# The Effect of Lung Inflation on the $T_2^*$ of $^{129}Xe$ in the Human Lungs at 1.5 T and 3 T

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**Introduction:** The $T_2^*$ of gas in the lungs is largely affected by magnetic field inhomogoneity at tissue/air interfaces with a bulk susceptibility difference of $\Delta\chi \approx 9$ ppm.[1] Experiments in human lungs at 1.5 T have shown that the $T_2^*$ of $^3He$ is about 60% larger during inspiration compared to at expiration.[2] The aim of this work was to investigate the influence of lung inflation level on the $T_2^*$ of inhaled $^{129}Xe$ in the human lungs at 1.5 T and 3 T.

**Materials and Methods:**

Experiments were performed on whole-body clinical MR systems, a 1.5 T Signa HDx (GE, Milwaukee, WI, USA) and a 3 T Philips Achieva (Best, Netherlands). Flexible twin Helmholtz quadrature transmit-receive coils (CMRS, USA) were used at both field strengths. $^{129}Xe$ was polarised by Rubidium (Rb) spin exchange using a homebuilt regulatory-approved polariser system.[3] After 30-40 minutes accumulation, the frozen xenon was then sublimated and collected in 300 mℓ doses in a 1 ℓ Tedlar bag which was filled up with medical grade $N_2$ gas. The typical polarisation of the gas after thawing was 14%.[4] An interleaved dual echo time 2D spoiled gradient echo pulse-sequence was used for $T_2^*$ measurement.[5] Sequence parameters were 6 coronal slices of 30 mm thickness covering the whole lung, FOV of 38.4 cm, 64 x 64 matrix, BW 8 kHz, flip angle 7°. $TE_1/TE_2$ used at 1.5 T were 2.9 ms/18 ms, $TE_1/TE_2$ used at 3 T were 4.4 ms/ 11 ms. For the first scan, the volunteer was asked to inhale the 1 ℓ bag of $^{129}Xe$ gas from a state of full expiration and hold his breath after inhalation **(Fig. 1 (a))**. In the second scan, the volunteer was asked to top up to total lung capacity by inspiration of room air after the bag inhalation **(Fig. 1 (b))**.

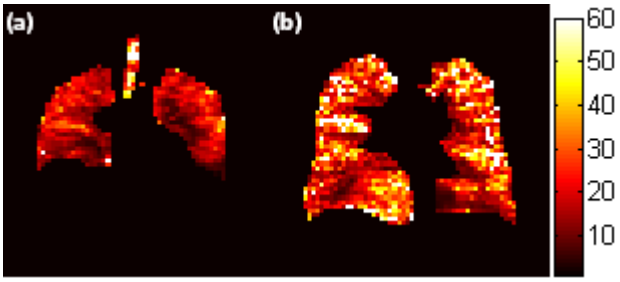


***Figure 1.*** *$T_2^*$ maps of a single slice of a healthy volunteer (41 years old, 88 kg) in ms at 3 T at FRV + 1ℓ (a) and TLC (b).*

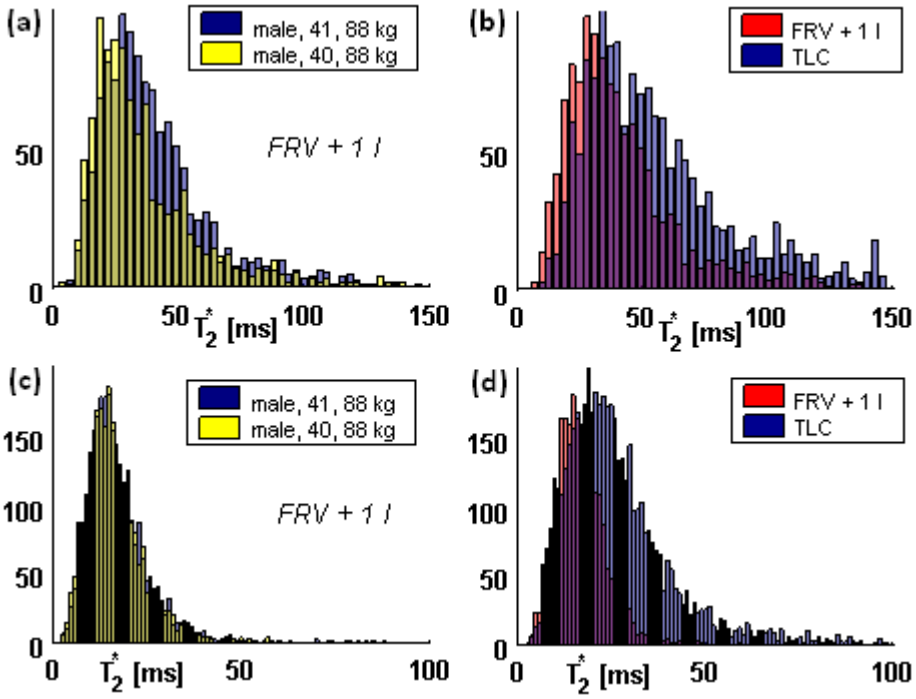


***Figure 2.*** *The distribution of $T_2^*$ of two healthy volunteers (40 years old , 88 kg; 41 years old, 88 kg) as measured from all coronal lung slices with hyperpolarised $^{129}Xe$ at $B_0$ field strengths of **1.5 T (a)** and **3 T (c)** showing reproducibility at FRV + 1 ℓ; as well as the distribution of $T_2^*$ while imaging at forced residual volume (FRV) +1 ℓ and total lung capacity (TLC) as measured from all coronal slices at $B_0$ field strengths of **1.5 T (b)** and **3 T (d)** of one healthy volunteer (41 years old, 88 kg).*

**Results and Discussion:** $T_2^*$ histograms from all slices from both volunteers from the first scan (forced residual volume (FRV) + 1 ℓ), (40 years old male, 88 kg, 41 years old male, 88 kg) are shown in **Fig. 2 ((a) and (c))** with median values of 25 ± 13 ms and 18 ± 6 ms at 1.5 T and 3 T, respectively, showing reproducibility. The uncertainty was measured as the FWHM of the histogram. These values are shorter than the only other previously reported values in the conference literature[6]; however, the results from the measurements at TLC coincide with ref. [6] with median values of 52 ± 20 ms and 24 ± 11 ms at 1.5 T and 3 T, respectively. This is shown in **Fig. 2 ((b) and (d))** as histograms of all slices, indicating a dependence of the transverse relaxation constant $T_2^*$ on lung inflation volume, which has previously been observed with $^3He$.[1] In this state of inflation, $^{129}Xe$ in the lungs also demonstrates a pseudo-static dephasing regime, with linear dependence of relaxation rate on $B_0$ as observed for $^3He$[5]. **Conclusion:** In this study, the transverse relaxation time, $T_2^*$ of inhaled $^{129}Xe$ gas was demonstrated to be dependent upon lung inflation level, with a stronger dependence at the higher field strength of 3 T. This is as expected given the stronger field inhomogoneity at higher $B_0$. The strong dependence of $T_2$* on inflation at 3T suggest that it could be a quantitative metric of alveolar geometry in emphysema. Even though imaging with the lungs at TLC incurs a SNR loss though gas dilution, the longer $T_2^*$ potentially counters this effect by enabling a narrower bandwidth, which can lead to higher SNR, as predicted by theory.[7]

**References:** [1]Chen et al,. MRM. 42(4):729-737 (1999); [2]Deppe et al,. Proceedings to ISMRM, Stockholm, Sweden (2010); [3]Parnell et al,. JAP 108:064908 (2010). [4]Norquay et al, Proceedings to British Chapter ISMRM, Manchester (2011); [5]Deppe et al,. JMRI 30(2):418-423 (2009); [6]Mugler,III,et al,. Proceedings to ISMRM. Hawaii,US (2009). [7]Parra-Robles et al,. Med Phys 32(1):221-229 (2005). ***Acknowledgements**: EPSRC. EP/D070252/1. (1)*