

Full brain and Territorial Arterial Spin Labeling with external RF shimmed labeling coil at 7 Tesla

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Introduction: Arterial spin labeling is a rising technology for measuring cerebral blood flow (CBF) as early marker for cerebrovascular problems. 3T MRI is the current high end standard for such perfusion measurements. The current rise of ultra high field MRI also triggered the development of high field ASL [1]. Moving to 7T MRI can theoretically result in higher SNR of the CBF signal [2], due to higher intrinsic SNR and longer T_1 relaxation time constant of blood. It is still a major challenge to acquire full brain CBF maps at 7T. To reach the low parts of the brain, tag slabs have to be located below the brain towards the neck. However, due to the absence of a body coil at 7T, excitation has to be performed locally. Commonly used head coils cannot reach the neck to apply the high B_1^+ needed for the adiabatic inversion pulses. Here we apply a radiative U-Tube pillow as a transmitter [3] for external labeling in the neck and performed full brain pulsed ASL experiments in healthy volunteers.

Materials and methods: Hardware setup: All scans were performed on a whole body 7T MRI scanner (Achieva 7.0 T, Philips Healthcare, Cleveland). A birdcage head coil was used in combination with a 32 channel receive coil (Nova Medical Systems, Wilmington, MA, USA). For labelling in the neck, a simple U-Tube transmitter [3] was added to the setup (fig1). The head- and neck transmit coils were driven each by a 4kW amplifier. In case of the neck coil, the power was split up in two, to feed two antenna's on the U-tube, each with 2 kW. Experiments: Sagittal B_1^+ maps (Actual Flip angle Imaging) were acquired. 3rd Order image based B_0 shimming was applied in the brain and sagittal B_0 maps were acquired after shimming. Whole brain perfusion maps were acquired using a PULSAR [4] pulsed ASL sequence, with WET [4] presaturation, and single 90deg post-saturation. No background suppression was applied. Labelling parameters: FOCI pulse, amplitude: duration: 12 ms, bandwidth 2 kHz, label delay: 1500 ms, slab thickness: 100 mm, planning as showed in fig 1. Readout: single shot EPI, 15 slices, slice thickness: 5mm, slice gap 2 mm, voxelsize 3.75 x 3.75 mm², SENSE acceleration factor 2, $T_R = 4000$ ms. RF shimming was applied to either label the full brain, or to label selectively to acquire left/right territorial labelling.

Results and Discussion: Figure 2 shows the coronal B_1^+ map and the B_0 map. B_0 was shimmed in the brain only, in order not to compromise the B_0 sensitive EPI readouts. Due to the higher order shim terms, there was a B_0 offset in the neck. For all volunteers this offset was below 800 Hz. Therefore, the bandwidth of the labelling pulse was sufficiently high (2 kHz) to cause minimal slab displacements. Figure 3 shows the whole brain summed difference maps of images obtained with and without full labelling. While only steered with two transmit antennas, still spatially selective labelling was possible causing close to separate labelling of the left and right hemisphere (Fig. 4). More accurate selectivity may be expected when increasing the number of transmit elements on the U-Tube.

Conclusion: Using the U-tube as a radiative pillow, full brain arterial spin labelling at 7T is feasible, when combined with a 32 channel NOVA headcoil. Territorial ASL is possible due to the independent RF coils combined with RF shimming.

References: [1] Gharic et al, Magn Res Mater Phy 2012 25:83-93 [2] Wen-Ming Lu et al. MRM 2012 Apr 9, [3] Koning et al, MRM 2012 Jul 3, [4] Golay et al, MRM 2005 53: 15-21

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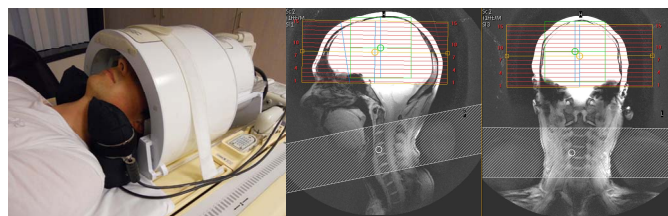


Figure 1. Left) Birdcage head coil in combination with a U-Tube neck coil for labelling. Right) full head and neck overview image with planning of the ASL experiment.

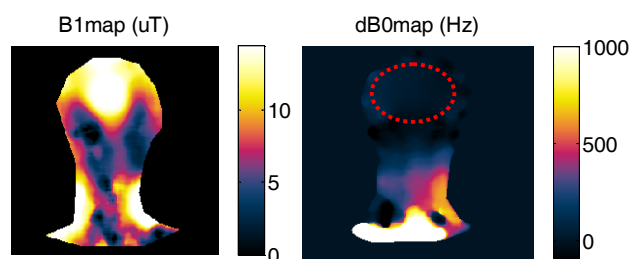


Figure 2. Coronal B_1^+ map and B_0 map of head and neck. Red circle shows B_0 shimmed volume.

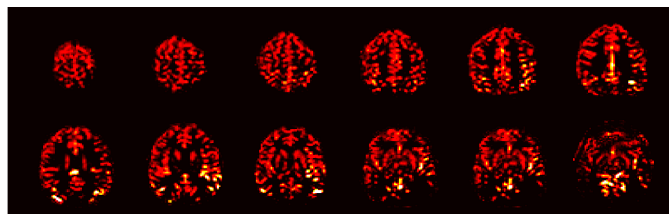


Figure 3. whole brain summed subtraction images. Labelled using planning shown in fig 1.

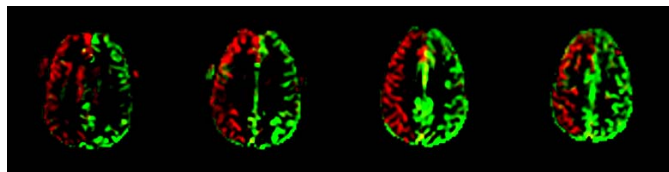


Figure 4. Territorial ASL taking advantage of the freedom of separate coils and RF shimming which is commonly available on the 7Tesla systems.