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 \( k^{\text{trans}} \) 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 \( T_1 \)s. Different kinetic parameters (\( k^{\text{trans}} \), \( k_{\text{ep}} \), \( v_e \) and IAUC) were calculated using these new created TECs.

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

\[
NR = \frac{P_{\text{post}} - P_{\text{pre}}}{P_{\text{pre}}}.
\]

Where \( P \) represents those kinetic parameters and superscripts represent pre- and post-treatment. First, NRs were calculated using different assumed \( T_1 \)s for two same true \( T_1 \)s for pre- and post-treatment. Second, NRs were calculated using different assumed \( T_1 \)s for two different true \( T_1 \)s 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 measured \( T_1 \) and an assumed \( T_1 \).

Results

Fig. 1a shows that three of four kinetic parameters except \( k_{\text{ep}} \) were highly dependent on the assumed \( T_1 \). Fig. 1b shows that four NRs were almost independent of the assumed \( T_1 \) when true \( T_1 \)s for pre- and post-treatment were the same. Fig. 2 shows that three of four NRs except NR of \( k_{\text{ep}} \) 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, \( k_{\text{ep}} \) 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 \( k_{\text{ep}} \) as the pharmacokinetic parameter of choice for both cross-sectional and longitudinal clinical studies.

Reference