Effect of Chemical Exchange on T1 Values Calculated using DESPOT1

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INTRODUCTION: The DESPOT1[1,2] (Driven Equilibrium Single Pulse Observation of T_1) T_1 mapping method derives T_1 from a series of spoiled steady-state free precession (SPGR) images acquired with constant repetition time, *TR,* and incremented flip angle, α. A limitation of the method, however, is the assumption of single T_1 relaxation within each voxel. Though not commonly considered, it is reasonable to believe that the myelin-bound and intra and extracellular water compartments in white and grey matter that give rise to distinguishable T_2 values[3] will also yield discernible T_1 values. To date, however, only a handful of reports have demonstrated multi-component T_1 relaxation *in vivo*[4,5]. Here we use simulations to investigate the effect of 2-component T_1 relaxation and chemical exchange on the single-component, '*apparent*' T_1 values derived with DESPOT1 and examine the influence of experimental parameters. Further, we compare the DESPOT1 values with those expected to be measured using a conventional inversion-recovery (IR) approach.

METHODS: The effect of chemical exchange (between *a* and *b*) on the SPGR signal has been considered previously[6], with the measured signal given by, $SPGR_2 = \dfrac{A^{-1}C(1-e^{A\bullet TR})\sin\alpha}{1-e^{A\bullet TR}\cos\alpha}$, where $A = \begin{bmatrix} -1/T_{1,a}-k_{ab} & k_{ba} \\ k_{ab} & -1/T_{1,b}-k_{ba} \end{bmatrix}$, $C = M_o\begin{bmatrix} f_a/T_{1,a} \\ f_b/T_{1,b} \end{bmatrix}$, k_{ab} and k_{ba} are the governing exchange rates, and f_i is the volume fraction of component *i.* To investigate the effect of exchange on DESPOT1, a series of simulations were performed. In the first, T_1 values were calculated from successively incremented dual angle data (α_1, α_2), with the two angles separated by 5° and α_1 from 1° to 25°. In the second simulation, $SPGR_2$ data were generated at α = 1° to 30° over the *TR* range 3ms to 50ms with *apparent* T_1 values calculated using conventional DESPOT1 processing[1,2]. Finally, $SPGR_2$ data were generated at α = 1° to 30° and *TR* = 5ms while f_a was varied from 0% to 100%. These values were compared with volume-averaged T_1 values determined as $T_1 = f_aT_{1,a} + f_bT_{1,b}$. For all simulations, $T_{1,a}$=350ms, $T_{1,b}$=1200ms, f_a=0.2, and $k_{ab} = k_{ba} = 0.002ms^{-1}$ [5].

RESULTS / DISCUSSION: Figs. 1 and 2 contain the results of our simulations investigating the influence of flip angle combination and *TR* on the *apparent* DESPOT1 T_1 values. Figure 3 shows a comparison of DESPOT1 and volume-averaged T_1 values.

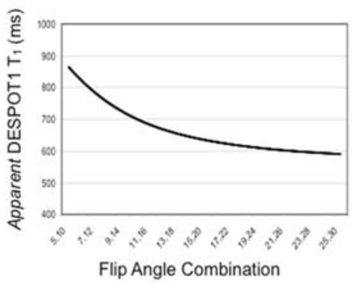

Figure 1: Impact of flip angle combination on DESPOT1 T_1 values.

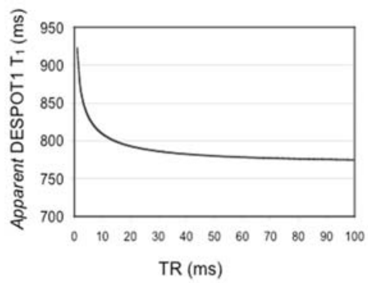

Figure 2: Effect of TR on DESPOT1 T_1 values.

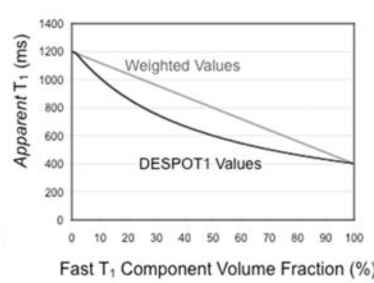

Figure 3: Comparison of DESPOT1 and volume-weighted T_1 values.

In the presence of exchange, DESPOT1 shows high sensitivity to both flip angle combination (Fig. 1).and *TR* (Fig. 2. A decrease in apparent T_1 is noted as the flip angle pair is increased and, likewise, as *TR* is increased. A comparison of DESPOT1 and volume-weighted T_1 values (as would be anticipated to be measured using an inversion-recovery approach), Fig. 3, shows a general underestimation of the DESPOT1 values, suggestive of an increased sensitivity of the DESPOT1 method to fast T_1 components.

CONCLUSION: In the presence of 2-component exchange, the general DESPOT1 processing approach provides *apparent* T_1 values which are, in general, more heavily biased towards the short T_1 component than corresponding values expected from IR approaches. Further, sensitivity to acquisition parameters has also been shown, suggesting that care should be taken in parameter choice to ensure repeatable results. The observed increased sensitivity to short T_1 components may be advantageous for imaging applications focused on myelin degeneration or brain maturation.

REFERENCES: [1] Christensen KA *et al.* J Phys Chem 78:1971-1977 (1974), [2] Deoni SCL *et al.* MRM 46:515-526 (2003), [3] Whittal K *et al.* MRM 37:34-43 (1997), [4] Does M et al. MRI 16:1033-1041 (1998), [5] Kreis R *et al.* Proc. SMRM 1963 (1992), [6] Spencer RGS *et al.* JMR 84:223-235 (1989).