Assessment of Physiological Parameters Estimated by DCE MRI with Delayed or Dispersed Arterial Input Function

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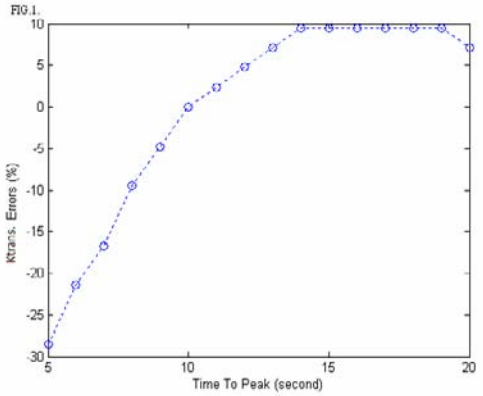
Introduction

T1-weighted dynamic contrast-enhanced MR imaging (DCE-MRI) has emerged as a promising tool for diagnosis and prognosis of cancer due to its ability for quantitative imaging of tumor vascularity. Quantitative parameters related to physiological processes, e.g. K^{trans} (volume transfer constant), can be obtained through kinetic model analysis by iterative fitting of a model function with physiology-based parameters. However, the main challenge associated with kinetic modeling analysis is the need of an arterial input function (AIF). To alleviate the invasive acquisition of the AIF, model based input functions are often used. This study is aimed to evaluate the influences of inaccurate arterial input function to the physiological parameters derived from kinetic model of DCE-MRI. Thirty-nine conditions, including different combinations of SNRs, delay times, and dispersed shapes of AIF, of each with 1000 noise trials, were simulated to estimate physiological parameters of K^{trans} (volume transfer constant), *Vp* (capillary plasma volume), and *Ve* (interstitial volume) in a tracer-kinetic model, based on concentration time curves derived from an ideal AIF.

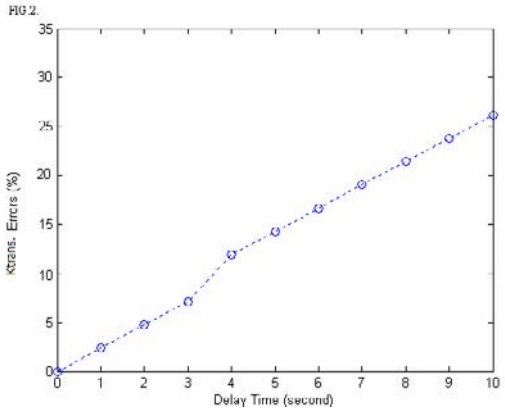
Methods

The arterial input function (AIF) was simulated as a time-dependent function with parameters of delay time, and time-to-peak (*tp*) to describe the dispersed shapes of AIF [2]. The Gaussian noise model was assumed [3]. The signal-to-time course was simulated with a spin echo sequence with repetition time (TR) of 1 second, echo time (TE) of 22.7ms [4], and baseline signal of 1000, along with an ideal AIF with values of 100, 10 sec, and 10 sec for SNR, *tp*, and delay time, respectively . The underlying kinetic parameters of K^{trans}, *Vp*, and *Ve* based on breast cancer physiological conditions [1] were used in the concentration curve simulation. Different combinations of SNR (5~100), *tp* (5~20sec), and delay time (0~10sec) were simulated to generate non-ideal AIF's of total 39 conditions. Then each simulated AIF was used to estimate the kinetic parameters [1] from fitting the above simulated concentration curve data using least-square method. The mean values, standard deviations, coefficient of variation and error percentage of estimated K^{trans}, *Vp*, and *Ve* were calculated. However, only results of K^{trans} were shown here.



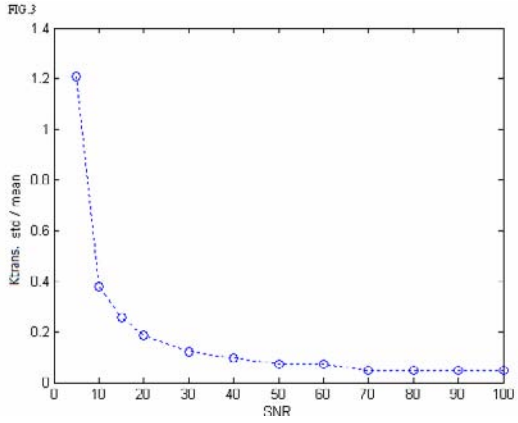
Results

The percentage errors of K^{trans} vs. time-to-peak were plotted in Fig. 1 with -30% to 10% estimation error associated with negative to positive AIF curve dispersion. Figure 2 shows the relationship of percentage errors of K^{trans} to delay times, while Fig.3 plots the CV of K^{trans} with varying SNR. Interestingly, the percentage errors increase linearly with delay times, and there is significant CV in lower SNR.



Discussion

As expected, the estimation of kinetic parameter K^{trans} is influenced by the AIF model. The preliminary results show over 40% of CV in lower SNR, and -30% to 10% errors from incorrect dispersion of AIF, while errors increase linearly with delay times. The preliminary results suggest that care must be taken in using non-invasive or model-based AIF in the kinetic model analysis. Future work will include phantom study using real DCE-MRI data acquisition, as well as the effects of other related parameters.



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