Selective arterial spin labeling MRI assessment of the contribution of the external carotid artery to brain perfusion in patients with symptomatic internal carotid artery occlusion

J. Hendrikse[1], J. Van der Grond[2], and P. Van Laar[3]
[1]Radiology, UMC Utrecht, Utrecht, Utrecht, Netherlands, [2]UMC Leiden, Netherlands, [3]UMC Utrecht, Netherlands

Introduction

Thus far, the contribution of the external carotid artery (ECA) to cerebral perfusion in patients with symptomatic internal carotid artery (ICA) occlusion was difficult to assess. Intraarterial digital subtraction angiography (DSA), magnetic resonance angiography and transcranial Doppler (TCD) have shown the presence of ECA collateral flow, but not the extent of the contribution to cerebral perfusion. Recently, selective arterial spin labeling (ASL) MRI was introduced as a method to quantify the contribution of individual arteries to the perfusion of the brain (for review see; Paiva et al, NMR Biomed 2007, Van Laar et al, Radiology 2008). The aim of the present study was to investigate the qualitative and quantitative contribution of the ipsilateral ECA to cerebral perfusion in patients with symptomatic ICA occlusion. Grading of the qualitative contribution of the ECA was performed with intraarterial DSA and the quantitative contribution was assessed with selective ASL MRI.

Methods

MR imaging was performed by using a 1.5-T or 3.0-T whole-body system (Philips Medical Systems, Best, The Netherlands). Perfusion territory imaging of the ipsilateral ECA and the other brain feeding arteries (contralateral ICA and vertebrobasilar arteries (VBA)) was achieved by using a regional perfusion imaging sequence (Figure 1, see Hendrikse et al, Stroke 2004). To assess the presence of ECA collateral pathways, biplane (anterior-posterior and lateral) intraarterial DSA intracranial views were examined. The appearance of the ECA collaterals was then graded on a 3-point scale: 1, slight collateral distribution, often with dilution; 2, small but definite collateral supply (e.g., retrograde flow in ophthalmic artery with filling of carotid siphon); 3, full collateral filling (e.g., to MCA and/or ACA and/or PCA). Thirty consecutive patients (24 men and 6 women, mean age, 63 years ± 10 (SD, standard deviation) who met our study criteria were included between June 2004 and December 2006. All patients had an angiographically proven unilateral ICA occlusion that was associated with transient or minor disabling ischemic attacks.

Results

Six (20%) of 30 patients with unilateral ICA occlusion had ECA grade 1 collateral flow on intraarterial DSA, 6 (20%) patients had ECA grade 2 collateral flow, and 18 (60%) patients had ECA grade 3 collateral flow. Subcategories of patients with ECA grade 1, grade 2 and grade 3 showed considerably lower variation in perfusion territories of the ECA ipsilateral to the side of the ICA occlusion compared with the group as a whole (see figures 2 and 3). The perfusion territory maps in patients with ECA grade 1 demonstrated that the ECA in these patients did not contribute to the cerebral blood flow. In patients with grade 2 the ECA supplied a focal region of the ipsilateral MCA territory, and in patients with grade 3 the ECA supplied the MCA and, to a lesser extent, the ACA perfusion territory ipsilateral to the side of the occlusion (Figure 3).
The mean rCBF of the perfusion territory supplied by the ECA on the side of the ICA occlusion, showed no significant difference (P value = .70) in rCBF between patients with ECA grade 2 collateral flow (mean ± SD 57 ± 16 ml/min/100gr) and patients with ECA grade 3 collateral flow (60 ± 12 ml/min/100gr).

Conclusion

In patients with symptomatic ICA occlusion focal brain regions strongly depend on the contribution to cerebral perfusion of the ECA ipsilateral to the side of the ICA occlusion, even in patients with a limited ECA collateral supply on intraarterial DSA.

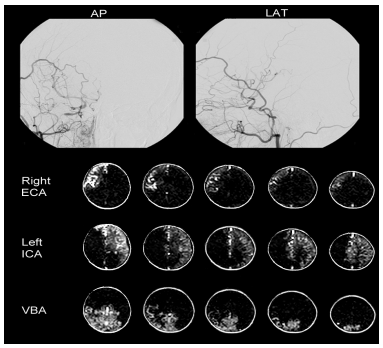

Figure 1. Top: Angiogram of the common carotid artery on the side of the internal carotid artery (ICA) occlusion *Bottom*: Transverse arterial spin labeling MRI perfusion territory images

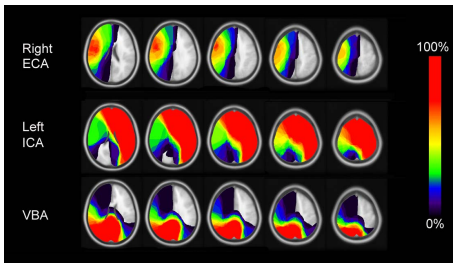

Figure 2. Transverse segmented perfusion territory maps of the external carotid artery (ECA) ipsilateral to the ICA occlusion, the non-occluded contralateral unilateral internal carotid artery (ICA) and vertebrobasilar arteries (VBA) in all patients with ICA occlusion. Colors correspond to the color bar, which indicates the percentage of patients who demonstrated perfusion in that region of the brain.

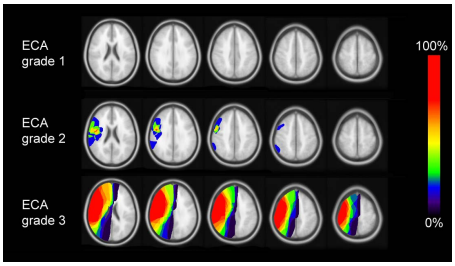

Figure 3 Transverse segmented perfusion territory maps of the external carotid artery (ECA) in patients with unilateral internal carotid artery (ICA) occlusion. Colors correspond to the color bar, which indicates the percentage of patients who demonstrated perfusion in that region of the brain.