Assessment of Arterial Supply to Arteriovenous Malformations with Vessel-Encoded Arterial Spin Labeling Dynamic Angiography

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Introduction: Assessment of the blood supply to arteriovenous malformations (AVMs) is important for planning endovascular embolization therapy. Artery-selective angiography is typically limited to invasive x-ray methods that carry some risks to the patient. Vessel-encoded pseudocontinuous arterial spin labeling (VEPCASL[1]) 2D dynamic angiography with a balanced steady-state free precession readout and cardiac triggering has recently been shown to be capable of visualizing artery-specific flow patterns from 13 vessels above the circle of Willis in healthy volunteers[2]. This may make it a useful tool for investigating the blood supply to AVMs where there are often a large number of feeding arteries. Here we apply this novel method to obtain vessel-selective dynamic angiograms of the arteries feeding AVMs non-invasively and without contrast agent.

Methods: Five patients (3 male, mean age 51) with unruptured AVMs were scanned at 3T under approval from local ethical and institutional committees. 3D time-of-flight (TOF) angiography was performed for labeling plane selection and vessel localization. The labeling plane was chosen such that it was sufficiently far from the AVM (>1.5cm) to prevent the labeling artefact interfering with the imaging region, and such that the arteries ran approximately normal to the plane. Vessel-encodings were determined on a per subject basis to separate the signals arising from each of the main feeding arteries and varied between 10 and 14 cycles in these patients. Oblique transverse (TRA), coronal (COR) and sagittal (SAG) acquisitions were performed with tag duration=800ms, voxel size 1×1mm, slab thickness 50-100mm (to cover the AVM), temporal resolution 61ms, acquisition window ~1600ms (depending on the cardiac cycle), acquisition time ~4 mins each. Vessel-specific angiograms were decoded from the data using a Bayesian maximum *a posteriori* method[3].

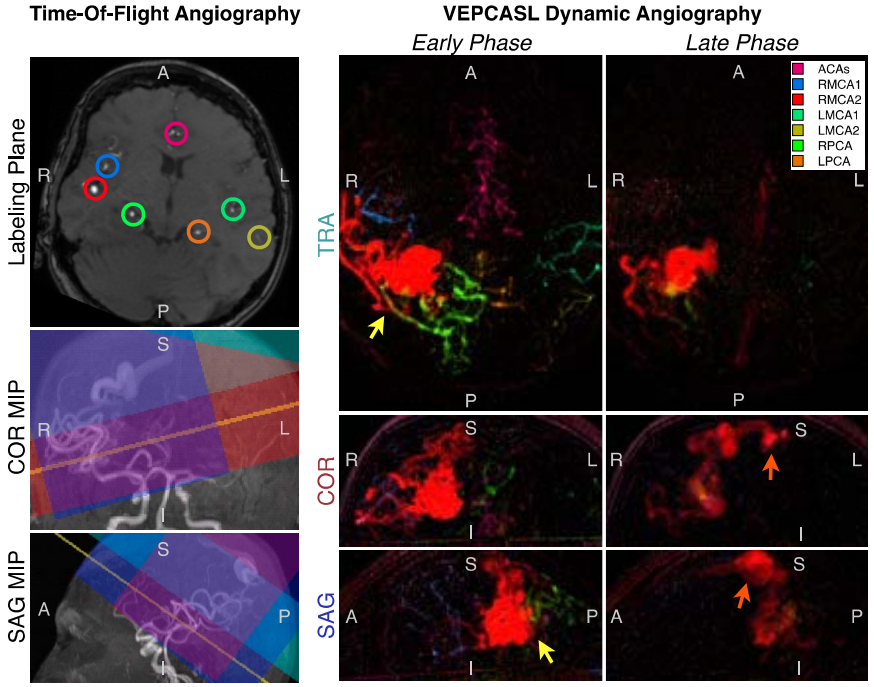

Figure 1: Example images from an AVM patient: TOF images (left) showing the selected labeling plane with the feeding arteries circled: the anterior cerebral arteries (ACAs), branches of the right and left middle cerebral arteries (RMCA1&2, LMCA1&2) and the right and left posterior cerebral arteries (RPCA and LPCA). TOF maximum intensity projections show the locations of the VEPCASL oblique TRA (cyan), COR (red) and SAG (blue) imaging volumes as well as the labeling plane (yellow). VEPCASL images are color-coded according to the artery supplying each voxel (see legend inset) whilst allowing for mixing. In this patient the AVM appears to be supplied mainly by the RPCA and the posterior branch of the RMCA (yellow arrows). Draining into large veins can also be seen in later time frames (orange arrows).

Results: Fig. 1 shows TOF and VEPCASL images at an early and late phase from one patient. The arterial supply and venous drainage is clearly visualized and there is excellent separation of the signals from each feeding artery. Some minor motion artefact can be seen at the scalp but this did not affect the depiction of the vessels significantly. Fig. 2 shows transverse oblique VEPCASL images from the other four patients, demonstrating the good image quality obtained in all cases. Some minor artefact was present between brain hemispheres in some cases, perhaps due to pulsatile flow of cerebrospinal fluid.

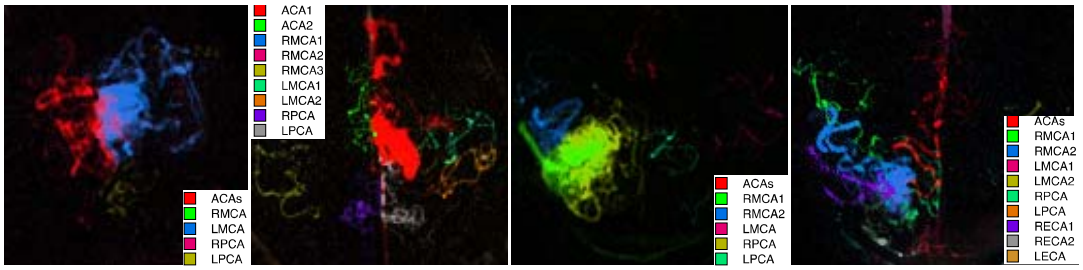

Figure 2: Early phase transverse oblique VEPCASL images from the other four patients (ECA = external carotid artery).

Discussion: We hope this technique will provide valuable information to aid therapeutic planning for endovascular embolization of AVMs. Further work is needed in validation, acquisition acceleration for 4D imaging, reduction of the labeling plane artefact for tagging closer to the lesion, comparison with other vessel-selective methods, both MRI[4] and x-ray based, and the modification of a kinetic model[5] to extract quantitative measures of blood flow from these images.

References: [1] Wong, MRM 58: 1086-1091 (2007); [2] Okell, ISMRM (2012): #582; [3] Chappell, Med Im Analysis 16:831-839 (2012); [4] Helle, ISMRM (2011): #364; [5] Okell, MRM 68:969-979 (2012)

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