Pulsed Arterial Spin Labeling of the Brain with Body Coil Excitation

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Introduction

Arterial spin labeling (ASL) is achieved by subtraction of control from the tagged images. In Flow-Sensitive Alternating Inversion Recovery (FAIR) [1], the most commonly used method, selective and non-selective inversion pulses are alternated. Most brain perfusion is accomplished with transmit-receive head coils which have a relatively small excitation volume thus limiting the tagging bolus [2]. The advent of receive-only head coil arrays makes necessary body coil excitation, with the consequence that a non-selective inversion pulse creates a much larger tagging bolus. After an appropriate post-labeling delay a significant volume of tagged arterial blood remains. As a consequence, the continued inflow of labeled spins causes undesired vascular enhancement and the remaining label may not have fully decayed at the time of the next inversion pulse, thus limiting the minimum TR [3], a problem that may be exacerbated at high field. Here it is shown that substitution of the nonselective by a wide-slab selective pulse remedies both problems.

Methods

In-vivo images in volunteers were acquired on a 1.5T Siemens Sonata whole-body scanner with the body coil and the vendor's receive-only phased-array head coil, using a custom-designed single-shot spin-echo EPI pulse sequence with the following parameters: slice thickness 8mm, matrix 64 × 64, FOV 24 cm^2, number of averages 40, TE 25 ms. The non-selective inversion pulse in FAIR was replaced by a slab-selective pulse, yielding a tagging bolus of reduced width (Fig 1). The gradient for the slab-selective pulse was varied corresponding to a 1.5~20cm tagging bolus. The slab-selective tagging was compared to non-selective tagging for QUIPSS II [4] technique, which also creates a limited bolus size ("time-width") by applying a saturation pulse for quantitative perfusion measurement

Results

Fig. 2 displays the intensity of the perfusion-weighted signal as function of the thickness of the tagging slab in two subjects. It is noted that the global intensity reaches a plateau at ~15cm commensurate with an average flow velocity of ~10cm/s. Data indicate that no blood from outside that critical tagging distance reaches the imaging slab. The image obtained with the wider tagging slab (Fig. 3a versus b) shows significant intravascular signal. In a second set of experiments using non-selective and slab-selective inversion, a QUIPSS II saturation pulse of 10cm width was applied after a 600ms labeling delay (for total post-labeling time of 1.4 sec, Fig. 4). Note the higher signal with nonselective tagging but again greater intravascular signal contamination (Fig. 4a vs. b). The imperfection of the saturation pulse is accountable for the difference between the two images in that saturation with the 90° *sinc* pulse does not fully suppress the tagged blood prior to entering the imaging slices [5]. The data indicate that tagging via non-selective inversion by the body coil may overestimate perfusion due to incomplete QUIPSS II saturation.

Finally, the use of slab-selective inversion should enable shorter TR. As tagging and control are alternated at TR = 1.8s, about 10% of the ASL signal will be lost due to the entry of spins inverted during the control phase. In this preliminary work a 5% SNR enhancement was noted by replacement of non-selective with slab-selective inversion.

Conclusion

In pulsed ASL the use of the body coil for magnetization inversion in situations where receive-only head coils are used, has potentially adverse implications. The use of a slab-selective inversion pulses for labeling is shown to remedy these issues.

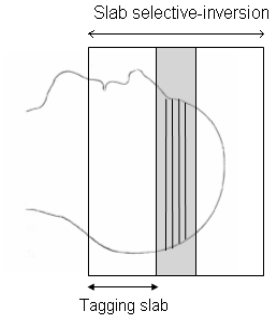


Fig 1. Wide slab-selective inversion for tagging and a narrow slab-selective inversion for control (the shaded region). The "tagging slab" defines the thickness of the tagged bolus.

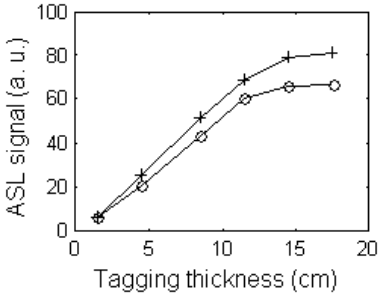
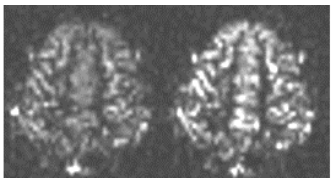
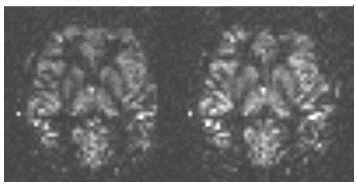


Fig. 2 ASL intensity (summed over entire scan volume) versus bolus thickness, with post-labeling delay of 1.4 (+) and 1.55 sec (o) for 2 different subjects.



a b

Fig. 3 FAIR images with a tagging slab thickness of 8cm (a); 16 cm (b).



a b

Fig. 4 QUIPSS II with 8cm slab-selective tagging (a); tagging with non-selective inversion (b).

References

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