Visualization of distinct collateral flow territories in patients with symptomatic carotid artery occlusion

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Introduction

The importance of collateral circulation to maintain adequate cerebral perfusion in patients with carotid artery occlusion is widely acknowledged.[1] Still, the importance and actual contribution of the individual collateral pathways remains difficult to assess and has lead to many speculations concerning its relevance to clinical outcome. Recently, selective arterial spin labeling (ASL) MRI is introduced as a non-invasive method to quantify the contribution of individual arteries to the perfusion of the brain. The aim of the present study was to investigate in patients with symptomatic internal carotid artery (ICA) occlusion the extent of the collateral flow territories originating from the contralateral ICA and posterior circulation.

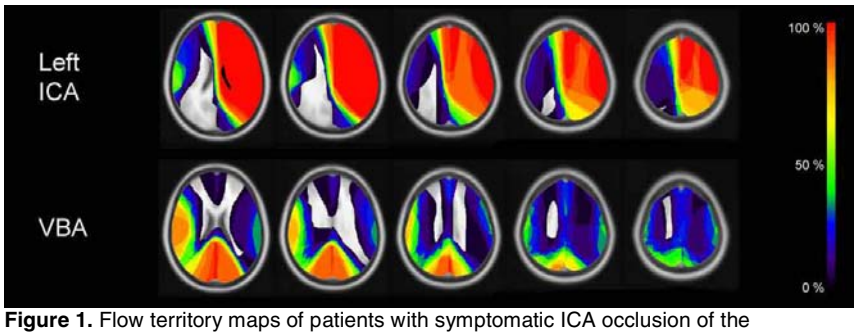

Figure 1. Flow territory maps of patients with symptomatic ICA occlusion of the contralateral ICA and posterior circulation (VBA: vertebrobasilar arteries) projected on a standardized brain. The side with the symptomatic occlusion was standardized to the right ICA. Colors indicating the percentage of patients with overlap of the flow territories.

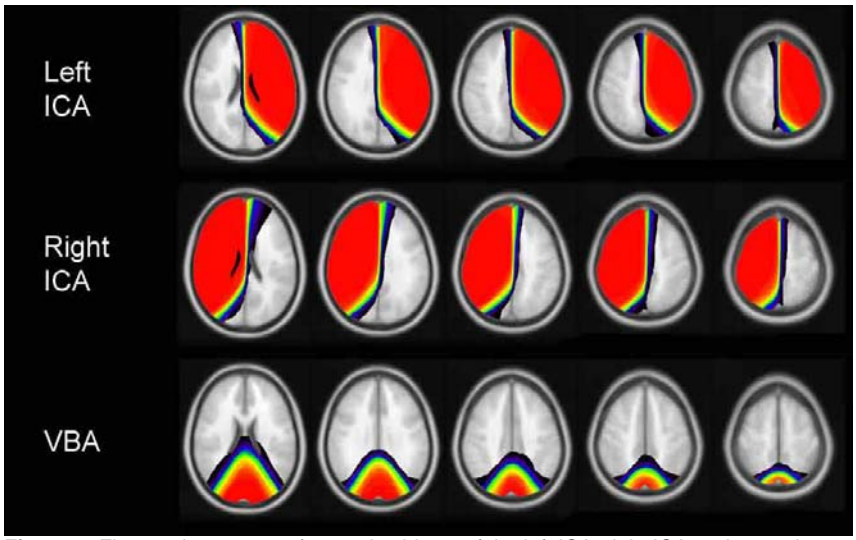

Figure 2. Flow territory maps of control subjects of the left ICA, right ICA and posterior circulation (VBA) projected on a standardized brain. Colors correspond to the color bar in figure 1.

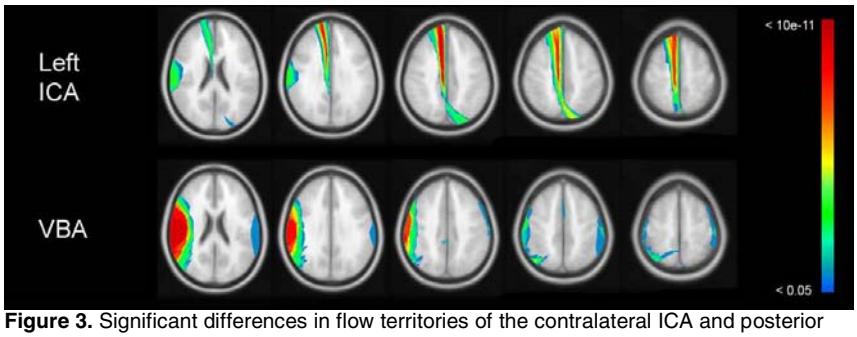

Figure 3. Significant differences in flow territories of the contralateral ICA and posterior circulation between patients with symptomatic ICA occlusion and control subjects. Color bar with logarithmic scale indicating significant p-values (after Chi-square testing with Bonferroni correction).

Materials and Methods

23 symptomatic patients (22 men, 1 woman; mean age 58 years) with ICA occlusion and 68 age-matched control subjects (57 men, 11 women; mean age 59 years) without abnormalities on MRI images of the brain and without hemodynamic significant (>70%) ICA obstruction were included in the study. MRI was performed on a 1.5-T whole body system. Flow territory mapping of the ICA contralateral to the occluded 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 x128 matrix; averages = 30. Voxel based Chi-square testing with Bonferroni correction was performed to analyze significant difference in extent of the flow territories.

Results

Flow territory maps in patients with symptomatic ICA occlusion (Figure 1) showed a relatively large variation in flow territories of the contralateral ICA and posterior circulation compared with control subjects (Figure 2). Figure 3 shows the differences in flow territories between patients with symptomatic ICA occlusion and control subjects, demonstrating that in patients the posterior circulation supplies a significantly ($p<0.05$) larger part of the middle cerebral artery (MCA) flow territory ipsilateral to the occluded ICA than in control subjects. The flow territory of the contralateral ICA is significantly ($p<0.05$) extended to the anterior cerebral artery (ACA) flow territory on the side of the occlusion, rather than the corresponding ipsilateral MCA flow territory.

Conclusion

Although previous studies have shown that in patients with ICA occlusion various collateral pathways (Circle of Willis, leptomeningeal anastomoses or reversed flow in the ophthalmic artery) may be recruited, our data show that in essence the MCA flow territory ipsilateral to the occluded ICA is dependent on the posterior circulation, whereas the contralateral ICA usually supplies the ACA flow territory on the occluded side.

References

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2. Hendrikse J, van der Grond J, Lu H, van Zijl PC, Golay X. Flow territory mapping of the cerebral arteries with regional perfusion MRI. *Stroke* 2004;35:882-887.