Comparison of Vessel-Encoded Arterial Spin Labeling Dynamic Angiography with X-Ray Digital Subtraction Angiography in Patients with Vertebrobasilar Disease

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Introduction: Vessel-selective angiographic information about cerebral blood flow patterns, including collateral flow, is often only available via x-ray digital subtraction angiography (DSA), which is invasive, expensive and carries a procedural risk. Recently a non-invasive, non-contrast method[1] based on the principles of vessel-encoded pseudocontinuous arterial spin labelling[2] (VEPCASL) was proposed for obtaining this important information. In this study we compared VEPCASL dynamic angiography with x-ray DSA for the assessment of collateral flow and the strength of flow in the four brain-feeding arteries in a cohort of patients with atheromatous disease in the vertebro-basilar arteries.

Methods: Twenty-one patients (17 male, mean age 67, range 31-81) with significant (>50%) stenosis in at least one vertebral or the basilar artery who underwent DSA also underwent VEPCASL dynamic angiography. The study was approved by the local ethics committee. VEPCASL dynamic angiography was performed in transverse and coronal planes as per Okell *et al.*[1] to visualize flow patterns arising from the right and left internal carotid arteries (RICA and LICA) and vertebral arteries (RVA and LVA). DSA and anonymised VEPCASL images (presented separately for each feeding artery in inverted grayscale) were scored in consensus by two interventional neuroradiologists in a random order using all available views. Scoring was performed for: a) the degree of anterior to posterior collateral flow through the circle of Willis on the left and right sides (0=none, 1=little/ambiguous, 2=definite); b) the flow in each artery proximal to the circle of Willis (0=none, 1=limited, 2=normal); c) late filling from each feeding artery (0=very delayed, 1=delayed, 2=normal), and d) vertebral artery dominance (right, left or equal). Where only a subset of arteries had been injected during x-ray DSA, only these were included in the analysis. The VEPCASL images were also scored for degree of motion corruption (0=uninterpretable, 1=partially interpretable, 2=fully interpretable). The proportion of measurements in agreement to within one point ($P_{\pm 1}$) and linearly weighted Cohen's kappa coefficients (κ) were calculated to assess the degree of agreement between the two modalities.

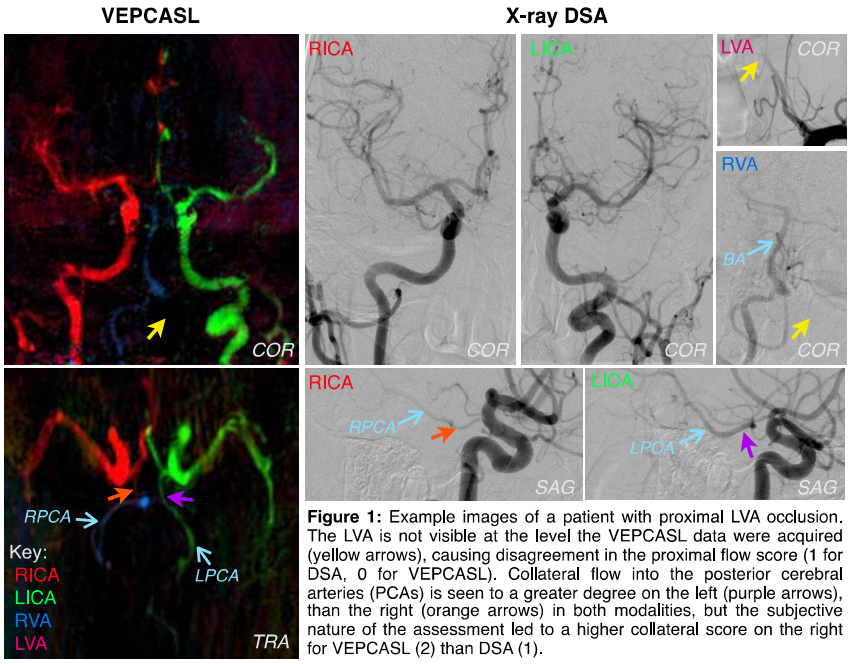

Figure 1: Example images of a patient with proximal LVA occlusion. The LVA is not visible at the level the VEPCASL data were acquired (yellow arrows), causing disagreement in the proximal flow score (1 for DSA, 0 for VEPCASL). Collateral flow into the posterior cerebral arteries (PCAs) is seen to a greater degree on the left (purple arrows), than the right (orange arrows) in both modalities, but the subjective nature of the assessment led to a higher collateral score on the right for VEPCASL (2) than DSA (1).

Results and Discussion: Fig. 1 shows examples of VEPCASL and x-ray DSA data in the same patient, showing good qualitative agreement. Differences in the scores in this subject become apparent due to the differing field of view and subjective nature of the scoring. We therefore considered scores within ±1 to be in reasonable agreement. Fig. 2 shows contingency tables that demonstrate reasonable agreement in all categories ($P_{\pm 1} \geq 92\%$). κ was high for assessing VA dominance, but lower in other categories. This was likely due to variability in the subjective scoring as well as the inability to obtain high κ values for asymmetric skewed distributions such as these. In addition, flow patterns could potentially have changed between the MRI and x-ray examinations (median time interval = 22 days). VEPCASL appeared to give lower flow scores on average, particularly in the VAs and basilar artery (BA). This could be due to the lower spatial resolution and signal-to-noise ratio, preventing small amounts of flow from being clearly visualized. It could also be due to the injection pressure that is applied during DSA increasing the apparent flow through stenosed arteries, giving a misrepresentation of the true physiology[3] while the injection is being performed. No VEPCASL images were considered to be uninterpretable due to motion corruption, although 44% were only partially interpretable, motivating further work in acquisition acceleration and motion correction strategies.

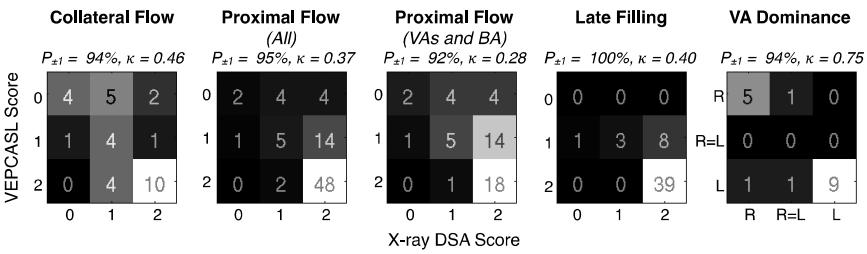

Figure 2: Contingency tables showing the agreement between VEPCASL dynamic angiography and x-ray DSA in each category.

Conclusions: VEPCASL dynamic angiography provides similar qualitative information to x-ray DSA regarding collateral flow patterns and the flow within each brain-feeding artery. It may thus provide a useful non-invasive tool for prognosis and pre-surgical planning in patients with vascular disease.

References: [1] Okell, MRM 64: 698–706 (2010); [2] Wong, MRM 58: 1086-1091 (2007); [3] Liebeskind, Stroke 34:2279-84 (2003)

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