Fast blood T1 measurement in children and adults

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Introduction: An accurate estimate of the T_1 of blood is necessary for reliable quantification of perfusion with arterial spin labelling (ASL) methods. Knowledge of the blood T_1 is particularly important for ASL studies in young children, where the decreased hematocrit and increased T_1 relative to typical adult values may lead to an overestimate of the perfusion. Recently, several fast T_1 mapping methods have been introduced which can be used to estimate the blood T_1 in vivo,[1,2] but most of these methods require specialist pulse sequences, and to date blood T_1 values have not been reported in vivo for neonates or children younger than 7 years. Here we evaluate a fast T_1 mapping protocol based on the variable flip angle, spoiled gradient echo method.[3-5] This protocol was tested in a group of 18 subjects, ranging in age from 7 weeks to 64 years, and the age dependence of the blood T_1 values was assessed.

Methods: The subject group consisted of 8 adults (4 male, age range 26-64) and 10 children (5 male, age range 7 weeks – 15 years), including four preterm neonates scanned approximately at term-equivalent age. Imaging studies were performed with a 3T GE HD.xt TwinSpeed MRI scanner (GE Medical Systems, Milwaukee, WI, USA), using an 8-channel receive-only head coil with a quadrature body transmit coil. Variable flip angle spoiled gradient-recalled echo (SPGR) images were acquired with a 3D fast sagittal SPGR protocol, with TE/TR = 1.6/5.5 ms, slice thickness = 2mm (interpolated to 1mm with ZIP2), matrix = 256x192, asset factor = 2, Nex=1, FOV 24 cm.[3,4] For each subject, three SPGR volumes were acquired with flip angles of 2, 10, and 20 degrees, with identical gain and shim settings. Each volume took approximately 30 seconds to acquire, resulting in a total scan time of 90 seconds. From the linearised SPGR signal equation, the T_1 was calculated from a linear regression of $S_i/\sin(\alpha_i)$ vs $S_i/\tan(\alpha_i)$ where S_i represents the SPGR signal measurements for a given flip angle α_i, and the T_1 is given by $T_1 = -TR/\ln(m)$, where m is the slope of the regression line.[3-5] For n=14 subjects the average T_1 for each subject was derived by discarding the minimum and maximum T_1 values from four regions of interest (ROIs) in the jugular veins and averaging the T_1 values for the remaining two regions. For the 4 neonates, the T_1 blood values were calculated from the average of the two median T_1 values derived from four ROIs in the transverse and sagittal sinuses.

Results: The mean T_1 measured for the 8 adults was 1600 ms, and the mean T1 for the neonates was 2130 ms. The blood T_1 values decreased by approximately 9 ms each year over the age range 0-64 years, but this decrease was most pronounced in the first six months of age and appeared to approach adult values by age 15, in keeping with the age dependence of hematocrit values reported previously.[6,7] The T_1 values measured over the age range 7-39 years are also consistent with those observed with a multiphase IR-prepared, balanced SSFP method.[1]

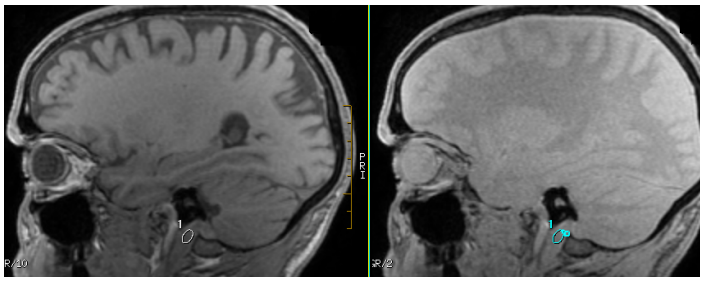

Figure 1. Representative SPGR images acquired with flip angles of 10 degrees (left) and 2 degrees (right). An example ROI is shown in the jugular vein.

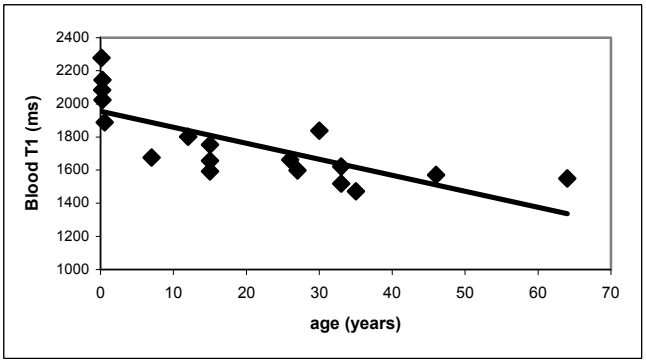

Figure 2. Age dependence of the blood T1 values.

Discussion: These results demonstrate that fast blood T_1 measurements can be reliably performed in young children, using a standard 3D SPGR sequence with multiple flip angles. While this method does not account for B_1 inhomogeneity effects, the T_1 values estimated using this protocol are in good agreement with those derived using inversion recovery or SSFP methods,[1] and the relative differences in blood T_1 with age are consistent with the range in hematocrit values reported over a comparable age range.[6,7] This protocol also offers the advantage of wide availability on any scanner, as it does not require implementation of a specialist pulse sequence.

References: [1]Wu WC et al. *MRM* 64: 1140-1147 (2010), [2]Qin Q and van Zijl PC. *Proc ISMRM* 17 (2009), 3624. [3]Cheng HM and Wright GA. *MRM* 55:566–574 (2006), [4]Cheng HM. *JMRI* 25:1073–1078 (2007), [5]Deoni SC et al. *MRM* 49:515-526 (2003). [6]Jopling J et al. *Pediatrics* 123:e333-e337 (2009), [7]Yip R et al. *Am J Clin Nutrition* 39:427-436 (1984).