High Sensitivity CASL Perfusion MRI at 3T Using a 16 Channel Receiver Coil Array

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Introduction

A number of arterial spin labeling (ASL) perfusion MRI techniques have been demonstrated in the recent years. However, because of low sensitivity, ASL methods are still not widely used. Recent work on continuous ASL (CASL) using a separate neck labeling coil (1,2) and use of receiver coil arrays for brain imaging (3) indicate that a significant improvement in ASL perfusion imaging can be realized by combing these two approaches. This work is aimed at improving the sensitivity of ASL perfusion MRI by the use of a close fitting receiver coil array. Here we demonstrate high-sensitivity, continuous ASL (CASL) perfusion MRI of the human brain at 3T using a neck labeling coil and a 16 channel receiver coil array.

Method

Five volunteers were scanned under an NIH approved IRB protocol using a 3.0 T GE Signa system interfaced to a custom built 16 channel, fast digital receiver system (4). A 16 element, brain array coil (5) was used for signal reception and the standard body RF coil was used for excitation. Continuous arterial spin labeling of the blood flowing in the carotid /vertebral arteries was accomplished using a separate surface labeling coil (two 6.5 cm X 4.5 cm rectangular loops) placed on the neck. The labeling coil was connected to an external homemade RF channel (RF synthesizer + RF amplifier + power monitor) which was gated by a TTL pulse from the scanner.

Image acquisition was performed with a single shot, 2D gradient-echo EPI sequence. Prior to image acquisition (13 slices in 0.8 s), RF power (~1.0 W average) was applied to the labeling coil for 3 s at an offset of ~20 kHz in the presence of a 0.3 G/cm gradient along the S/I direction. A post-labeling delay of 1.2 s was allowed between the labeling and the image acquisition periods (effective TR = 5 s). The body transmit coil and the receiver coil array were detuned during the labeling period and the labeling coil was detuned during image acquisition. Arterial spin labeled and control images were acquired alternatively by reversing the polarity of the labeling gradient. Images were acquired with 3.0 mm slice thickness, TE 18-26 ms and in-plane resolutions ranging form 4X4 mm^2 to 1.5X1.5 mm^2. Intensity corrected images were reconstructed using the SENSE algorithm (3).

Results

Figures 1 shows high resolution (1.5 X 1.5 x 3.0 mm^3), brain CASL perfusion difference (control–label) images of a normal volunteer obtained in 10 min 30 s. Perfusion in all regions are depicted with good sensitivity indicating good labeling efficiency in the carotid/vertebral arteries. The difference signal in the gray matter is ~0.9% of the control image intensity and the signal-to-noise ratio (SNR) of the difference images is ~10:1. Figure 2 shows perfusion data at different resolutions signal averaged long enough to produce a difference image SNR of ~10:1. Figure 2 image resolutions and signal averaging time are: A) 4X4X3 mm^3 - 20 s, B) 3X3X3 mm^3 - 1 min 20s, C) 2x2x3 mm^3 - 5 min 40 s, D) 1.5X1.5X3 mm^3 - 10 min 30s.

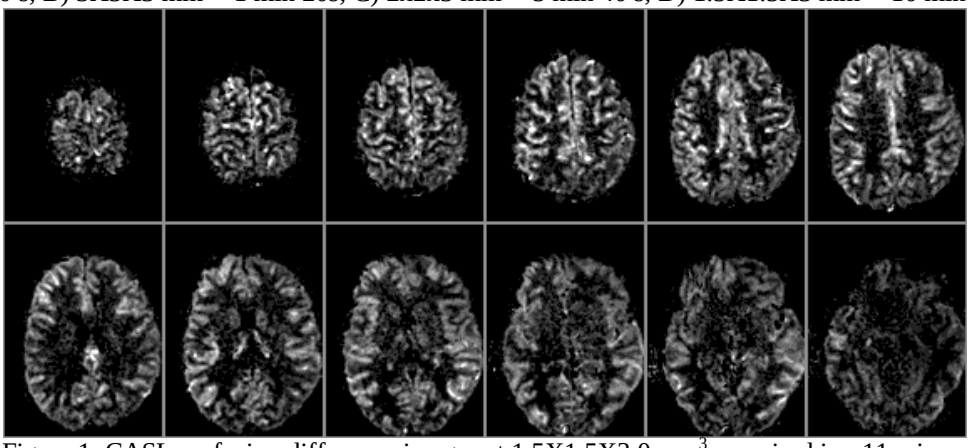

Figure 1: CASL perfusion difference images at 1.5X1.5X3.0 mm^3 acquired in ~11 min.

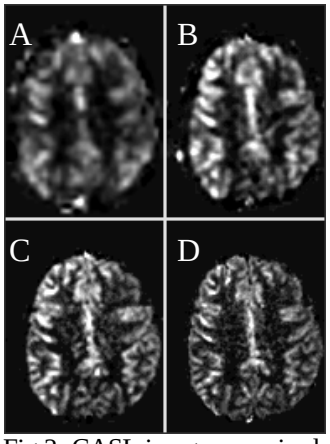

Fig 2: CASL images acquired at different resolutions.

Discussion

Results shown above indicate that the use of a close fitting receiver coil array can provide a significant gain in SNR in CASL perfusion studies. Use of a neck labeling coil provides whole brain coverage subjected to the receiver coil array sensitivity profile. The method allows lower resolution perfusion images (3X3X3 mm^3) with short scan times (~1-2 min) suitable for clinical applications or high resolution (1.5X1.5X3 mm^3) studies with longer scan times (~11 min) for more appropriate for functional MRI. The method can be extended to higher magnetic fields for further gains in sensitivity.

References

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