Effect of Using Localized Arterial Input Functions on Cerebral Blood Flow Maps in Dynamic Susceptibility Contrast MRI

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Introduction

Methods for automatic local arterial input function (AIF) generation have been presented previously [1,2]. In this study, we use a localized AIF method that scores each voxel, selects the most ideal candidates, and then defines an AIF for each voxel in the brain through interpolation and smoothing. The effect that this method has on the resulting cerebral blood flow (CBF) maps is then analyzed against maps created with a user-selected global AIF.

Methods

Analysis was performed on gradient echo EPI images from 20 acute stroke patients scanned on a 1.5 T MRI system (GE Medical Systems, Milwaukee, WI.). The scan parameters were TR 1.5 s, TE 65 ms, FoV 220 mm, 11 slices, 6 mm slice thickness, 1 mm gap, matrix size 128x128. Each image set was analyzed with a global AIF manually selected from the MCA in the hemisphere contralateral to the lesion in addition to an automated localized AIF approach as described below. In both cases, CBF maps were calculated with a standard SVD-based approach [3].

The localized AIF calculation proceeded by first excluding voxels from AIF selection on the basis of their CBV, time to peak, width, as well as other statistics designed to eliminate noise and motion artifacts. Next, a search cube of $28mm^3$ was centered on each voxel in the brain, and a score was calculated for each voxel in the search cube on the basis of normalized first moment, average slope, maximum height and FWHM. The three voxels with the lowest score were then interpolated with a 3-D 28mm FWHM Gaussian kernel and the result was taken as the AIF for the centered voxel. The localized AIFs were then smoothed with the same Gaussian kernel used for interpolation.

Comparison of the two methods proceeded by creating histograms of the ratio (R_{LG}) of the CBF maps created by the local AIF method (lCBF) to those created by the global AIF method (gCBF) on a voxel-by-voxel basis. The gCBF values underlying the area of the histogram where R_{LG} exceeded 1.75 standard deviations beyond its mean were then placed in a histogram. From this histogram, the percentage of low flow voxels (designated as less than the mean of gCBF) was calculated for each patient. The locations of these low flow voxels were mapped back to the lCBF maps for visual comparison of their location. In addition, the same analysis was carried out for $1/R_{LG}$ to determine the locations where gCBF was predicting a significantly higher flow than lCBF.

Results and Conclusion

The average percentage of low flow voxels for R_{LG} was 87% with a standard deviation of 6.3%. This indicates that for the local AIF method, a vast majority of the voxels in which significant increases in blood flow are predicted occur in areas of low flow. This can be seen in Figure 1, which displays the resulting histograms from one of the analyzed patients. Upon inspection of the locations of the low flow voxels with increased lCBF it was seen that for 7 patients these voxels were highly concentrated in the hemisphere ipsilateral to the lesion. However, no such concentration was as apparent for the voxels with increased gCBF. Figure 2 shows the overlays of lesion extent from follow-up T2 images and increased local CBF onto lCBF maps on a selected slice for 6 of the above mentioned patients. These results suggest that the local AIF method reduced effects caused by delay of the AIF between the two hemispheres when a global AIF is selected.

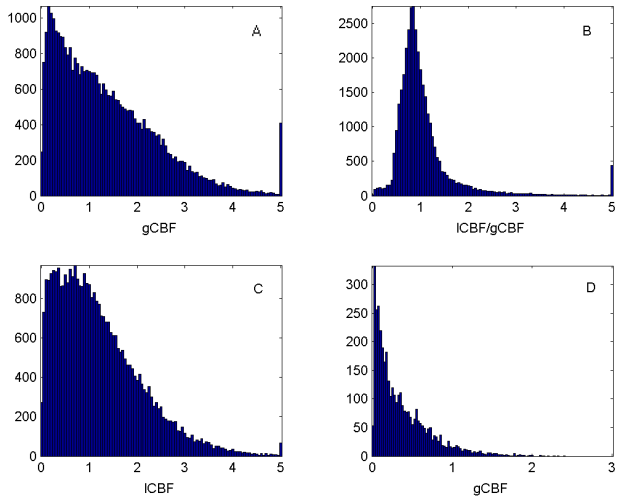

Figure 1: Histograms showing gCBF (A) and lCBF (C) for a selected patient. In addition, the histogram of the ratio of lCBF to gCBF is shown in (B) as well as a histogram of the gCBF conditioned on lCBF/gCBF being greater than 1.75 standard deviations beyond its mean (D). Note the flattening out of the low flow in (C) as compared to (A), showing the effect of the local AIF algorithm. Also note the significant number of voxels at low flow in (D), suggesting that the local AIF algorithm is increasing low flow values.

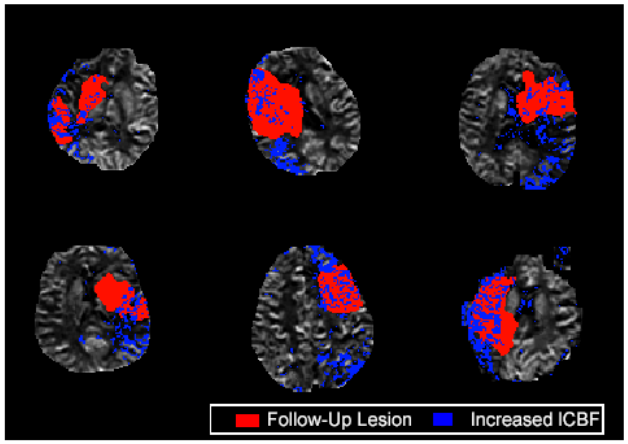

Figure 2: Local CBF maps showing lesion area from follow-up T2 images as well as the voxels with increased flow values as compared to the global CBF for six different patients. Note the high concentration of these voxels in the ipsilateral hemisphere, suggesting that the local AIF is overcoming delay issues between the contralateral and ipsilateral hemispheres.

Acknowledgements

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