Absolute cerebral blood flow in normal volunteers: Correlation between CT-perfusion and dynamic susceptibility contrast MRI

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Introduction

Cerebral CT-perfusion and dynamic susceptibility contrast MRI (DSC-MRI) are in clinical practice already widely used, and quantitative perfusion parameters are often essential. CT-perfusion built on a direct and robust relation between signal and contrast and a smaller voxel size than other perfusion techniques, is generally considered to report perfusion values in absolute terms [1, 2]. DSC-MRI, however, still struggles to attain reproducible absolute quantification of cerebral blood flow (CBF) mainly due to partial volume effects (PVEs). PVEs influence the arterial concentration time curve (AIF) [3], causing overestimation of CBF. To improve the reproducibility of AIF registration in DSC-MRI, we rescaled the time integral by use of a venous output function according to a recently described method by Knutsson et al [4] at 3T. In order to access the accuracy of this method at 1.5 T, we compared absolute perfusion parameters obtained by DSC-MRI and CT-perfusion. Our hypothesis was that DSC-MRI- based CBF estimates, calculated using a rescaled AIF, would better correlate with CT-perfusion than DSC-MRI estimates, calculated without this approach.

Methods

CBF was measured in 21 elderly, healthy volunteers using CT-perfusion and DSC-MRI on two consecutive days at the same time of day. MR-perfusion was obtained with gradient-echo echo-planar imaging at 1.5 T. Two sets of parametric maps were created off line. The first set was calculated using a global AIF in the anterior cerebral artery (ACA) and a block-circulant matrix deconvolution [5]. For the second set, an alternative arterial concentration time integral estimate, rescaled by use of a venous output function, was implemented, while keeping all other variables constant. CT-perfusion was performed on a 16-channel multi detector array scanner. Perfusion CT data were analyzed on an Advantage Window workstation 4.1 (GE Medical Systems, USA) using the software program CT-perfusion 3 and an AIF placed in the ACA. From the MRI perfusion maps and images from the fluid-attenuated inversion recovery sequence, four sections were chosen, which best matched the CT-perfusion. A total of 32 regions of interest (ROIs) covered representative areas of white matter, central grey matter, as well as the whole brain, and were pooled for statistical analysis in SPSS 13.0. The mean CBF differences of CT-perfusion and DSC-MRI on one hand and CT-perfusion and rescaled DSC-MRI on the other hand were compared by paired samples t test. Linear regression analysis was used to evaluate the correlation of data sets. Significance was stated at $p \leq 0.05$.

Results

Table 1 shows the CBF estimates obtained by DSC-MRI and CT-perfusion for different anatomical regions. The mean CBF differences for all anatomical regions between CT-perfusion and DSC-MRI on one hand and CT-perfusion and rescaled DSC-MRI on the other hand were strongly significant. DSC-MRI-based CBF estimates, calculated without the venous sinus correction, did not result in a significant correlation with CT-perfusion in any of the anatomical regions. The corresponding CBF values, acquired by use of the rescaled AIF, showed a fair to moderate degree of correlation with CT-perfusion for the central grey matter (CBF_{CT}= 33.66+0.149 x $CBF_{rescaled\ DSC\text{-}MRI}$, R^2= 0.211, Figure 1) and for the whole brain (CBF_{CT}= 36.52+0.198 x $CBF_{rescaled\ DSC\text{-}MRI}$, R^2= 0.205).

CBF[ml/(min·100g)]	CT-perfusion	DSC-MRI	Rescaled DSC-MRI
White matter	13.41+/-2.47	50.73+/-18.36	24.99+/-10.73
Central grey matter	42.67+/-7.49	115.47+/-44.63	56.47+/-24.30
Whole brain	48.52+/-8.82	126.76+/-47.46	58.46+/-20.65

Table 1. Pooled cerebral blood flow estimates (mean +/- standard deviation) for 21 healthy, elderly subjects. Rescaled DSC-MRI is calculated by use of a venous sinus time integral correction approach.

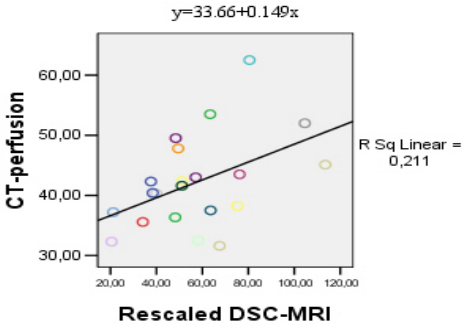

Figure1. Scatter plot for pooled central grey matter CBF estimates in 21 subjects. Rescaled DSC-MRI is calculated by use of a venous sinus time integral correction approach.

Discussion and conclusion

The grey matter and whole brain CBF estimates for CT-perfusion are within the range predicted by a previous PET study for this age group [6]. The CBF values for white matter are somewhat low, which might be due to a tissue inherent lower contrast-to-noise-ratio leading to lower accuracy. This might also explain the lack of significant correlation between CT-perfusion and DSC-MRI in white matter. When CBF values were not corrected for PVEs, no correlation was found between DSC-MRI and CT-based CBF estimates, calculated using commercially available software. CBF values for the whole brain and central grey matter, calculated with a partial volume corrected AIF, correlated fair to moderately with the CT-perfusion. Our CBF estimates, obtained by rescaled DSC-MRI, are considerably lower and closer to the normal range than the results from most previous 1.5 T DSC-MRI experiments. However, they are still higher than the corresponding results from CT-perfusion, which might reflect some remaining influence of the AIF by PVEs and other factors as for example differences in $\Delta R2^*$ between large vessels and tissue. Our results indicate that the used method for correction of PVEs in DSC-MRI experiments is a valid approach at 1.5T.

References

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