

Changes in flow territories in patients with symptomatic carotid artery stenosis before and after carotid desobstruction: a selective arterial spin labeling MRI study

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Introduction

Although the importance of hemodynamic factors in the pathogenesis of cerebral ischemia in patients with severe internal carotid artery (ICA) stenosis remains unclear, it is accepted that collateral flow is important to compensate for the decreased arterial perfusion pressure distal to the stenosis, to maintain adequate cerebral perfusion.¹ However, the actual contribution of the collateral arteries to regional perfusion remains unknown. Recently, non-invasive selective arterial spin labeling (ASL) MRI has been introduced, offering the possibility to study the collateral contribution of individual brain feeding arteries by selective labeling.² The aim of the present study is to outline the flow territory contributions of the brain feeding arteries obtained with selective ASL MRI in symptomatic patients with severe ICA stenosis. Furthermore, reversibility of changes is investigated by the evaluation of follow-up ASL MRI after carotid endarterectomy (CEA) or stent placement.

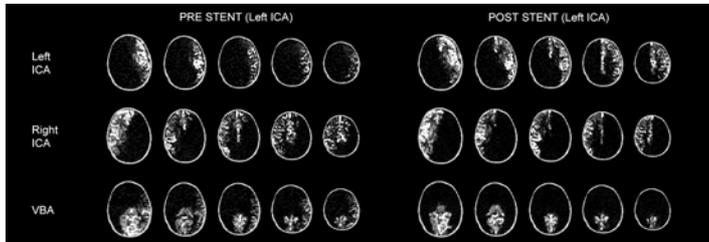


Figure 1. Representative flow territory images of a patient with symptomatic severe left-sided ICA stenosis before and after stent placement.

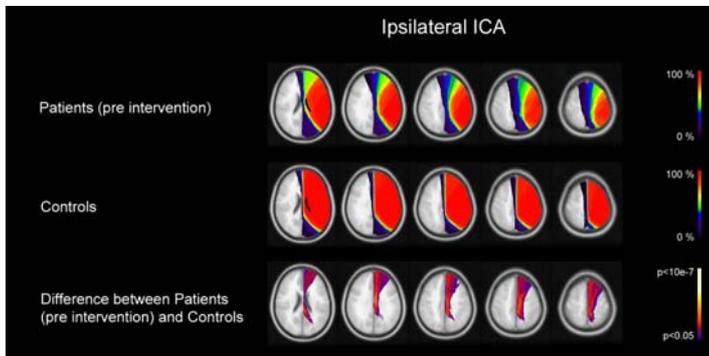


Figure 2a. Flow territory maps of the ipsilateral (stenosed) ICA.

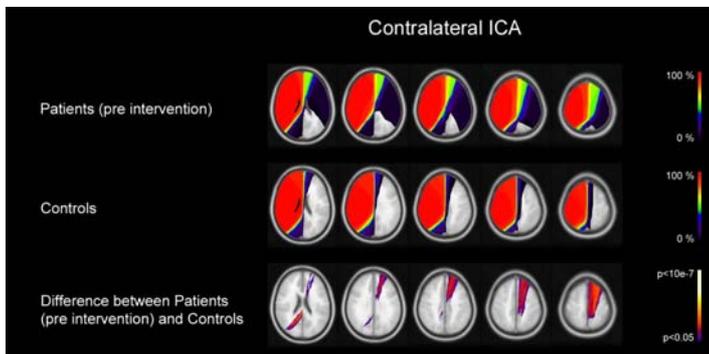


Figure 2b. Flow territory maps of the contralateral ICA.

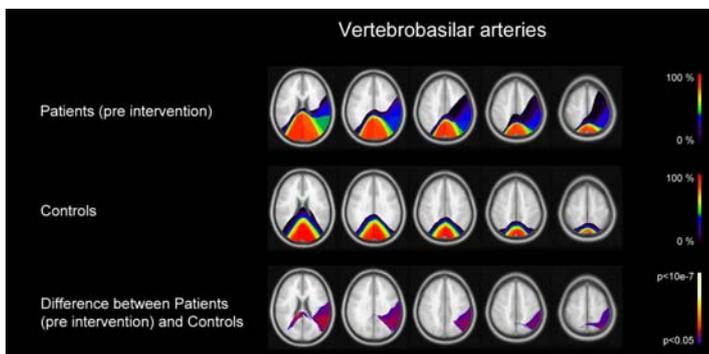


Figure 2c. Flow territory maps of the vertebrobasilar arteries (basilar artery and left and right vertebral arteries).

Materials and Methods

24 symptomatic patients (15 men, 9 women; mean age 67 years) with $>70\%$ ICA stenosis and 40 age/sex matched control subjects (25 men, 15 women; mean age 67 years), without abnormalities on MRI of the brain and without ICA obstruction were included in the study. In twelve patients CEA was performed and stent placement was carried out in the remaining twelve patients. MRI was performed one day before and one month after carotid desobstruction on a 1.5-T whole body system. Flow territory mapping of the ipsilateral ICA, contralateral ICA and the posterior circulation (vertebrobasilar arteries) was performed with selective ASL MRI.² The inversion is achieved by applying two consecutive slice-selective 90° RF pulses. Subsequently, three saturation pulses are applied on the imaging slices to remove the effects of labeling pulses. A delay of 1600 ms was used to allow the blood to flow to the tissue. Other parameters of the selective ASL MRI scans were: TR = 3000 ms; TE = 5.6 ms; 62% partial Fourier acquisition; number of slices = 5; slice thickness = 8 mm; time between slices = 25 ms; FOV = 240 x 240 mm; matrix = 64 x 64; zero filling to 128 x 128 matrix; averages = 30. Voxel based Chi-square testing with Bonferroni correction was performed to analyze significant difference in extent of the flow territories.

Results

Representative flow territory images of a patient with severe left-sided ICA stenosis before and after stent placement are shown in Figure 1. Figures 2a-c show the frequency of the presence of flow when individual arteries are selectively labelled, i.e. the ICA ipsilateral to the stenosis, the contralateral ICA and posterior circulation, in patients ($n=24$) and control subjects ($n=40$). Data are projected on a standardized brain. The flow territory of the ipsilateral ICA in patients with ICA stenosis was significantly ($p < 0.05$) smaller than in control subjects (Figure 2a). The flow territories of the contralateral ICA (Figure 2b) and posterior circulation (Figure 2c) were significantly ($p < 0.05$) larger compared with control subjects. Colors of the top and middle rows in Figures 2a-c indicate the percentage of subjects with overlap of the flow territories. The bottom rows show the significant differences in flow territories between patients and controls (color bar with logarithmic scale indicating significant p-values). After carotid desobstruction no significant differences in flow territories between patients and controls were found.

Conclusion

In patients with symptomatic severe ICA stenosis, carotid desobstruction results in a normalization of the territorial distribution. Providing flow territory information of the brain feeding arteries, selective ASL MRI seems well suited for non-invasive evaluation of cerebral hemodynamics, especially when collateral flow patterns are of interest.

References

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