Theoretical and experimental comparison of different techniques for continuous arterial spin labelling

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Introduction: Continuous arterial spin labelling is the most sensitive technique for perfusion measurements. Several schemes for tag and control scans have been developped to overcome the technical and conceptual problems of this technique. Here, four different approaches for tag and control are simulated and compared experimentally.

Sequence	Label	Control
CASL [1]	Continuous label with separate neck coils	None
ss (single slice)-ACASL [2]	Almost continuous (interrupted) label with imaging coil	Same label applied opposite to imaging slice
ms (multi slice)-ACASL [3]	Almost continuous (interrupted) label with imaging coil	Double inversion with rapidly oscillating pulse shape
PCASL [4]	Large number of short shaped pulses and gradients	Same, but made transparent by alternating phases

Subjects and Methods: Four sequence variants are compared that differ only in the way the tag or control pulses are applied (see table). These four techniques were implemented on a Siemens Trio with an EPI-readout. Label and control mechanisms were simulated, varying all relevant parameters to optimize sequence settings of all measurements. In addition, the simulation results were used to estimate the theoretical sensitivities of the sequences.

Results: Five volunteers were examined twice with each of the four techniques, as well as with a standard FAIR protocol as representative of pulsed ASL. For all CASL measurements, the tagging duration was 2 s with a delay of 1s before acquiring 7 slices (ss-ACASL: 1 slice). 64 control/tag pairs were acquired within 8.5 min. Only the center slice was used for further analysis. Figure 1 shows typical perfusion images acquired with all five sequences. SNR was calculated by taking the mean of the perfusion image over a grey matter mask generated from a high-resolution anatomical image, giving a mean SNR over the entire grey matter area of all subjects of 11.2 for the ss-ACASL sequence.

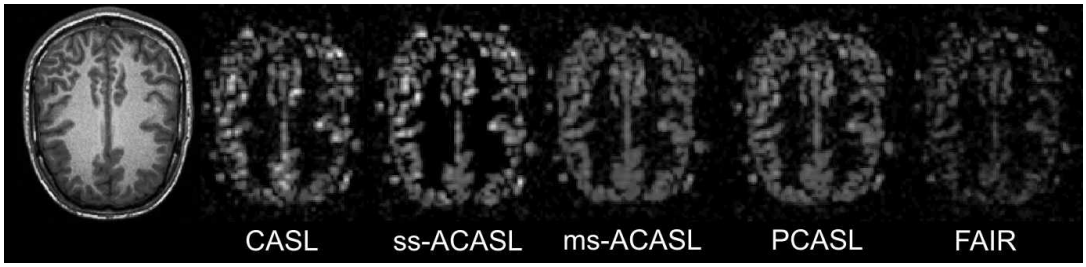

Fig. 1: Perfusion images acquired with all five sequences (equal scaling).

Fig. 2 shows the magnetization differences between tag and control scan as calculated in the simulations compared to the actual sensitivity of the experiments, with the sensitivity of ss-ACASL set to 100% in both cases. Simulated and experimental results are in good agreement.

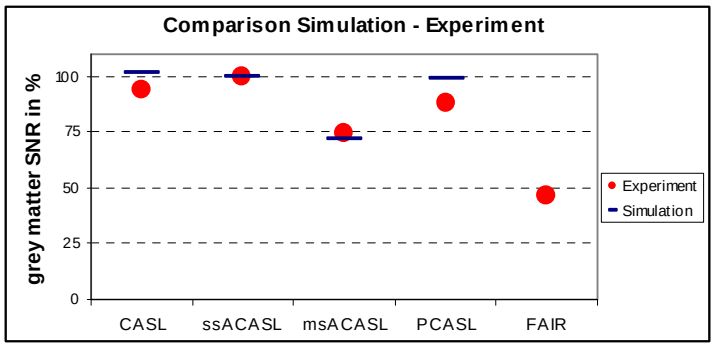

Fig. 2: Comparison of grey matter SNRs of the different sequences between simulation and experiment.

Conclusion: Using sequence parameters that were carefully optimized in Bloch equation simulations, all CASL techniques give excellent results and are clearly superior to the pulsed ASL sequence. The agreement between theoretical results and experiment shows the validity of the simulations.

References:

[1] Zaharchuk, MRM 41
[2] Williams, PNAS 89
[3] Alsop, Radiology 208
[4] Wong, MRM 58