# Image-based Measurement of T2* for Dissolved-phase Xe129 in the Human Lung

John P. Mugler, III[1], Talissa A. Altes[1], Iulian C. Ruset[2,3], G. Wilson Miller[1], Jaime F. Mata[1], Kun Qing[4], Igor Tsentalovich[2], F. William Hersman[2,3], and Kai Ruppert[1]
*[1]Radiology & Medical Imaging, University of Virginia, Charlottesville, VA, United States, [2]Physics, University of New Hampshire, Durham, NH, United States, [3]Xemed, LLC, Durham, NH, United States, [4]Biomedical Engineering, University of Virginia, Charlottesville, VA, United States*

**Introduction:** The relatively high solubility of xenon in biological tissues combined with an exquisite sensitivity to its environment, which results in an enormous range of chemical shifts upon solution, make hyperpolarized Xe129 particularly useful for exploring characteristics of lung function, such as gas uptake and exchange. Despite the low proportion (~1-2%) of Xe129 that dissolves in the parenchyma and blood of the human lung upon inhalation, recent studies have demonstrated the feasibility of directly imaging the "dissolved-phase" component of Xe129 during a short breath-hold acquisition [1,2]. Although these methods have substantial potential to provide new insights into lung disease, optimization is needed to most efficiently use the weak dissolved-phase signal. As a step toward providing the necessary information for such technique optimization, the purpose of this work was to perform image-based measurements of the T2* of dissolved-phase Xe129 in the human lung.

**Methods:** Imaging was performed at 1.5T (Avanto, Siemens Medical Solutions, Malvern, PA) using a rigid chest RF coil (custom built). The gradient-echo-based method described in reference [2] was used for simultaneous imaging of the gas-phase and dissolved-phase components of Xe129 in the lung. Enriched xenon gas (87% Xe129) was polarized by collisional spin exchange with an optically-pumped rubidium vapor using a prototype commercial system (XeBox-E10, Xemed LLC, Durham NH). Each subject inhaled a gas mixture having a total oxygen concentration of 21% and containing 0.5-L of hyperpolarized Xe129 polarized to 30-50%, room air and oxygen. 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.

Coronal projection images were obtained at two TE values in three healthy subjects (#1, female, 22 yrs; #2, female 19 yrs; #3, male, 64 yrs) using the following sequence parameters: TR/TE1/TE2, 200/2.8/5.6 ms; flip angle at dissolved phase, 30°; NEX, 2; PE order, sequential; in-plane spatial resolution, 12 x 12 $mm^2$. In subject 2, the T2* measurement was performed twice. Since the dissolved-phase component of the image contains signal contributions from both the red blood cell and parenchyma/plasma compartments, which are separated by approximately 20 ppm in frequency, the TE values were chosen to correspond to the first and second in-phase times for these compartments so that chemical-shift induced modulation of the signal intensity [3] would be suppressed. Data for the two TE values were obtained in the standard interleaved fashion. T2* values were estimated on a pixel-by-pixel basis, assuming mono-exponential decay.

**Results and Discussion:** Median T2* values were 2.3 ms (subject 1), 2.0 and 2.1 ms (subject 2), and 2.0 ms (subject 3). The T2* values were generally uniform across the lung, as expected for healthy subjects. Figure 1 shows the gas- and dissolved-phase images from subject 3 for the first echo time, and the calculated T2* maps. The corresponding histogram of dissolved-phase T2* values is given in Fig. 2.

The image-based T2* values found in this study are in the same range as T2* values estimated from the spectral linewidths of the dissolved-phase components in whole-lung spectra (1.5 - 2.4 ms at 1.5T, ref. [1]). Nonetheless, the measurements performed for this study provide a composite value for the red blood cell and parenchyma/plasma compartments; additional studies will be needed to determine if image-based measurements yield substantially different values for these compartments. Since only two echo times were used, we have insufficient information to assess the validity of the assumption of mono-exponential decay.

**Conclusions:** At 1.5T, the median T2* value for dissolved-phase Xe129 in the lung is approximately 2 ms, which is similar in magnitude to the proton T2* value for lung tissue (~1 ms). These image-based results confirm the need to achieve very short echo times for maximizing the signal-to-noise ratio in direct imaging of dissolved-phase Xe129 in the lung.

**References:** **1.** Cleveland ZI et al. PLoS ONE 5(8): e12192. **2.** Mugler JP 3rd et al. PNAS USA 2010; 107(50):21707-21712. **3.** Ruppert K et al. ISMRM 2010; 2552.

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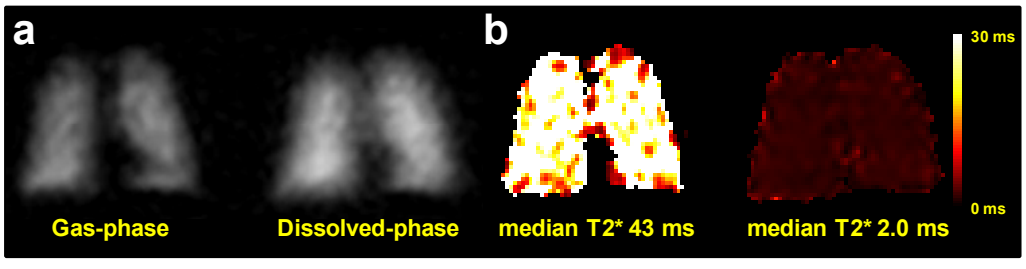


**Fig. 1.** (**a**) Coronal 2D projection image (TE 2.8 ms) demonstrating simultaneous depiction of gas-phase and dissolved-phase Xe129 in subject 3. (**b**) T2* maps for the gas-phase (left) and dissolved-phase (right) components.

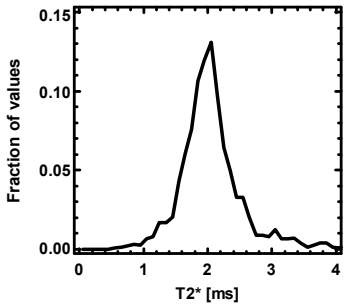


**Fig. 2.** Histogram of dissolved-phase T2* values corresponding to the T2* map in Fig. 1b.