Improvement in high field pulsed arterial spin labelling using dielectric pads: a simulation and experimental study

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Introduction. The major challenges with the implementation of pulsed ASL sequences at 7 T is the rapid drop-off in B_1 when trying to invert blood in the neck region [1] and the increased B_0 inhomogeneities present in this region. The ability to "manipulate" the distribution of the B_1 field has been shown at 7 T [2], although there have been few subsequent attempts to utilize this ability. Here, we use water bags to increase the strength of the B_1^+ field for pulsed ASL, and show significant improvements in both labelling efficiency, and the quality of the resulting perfusion data.

Methods. Simulations were performed using a discretized model of the human body and a finite-difference time-domain (FDTD) method with commercially-available software (xFDTD, Remcom Inc). The transmit RF coil (NM-008A-7, Nova Medical), is a quadrature birdcage design with 16 multi-segmented elements, o.d. 37.5 cm, i.d. 29.2 cm, length 26 cm: the receiver is a 16-channel receive array (Nova Medical, NMSC-025-16-7P). Water bags were modelled with a dielectric constant of 80 and zero conductivity: the geometry is shown in Figure 1(a). All MRI experiments were performed on a Philips Achieva 7T whole-body system. Data acquisition parameters for pulsed ASL were: 0.5 ms Hanning pulses with pulse interval of 1 ms, label duration 1350 ms, post labeling delay 1250 ms and a single shot EPI with 17 slices, slice gap 1 mm, voxel size 2.3 x 2.3 x 6 mm^3 and TR/TE of 12500/11 ms for imaging.

Results and Discussion. Figures 1(b) and (c) show quantitative plots of the B1+ field for a sagittal slice through the plane of the carotid artery without (b) and with (c) the water bags present. The B1+ within the carotid artery increases from 0.038 µT/Watt to 0.013 µT/Watt, an increase of 250%, with the water bags in place. However, the average B_1^+ averaged over the whole brain decreases by less than 5%, from 0.4 µT/Watt to 0.38 µT/Watt, meaning that the sensitivity of the perfusion region-of-interest remains essentially identical. Figure 2 shows SNR plots for the perfusion images obtained with and without the water bags, illustrating a significant increase in the SNR with the bags present. The SNR is defined as the mean / standard error of the mean of the perfusion measurements within one scan.

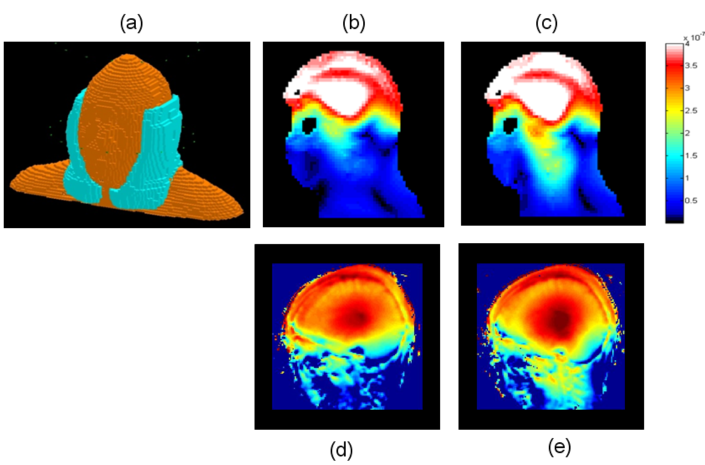

Figure 1. (a) Surface rendering of the electromagnetic set up, dielectric water bags are shaded in blue. (b) Simulated B_1^+ map in the absence of the water bags, and (c) with water bags in place. The scale on the right hand side shows a maximum value of 0.4 µT/Watt. In (d) and (e) corresponding results of measured B_1^+ maps are shown.

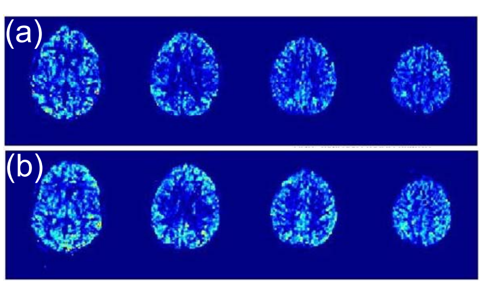

Figure 2. Perfusion SNR maps obtained (a) in the absence of water bags, and (b) with water bags present.

References. [1] Q.X.Yang et al. J.Magn.Reson.Imag. 24, 197, 2006.