Arterial spin labeling MRI measurements of timing parameters in relation to collateral flow patterns in patients with carotid artery occlusion

R. P. Bokkers[1], P. J. van Laar[1], K. C. van de Ven[1], L. J. Kappelle[2], C. J. Klijn[2], and J. Hendrikse[1]

[1]Radiology, University Medical Center Utrecht, Utrecht, Netherlands, [2]Neurology, University Medical Center Utrecht, Utrecht, Netherlands

Introduction

Occlusion of the internal carotid artery (ICA) may lead to a reduced cerebral perfusion pressure (CPP). As the CPP decreases, pressure is initially maintained by a compensatory vasodilation of arterioles and subsequently by an increase in the oxygen extraction fraction. However, regionally the cerebral hemodynamic status is not only dependent of the degree of carotid obstruction, but other factors, such as the contribution of collateral pathways are also of importance. We hypothesize that the length and tortuosity of the leptomeningeal collaterals will result in an increased travel distance of the blood. As a result of the elongation of blood flow routes via collateral channels the arrival times of the blood delivered by collaterals may vary regionally. Knowledge of the arrival times of arterial blood may provide additional information of collateral flow and may be used to identify hemodynamically impaired areas. The aim of the present study was, first, to investigate hemodynamic parameters in different areas of the brain in patients with a symptomatic unilateral occlusion of the ICA, and second, to evaluate the effect of collateral flow upon regional hemodynamics

Methods and materials

Seventeen patients (15 male, 2 female, mean age 57) with a symptomatic unilateral ICA occlusion and twenty-nine sex and age-matched control subjects were investigated. A pulsed transfer insensitive labeling technique (TURBO-TILT) was used to regionally quantify CBF, transit time and trailing edge on a 1.5 T system (Gyroscan ACS-NT, Philips Medical Systems, Best, The Netherlands) (figure 1) (Hendrikse, MRM 2003). Intra-arterial digital subtraction angiography and MR angiography were used to grade collateral flow. Differences in regional hemodynamic parameters were analyzed with Students's t-test and one-way ANOVA, with Bonferroni correction.

Results

Figure 2 and 3 show the cerebral blood flow and trailing edge results over all regions in the hemisphere ipsilateral and contralateral to the ICA occlusion, and the control subjects. In patients with leptomeningeal collaterals (n=8) the trailing edge was prolonged in the frontal lobe (2436±779 and 1648±604 ms; p=0.03) and decreased in the occipital lobe (1815±363 and 2388±609 ms; p=0.04) compared with patients without leptomeningeal collateral flow. Neither flow via the anterior or posterior pathway did result in regionally different hemodynamic parameters.

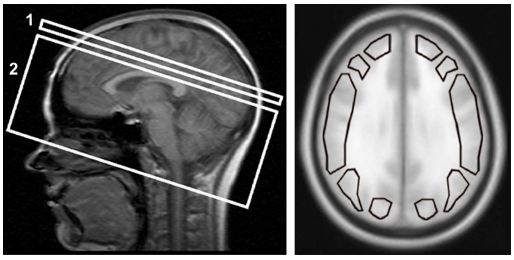

Figure 1: *Orientation of the imaging slice (1) and the labeling slab (2), parallel to the orbitomeatal angle (left). ROIs used for quantification of the hemodynamic parameters (right). In each hemisphere, five regions of interests were drawn in the frontal, fronto-parietal, parietal, occipito-parietal region and occipital region.*

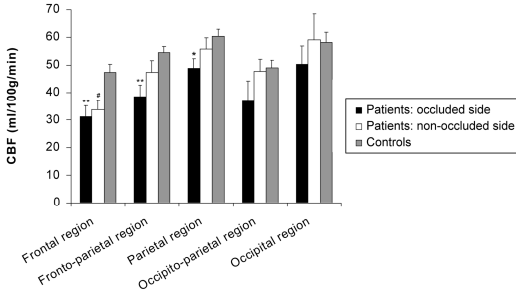

Figure 2: *Estimated CBF (mean ± SD)over all regions with standard deviation. *p < 0.05, **p < 0.01, indicate a significant difference between the hemisphere ipsilateral to the ICA occlusion and the control subjects. # indicates a significant (p < 0.01) difference between the hemisphere contralateral to the ICA occlusion and the control subjects.*

Conclusion

A significant heterogeneity of regional cerebral hemodynamics was found, with decreased CBF and increased timing parameters in the hemisphere ipsilateral to the ICA occlusion. Additionally, in patients with leptomeningeal collateral flow ipsilateral to the occlusion a decreased CBF in the fronto-parietal region and a prolonged trailing edge in the frontal region was found. In conclusion, regional assessment of timing parameters with ASL at multiple delay times may be used to quantify the delay of arterial blood flow associated with collateral perfusion, and may indicate the extent of such collateral perfusion.

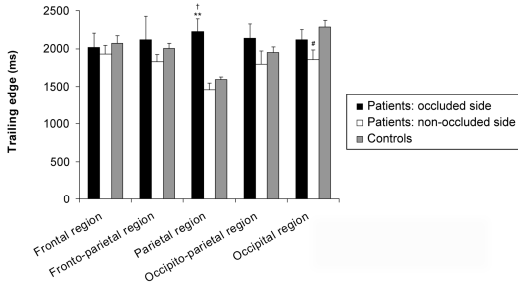

Figure 3: *Trailing edge time (mean ± SD) over all regions. ** indicate a significant (p < 0.01) difference between the hemisphere ipsilateral to the ICA occlusion and the control subjects. # indicates a significant (p < 0.01) asymmetry between the hemisphere contralateral to the ICA occlusion and the control subjects. † indicates a significant (p < 0.05) difference between the hemisphere*