

## T2\* and Frequency Shift Maps of Healthy and CF Subjects

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**Introduction:** Hyperpolarized xenon-129 (HP Xe129) as a gaseous contrasting agent has allowed for unique approaches to probing lung physiology and function. Three-dimensional Single-Breath Chemical Shift Imaging (3D SB-CSI) makes use of HP Xe129 and MR spectroscopy to non-invasively assess regional ventilation and multiple compartment gas uptake/exchange, allowing for a more comprehensive understanding of lung physiology and disease progression [1,2]. Here, we present a robust dissolved-phase fitting method for post processing Xe-129 3D SB-CSI data, capable of extracting additional parameters with possible physiological importance.

**Methods:** A total of nine subjects underwent HP Xe129 3D SB-CSI: eight healthy subjects and one cystic fibrosis (CF) subject. Imaging was performed on a 1.5T clinical system (Avanto, Siemens Medical Solutions) with a transmit/receive RF coil (Clinical MR Solutions) tuned to the frequency of Xe-129. A commercial prototype system was used to polarize isotopically enriched (~87%) Xe-129 to ~40% (XeMed LLC). The 3D SB-CSI sequence parameters were, TR/TE: 23.3ms/1.0ms, matrix: 128x128x8 voxels (after in-plane interpolation), FOV: 280-320mm<sup>2</sup>, and slice thickness: 20-25mm. Matlab (Mathworks, Natick, MA) was used for post-processing, in which the acquired FIDs were filtered, zero-filled, and phase corrected. Using the real part of the signal, gas, tissue, and RBC peaks were fitted to a Lorentzian model that accounted for amplitude, frequency shifts, T2\* and phase relative to the gas peak with an R<sup>2</sup> > 0.97.

**Results:** The average global tissue/RBC ratio, frequency shifts for tissue and RBC components, and T2\* values for the tissue and RBC components of healthy subjects were similar to those reported in the literature (Table 1). When comparing healthy to CF subjects, the CF subject had elevated tissue/RBC values, in line with previous reports of a larger group of CF subjects [2]. Interesting is the 1.7-ppm frequency shift in the RBC peak for the CF subject compared to that of healthy subjects. This is similar to a 2.4-ppm shift in RBC frequency in idiopathic pulmonary fibrotic (IPF) subjects reported by Kaushik et al. [4]. A closer inspection of the CF RBC frequency-shift maps reveals that they tend to have a more heterogeneous appearance. No significant differences were found between healthy and CF subjects in the global average RBC and tissue T2\* and tissue frequency shift.

**Conclusion:** With this new fitting method, we were able to regionally quantify gas exchange between the tissue and RBC and extract additional information from the spectral data including the frequencies and T2\* of each component. Our global measurements of the tissue/RBC ratio, frequency shift and T2\* values of healthy subjects were similar to those reported in the literature (Table 1). More importantly, our technique was able to generate T2\* and frequency-shift maps of each component allowing for a regional analysis of each parameter. Global changes in the RBC T2\* and frequency-shift of the were previously reported to be correlated with the oxygenation of the blood [4]. Using the RBC frequency-shift maps, regions of deoxygenated blood can perhaps be identified. The CF subject had elevated tissue/RBC values, indicating impaired gas exchange between the tissue and RBCs. The ability to analyze the frequency-shift and T2\* parameters on a regional level presents new avenues for probing and understanding lung physiology and disease progression.

**References:** [1] Mata J. ISMRM, Stockholm, 2010. [2] Guan et al. ISMRM, Milan, 2014. [3] Chang Y. MRM, 2014. [4] Kaushik, S. JAP, 2014.

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Table 1: Global Average Tissue/RBC, T2\*, and Frequency Shift

	Healthy	Cystic Fibrosis	Healthy Literature [2,3]
Tissue/RBC	2.5±0.35	2.9	2.4 ±0.53
Tis. PP. [ppm]	197.1±0.32	197.3	197.3 ±0.6
RBC PP. [ppm]	215.0±0.69	213.4	216.5 ±1.3
Tis. T2* [ms]	2.0±0.07	1.91	2.3 ±0.2
RBC T2* [ms]	1.7±0.11	1.6	1.7 ±0.1

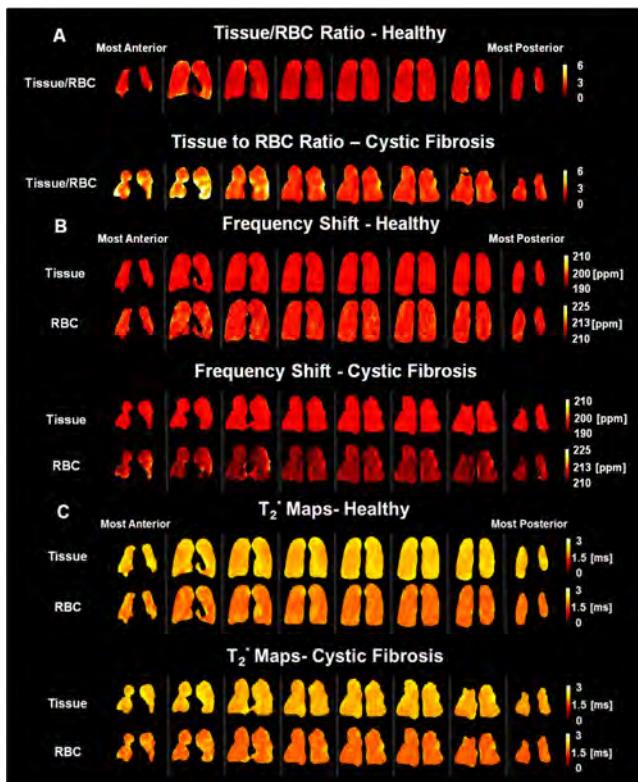


Figure 1: (A) Coronal tissue/RBC maps for a healthy and CF subject. Note the elevated values for the CF. (B) Maps of the Tissue and RBC frequency shifts relative to the gas peak. Note the position shift throughout the lung for the RBC peak on the CF subject. (C) T2\* maps of the tissue and RBC component for a healthy and a CF subject.