Determination of artery input function in dynamic susceptibility contrast MRI based on regions around arteries segmented by independent component analysis

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Introduction. Dynamic susceptibility contrast MRI (DSC-MRI) is commonly used to measure perfusion of brain tissues. Cerebral blood flow (CBF), one of the perfusion characteristics, is calculated by a deconvolution of arterial input function (AIF) and concentration of interested tissue.Previous studies suggested that the segmented region of AIF is around vessel from which the stronger T2* effect is observed during contrast agent passage[1,2].Significant partial volume effect severely contaminates signal at the region of interest (ROI) if selected manually[3]. In this study, in order to alleviate the partial volume effect independent component analysis (ICA) method[4] is utilized to select ROI around vessel via semi-automatic process.

Methods. A series of spin-echo EPI MR scans (1.5 Tesla, TR=1.5 s, TE=60 ms, 7 axial slices, slice thickness = 6 mm, matrix size = 64 × 64, in-plane resolution = 3.4 mm × 3.4 mm, 60 dynamic measurements) were performed in ten normal subjects. All subjects received 0.2 mmol/kg Gd-DTPA contrast agent. AIFs were calculated by two methods: (1) manually selected ROI (Manu-roi) and (2) weighted average of each component selected by ICA (ICA-weighting). The ICA produced 40 spatially independent maps (cover 99% of the eigenvalues). These maps were examined to select two interest maps: map (ICA-aw) of artery and map (ICA-sw) of tissue around middle cerebral artery (MCA). The AIF candidate voxels were selected from the fifty largest voxels of z-value (z-value was defined as $z_i = \frac{x_i - \text{mean(map)}}{\text{Std(map)}}$). Afterward, the AIF was determined after weighting: $AIF = \sum_{roi} Q \times C_{roi}$, where Q is the weighting from z-value and C is the concentration of selected voxels. The CBFs were compared from these two AIF determinations after adaptive singular value decomposition (SVD) calculation[5].

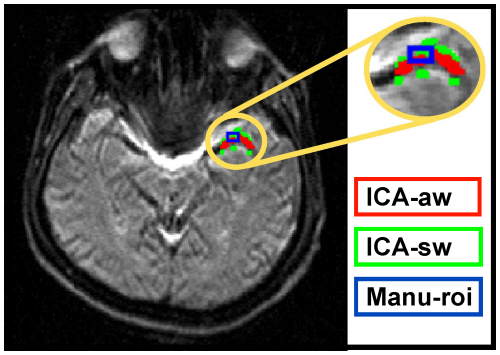

Figure1. Regions selected by manual ROI and ICA method (blue: manual selection; red and green: artery and its surrounding tissue selected by weighted-ICA). The bigger VOI are shown in the subsection figure.

Results. Three selected ROIs for AIF determination with Manu-roi and ICA-weighting methods are presented in Figure 1. ICA alleviates partial volume effect and results in better boundary discrimination and less inter-subject variance. The corresponding time courses show physiological properties of blood from these three regions, such as a recirculation response for artery and a flatter response for surrounding tissue (see Figure 2). The CBF values calculated by the weighted ICA method were 41.1±4.9 and 22.1±2.3 mL/100g/min for cortical gray matter (GM) and deep white matter (WM) regions, respectively. The CBF values obtained based on the manual ROIs were 53.6±12.0 and 27.9±5.9 mL/100g/min for the same two regions, respectively. The CBF values and GM/WM ratios obtained from both methods were in good agreement with those found in the literatures[6].

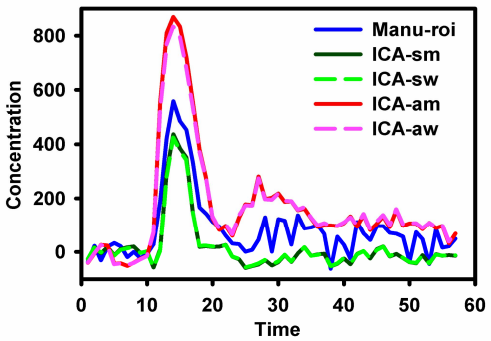

Figure 2. Different AIFs were determined by (1) the artery with weighted-ICA (red solid line); (2) average of the artery with manual ROI (blue line); (3) surrounding tissue with weighted-ICA (dark green solid line). This figure also shows the result for the average-ICA in the regions of artery and the surrounding tissue with pink dash line and green dash line, respectively.

Discussion. In this study, two ICA weighting ways are used to determine AIF: average and weighting average. The comparison (see Figure 2) between average-ICA and weighted-ICA showed that there was no significant difference because the selected voxels are highly consistent each other. Therefore the partial volume effect within these voxels had a limited influence. In conclusion, this work provides three benefits to achieve the more précise calculation of CBF: (1) ICA provides a semi-automatic tool to select interest component; (2) ICA decomposes signal without partial volume effect; (3) ICA determines AIF in the tissue around artery for CBF quantification.

References.

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