Visualization of Collateral Supply by Two-coil Continuous Arterial Spin Labeling

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Indroduction

Besides the degree of stenosis, knowledge of the amount of compromise of cerebral blood flow (CBF), the affected perfusion territories, and whether collateral flow is available are important parameters for assessing stroke risk in patients with carotid artery occlusive disease. Continuous arterial spin labeling (CASL) is a noninvasive method for perfusion imaging exploiting magnetically labeled water as an endogeneous tracer. Among the approaches that have been suggested for mapping the perfusion territories of major brain-supplying arteries are CASL with separate coils for labeling (of the right- or left-sided carotid) and imaging [1-4], the use of spatially selective two-dimensional (2D) radiofrequency (RF) pulses [5], or single-coil experiments with an oblique labeling plane or precessionary motion of the labeling gradient to achieve selective labeling [6, 7]. Purpose of this pilot study was to investigate the potential of non-invasive perfusion territory imaging by CASL for an assessment of the hemodynamic status of the brain in two patients with known carotid artery disease.

Patients and Methods

Patient 1 (male, 68 years) had an asymptomatic stenosis of the left internal carotid artery (ICA). In patient 2 (male, 28 years) an aneurysm of the left ICA had developed after an accident during childhood and caused a minor stroke. It was treated by embolization coil occlusion after carotid balloon occlusion test revealed that the patient would tolerate permanent ICA occlusion due to sufficient collateral supply to the left hemisphere. Perfusion imaging was performed twice in this patient, prior to and three months after the intervention.

All MRI experiments were performed on a 3-T whole-body scanner (Bruker Medical, Ettlingen, Germany). For CASL, a circular coil of 6-cm diameter was placed over the right common carotid artery (CCA) of the patient. A continuous RF pulse with a power of approximately 1.2 W was applied under pulse-program control during labeling periods of 3.5 s along with a gradient of amplitude 2.5 mT/m. A total of 100 interleaved repetitions were acquired with an effective *TR* of 7 s with and without application of the CASL pulse during odd and even repetitions, respectively. To account for the transit time from the labeling plane to the region of interest, a post-labeling delay of 1.5 s was introduced before multi-slice image acquisition. Axial images were recorded sequentially from superior to inferior with a custom-built helmet resonator and a spin-echo EPI sequence (*TE* 50 ms; bandwidth 100 kHz; echo position at 50%; matrix 64 x 64; 10 slices). Additional 2D T_1-weighted images (MDEFT) were recorded at the identical slice positions as anatomical reference. After data acquisition, the label coil was repositioned, and the whole procedure was repeated with CASL applied to the left CCA.

Results & Discussion

No significant differences in the perfusion of the left and right hemisphere were observed in patient 1 consistent with the clinical status of an asymptomatic stenosis of the ICA.

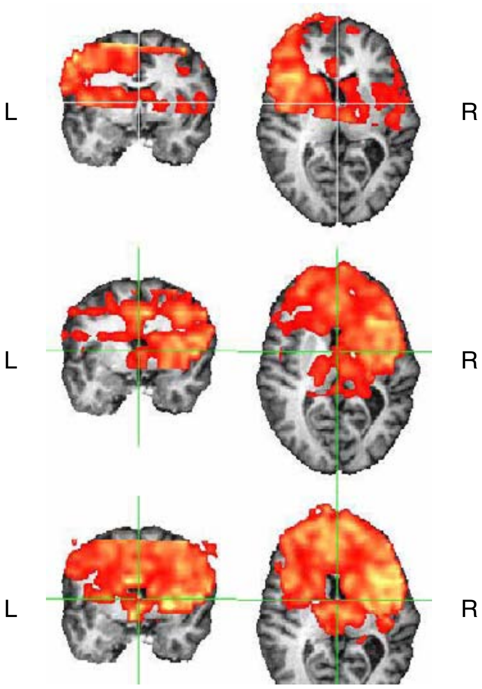

Figure 1. Perfusion territories of the left (top) and right ICA (middle) at the first examination and of the right ICA three months after occlusion of the left ICA (bottom) indicating collateral supply.

Perfusion-weighted images (arbitrary units) recorded in patient 2 before and after embolization coil occlusion of the left ICA are shown in Fig. 1. The perfusion data were registered to a T_1-weighted 3D data set (MDEFT) to allow for a direct comparison of individual slices acquired in separate sessions. As expected, the area of significant signal change obtained when labeling the blood in the left CCA was limited to the left side (top row) whereas the right CCA supplied blood predominantly to the right hemisphere with an indication of some overflow to the left side in the frontal region (middle row). Following left ICA occlusion, perfusion contrast was created almost symmetrically in both hemispheres when labeling the blood of the right CCA (bottom row). This verifies the existence of sufficient collateral supply in agreement with the information from the carotid balloon occlusion test.

Our preliminary results indicate a potential of CASL-based perfusion imaging to assess the significance of carotid artery stenosis and potentially compensating collateral flow. Due to the possibility to perform repeat scanning, it might be used for screening purposes of for monitoring perfusion changes during therapeutic interventions, which is not achieved by more invasive methods, such as PET or dynamic susceptibility contrast MRI.

References

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