

Improved estimation of cerebral artery branch territories using cluster-based segmentation of vessel-encoded pseudocontinuous ASL data

Akash P Kansagra¹, and Eric C Wong²

¹Radiology and Biomedical Imaging, UC San Francisco, San Francisco, CA, United States, ²Radiology and Psychiatry, UC San Diego, San Diego, CA, United States

Introduction

Perfusion imaging using vessel encoded pseudo-continuous ASL (VEPCASL) is based on the simultaneous application of vessel-specific magnetic tags to inflowing arteries according to their positions within a 2D labeling plane [1]. VEPCASL data have traditionally been processed into vascular territory maps via cluster-based segmentation of measured tagging data obtained during multiple VEPCASL acquisitions [2-4]. However, the quality and reliability of territory mapping is often compromised by cluster overlap. Here we describe improvements in vascular territory segmentation made possible by performing clustering in the higher-dimensional space created by combining tagging data with the spatial coordinates of each voxel.

Methods

VEPCASL scans were performed in five healthy volunteers on a GE 3T magnet with an 8 channel head coil under an IRB approved protocol. Labeling was performed above the circle of Willis during each of four VEPCASL scans extending from ACA to PCA, left MCA branches to right MCA branches, ACA to ACA-PCA midpoint, and left MCA to left MCA-right MCA midpoint, respectively. Imaging parameters were: 2x2x8 mm resolution, TR 3300 ms, 40 excitations, 2 interleaves, single-shot spiral acquisition, 1600 ms labeling pulse train length, and 1000 ms post-labeling delay. Tagging data from each VEPCASL acquisition were used to populate a four-dimensional tagging space (**Figure 1**). An expectation maximization Gaussian mixture model was then used to perform cluster-based segmentation of tagging data alone or in combination with 2D Cartesian coordinates of the associated image voxel. Spatial coordinates were normalized by half of the field-of-view. Similarity of vascular territory maps was computed as the fraction of voxel pairs in one map with concordant classification in a second map, with concordance achieved if both pairs were assigned to the same cluster in each map or distinct clusters in each map.

Results

Representative vascular territory maps generated with and without spatial information are shown in **Figure 2**. Both maps grossly resemble the expected distribution of vascular territories above the circle of Willis, including the presence of ACA, MCA, and PCA artery territories. However, the addition of spatial data results in identification of four left and three right MCA branch territories, compared with three and one, respectively, in the map obtained without the benefit of spatial information. The addition of voxel coordinates also reduces "speckling" artifact in the ACA, PCA, and central left MCA branch territories that results from misclassification of voxels contained within larger territories. Repeated clustering of data also demonstrated greater reproducibility of vascular territory maps when spatial data were included in the clustering method. Average concordance of voxel pairs across five subjects was 0.353% without spatial data and 0.324% with 2D Cartesian data, indicating greater reproducibility of vascular territories obtained after accounting for voxel location.

Conclusion

Cluster-based segmentation of VEPCASL data for the purpose of vascular territory mapping permits improved estimation of vascular territories when measured tagging data are supplemented with spatial information encoding voxel coordinates during the clustering step. These improvements are manifest as more reasonable geographic extent and distribution of territories, reduced misclassification artifact, and enhanced reproducibility of vascular territory maps. These results suggest a means to enhance the quality of complex vascular territory maps using simple and straightforward modifications of existing segmentation strategies.

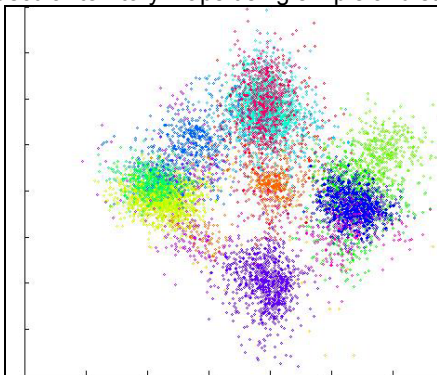


Figure 1. Two-dimensional projection of four-dimensional tagging space. Segmentation by vascular territories is indicated by color.

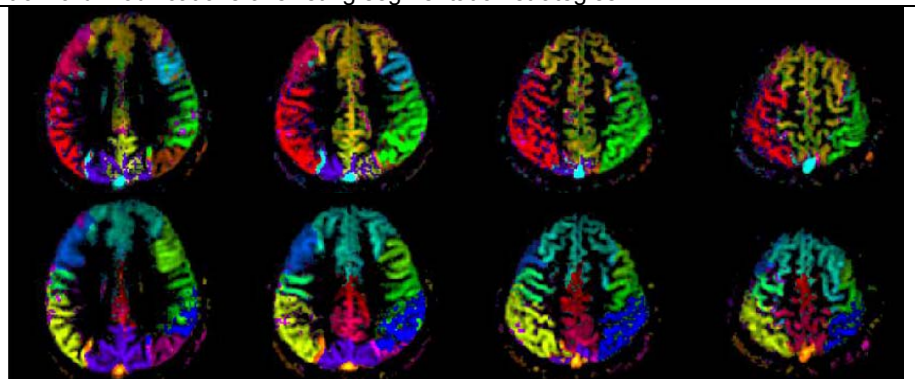


Figure 2. Top: Colorized vascular territory map obtained by cluster-based segmentation of four-dimensional tagging data. Bottom: Vascular territory map in the same patient obtained following six-dimensional segmentation of measured tagging data supplemented by 2D Cartesian coordinates of each voxel. Colorization of the bottom row corresponds to the scatter plot in Figure 1.

References

- [1] Wong EC. Magn Reson Med 2007;58:1086-1091. [2] Wong EC, Kansagra AP. ISMRM 2008, p. 182. [3] Wu W-C. ISMRM 2011, p. 295. [4] Chappell MA, et al. Magn Reson Med 2010;64:1529-1539.