T2* for Hyperpolarized Xe129 in the Healthy Human Lung at 1.5T and 3T

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Introduction: The majority of techniques used for hyperpolarized-gas imaging of the lung are based on gradient-echo pulse sequences. The T2* relaxation time is an important parameter in the design and optimization of gradient-echo-based methods. The purpose of this work was to measure T2* for hyperpolarized Xe129 in the healthy human lung at 1.5T and 3T.

Methods: To calculate maps of the T2* values for Xe129 in the lung, low-flip-angle, spoiled, gradient-echo images were acquired at two echo times (TEs) using an interleaved acquisition (i.e., data was acquired in the order: phase-encode (PE) line 1, TE1; PE line 1, TE2; PE line 2, TE1; PE line 2, TE2; etc.). After applying a noise threshold to the images, T2* maps were calculated on a pixel-by-pixel basis from the two T2*-weighted images by assuming a mono-exponential decay due to T2* relaxation. The mean, standard deviation and median of the T2* values were calculated for all pixels evaluated within each section, and for all pixels evaluated within the lung of each subject. Histograms were also calculated for each subject.

T2*-weighted image sets were acquired in three healthy subjects at 1.5T (Avanto, Siemens Medical Solutions) and in three healthy subjects at 3T (Trio). A flexible chest RF coil (Clinical MR Solutions, Brookfield, WI) was used for imaging at 1.5T, and a 32-channel array chest RF coil (custom built) [1] or flexible chest RF coil (Clinical MR Solutions) was used at 3T. Enriched xenon gas (87% Xe129) was polarized by collisional spin exchange with an optically-pumped rubidium vapor using a prototype commercial system (Xemed LLC, Durham NH). All experiments were performed under a Physician's IND for imaging with hyperpolarized Xe129 using a protocol approved by our institutional review board. Informed consent was obtained in all cases. Each subject inhaled approximately one liter of gas containing a mixture of hyperpolarized Xe129 (~ 0.5 L), room air and oxygen; the Xe129 polarization was ~20%. Pulse sequence parameters for the 1.5T acquisitions were: TR1/TE1, 11/5 ms; TR2/TE2, 26/20 ms; flip-angle, 9°. Pulse sequence parameters for the 3T acquisitions were: TR1/TE1, 8/3 ms (flexible coil) or TR1/TE1, 12/4 ms (array coil); TR2/TE2, 16/11 ms (flexible coil) or 18/12 ms (array coil); flip-angle, 7° (array coil) or 9° (flexible coil). Parameters common to all acquisitions included: matrix, 64x56; FOV, 38 x 33.3 cm; slice thickness, 3 cm; PE order, sequential.

Results: The mean T2* values (averaged over all pixels for all subjects) were 50.4 and 27.4 ms at 1.5T and 3T, respectively; the mean value at 1.5T was approximately twice that at 3T. The mean, standard deviation and median of the T2* values for each subject are listed in Table 1. At each field strength, all three subjects had similar T2* values. Representative histograms of the T2* values from the entire lung are shown in Fig. 1 for a subject at 1.5T (Fig. 1a) and for a different subject at 3T (Fig. 1b); the corresponding T2* maps are shown in Fig. 2. A regional decrease in T2* was seen at the susceptibility interface between the abdominal organs and the lung, as expected.

The mean T2* value for Xe129 at 3T was essentially the same as that reported for He3 at 1.5T (26.8 ms) [2]. The mean T2* values at 1.5T and 3T were, as expected, less than the value of 135 ms measured for Xe129 at 0.2T [3].

Conclusions: T2* maps were obtained for Xe129 in the healthy human lung at 1.5T and 3T. At 1.5 T, the mean T2* value for Xe129 is substantially longer than that for He3. This longer T2* for Xe129 will permit the data sampling periods (receiver bandwidths) used for Xe129 to be longer (lower) than those suitable for He3.

References: **1.** Dregely I et al. ISMRM 17 (2009); submitted. **2.** Salerno M et al. MRM 2005; 53:212. **3.** Patz S et al. Acad Radiol 2008; 15:713.

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Table 1: Measured T2* values in six healthy subjects.

Subject #	Field [T]	Mean [ms]	STD [ms]	Median [ms]
106	1.5	49.7	30.7	41.5
108	1.5	53.7	32.9	44.7
124	1.5	47.8	31.6	38.4
109	3	26.9	14.7	22.9
111	3	27.7	14.1	25.2
119	3	27.6	17.1	22.8

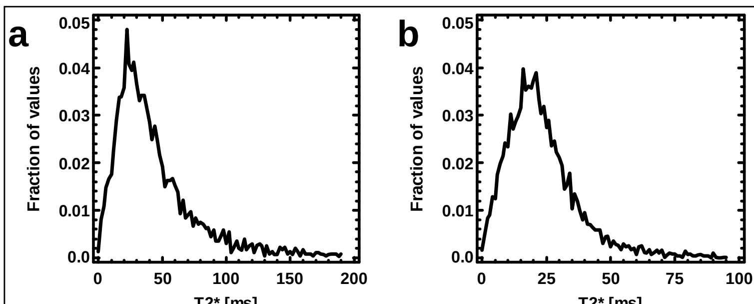

Fig. 1. Histograms of the T2* values in the lungs of (**a**) subject 108 at 1.5T and (**b**) subject 111 at 3T.

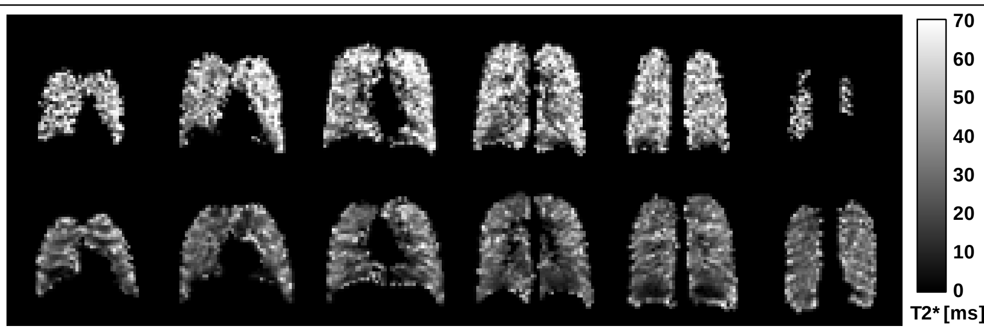

Fig. 2. T2* maps for subject 108 at 1.5T (upper row) and subject 111 at 3T (lower row).