Voxel-specific brain arterial input functions from DSC-MRI and blind deconvolution in a group of healthy males

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Purpose: To investigate in a healthy population the properties of voxel-specific arterial input functions that were obtained using a recently published blind estimation approach. Arterial input functions may differ between brain regions due to delay and dispersion effects in the vascular supply network. Unless corrected for, these differences may degrade quantitative estimations of cerebral blood flow in dynamic susceptibility contrast perfusion imaging (DSC-MRI).

Methods: DSC-MRI was performed in all participants (N = 44, 53 ± 7 years) using a Vision 1.5T MR scanner (Siemens Erlangen, Germany), the contrast agent Gadovist (Bayer Schering Pharma, Berling, Germany) and a MRI compatible power injector (Medrad, Warrendale, PA). The dose of contrast agent was according to body weight (0.2 ml/kg, 5ml/s). Eleven slices were obtained using vendor provided gradient echo echo planar imaging (TR/TE=1442/60.82 ms, Field of view 230 mm, Image matrix =128x128, Flip angle 90 degrees, slice thickness 5 mm). Voxel-specific arterial input functions were obtained using a recently published blind deconvolution approach (Gruner et al 2007) based on the Lucy-Richardson maximum likelihood estimation algorithm (Richardson 1972, Lucy 1974, Fish 1995). In short, the voxel-specific arterial input functions were estimated iteratively from the contrast agent concentrations over time by posing mathematical constrains such as non-negativity and conservation of contrast agent. It was assumed that these constraints were sufficient to identify the arterial input function correctly. The estimated arterial input functions were qualitatively and quantitatively assessed, through visual inspection or by comparing of time-to-peak (delays) and peak amplitude (dispersion) values between eight brain regions in the left hemisphere (superior frontal cortex, centrum semiovale, occipital cortex, thalamus, putamen, temporal cortex, cerebellum, basal frontal cortex). Additional comparison to manually selected arterial input functions in the close vicinity of the middle cerebral artery (MCA) was performed.

Results: The estimated voxel specific arterial input functions varied across brain regions, showing various degrees of delay and dispersion properties, Fig.1. The average *vsMCA* (i.e. the voxel-specific arterial input function selected near the left MCA) was the highest and earliest, followed by the arterial input functions in the putamen, then by almost simultaneous arriving arterial input functions in the basal temporal cortex, the basal frontal cortex, the thalamus, superior frontal cortex, the cerebellum, with a slight delay to the occipital cortex and the centrum semiovale, Fig.2. Differences in delays and dispersion were larger within one brain region across participants, than across regions within one participant. In half of the participants (N=21), a good correlation (|correlation coefficient|> 0.75) was found between the estimated and manually selected arterial input functions in regions close to the MCA.

Discussion/Conclusion: The difference in delay and dispersion in the arterial input functions from different brain regions were consistent with expectations of the vascular supply of normal tissue. The vascular supply for each participant followed similar distribution patterns, and the estimated arterial input functions could be useful for visualizing normal (and possibly abnormal) supply patterns. The blind approach appears to produce reasonable estimates of voxel-specific arterial input functions, and as such the approach could potentially circumvent some of the difficulties commonly reported in manual or semi-automatic approaches (i.e. user-interaction, time consumption, partial volume effects related to manual selection of arterial input functions).

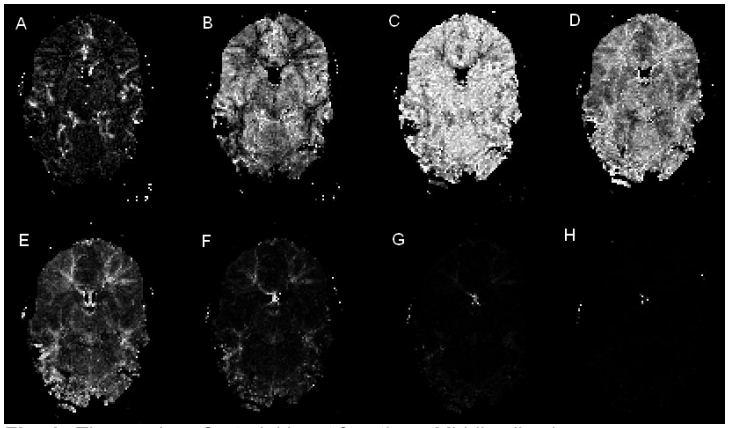

Fig. 1: *Time series of arterial input functions.* Middle slice in one randomly selected participant. The arterial input function for one voxel is shown as intensity values across the images. The temporal resolution between images along the row is 1.44 seconds.

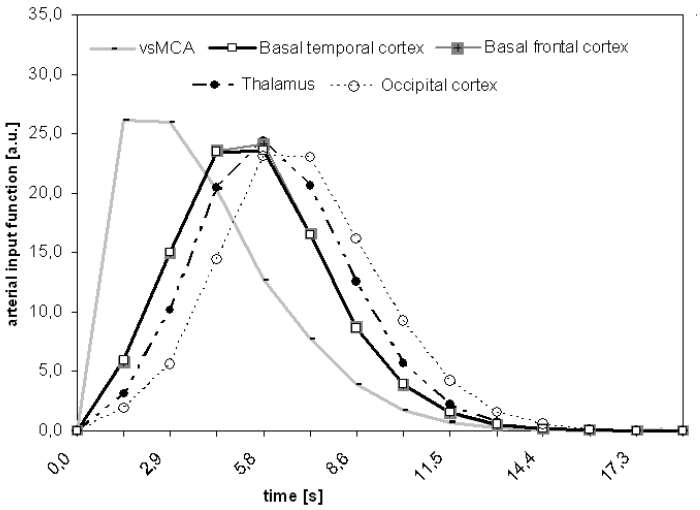

Fig. 2: *Mean group voxel-specific arterial input functions*. Results from four region of interests in the left hemisphere; temporal cortex, basal frontal cortex, thalamus and occipital cortex. The voxel-specific arterial input function selected near the left MCA (averaged for all participants) included for reference (vsMCA, solid gray line).