

Bayesian Estimation of Cerebral Perfusion Using a Reduced Contrast-dose Dynamic Susceptibility Contrast Perfusion at 3.0T

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Target audience: MR scientists, Neuroradiologists and Neurologists.

Background: Brain dynamic susceptibility contrast (DSC) perfusion has been increasingly used in conjunction with other enhanced applications such as contrast-enhanced MR angiography (CE-MRA) for evaluation of patients with acute stroke ¹ or with dynamic contrast enhanced (DCE) perfusion in evaluation of brain tumors ². Reducing the contrast dose in these combined multi-injection protocols seems logical to reduce the risk of nephrogenic systemic fibrosis and health care cost, however, the lower SNR can be limiting for accurate calculation of cerebral perfusion parameters ³. Bayesian probabilistic method ⁴, has been shown to be less sensitive to low SNR and has the potential for more accurate calculation of cerebral perfusion in low-dose protocols.

Purpose: The purpose of this study was to establish the feasibility of a reduced contrast-dose brain DSC perfusion using a probabilistic Bayesian method and compare the result with block-circulant singular value deconvolution (cSVD) that is used routinely in clinical practice.

Methods: In this prospective study, 20 patients (12M, 34-70y/o) who were referred for contrast enhanced brain MRI underwent 2 consecutive DSC-perfusion scans at 3T using two different doses of Gadolinium (Gd). A total of 0.1 and 0.05 mmol/kg of Gd was used for full-dose (FD) and half-dose (HD) scans which were performed 8 minutes apart. DSC perfusion was performed using a gradient-EPI sequence with identical sequence parameters (TR/TE: 1450/22 msec, FA 90°, matrix 128 mm, slices 30 x 4 mm, bandwidth 1500 Hz/pixel, GRAPPA x3). Using a FDA approved software (Olea Medical, La Ciotat, France), all DSC scans were processed with cSVD and Bayesian probabilistic method. Coregistered parametric maps of cerebral blood flow (CBF), cerebral blood volume (CBV) and mean transit time (MTT) from both FD and HD scans were analyzed for quantitative measurement along the middle cerebral artery distribution using a ROI-based analysis. The quantitative perfusion values between the cSVD and Bayesian methods in FD and HD groups were compared with regression analysis and un-paired t-test.

Results: The mean of SNR values was significantly ($p < 0.0001$) lower in the HD group (12.9) compared to FD group (20.1). Using Bayesian method, the mean of CBF (ml/100 g/min), CBV (ml/g) and MTT (sec) values in FD/HD group were 48.6/38.9 ($p=0.16$), 1.8/1.5 ($p=0.1$) and 3.6/3.4 ($p=0.9$) respectively. Using cSVD method, the mean of CBF (ml/100 g/min), CBV (ml/g) and MTT (sec) values in FD/HD group were 44/25 ($p < 0.0001$), 1.9/1.3 ($p=0.004$) and 4/5.2 ($p=0.01$) respectively. In FD scans, there was no statistically significant difference between Bayesian and cSVD for calculation of CBF ($P=0.52$), CBV ($p=0.61$) and MTT ($p=0.17$). In HD scans, there was statistically significant difference between Bayesian and cSVD for calculation of CBF ($P=0.009$), and MTT ($p=0.001$) but not for the CBV values ($p=0.14$).

Discussion: Although Bayesian compared equally to cSVD in FD scans, it outperformed cSVD in HD group where the SNR is lower by approximately 36%. The Bayesian method is less sensitive to low SNR and can result in acceptable quantitative measurement of cerebral perfusion identical to FD scans. Our results are in agreement with what is expected according to prior reported numerical simulation ⁴.

Conclusion: Reduced contrast-dose (0.05-mmol/kg) DSC perfusion of the brain is feasible at 3.0T using Bayesian probabilistic method with comparable quantitative results to 0.1 mmol/kg.

References:

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