Water Exchange Effect in Dynamic Contrast Enhanced MRI Pharmacokinetic Modeling

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Dynamic Contrast Enhanced (DCE) MRI has long been recognized for its potentials in investigating vascular properties *in vivo*. The information-rich DCE-MRI method, with its multiple acquisitions during contrast reagent (CR) passage, can lead to insights of vascular properties that are not available with conventional static MR images. For *in vivo* applications, the time-course of the image contrast change, and thus the DCE-MRI signature, is achieved through the CR's ability to alter the longitudinal relaxation time constants (T_1) of the ^1H_2O signals from particular tissue compartments, while leaving some others almost unchanged. This indicates that intercompartmental transport of water (water exchange) will play a profound role in DCE-MRI pharmacokinetic data analysis.

In clinical DCE-MRI applications, due to the tradeoff among spatial coverage, signal to noise ratio (SNR), and spatiotemporal resolution requirements, most DCE-MRI data are often acquired at conditions that are not water exchange sensitive. Exchange minimized approach was proposed to further aid model simplification. Thus, generalized DCE-MRI pharmacokinetic models used in the field intrinsically assumes fast water exchange [1, 2]. This fast water exchange limit (FXL) has two major implications: 1) DCE-MRI behaves like a nuclear medicine tracer; 2) all *in vivo* compartments are granted equal status for their contributions to overall signal change. With a rather flexible and resourceful MRI acquisition technique, neither these two implications may hold for all applications. Furthermore, the exchange minimized approach commonly required for FXL often comes with a severe SNR penalty.

Using a recently developed 3-site water exchange model [3] based on the most commonly used gradient echo acquisitions for DCE-MRI, we demonstrate the implications of water exchange on DCE-MRI pharmacokinetic modeling. Although both water exchange (transendothelial and transcytolemmal) and CR trans-capillary kinetics should remain relatively constant during a DCE-MRI study, the sensitivity of DCE-MRI acquisition to water exchange actually varies with imaging sequence parameters (repetition time, flip angle), tissue of interest (FDA approved Gadolinium based CRs can be considered total intravascular for normal brain but totally extracellular for leaky tumor), and/or CR dose. Precision and accuracy of model parameters at some different water exchange regimes will be discussed.

References:

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