Detection of Pulmonary Proton Density at 6.5mT

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Introduction

MR scientists have traditionally worked to improve spatial resolution. We claim, however, that very low spatial resolution measurements of lung density can provide important functional information. And by operating at very low spatial resolution, one can use a much lower field strength, i.e. less than 10mT. If one uses a very low B_o field, the magnet can be made portable so that it can be used in an Intensive Care Unit (ICU). In particular, our long-term goal is to build a bedside scanner that can provide regional measurements of lung density (or lung patency) in an ICU. Such information could provide quantitative feedback on how to optimally adjust mechanical ventilation settings in patients who have Acute Lung Injury (ALI) and cannot be transported to a traditional MRI scanner. As a first step, in the work presented here, we show that very low field measurements of the lung can detect expected proton density changes in the lung associated with different lung volumes.

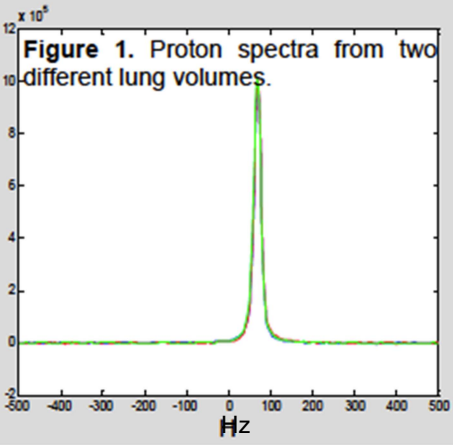

Figure 1. Proton spectra from two different lung volumes.

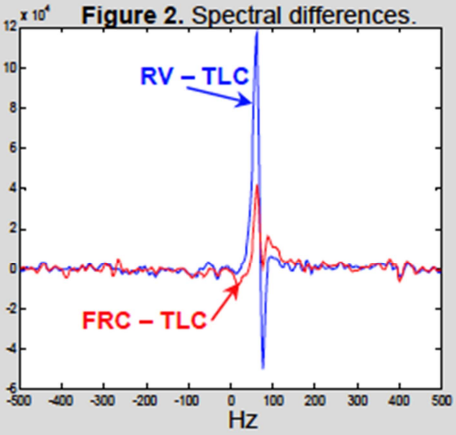

Figure 2. Spectral differences.

Method

A whole body low field scanner (B_o=6.5mT, 276kHz Larmor frequency) located inside a RF shielded room at the Martinos Biomedical Imaging Center, Charlestown, MA was used for these measurements. A 4-inch diameter surface coil was constructed and, with an ace bandage, secured to the posterior surface of the chest. Based on the B_1 field profile, we estimate that approximately 50cc of lung tissue was sampled with this coil. FIDs were acquired at three different lung volumes that effectively changed the lung density in a known manner. We asked a subject to hold their breath at (a) full expiration, i.e. Residual Volume (RV); (b) a volume corresponding to relaxed exhalation or ~Functional Residual Volume (FRC); and (c) full inspiration or Total Lung Capacity (TLC). We acquired 16 averages in ~2.5s at each of the three lung volumes.

Results

Because the low field magnet was a whole body magnet and gradients were not used, the only spatial localization was due to the RF surface coil. Thus the integrated area under the NMR proton spectral peak included not only the lung parenchyma but also a significant signal from the near field region that was not part of the lung. Figure 1 shows spectra from two different lung volumes that are visually not distinct from each other and indicate that the vast majority of the observed signal was not from the lung. Figure 2 shows actual spectra differences between the spectrum at TLC and the other two lung volumes. Integration of the difference spectra in Figure 2 are shown in Figure 3 as a function of lung volume. As expected, there is a higher signal in the detected region defined by the B_1 coil at lower lung volumes because of the higher density of the lung. Also note that when spectra from different lung volumes were subtracted from each other, the difference spectra had a signal to noise ratio >10.

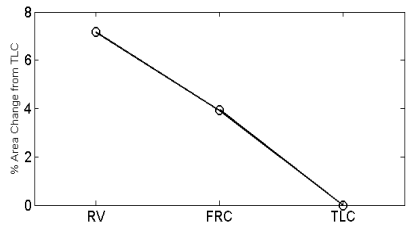

Figure 3. % change in NMR signal relative to that obtained at TLC.

Conclusion

We conclude that low spatial resolution measurements of lung density are possible at very low field strength. These data establish the feasibility of building a low field, portable, scanner that can be used to establish changes in lung patency during breathing. (1)

Acknowledgements

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References

1. Patz S, Hrovat MI, Butler JP. *Systems and Methods for Portable Magnetic Resonance Measureents of Lung Properties.* US Patent application, July 27, 2012.