A Method for Automatic Selection of the Labeling Slabs in Regional Arterial Spin Labeling

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INTRODUCTION: Arterial Spin Labeling (ASL) is an established technique for non-invasive measurement of cerebral perfusion. In conventional ASL, blood spins of all large feeding arteries are inverted in a slab perpendicular to them to acquire an image of the entire brain perfusion. To visualize the vascular territories of single arteries rather than the whole vascular tree the method of regional ASL (regASL) is an appropriate choice [1]. By positioning oblique slabs, labeling of selective regions can be accomplished and thus tagging of only specific vessels is feasible. However, performing a separate experiment for every feeding artery is time-consuming since labeling of the left and right internal carotid arteries (lICA and rICA) as well as the posterior circulation (post) must be considered. Cycled regASL [2] offers a possibility to decrease measurement time and increase SNR by tagging two arteries simultaneously for all combinations of lICA, rICA and the posterior circulation. The territory supplied by each single artery can be reconstructed with simple algebraic operations.
Careful positioning of the inversion slabs is of great importance. Due to the proximity of the vessels and their intricate shape finding and territorial perfusion. Semi-automatic methods have been proposed [3], but most implementations are still performed manually. Here, we present a completely automatic method for positioning the inversion slabs.

METHODS: Time-of-flight (TOF) images are acquired in the neck and lower brain regions. Subsequently, post-processing performs in four steps: 1) segmentation of all feeding arteries, 2) recognition of single arteries, 3) separation of two arteries from the remaining one by a plane, 4) calculation the width of the slab.
Segmentation is performed using a region growing algorithm. The required parameters, namely seeds, lower and upper threshold, are estimated from the intensity histogram. A connected component filter is applied which assigns a different grey scale value to each of the segmented arteries. To locate the delineating planes in the third step, the classificator support vector machines (SVM) is used. The two input classes in feature space are made up of the coordinate vectors of the vessels to be separated. The SVM algorithm computes a plane for which the distance between input vectors and the plane becomes maximal for both classes. Finally, we determine the width of the inversion slabs by calculating the distance from the arterial voxels to the plane and finding its maximum. The plane is fully characterized by its normal vector, the distance from the origin and its width, hence only these parameters are passed to the imaging sequence. In the current implementation regional perfusion imaging was performed with single-shot 3D-GRASE readout [2].
The described procedure was tested on the TOF images of four healthy volunteers (age: 20-37).
For a slab the labeling efficiency is quantified by measuring the number of voxels of the arteries that are supposed to be inside the slab, the number of arterial voxels that, in fact, are positioned in the slab as well as the amount of voxels of the excluded artery in the slab.
The TOF images were acquired on a 3T scanner (Magnetom Trio; Siemens, Erlangen, Germany) with the following parameters:
TR = 25ms, TE = 7ms, flip = 25°, 3 slabs, 65slices,slice thickness=2mm,
resolution = 0.39 mm x 0.39 mm x 2 mm.

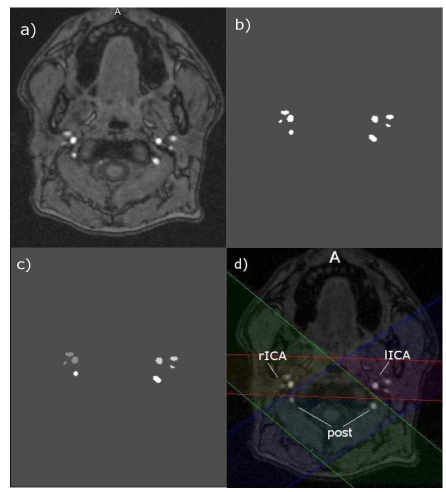

Fig.1: a) TOF image, b)- c) post- processing steps b) vessel segmentation, c) recognition of single arteries, d) resulting slabs

RESULTS and DISCUSSION: Figure 1 shows the post-processing steps of a middle slice in one volunteer. The resulting inversion slabs are highlighted in colours in figure 1.d). In table 1 the labeling efficiencies averaged over the results of the four tested subjects are listed. The entries of the table represent the percentage of the voxels belonging to the arteries named in the column that are located in the slab found for the combination of arteries listed in the respective row. In all volunteers within the upper slices the lICA and rICA were not separable from the posterior circulation by a linear plane due to anatomical reasons. To avoid errors in the labeling the saturation slab of the imaging region was extended to these slices. Apart from this error an accurate delineation was achieved when the parameter for error tolerance in the SVM algorithm was set appropriately. Overall processing time was between 100 and 120 seconds on a standard PC, including DICOM-sorting and transformation between the image and scanner coordinate system.
The main advantage of automatic planning compared to manual placing of the slabs is its operator-independence. Only using the same underlying process to find the tagging slabs, comparison of different measurements is possible in a consistent way.

	lICA&post	rICA&post	lICA&rICA
lICA	100.0	0.0	97.3±1.5
rICA	0.0	100.0	97.1±1.9
post	100.0	100.0	0.0

Table 1: label efficiency, percentage of voxels

REFERENCES: [1] Hendrikse, J., et al., Flow territory mapping of the cerebral arteries with regional perfusion MRI. Stroke, 2004. 35(4): p. 882-7.
[2] Gunther, M., Efficient visualization of vascular territories in the human brain by cycled arterial spin labeling MRI. Magn Reson Med, 2006. 56(3): p. 671-5
[3] I.Zimine, E.T.Peterson, F.Sardou, X. Golay, Automatic planning for regional perfusion imaging. ISMRM, 2006