# Single acquisition time-resolved $T_2^*$ mapping in lungs using HYPR $^3$He MRI

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**Purpose:** Local $T_2^*$ measurement of HP $^3$He in the lung was suggested as a potential diagnostic biomarker of tissue microstucture changes [1]. Indeed, $T_2^*$ values are very sensitive to inflation state of the lung and might be of particular interest for characterization of emphysema-like disease. However, standard $T_2^*$ mapping protocol at different lung inflation state involves multiple gas inhalations. In this study, $T_2^*$ mapping protocol combining HYPR reconstruction [2] and spontaneous breathing ventilation [3] was implemented. The protocol, validated on rats, was designed for single acquisition of multiple echo time ventilation images obtained at different inflation states of the lung.

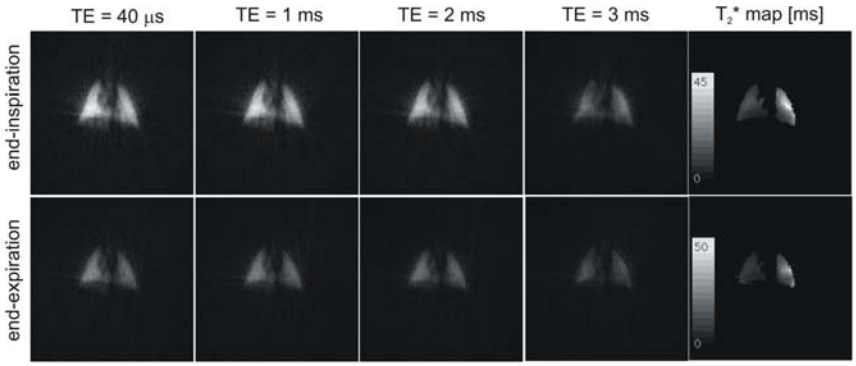
**Methods:** Experiments were performed on a 2T magnet with $^3$He gas polarized to about 20%. Pathogen-free Sprague-Dawley rats were anesthetized and place supine in the RF coil with a mask fixed on their head. A latex gas reservoir containing 40ml of polarized $^3$He was connected to the mask and the acquisition was launched. Ten continuous 2D radially sampled k-space (100 radials/image, 15º flip angle, TR=10ms, 80mm FOV) were acquired during 20 seconds. For each projection angle increment, the signal was acquired at four different echo times (40µs, 1ms, 2ms and 3ms). Cine ventilation images retrospectively synchronized with the breathing cycle of the animal [3] were reconstructed using gridding. The HYPR algorithm was applied to obtain high temporal resolution frames.

**Results:** Series of 4 HYPR images corresponding to different echo times (TE) at end-inspiration and end-expiration phases were reconstructed. The image acquired at the shortest echo time served as the composite image for all HYPR frames. Typical $T_2^*$ maps corresponding to end-inspiration and end-expiration phases are presented in Fig. 1. The mean $T_2^*$ values from a ROI containing all the lung parenchyma distal to the main bronchi were computed (Table 1). The mean $T_2^*$ values at end-inspiration were systematically higher (average change of 40%) than the ones at end-expiration, reflecting the dependence of the $T_2^*$ on the inflation state of the lung. The $T_2$* mapping results were in agreement with the ones found in previous studies [1]. In order to test the possibility of further reducing the total acquisition time, the projections used for HYPR reconstruction were selected from artificially reduced data sets. Series of $T_2^*$ weighted HYPR frames reconstructed from projections acquired during the initial 25%, 33%, 40% and 50% part of the acquisition were obtained. Even for highly undersampled data, $T_2^*$ values were found to be similar to those obtained with the complete data set.

**Table 1.** The mean $T_2^*$ values for all animals assessed from the complete and the undersampled data sets.

| | ACQ time (s) | $T_2^*$ at end-inspiration (ms) | $T_2^*$ at end-expiration (ms) |
|---|---|---|---|
| **complete data set** | 20.0 | 12.2 ± 3.3 | 8.2 ± 1.5 |
| **50% of projections** | 11.75 | 12.0 ± 4.5 | 8.2 ± 2.0 |
| **40% of projections** | 11.0 | 12.6 ± 4.4 | 8.1 ± 1.8 |
| **33% of projections** | 9.45 | 12.5 ± 4.6 | 8.1 ± 1.6 |
| **25% of projections** | 8.45 | 11.8 ± 4.2 | 7.7 ± 1.8 |

**Figure 1.** Typical native ventilation images and $T_2^*$ maps of HP $^3$He in rats lungs at end-inspiration and end-expiration.




**Conclusions:** Using HYPR reconstruction, time-resolved $T_2^*$ maps corresponding to different lung inflation states can be obtained within a single $^3$He ventilation acquisition. The variations of $T_2^*$ measured at different breathing phases at tidal volume demonstrate the sensitivity of the technique for detecting changes in the $^3$He physical environment. The imaging protocol used in this study is easy to implement and does not require intubation nor mechanical ventilation, being appropriate for longitudinal investigation. This $T_2^*$ mapping protocol will be applied to assess changes in the structure and elastic properties of lung tissue in animal models of pulmonary diseases such as emphysema and fibrosis.

**References:** 1. Chen J et al., Magn Reson Med 42:729 (1999), 2. Mistretta C et al., Magn Reson Med 37:706 (2006), 3. Stupar V et al., NMR Biomed 20:104 (2007)