Hyperpolarised ^{129}Xe gas lung MRI – B_0 field strength comparisons at 1.5 T and 3 T

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Introduction: Signal-to-noise ratio (SNR) in hyperpolarised MRI is less dependent upon static magnetic field strength, B_0, due to the B_0-independent polarization.[1] Unlike conventional thermally polarised MRI, where, in a sample noise dominated regime, the SNR increases with increased B_0, the effect of B_0 is less important for hyperpolarised nuclei. The aim of this study was to perform systematic experiments at the clinically relevant field strengths of 1.5 T and 3 T to compare the SNR of inhaled hyperpolarised ^{129}Xe lung MRI using radiofrequency (RF) coils of the same geometrical design. SNR and T_2^* were measured using ventilation images of healthy volunteers at both field strengths.

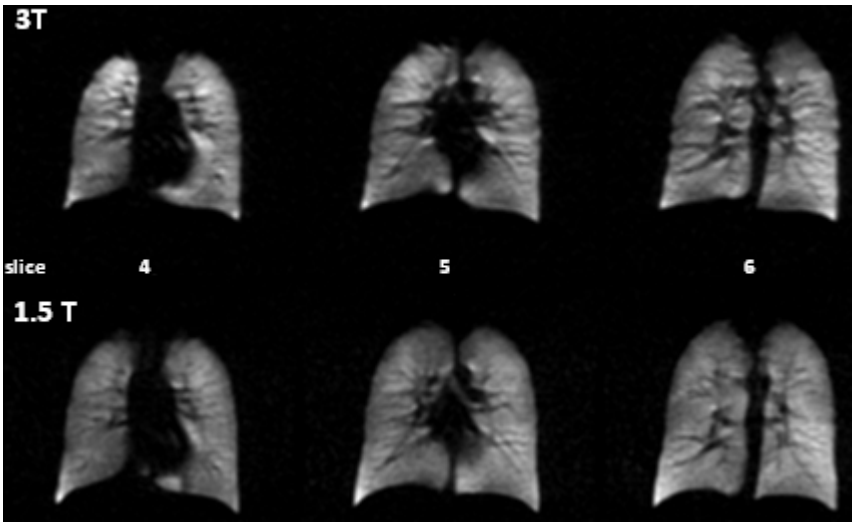

Figure 1. *Central slice-by-slice comparison of the lungs of volunteer 1 obtained with 129Xe ventilation sequence at 3 T and 1.5 T. Notice the increased susceptibility dephasing at 3 T around the blood vessels.*

Gender, age,[weight]	Sequence parameters (TR/TE)	SNR at 1.5 T pre-normalisation	SNR at 1.5 T post normalisation	SNR at 3 T
F, 25, [50 kg]	18 ms / 4.2 ms	44.1	55.1	51.3
M, 40, [88 kg]	6.2 ms / 3.0 ms	27.1	33.9	35.7

Table 1. *Mean SNRs from slice-by-slice ROI calculations of the whole lung of three volunteers. The differences between volunteers are due to differences in sequence parameters, which were kept constant for each volunteer across both scanners.*

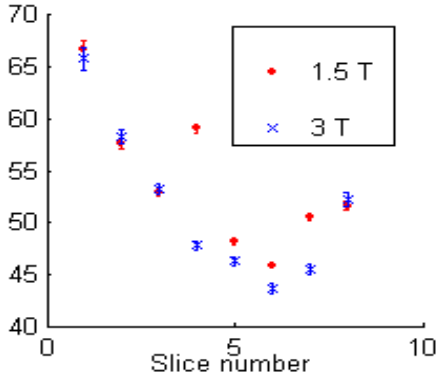

Figure 2. *Comparison of the mean SNR of the left and right lung as a function of slice number for regions of interest at 1.5 T and 3 T post normalisation. Note the higher SNR in anterior slices, which indicates T_1 decay resulting from the anterior to posterior imaging order.*

Figure 3. *Comparable slice of the same volunteer (F, 26) with 300 ml ^{129}Xe (left, centric, 96 x 96 x 15mm) and ^{3}He (right, sequential, 192 x 192 x 10 mm) at 1.5 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, resonating at 17.7 MHz and 35.4 MHz for 1.5 T and 3 T, respectively. ^{129}Xe was polarised by Rubidium (Rb) spin exchange using a homebuilt regulatory-approved polariser system[2] collected in the solid state. 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%. Prior to *in vivo* imaging, experiments were made for normalisation purposes using thermally polarised ^{129}Xe phantoms, which remove additional system-dependent noise factors (e.g. TR switch insertion loss and preamp noise figure).[3] ^{129}Xe ventilation images were obtained using a 2D spoiled gradient echo sequence. Pulse sequence parameters were kept consistent between the two scanners: 15 mm coronal slices covering the whole lung, FOV of 38.4 cm x 38.4 cm, resolution of 96 x 96 matrix, BW of 4 kHz, TE/TR of 4.15/18 ms, centric encoding, flip angle of 9°.

Results: The normalised SNR from a phantom at 3 T and 1.5 T was 45.69 and 36.55 respectively, giving a normalising factor of 1.25.[3] **Fig. 1** shows central slices of the ventilation images of the same volunteer acquired at 3 T (top) and 1.5 T (bottom). Two regions of interest (whole lung less major airways) were selected on the left and right lungs, as well as a ROI for background noise. The SNRs were then calculated, taking into account the normalising factor, and plotted in **Fig. 2** slice by slice along with their standard deviation at both field strengths. The means of SNRs of the two volunteers are summarised in Table 1.

Dicussion: These preliminary results, obtained using RF coils of the same geometry, suggest that the SNR of the hyperpolarised ^{129}Xe MRI is not highly dependent on the field strengths. T_2^* histograms from all slices from the two male volunteers has shown reproducible T_2^* median values of 25 ± 13 ms and 18 ± 6 ms at 1.5 T and 3 T, respectively. These values are shorter than the only other previously reported values in the conference literature.[4] These preliminary results show promising future for hyperpolarised ^{129}Xe imaging as it has been demonstrated that high quality images can be obtained with small doses of 300 m/ ^{129}Xe gas at both clinical field strengths, opening up opportunities for clinical ^{129}Xe imaging as an alternative to ^{3}He (**Fig. 3**).

References: [1]Parra-Robles et al,. Med. Phys. 32:221–229 (2005) [2]Parnell et al,. JAP 108:064908 (2010) [3]Dominguez. et al,. MRM DOI 10:1002 (2011). [4]Mugler, III, et al,. Proc. to ISMRM . Hawaii, US(2009).

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