2D RF versus slice selective RF tagging pulses in brain ASL

S. Konstandin[1], P. M. Heiler[1], and L. R. Schad[1]
[1]Computer Assisted Clinical Medicine, University of Heidelberg, Mannheim, Germany

Introduction:

Arterial spin labeling (ASL) [1] is an important technique for the diagnosis of various cerebrovascular diseases. Standard perfusion ASL methods for functional brain imaging use inversion pulses in a transversal slice to determine the cerebral perfusion territories of all major blood vessels. However due to tagging of all feeding arteries, regions supplied by different arteries can not be distinguished. In this work, therefore, we implemented a two-dimensional selective inversion pulse to tag either the left or the right internal carotid artery (ICA). Alternatively, a sagittal slice selective inversion pulse along the ICA was used to tag the inflowing blood. Both techniques are based on an EPI sequence with the same parameters for data acquisition. Resulting ASL images and relative perfusion signals were compared to determine the optimal measurement technique.

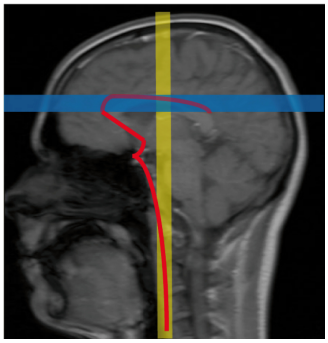

Figure 1: *Illustration of the readout slice (blue) and the 2D rod (yellow). Only one ICA (red) was tagged.*

Methods:

A 2D-rod located as shown in Fig.1 was inverted in order to tag the blood in the ICA. The 2D RF pulse was based on a constant-angle spiral trajectory with 23 turns and a Gaussian RF amplitude. The maximum gradient strength was 20 mT/m to obtain a resolution d_{FWHM} of 10mm encompassing a typical vessel diameter of 4-6mm. The side lobe radius was 25cm, the pulse length 13ms. Fig.2 shows the timing scheme of the EPI-ASL sequence with 2D inversion. Immediately before and after the tagging pulse a triple saturation pulse was applied [3] in the image acquisition slice to avoid signal originating from the tagged volume overlapping with the readout slice. The whole experiment was repeated by replacing the 2D RF pulse with a sagittal slice selective labeling pulse. In both experiments the slice of interest was acquired 1.8s after the tagging pulse with a generic EPI sequence. Initial experiments showed that at an inflow time TI of 1.8s the ASL signal reaches its optimum. Control images were acquired with a RF pulse of zero amplitude. The measurements were performed on a 1.5T whole-body scanner (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) with the following parameters: TR=2.2s, TE=42ms, TI=1.8s.
70 control and 70 tag images were acquired, averaged and subtracted from each other. The total measurement time was 5:08 min.

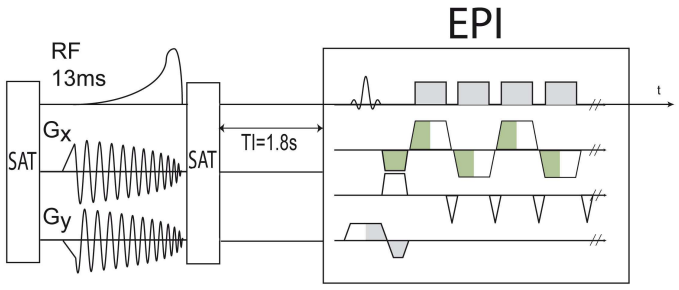

Figure 2: *Timing scheme for ASL sequence with 2D RF tagging pulse. The SAT-block consists of a triple saturation pulse applied in the image slice. The perfusion signal reaches its maximum at an inflow time TI of 1.8s. At the end, the slice of interest is acquired with a usual EPI-readout.*

Results:

In Fig.3 the ASL results are shown. The 2D RF pulse was used to tag the right (a) and left (b) ICA. The perfusion signal was about (0.4-1.1)% of the total signal. The results of the method using the sagittal labeling slice are shown in fig.3c (right artery) and 3d (left artery). In this case the perfusion signal was about (0.8-1.4)% of the total signal.

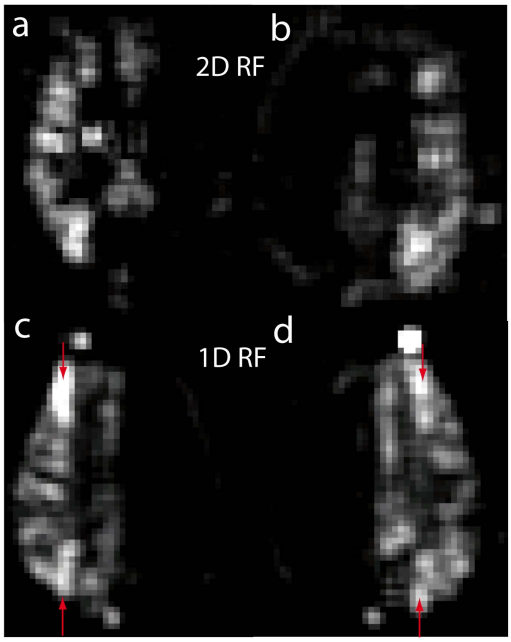

Figure 3: *a) and b) show the results of tagging the right and left artery with a 2D pulse. In c) and d) a sagittal labeling slice was used.*

Discussion:

It could be verified that by tagging one single ICA, only the supplied hemisphere of the brain accounts to the signal. The technique using the sagittal labeling slice delivers higher perfusion values due to tagging more blood when applying this method. However, the signal in the image acquisition slice could not be completely saturated while the tagging pulse is applied leading to an increased signal in the overlapping area with the labeling slice (red arrows). An advantage of using a 2D RF pulse is that only a tiny rod will be tagged and therefore, this method is more selective.

References:

[1] Detre JA, Leigh JS, Williams DS, Koretsky AP. Perfusion Imaging. Magn Reson Imaging 1992:23:37-45
[2] Pauly J, Nishimura D, Macovski A. A k-space analysis of small tip angle excitation. J Magn Reson 1989:81:43-56.
[3] Davies NP, Jezzard P. Selective Arterial Spin Labeling (SASL): Perfusion Territory Mapping of Selected Feeding Arteries Tagged Using Two-Dimensional Radiofrequency Pulses. Magn Reson Imaging 2003:49:1133-1142.