Partial Volume Compensation for Improved Reliability of BBB permeability

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Introduction

BBB plays an important role in the patho-physiology of many CNS disorders. In the past, a number of laboratory techniques have been proposed to quantify permeability coefficient, k_i, an important index of barrier function. Recently, MRI [1] has been used to estimate k_i based on the graphical plot technique proposed by Patlak *et al*. This MR technique was found to be in good agreement with the gold standard QAR technique. However, reduced image SNR among other factors such as partial volume effect (PVE), did not allow reliable estimation of permeability coefficients. This proof-of-principle study evaluates the effect of Fractional Tissue Component (FTC) (FTC is defined as the percentage of a single tissue type contained in each pixel).on BBB permeability coefficient values using a simulation model and proposes a post-processing technique for PV compensation in order to obtain reliable permeability coefficient values.

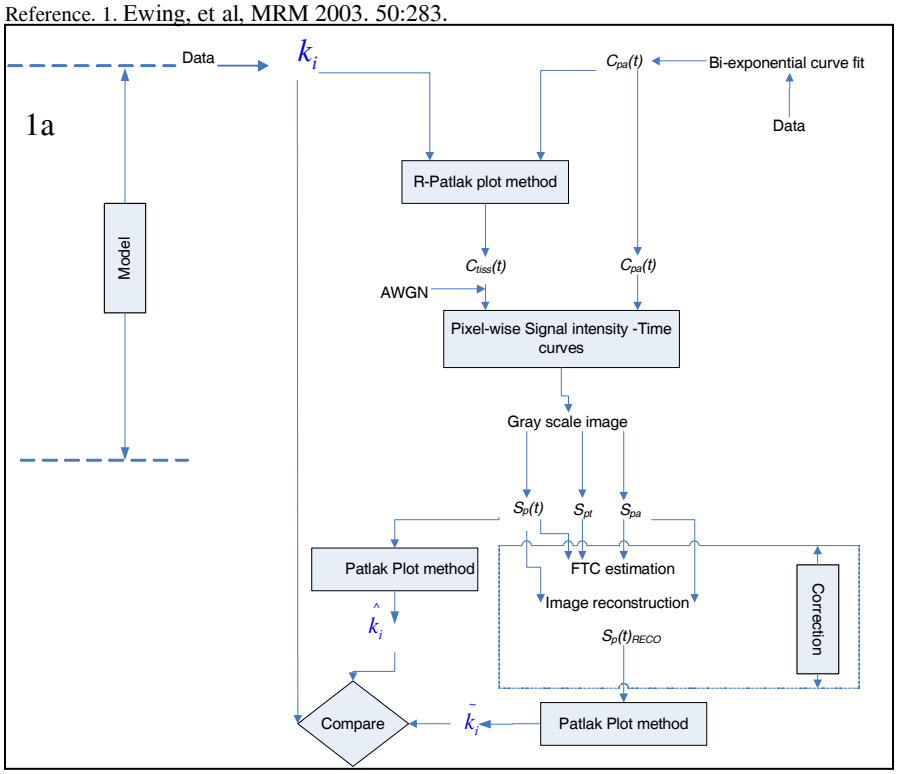
Materials and Methods

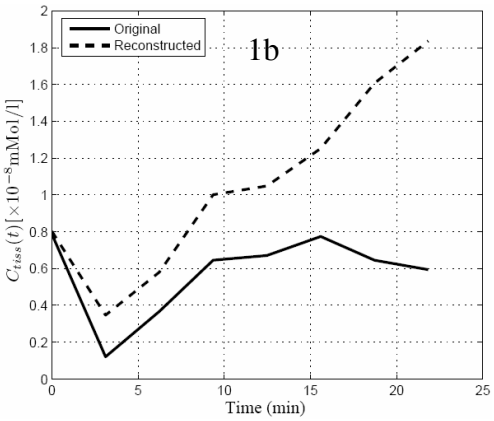
A computer simulation model is presented that evaluates the effect of FTC on permeability coefficient estimates. Beginning with a known k_i, a FTC compensation technique is proposed that aims at correcting calculated k_i to obtain the original estimate. The application of the FTC compensation technique is shown using a rat stroke brain model. MRI experiments were performed in Wistar rats (N=2) on a 4.7T Biospec MR system. After acquiring localizer images, T2 weighted, DWI images were acquired. Finally, a rapid T1 mapping protocol was implemented to acquire one pre-Gad-DTPA baseline data set followed by post injection data sets at 3-minute interval for 45 minutes. Information obtained from the Gad-DTPA distribution is fitted to a linear equation, representing a model of unidirectional tracer kinetics in one compartment. The slope of the straight line fit to the time-series data is an estimate of tissue permeability, Data was post processed without and with application of PV compensation technique to obtain an estimate of k_i.

Results and Discussion

The findings of the simulation experiments agree well with the results obtained from MR experiments. Simulation experiments have provided useful insight into the effect due to FTC on permeability coefficient estimate. Results from the MR experiments suggest that it may be important to perform FTC compensation in order to improve the reliability of permeability coefficient estimates. Future work involves classification of tissue component into gray, white matter and CSF, to improve the accuracy of the compensation technique and to investigate repeatability of the technique in a larger group of animals.

Reference. 1. Ewing, et al, MRM 2003. 50:283.





Figures. (1a.) Schematic showing the partial volume simulation and correction model used in this study. (1b.) Shows TAC for Gad-DTPA in a pixel containing tissue and plasma components. The bold and dashed line represents uncompensated and compensated TAC. By compensating for the TAC, PV compensated reliable permeability coefficient values can be obtained.