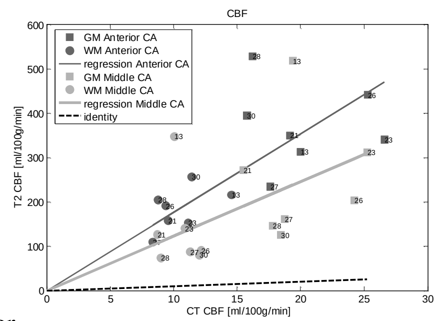
DSC-MRI perfusion imaging: which input function? – A comparison to CT perfusion imaging

I. K. Mikkelsen[1], D. Ziegelitz[2], B. F. Kjølby[1], G. Starck[3,4], A. Skimminge[5], M. T. Widmark[3], M. Tullberg[4], S. Holtås[6], and C. Wikkelsø[4]

[1]Centre for Functionally Integrative Neuroscience, Århus University, Århus, Denmark, [2]Sahlgrenska University Hospital, Göteborg, Sweden, [3]Dept of Medical Physics and Biomedical Engineering, Sahlgrenska University Hospital, Göteborg, Sweden, [4]Institution for Clinical Neuroscience, Göteborg University, Göteborg, Sweden, [5]Danish Research Centre for Magnetic Resonance, Copenhagen University Hospital, Hvidovre, Denmark, [6]Center for Medical Imaging and Physiology, MR division, Lund University Hospital, Lund, Sweden

Purpose: The choice of artery for input function (AIF) measurement in dynamic susceptibility contrast imaging (DSC-MRI) influences the cerebral blood flow estimates (CBF). The DSC-MRI has no simple correction scheme for partial volume effects, whereas this is easily corrected for with CT. This study investigates the correlation between DSC-MRI and CT perfusion values for typical CT and MR input functions.

Background: The MR signal during bolus passage of a paramagnetic contrast agent has no simple relationship to the contrast agent concentration: The arteries chosen for input functions are typically smaller than the voxel size (partial volume). Hence, the signal from such voxels depends on both the relaxation effect of the contrast agent in blood and in tissue which have been shown to differ [1,2]. Moreover, the artery causes field perturbations in the surrounding tissue, when the orientation of the vessel is not parallel to the main magnetic field (B0) [3]. Thus, the resulting shape of the AIF depends on vessel geometry, partial volume, and imaging parameters. In contrast, CT imaging provides a linear relationship between contrast concentration and signal change and partial volume effects are easily corrected for. Thus, the 4 slices measured with CT allow a sound comparison.



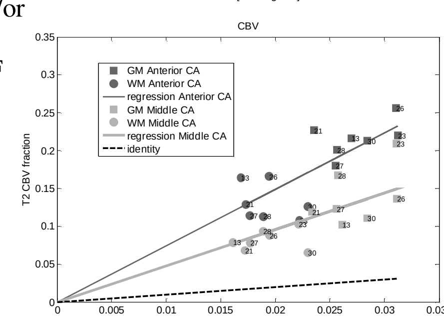
Methods: 7 healthy elderly subjects were scanned on two consecutive days at 10 Am on MR (Philips Intera 1.5T) and CT (GE, 16channel).

MR: GE sequence, TE=30ms ,TR=1s, matrix:128x128, 12 slices (4 slices analysed), sl=5mm. Gray (GM) and White matter (WM) ROIs were thresholded on a T1 map and aligned to bolus data. MR 'concentration' curves were calculated as $\Delta(1/T2^*)=-1/TE^*\ln(S(t)/S0)$, where S(t) is the measured signal, and S0 is the baseline signal.

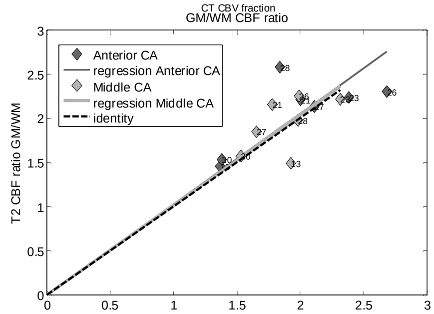
CT: TR=0.5s, matrix 512x512, 4 slices, sl=5mm. GM and WM was thresholded in average signal image. The CT concentration curves were calculated as C(t)=S(t)-S0.

The AIF was chosen in 1) ACA: branches of the anterior cerebral artery (pericallosal and/or callosomarginal artery), 2) MCA: the M2, M3 and /or M4 segments of the left middle cerebral artery as N pixels with highest peak concentration. $N_{CT}=35$. $N_{MR}=5$. The CT-AIF was rescaled to have same area under the curve as the venous curve (superior sagittal sinus).

The average concentration curves were calculated within GM and WM for each modality. Deconvolution with the AIF was performed with Gaussian Processes for Deconvolution [4], since it provides adaptive noise regularization. CBF was determined as peak of the deconvolved curve, which is the perfusion-weighted impulse response function. All calculations were performed in Matlab using a data-processing pipeline.



Results and discussion: The CBF for GM and WM shows slight correlation between CT and MR (fig 1). The MR CBF values are greatly overestimated as expected since no correction was performed for e.g. relaxivity differences between tissue and blood and partial volume. The correlation between CBV estimates is higher (fig 2) as expected, since the determination of an area under the impulse response function is less noise sensitive than the peak value used for CBF estimates. The ratio of CBF in GM to CBF in WM is independent on the specific area of the AIF, since it is the same scale factor for GM and WM. When the two modalities are compared (fig 3), the same correlation to CT is seen regardless of the choice of AIF. Moreover, the correlation lines fall on top of the identity line.



Conclusion: It is demonstrated that the correlation between DSC-MRI and CT are moderate for absolute CBF values whereas the correlation of the GM/WM CBF ratio between modalities follows the identity line. Absolute CBF measurement with DSC-MRI requires correction for partial volume effects: both direct effects of different T2* values in blood and tissue, and the secondary effect: the effect of field distortions that depends on vessel geometry. Partial volume is usually not corrected for in DSC-MRI even though sophisticated methods have been suggested [5,6].

The apparent correlation between GM/WM CBF ratios between CT and MR exists regardless of the input function chosen. Thus, this comparison study supports the current procedure for DSC-MRI perfusion estimation.

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