Dynamic Contrast Enhanced MRI Parameters Independent of Baseline T1 Values

J. Guo[1], and W. E. Reddick[1]

[1]Radiological Sciences, St. Jude Children's Research Hospital, memphis, TN, United States

Introduction

DCE MRI is a valuable technique for cancer diagnosis and accessing treatment efficacy. However, the repeatability of the DCE-MRI results hinders its further clinical application. The baseline T_1 is one of the key factors which could affect the accuracy and repeatability of pharmacokinetic parameters. When T_1 measurements are not available for some examinations in large human studies due to occasional motion or acquisition error, a T_1 value has to be assumed to calculate kinetic parameters. In this abstract, we investigated how errors in the assumed T_1 affect the estimation of kinetic parameters and which kinetic parameters were less sensitive to these errors in T_1.

Method

In simulations, an arterial input function (AIF) was created according to the experimentally-derived functional form [1]. The tissue enhancement curves (TEC) were then derived based on Tofts' two-compartment model [2] using different K^{trans} and v_e values. These tissue enhancement curves were converted to signal intensity curves according to the gradient echo signal equation using an assumed true T_1 (800 ms). After that, signal curves were converted back to TEC using the different assumed T_1s. Different kinetic parameters (K^{trans}, k_{ep}, v_e, and IAUC) were calculated using these new created TECs.

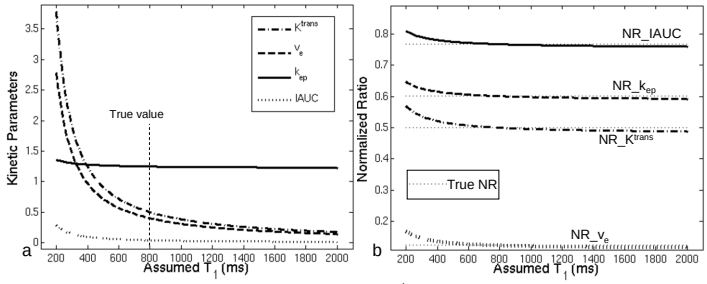

Fig. 1 (a) Plots of Kinetic parameters (K^{trans}, v_e, k_{ep}, IAUC) vs. assumed baseline T_1 when a true T_1=800 ms with K^{trans} = 0.5min^{-1}, IAUC = 0.039 M·s, k_{ep} = 1.25 min^{-1}, and ve = 0.4. (b) Plots of the normalized ratios (NR) of IAUC, k_{ep}, K^{trans} and v_e. True NRs are 0.77, 0.6, 0.5 and 0.125, respectively. The same true T_1 (800 ms) was assumed for both pre- and post-treatment.

In longitudinal studies, a normalized ratio of a parameter can be defined as

$$NR = \frac{P^{pre} - P^{post}}{P^{pre}} \qquad (1)$$

Where P represents those kinetic parameters and superscripts represent pre- and post-treatment. First, NRs were calculated using different assumed T_1s for two same true T_1s for pre- and post-treatment. Second, NRs were calculated using different assumed T_1s for two different true T_1s for pre- and post-treatment.

In human study, DCE-MRI data from a pediatric patient with Osteosarcoma treated on a phase II trial of multi-agent chemotherapy acquired previously were utilized. Single slice DCE MRI data were acquired using a 2D FLASH pulse sequence with the protocols: TR/TE=23/10 ms, 40° flip angle, xres/yres = 256/256, 10 mm thickness, 2 acquisitions. Each measurement time was 13 second for total 30 measurements. Kinetic parameters and the corresponding NRs were calculated using the measuredT_1 and an assumed T_1.

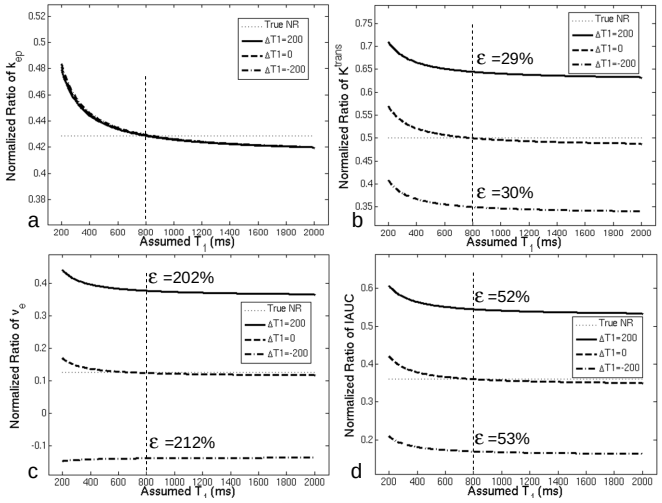

Fig. 2. Effects caused by the change of baseline T_1 due to the treatment. Plots of the normalized ratios (NR) of k_{ep} (a), K^{trans} (b), v_e (c) and IAUC (d) with different pre- and post-treatment baseline T_1 values. True NRs are 0.429, 0.5, 0.125 and 0.36, respectively. The change of baseline T_1 between pre- and post-treatment is calculated as $\Delta T_1 = T_1\_pre - T_1\_post$. The true T_1 (=800 ms) was assumed for pre-treatment. ε represents the percentage error at 800 ms.

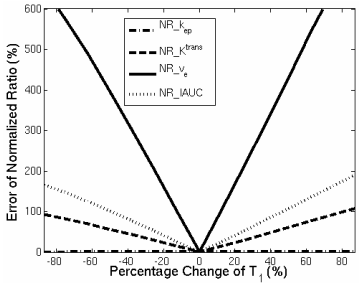

Fig. 3 Plots of the error of NRs vs. percentage change of T_1. The true T1_pre is fixed to 800 ms. The percentage is equal to (T_1_pre-T_1_post)/T_1_pre.

Results

Fig. 1a shows that three of four kinetic parameters except k_{ep} were highly dependent on the assumed T_1. Fig. 1b shows that four NRs were almost independent of the assumed T_1 when true T_1s for pre- and post-treatment were the same. Fig. 2 shows that three of four NRs except NR of k_{ep} were dramatically affected by the difference of two true T_1 values according to the simulation. Fig. 3 shows the error dependence of NRs on percentage change of T_1. Fig. 4 shows that in vivo results were consistent with those shown in Fig. 2 and 3.

Conclusion

In summary, k_{ep} and its NR are approximately independent of the absolute baseline T_1 value and their difference between pre- and post-treatment. The other kinetic parameters and their NR have to be carefully used when the baseline T_1 measurement is not available or not accurate. Based on our results, we would recommend using k_{ep} as the pharmacokinetic parameter of choice for both cross-sectional and longitudinal clinical studies.

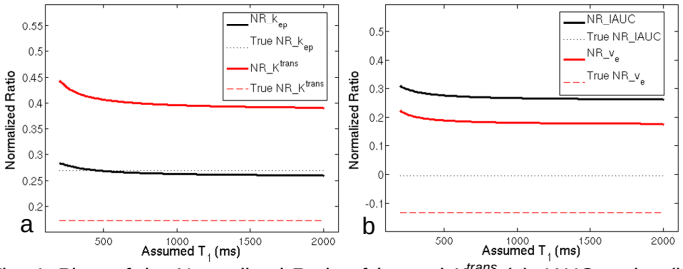

Fig. 4. Plots of the Normalized Ratio of k_{ep} and K^{trans} (a), IAUC and v_e (b) for a pediatric patient treated for OS. All parameters were calculated with the same assumed T_1 for pre- and post-treatment in comparison with true NR using measured T_1.

Reference

1. Parker GJ, et. al. Magn Reson Med 2006;56(5):993-1000.
2. Tofts PS, et. al. Magn Reson Med 1991;17(2): 357-367.