block durations respectively. Total acquisition time is approximately 6 min.

RESULTS & DISCUSSION

The inflow of labeled blood into the intracranial vasculature can be clearly seen in Figure 1. Early inflow phases are imaged and no loss of signal is seen for longer inflow phases. After each labeling block, the segmented acquisition with multiple readout RF pulses leads to a non-ideal point spread function which causes minor blurring of the arteries in phase encoding direction. This blurring effect can be decreased by increasing the number of segments or with a better sampling design of k-space within the segments.

The main motivation of this study is to benefit from the higher SNR at very high magnetic fields. However, pCASL is highly susceptible to B_0 variations which increase with the magnetic field. Previous studies proposed additional pre-scans and/or careful tuning of labeling parameters to obtain a better performance with pCASL at 7T [4, 8]. B_0 shimming is applied in this study and has to be improved in further studies. Furthermore, SAR limitations require the insertion of dead times after acquisition segments and between repetitions which leads to an increased total imaging time.

In this study, number of sampled inflow phases is controlled by number of repetitions, sampled inflow times are determined by labeling block duration and temporal resolution is determined by the difference of labeling block durations. Using the proposed design, dynamic angiography specific parameters can be changed in a flexible way so that the imaging protocol can be optimized for various applications.
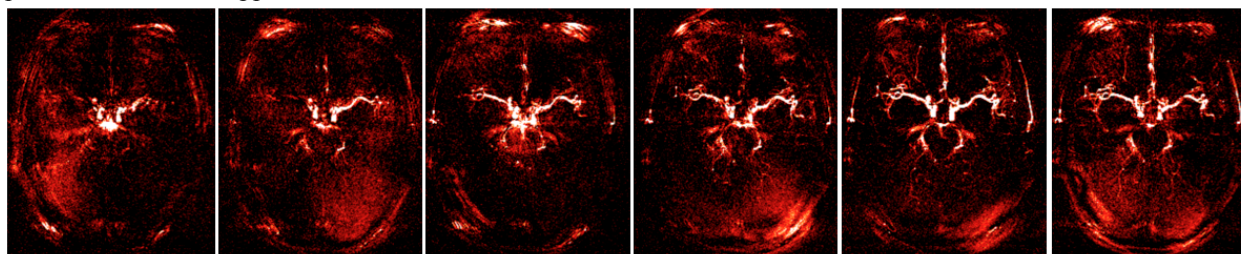
Figure 1: Dynamic angiography images of a healthy volunteer with 216/324/432/540/648/756ms labeling block durations.

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