

Supersensitive Pseudo-Continuous Arterial Spin Labeling

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Introduction:

Pseudo-continuous arterial spin labeling (psCASL) is a newly proposed technique, which employs a train of discrete RF pulses that mimics continuous ASL, but has a much lower SAR [1]. Recently Wong et al proposed an adaptation of pseudo-continuous ASL that allows for imaging of perfusion territories [2]. This adaptation employs gradients perpendicular to the labeling plane that generate phase shifts between vessels of interest. Since these gradients are only applied in one direction, it results only in a modulation of the labeling efficiency in a single direction, so that blood from other vessels may be tagged as well. For clinical purposes this can be disadvantageous, especially when the aim is to tag a single, intracranial artery in patients with altered arterial architecture. Here we describe a modified tagging scheme that can label a single vessel, can tune the size of the labeling spot, and that has the same SNR as conventional ASL.

Materials and Methods

The method is based on the gradient scheme of balanced psCASL, but employs an additional gradient switched after each RF pulse that is perpendicular to the labeling direction. The direction of the gradient is changed for every RF pulse in a random fashion. By changing the phase of the RF-pulses according to the applied extra gradients efficient inversion is achieved at the targeted vessel, whereas at other positions in the labeling plane phase variations prevent inversion. By increasing the strength of the added gradient, the labeling focus can be made more selective. Scanning and tagging parameters were as follows: Philips 3T Achieva scanner; FOV 220x220mm, voxel size of 2.7x2.7x6 mm, FFE-EPI read-out. Labeling duration 1.65 s, postlabeling delay 1.525 s with background suppression, 15 slices and 10 averages of label and control images. Scan time approximately 1:40 min. We investigated the selectivity by changing the location of the labeling focus for different scans in the right left direction (random order, the focus position was changed over a length of 10 mm starting from the middle of the targeted vessel). This procedure was repeated for different gradient strengths and we targeted the internal carotids of eight volunteers (3 female, 5 male).

Results and Discussions

Figure 1 shows the labeling efficiency as a function of the strength of the additional gradients. Increasing the gradient strength decreases the size of the labeling focus and labeling becomes more selective. If the labeling focus is too small it will not cover an entire vessel so that only part of the blood is tagged, this explains the reduced labeling efficiency for gradient strengths larger than about 8 mT/m. For gradient strengths smaller than 5.4 mT/m maximum labeling efficiency is achieved. This is in line with the fact that this gradient strength results in 0.5π phase difference over a distance of 6 mm, which is in the order of the ICA of this volunteer (approximately 5.5 mm). Figure 2 shows the ASL signal against the offset of the labeling focus with respect to the center of the selected vessel for two different gradient strengths. Clearly higher gradient strengths lead to improved selectivity of the method. This implies that a stronger gradient should be used when another vessel is located close to the targeted vessel. Figure 3a shows perfusion images of flow territories of right and left internal carotids of a normal volunteer. Due to a hypoplastic A1 segment on the right side both ACA territories are supplied by the same carotid artery. Figure 3b shows the flow territory of a branch of the MCA in another volunteer, showing the capabilities of the method to label small intracranial arteries.

References

- [1] Wu et al., Magn Reson Med 2007; 58:1020-1027
- [2] Wong, ISMRM 2006, p.668

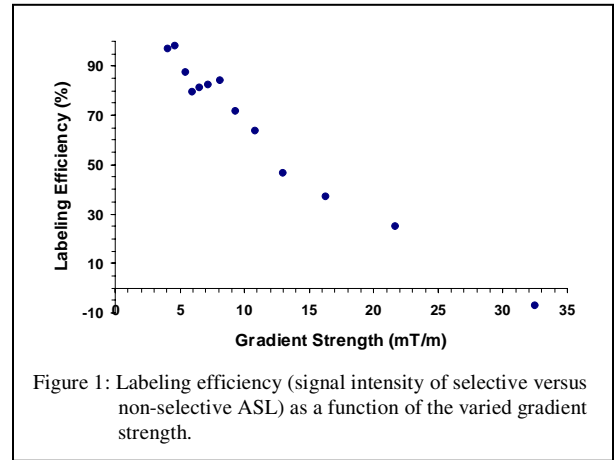


Figure 1: Labeling efficiency (signal intensity of selective versus non-selective ASL) as a function of the varied gradient strength.

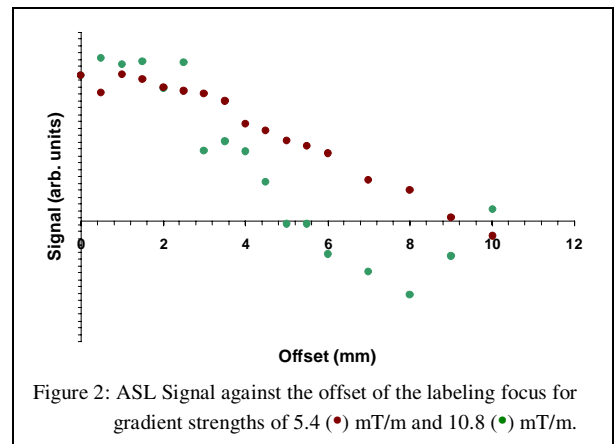


Figure 2: ASL Signal against the offset of the labeling focus for gradient strengths of 5.4 (●) mT/m and 10.8 (●) mT/m.

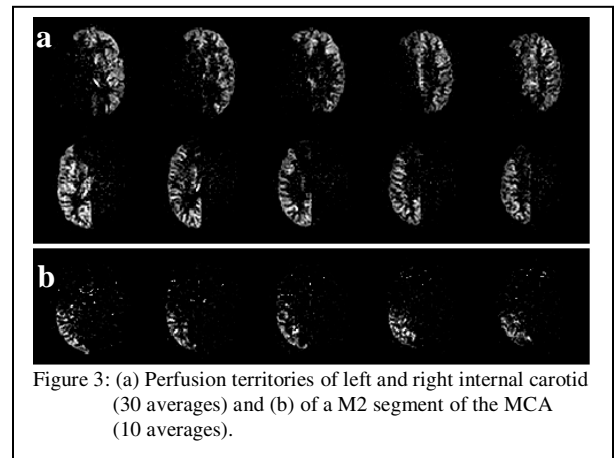


Figure 3: (a) Perfusion territories of left and right internal carotid (30 averages) and (b) of a M2 segment of the MCA (10 averages).