Repeatability of Automated Global and Local Arterial Input Function Deconvolution Methods for Generating Cerebral Blood Flow Maps

A. M. Stankiewicz[1,2], O. Wu[2], T. Benner[2], R. E. Irie[2], T. T. Batchelor[2], and A. G. Sorensen[2]
[1]Harvard University, Cambridge, MA, United States, [2]Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Boston, MA, United States

INTRODUCTION: Perfusion-weighted Magnetic Resonance Imaging (MRI) is used to assess the risk of tissue infarction in acute stroke patients[1] and tumor angiogenesis in cancer patients[2]. Radiologists and investigators inject a gadolinium-based tracer into the brain and image the signal concentration as a function of time in order to infer the cerebral flow rate[1]. Unfortunately, the standard method for deconvoluting the signal (singular value decomposition) is sensitive to the delay/dispersion of the signal in different regions of the brain[3], and typically requires a trained operator to manually select arterial input functions (AIFs). Recently, researchers have proposed alternative methods for deconvoluting the signal to address the drawbacks of the existing technique, including circular global AIF[4] (global AIF) and local AIF[5] deconvolution. The goal of this project was to compare and contrast the competing global AIF and local AIF deconvolution algorithms.

METHODS: Gradient echo EPI dynamic susceptibility contrast datasets of 13 tumor patients who had undergone 2 baseline MRI scans each, separated by 48 hours but with no intervening treatment or other change, for a total of 26 datasets, were included in this study. All scans were acquired using 0.2 mmol/kg Gd-DTPA injections at 5cc/s followed by saline flush, and imaging was performed at 3 Tesla on a TIM Trio (Siemens Medical Systems). Algorithms for global AIF[4] and local AIF[5] deconvolution were applied to all datasets to obtain CBF maps. Motion correction and smoothing (using a Hanning filter) were incorporated into processing, and images from the two scans were coregistered using FLIRT[6]. The background and all points above the upper threshold (defined as 5 times the median point value) were excluded. Image data sets were normalized to the median point value. Variation between two images was defined as the mean of the absolute values of the differences between matching points in the two images. Repeatability of the 2 competing deconvolution techniques was assessed by comparing the variation between CBF maps generated during each scan for each deconvolution method. Whole brain scans were utilized in our analysis.

RESULTS: The variation between global AIF CBF maps from the first and second scan was 0.220 ± 0.043, and the variation between local AIF CBF maps from the first and second scan was 0.263 ± 0.041 (P-value = 0.0015, statistically significant). The variation in the local AIF CBF maps versus the variation in the global AIF maps for the 13 patients (26 scans) is plotted below (Figure 1). Eleven out of 13 points lie above the y=x line indicating that the variability is greater when using the local AIF deconvolution method.

SAMPLE CASE: CBF maps from each of the two MRI scans (Scan 1 and Scan 2) as well as the ratio the two scans (Scan 1 / Scan 2) are shown for subject 6, slice 5 out of 10 (Figure 2). The ratio between the CBF maps is more inhomogeneous for local AIF CBF maps than for global AIF CBF maps.

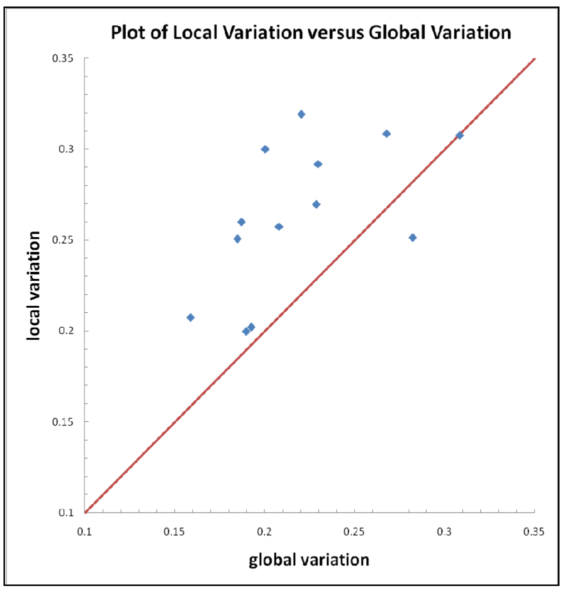

Figure 1

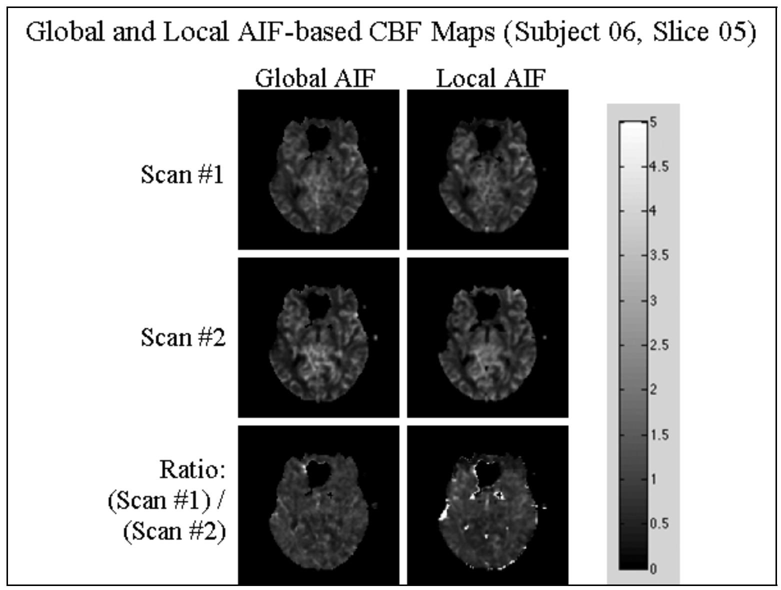

Figure 2

CONCLUSIONS: We found that the variation in local AIF CBF maps is greater than the variation for global AIF CBF maps. Since repeatability is inversely related to the variation between corresponding maps, our results suggest that repeatability may be better for global AIF-based CBF maps. Our methodology and results were greatly strengthened by a rare availability of double baseline scans separated only by two days which is an uncommon practice given payer coverage, contrast administration considerations, and logistics of MRI scanning. Compared to the standard method of obtaining CBF maps that requires a trained operator to manually select AIFs, the automated global AIF promises to deliver faster but still repeatable results. These findings may be particularly important in diagnosis and treatment of acute stroke patients and patients with brain tumors who could benefit from speedy diagnosis and risk stratification. Future work will include exploration of region-by-region variability as well as comparison of both high- and low-flow regions.

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