Dual vessel arterial spin labeling scheme for regional perfusion imaging

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INTRODUCTION: Regional Perfusion Imaging (RPI) has been recently proposed as a method allowing imaging of individual perfusion territories of the major feeding cerebral arteries [1]. This technique could become a valuable clinical tool for evaluation of patients with cerebro-vascular disorders, in particular patients at risk for stroke. The original RPI method is based on pulsed Arterial Spin Labeling (ASL) acquisition with inversion slabs positioned to selectively label water in the arteries of interest, as shown on figure 1a. Three separate scans are needed to image flow territories from the Left Internal Carotid Artery (LICA), Right ICA (RICA) and posterior circulation (POST). Here, we propose a new labeling scheme, shown in figure 1b, where lateral and posterior circulations are labeled simultaneously. Using two ASL acquisitions, labeling LICA+POST and RICA+POST, it is possible to recalculate individual flow territories. The advantages of this approach are reduced scan time for total RPI protocol, and potentially better labeling efficiency.

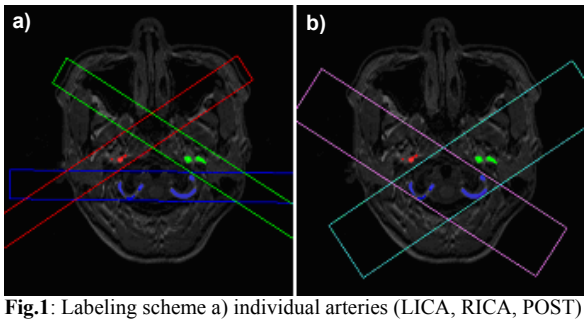

Fig.1: Labeling scheme a) individual arteries (LICA, RICA, POST) b) dual labeling (LICAPOST, RICAPOST)

METHODS: ASL data obtained with dual labeling provides two perfusion images: one with combined left and posterior (LP) flow territories and another with right and posterior (RP) territories. Individual flow territories can be calculated from these two images in a following manner:

$$POST = (LP + RP - |LP-RP|)/2, \quad LICA = LP - POST, \quad RICA = RP - POST \qquad (1)$$

In order to validate this approach, we performed an RPI study using the original (Fig. 1a) and the new (Fig. 1b) labeling schemes in 7 healthy volunteers after signature of informed consent. RPI data was acquired on a 3T clinical scanner (Philips Medical, Best, Netherlands) using the QUASAR sequence [2] with the following parameters: FOV=240 mm, matrix=64x64, 7 slices (8mm, 1.5mm gap), TR/TE=3000/19.5 ms, flip=34°, $TI_1/\Delta TI$=50/250 ms (12 time points), vascular crushing V_{enc}=6 cm/s, SENSE=2.5, 70 averages, total scan time=3.5 min. Five scans were done in each subject: 3 with the original, and 2 with the new dual labeling schemes using TOF and MIP images for accurate positioning of the inversion slabs. Perfusion maps were obtained using 3 parameter fit to the general kinetic model [3]. Mean gray matter regional CBF values were obtained from individually measured flow territories and from recalculated territories using (1). Gray matter masks were obtained from $R1_{eff}$ maps calculated for each data set separately.

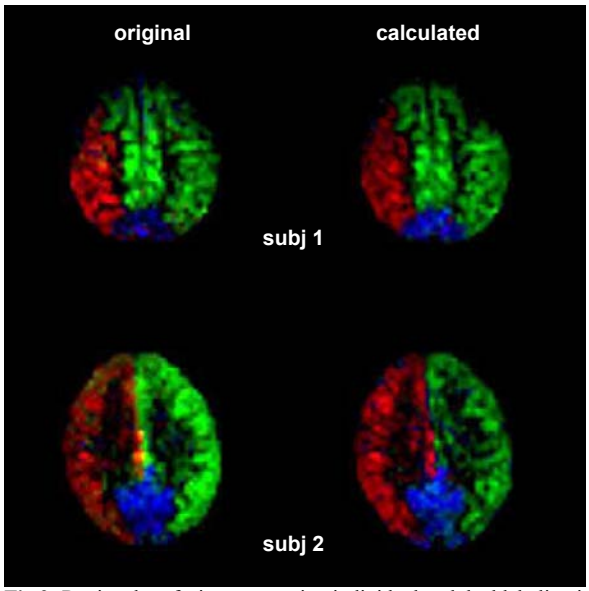

Fig.2: Regional perfusion maps using individual and dual labeling in two subjects with different variant of the circle of Willis. Values are scaled between 0 and 130 ml/min/100g

RESULTS and DISCUSSION: Figure 2 shows RPI maps obtained from the original and the new labeling approaches in two subjects. These images are obtained by combining three regional maps into a single RGB image (RICA-red channel, LICA-green channel, POST-blue channel). All three recomputed territories are very similar to the original ones and reveal flow distribution pattern dependent on the individual variant of the circle of Willis (missing right A1 segment in subject 1 and complete circle in subject 2) [4]. Mean regional CBF values averaged across all subjects are shown in figure 3. While flow values in the calculated territories (from 2 slabs) seem lower for LICA and RICA and higher in POST, the actual differences in regional CBF obtained by the original and new methods are not significant (paired t-test, p>0.2).

One of the most important factors affecting the overall quality of RPI is labeling efficiency of individual arteries. Because of tortuous anatomy of ICAs and posterior arteries (PA), it is often challenging to label one artery completely without touching the others. It is particularly difficult to separate PAs from ICAs. With the new labeling scheme, this issue becomes less important since posterior circulation is always labeled. Another advantage is that inclusion of external carotids is achieved automatically in most cases, due to the particular orientation of the inversion slabs, while it is difficult to obtain it using the original labeling scheme. This could be particularly useful for applications in patients with atherosclerosis in order to evaluate the importance of collateral perfusion via the external circulation.

In conclusion, a new labeling scheme for RPI and a simple method to obtain individual flow territories is proposed. Identical regional perfusion information can be obtained with two ASL acquisitions instead of three in the original RPI technique.

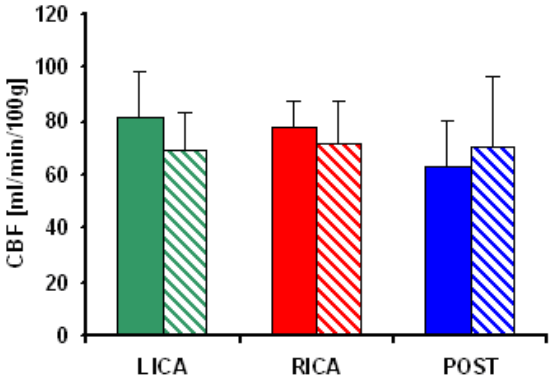

Fig.3: Regional gray matter CBF obtained using individual labeling (plain) and calculated territories from dual labeling scheme (stripes)

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