# In vivo blood T1 measurements at different field strengths: How much do we gain in ASL by moving to higher field strengths?

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**Introduction:** The longitudinal relaxation time ($T_1$) determines how fast the endogenous tracer of arterial spin labeling decays and is therefore one of the main determinants of the SNR of the resulting perfusion map. In addition, the blood $T_1$ is an important parameter for the calculation of quantitative CBF values and an accurate value is required for quantitative CBV measurements using the VASO technique. It is well-known that the blood $T_1$ increases with magnetic field strength and this is one reason why 7T MRI is very promising for ASL-applications. However, only a single *in vivo* study has so far provided measurements of $T_{1,\,blood}$ at 7 Tesla and this value (2600ms, [1]) was much higher than earlier ex-vitro measurements (2212ms, [2]). To be able to estimate the expected gain in SNR of ASL by moving to 7T, we have measured the $T_1$ of blood in the sagittal sinus at 7T and compared it to measurements at 1.5 and 3T.

**Materials and Methods:** Six healthy volunteers were scanned at 1.5T, 3T and 7T MRI scanners(Philips Healthcare) using a 32ch (3 and 7T) and 15ch (1.5T) head coil. Measurement of $T_{1,\,blood}$ was performed with the technique as proposed by Varela *et al* [3]. This sequence starts with a non-selective 180° inversion pulse followed by a slice-selective Look-Locker EPI readout (Fig.1). The following parameters were used: LL-EPI: $\alpha_{LL}$=95°; slice thickness: 2mm; voxel size: 1.5mm×1.5mm; TR= 10s (20s at 7T); SENSE-factor: 3.5 (3 and 7T )and 3 (1.5T); NSA: 6; first TI=190ms; ΔTI=150ms, nTI=60. The Nelder-Mead search method (function fminsearch, MATLAB, The MathWorks) was employed to obtain the blood T1 estimation by fitting the signal of each voxel as a function of three parameters ($M_0$, offset and $T_{1,\,blood}$):

$$M(TI)=abs(M_0*[1-2*e^{-\frac{offset+firstTI+(nTI-1)*\Delta TI}{T1,blood}}])$$

The offset was included in the model to correct for possible imperfect inversion efficiency.

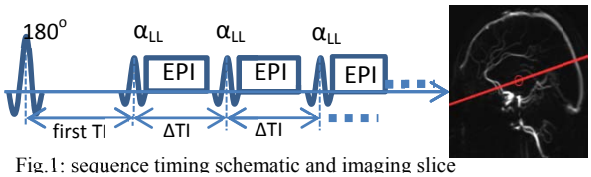


Fig.1: sequence timing schematic and imaging slice

**Results and Discussions:** Fig.2.a shows all the $T_{1,\,blood}$ values obtained from the six subjects at the three different field strengths. In every subject a clear increase in $T_{1,blood}$ could be appreciated for higher magnetic field strengths. Blood $T_1$ at 1.5T ranged from 1427ms to 1556ms with a population mean of 1480ms± 61ms . This is in agreement with previous studies[4]. $T_{1,blood}$ at 3T ranged from 1580ms to 1733ms with a population mean of 1649ms± 70ms, also in excellent agreement with ex-vitro measurement[6]. At 7T these values varied between 1864ms and 2254ms with a population mean of 2087ms±130ms. Our results in this study show that the relation of the longitudinal relaxation time $T_1$ and the field strength $B_0$ is approximately linear (Fig.2.c): $T_{1,\,blood}$ =110.2ms/T * B0+1316.2ms ($R^2$=1), which is in agreement with ex-vitro measurements ([2]). Furthermore, it can be observed that the $T_{1,\,blood}$ of female subjects are consistently higher than those of male subjects (Fig.2.b). This finding can be explained by the on average higher hematocrit in males[5].

Compared to the study of Rooney *et al*[1], this study shows a shorter $T_{1,\,blood}$ which implies that the anticipated gain in SNR for ASL scans by going to 7T is 20% smaller than that which could be expected based on Rooney's measurements. This lower value can be explained by the use of a specialized sequence for blood $T_1$ measurements in this study that employs 95° flip angles for the Look-Locker EPI readout, which leads to suppression of background signal and thereby elimination of partial volume effects with CSF.

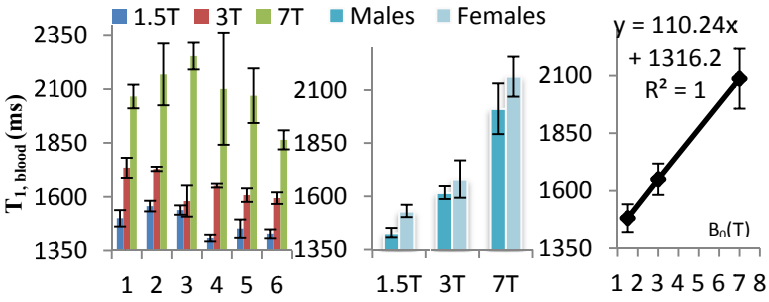


Fig.2: a): Blood T1 of each volunteers at three different field strengths. Subject 1-3 are females, 4-6 are males. b): Population average of $T_{1,\,blood}$ showing higher values for females than males. c): Blood $T_1$ as a function of the magnetic field strength showing a linear increase.

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