Patterns of collateralization in acute ischemic stroke in the posterior circulation

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Target audience: Neurologists, Stroke Neurologists

Purpose: Acute ischemic stroke in the posterior circulation accounts for approximately 15% of all ischemic strokes. A systematic investigation of cerebrovascular diseases in the posterior circulation was not undertaken until the New England Medical Center (NEMC) Posterior Circulation Registry was initiated. And even today, the medical literature dealing with the different aspects of acute ischemic stroke in the posterior circulation is sparse when it comes to novel neuroimaging procedures or findings and treatment options,[1] demonstration of collateral flow in acute ischemic stroke in the posterior circulation for example. In this study, we aimed to investigate and compare patterns of collateral flow in posterior circulation stroke with two different approaches: (1) presence of FLAIR vascular hyperintensities (FVH)[2] and (2) extent of collateralization on dynamic 4D angiograms generated from perfusion-weighted raw images.[3]

Methods: From a prospectively maintained MRI report database (2005-2013), we identified 38 patients with acute or subacute ischemic stroke due to occlusion of the posterior cerebral artery (PCA) or basilar artery (BA) who initially underwent a standard stroke MRI protocol including PWI as well as follow-up MRI within 1 week. Magnetic resonance imaging was performed on a 1.5-T MR system (Magnetom Sonata or Avanto, Siemens Medical Systems, Erlangen, Germany). A standardized protocol was used in all patients including (1) transverse, coronal and sagittal localizing sequences followed by transverse oblique contiguous images aligned with the inferior borders of the corpus callosum (applied on sequences 2 to 6); (2) T1-weighted images; (3) T2-weighted images; (4) DWI; (5) fluid attenuated inversion recovery (FLAIR) images; (6) PWI following the first pass of contrast bolus through the brain; and (7) a 3D time-of-flight MR angiography. The postprocessing of the perfusion-weighted raw images was performed by a specific software, Signal Processing In NMR (SPIN, The MRI Institute for Biomedial Research, Detroit, USA). In patients with PCA occlusion, the generated perfusion maps were qualitatively assessed by use of SPIN: a region of interest was placed in an area of hypoperfusion on the generated maps (CBF, CBV) as well as mirrored to the contralateral unaffected hemisphere. Finally, ratios between the physiological estimates (CBF, CBV) of the area of hypoperfusion and of the contralateral mirror ROI were determined. Furthermore, perfusion-weighted raw images were used to create a dynamic angiographic representation of blood flow as described recently.[3] For this purpose, the baseline prebolus image was subtracted from each frame of the raw perfusion data as in DSA by use of SPIN. The presence or absence of FVH was noted by using prespecified criteria (focal, tubular, or serpentine hyperintensity relative to gray matter in the subarachnoid space or extending into the brain parenchyma).[2] The quality of the collateral circulation was assessed using a modification of the American Society of Interventional and Therapeutic Neuroradiology/Society of Interventional Radiology (ASITN/SIR) Collateral Flow Grading System.[3]

Results: Of the included 38 patients, 29 (76.3%) had an unilateral PCA occlusion, 1 (3.3%) patient bilateral PCA occlusions and 8 (21.1%) a BA occlusion. Overall, FVH was present in 24 (80.0%) patients with PCA occlusion and in 6 (75.0%) patients with BA occlusion (for examples see Figure 1). Collateralization grade on dynamic 4D angiograms was 0 in 1 (3.3%) patient, 1 in 7 (23.3%), 3 in 14 (46.7%), and 4 in 8 (26.7%) patients with PCA occlusion (for an example see Figure 2). In patients with BA occlusion, collateralization was graded 1 in 2 (25.0%), 3 in 4 (50.0%), and 4 in 2 (25.0%) patients. In patients with PCA occlusion, the ischemic lesions had a mean volume of 6.10±8.05 cm^3 on initial DWI. On follow-up DWI, the ischemic lesions had a mean volume of 16.21±21.87 cm^3. Growth of DWI lesions was observed in 18 (60.0%) patients, partial reversal of DWI lesions in 2 (6.7%) patients. Perfusion weighted imaging showed an area of hypoperfusion in all patients with a mean volume of 30.17±13.37 cm^3. The mean CBF and CBV ratios were 0.72±0.32 and 0.84±0.35 respectively. In patients with BA occlusion, the ischemic lesions had a mean volume of 1.34±1.21 cm^3 on initial DWI. On follow-up DWI, the ischemic lesions had a mean volume of 3.18±2.87 cm^3. Growth of DWI lesions was observed in 6 (75.0%) patients. Perfusion weighted imaging showed an area of hypoperfusion in all patients with a mean volume of 58.11±30.05 cm^3. Patients with detection of FVH demonstrated a minor reduction of CBF (0.73±0.34 vs. 0.68±0.30; p=0.72) and CBV (0.86±0.37 vs. 0.73±0.26; p=0.42) in comparison to patients without FVH. Frequency of infarction growth did not differ significantly between patients with FVH (19/39 (63.3%)) and those without (5/8 (62.5%), 95%CI 0.21-5.20; p=0.97). Collateral grading moderately/highly correlated with rCBF (Spearman correlation, R=0.70, p<0.001) and rCBV (Spearman correlation, R=0.77, p<0.001). Frequency of infarction growth did not differ significantly between the different collateral grades (p=0.36).

Figure 1. Examples of FVH in PCA (A) and BA occlusion (B) on FLAIR images (large image and upper row) in comparison to follow-up TOF-MRA after recanalization (lower row).

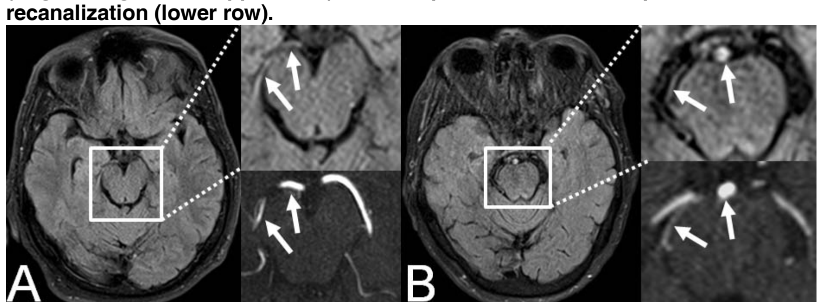
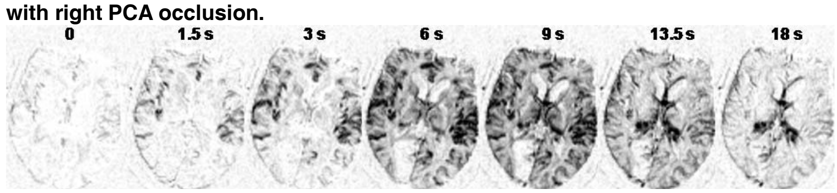


Figure 2. Example of collateral grade 1 on dynamic 4D angiogram in a patient with right PCA occlusion.



Discussion: FVH is a frequent finding in patients with PCA or BA occlusion. However, with regard to CBF and CBV ratios and the frequency of infarction growth on DWI there was no significant difference between patients with and without FVH. This may be at least partly attributed to the limited visualization of FVH in smaller vessel branches and the static imaging technique. In contrast to this, grading of collateral flow on dynamic 4D angiograms showed a moderate/high correlation with CBF and CBV ratios. Nevertheless, frequency of infarction growth did not differ between different collateral grades most likely reflecting that a MRI examination at a single time point may not be sufficient to draw conclusions about the quality of collateral flow in the course of disease.

Conclusion: This work demonstrates that collateralization in acute ischemic stroke in the posterior circulation may be assessed by different static and dynamic MRI techniques. Future studies with larger patient numbers are necessary to define more precisely the value of collateral blood flow imaging in posterior circulation stroke in daily clinical practice.

References: 1. Förster A et al. Recent advances in magnetic resonance imaging in posterior circulation stroke: implications for diagnosis and prognosis. Curr Treat Options Cardiovasc Med. 2011;13(3):268-77.
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