Asymmetry and Flow Dynamics in the Vertebrobasilar System as Assessed by Vessel Encoded Arterial Spin Labeling

A. P. Kansagra[1], and E. C. Wong[2]

[1]School of Medicine, University of California, San Diego, La Jolla, CA, United States, [2]Radiology and Psychiatry, University of California, San Diego, La Jolla, CA, United States

Introduction

Vessel encoded ASL allows for the efficient imaging of two or more vascular territories without exogenous contrast media (1). Here we discuss vertebral artery (VA) perfusion territory maps calculated from vessel encoded ASL data in five healthy subjects and reach conclusions about VA flow asymmetries and mixing in the vertebrobasilar system.

Methods

Vessel encoded ASL scans were performed in five healthy subjects (2 men and 3 women, aged 21-27) on a GE 3T system with a commercial 8 channel head coil under an IRB approved protocol. Two ASL scans were performed in each subject using a labeling plane approximately 7 cm inferior to the circle of Willis (**Figure 1**), well below the vertebrobasilar junction, with 64 x 64 resolution, FOV 22 cm x 8 mm, TR 3400 ms, 80 excitations, and single-shot spiral acquisition with fat saturation. The length of the labeling pulse train was 1600 ms, and the post-labeling delay was 1000 ms. Total scan time was 13 minutes. Perfusion-weighted images were generated according to the scheme described in (2). Statistical calculations were performed using the unpaired, two-tailed *t* test with α=0.05.

Results

The VA perfusion territories in our sample are consistent with the basilar artery (BA) territory, which typically perfuses the cerebellum and occipital lobe through the cerebellar and posterior cerebral arteries (PCA), respectively (**Figure 2A**). However, there are variants even in our small sample. In one subject, we found that the left PCA is supplied by the ipsilateral internal carotid artery through a persistent fetal pathway; the BA supplies only the right PCA (**Figure 2B**).

The mean fractional contribution of vertebrobasilar flow to total cerebral perfusion in our sample was 33.0±6.7%, with the remainder supplied by the carotid arteries. These data indicate that the carotid arteries supply the majority of the blood to the brain ($p<0.01$). The fraction of total BA flow supplied by the larger VA—whether left or right—in each subject was 70.0±8.4%, indicating that the two VAs do not contribute equally ($p<0.01$). However, the fraction of BA perfusion supplied specifically by the left VA was 52.6±23.7%, suggesting that there is no particular preference for left or right dominance ($p=0.82$). Finally, there is a relative lack of voxels with color intermediate between red and green in our sample, indicating that the supplies to the left and right PCA territories are measurably different. While this finding does not preclude the possibility of contralateral flow contribution from either VA, as might occur if one VA is dominant, it appears to be consistent with previous reports that the convergence of VA flows at the vertebrobasilar junction is relatively laminar (3).

Due to relative laminarity, different contributions of each VA, and anatomical variations, the spatial structure of each VA perfusion territory is complex and not obvious from anatomical considerations alone. For instance, we found one subject in whom the right VA supplies only the posteromedial portion of the cerebellum, with the remainder of the BA territory supplied by the left VA (**Figure 2C**). Complex vascular supplies such as these suggest a possible clinical role for perfusion territory imaging in the workup preceding certain interventions, such as intra-arterial chemotherapy for neoplasms of the posterior fossa.

Conclusion

Vessel encoded ASL permits non-invasive imaging of VA perfusion and produces well-defined vascular territories that are consistent with the distribution of the BA. It further reveals the complex morphologies of these territories arising from the relative laminarity of flow in the vertebrobasilar system, unequal contributions of the VAs, and anatomical variations found even in healthy subjects.

References

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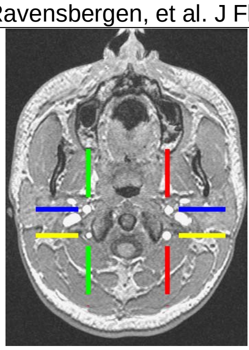

Figure 1. The first ASL scan separates left (red) and right (green) circulations, and the second separates carotid (blue) from vertebral arteries (yellow).

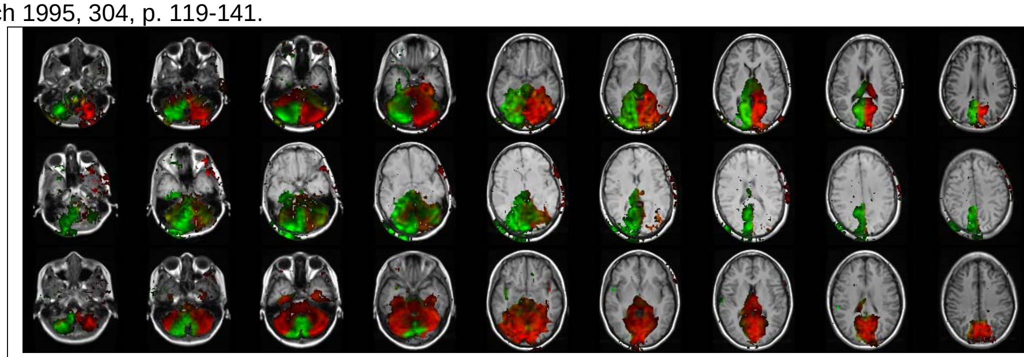

Figure 2. Vertebral artery territories in three healthy subjects overlaid on axial T1-weighted images. Red and green indicate left and right vertebral artery perfusion, respectively. **A**, a subject in whom vertebral blood does not mix in the basilar artery; **B**, a subject in whom the vertebral arteries supply only the right posterior cerebral artery; **C**, a subject with left vertebral artery dominance and right vertebral artery perfusion limited to the posteromedial cerebellum.