Comparison of Automatic Localized and Manual Global AIF Perfusion Imaging from DSC MRI by Vascular Territories

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Introduction: Dynamic susceptibility contrast enhanced T2*-weighted perfusion MR imaging (DSC) has increasingly been used to assess brain perfusion in various clinical settings such as cerebral ischemia, or for characterization of brain tumors [1]. DSC is further believed to be applicable especially in children due to a faster heart rate and smaller brain diameter which facilitates a tighter bolus of the contrast agent [2]. DSC perfusion evaluation generally requires manual selection of an arterial input function (AIF) based on one or more single voxels representing major feeding vessels. This single AIF from one specific vascular region is used as input for the whole brain perfusion calculation. This likely induces a inter-observer variability and is also not representative of the spatially varying flow dynamic in the brain. To address these problems an automatic local AIF approach has been proposed [3-5] that searches for representative regional AIFs and thus potentially overcomes operator bias and systematic errors due to regionally different flow and bolus patterns. The aim of our study was to compare two DSC methods, a manual global and an automatic local AIF approach, and examine their calculated regional perfusion differences as a function of vascular territory.

Methods: Eight pediatric DSC exams from an IRB approved phase I clinical trial at our institution were used to evaluate regional perfusion differences between the global and local AIF methods. DSC data was obtained from dynamic acquisition of T_2*-weighted EPI images on a 3T clinical MR system (Magnetom Trio, Siemens, Erlangen, Germany) (TE/TR=28ms/1800ms, FOV=210x210mm^2, matrix=128x96, 1562 Hz/voxel, 10 slices, 1.6 x 1.6 x 5.0 mm^3) during injection of a paramagnetic contrast agent (Magnevist, Bayer, Montville, NJ, USA). The global perfusion data was calculated using the PWI Task Card (MGH, Boston, MA, USA) by user-defined arterial inputs selected from the middle cerebral artery (MCA). Local AIF perfusion was calculated using the Local AIF Perfusion Works-in-Progress-Package (Siemens, Malvern, PA, USA) [3-5]. Perfusion territories of the MCA, anterior cerebral artery (ACA) and posterior cerebral artery (PCA) were manually segmented according to anatomical regions defined by Tatu et al. [6]. The DSC data was co-registered to a 3D T1 MPRAGE data set, acquired during the exam, using FLIRT (FSL, www.fmrib.ox.ac.uk/fsl). Gray and white matter regions of interests (ROI) were automatically segmented from the 3D T1 data set with FAST (FSL). To adjust for scaling between software programs, the perfusion values were normalized to the average gray matter perfusion in each slice for both the local and the global AIF method. An absolute percent difference between global and local AIF perfusion values was calculated from the normalized perfusion data. The gray matter, white matter, and territorial perfusion ROIs where then used to find the average difference in gray and white matter perfusion by vascular territory.

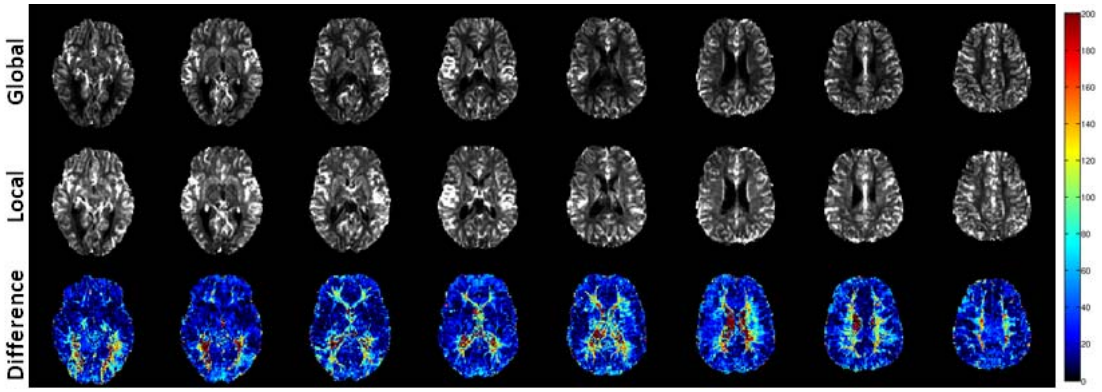

Figure 1: Perfusion maps calculated by using a global (upper row) and a local (middle row) AIF. The absolute % difference between both methods is shown in the bottom row. Note that the very large percent difference (red) corresponds to areas of cerebral spinal fluid.

Results: Figure 1 depicts a representative exam showing the calculated perfusion maps using a global AIF, local AIF, and the absolute difference between the methods. The local AIF method obtained higher perfusion values in the white matter compared to the global AIF method. Areas surrounding the MCA in the first slice, where the global AIF was selected correspond to areas that show the least difference between the two methods. However, the posterior areas of the brain in the first few slices depicted larger differences than the anterior areas. Table 1 shows the average difference across the eight exams by perfusion territory. The posterior area of the brain supplied by the PCA exhibited the largest difference in both gray and white matter.

	Gray Matter	White Matter
ACA	24.7%	29.8%
MCA	23.5%	34.8%
PCA	39.0%	43.4%

Table 1: The average difference in perfusion by vascular region.

Conclusions: Our results show that the local AIF obtained regional perfusion differences when compared to a global AIF method. The global AIF underestimated perfusion in white matter and in posterior areas of the brain corresponding to the PCA's vascular territory when compared to local AIF perfusion maps. These regional differences are believed to be the result of bolus dispersion caused by increased arterial transit time. The benefits of a local AIF to calculate perfusion is its decreased sensitivity to bolus delay and dispersion. In addition, as an automated method, the lack of operator bias improves accuracy when investigating longitudinal changes in perfusion during treatment.

References: [1] Rollin N, et.at. Neuroradiology 2006;48:150-159. [2] Huisman T, et.at. Eur Radiol. 2004;14:59-72. [3] Calamante F,et.al. MRM 2004;52:786-97. [4] Lorenz C, et.al. JMRI. 2006;24:57:65. [5] Lorenz C, et.al. JMRI. 2006 34:1133-9. [6] Tatu L. et.al. Neurology 1998;50:1699-1708.