Proton MRI of human lung using 2D radial acquisition at 1.5 T and 3.0 T

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Introduction

Magnetic resonance imaging of the lung is challenging because of low proton density, respiratory and cardiac motion and susceptibility effects at air-tissue interfaces on small scales. The latter cause a transverse relaxation time T2* of lung tissue in the order of one millisecond [1] which makes high-resolution lung images difficult with conventional Cartesian sampled spoiled gradient echo sequences. Spin-spin relaxation T2 of lung tissue is in the order of 40-80 ms at 1.5 T. But T2-weighted spin echo sequences are prone to blood flow and not suited for higher resolutions due to SAR limitations. Radial k-space sampling schemes should be beneficial for lung imaging since they are robust to motion [2] and they provide sub-millisecond echo times independent of resolution. The relaxation rate 1/T2* increases linearly with magnetic field strength [3]. However, higher field strength also provides higher signal. In this work, proton MRI of the human lung using a 2D radial spoiled gradient echo technique is compared at field strengths of 1.5 T and 3.0 T.

Materials and Methods

Measurements were performed on a 1.5 T and 3.0 T whole-body MR system (Siemens MAGNETOM Avanto and Trio, Erlangen, Germany) using a 12-channel thorax/spine coil as receiver. A healthy subject (male, age 27) was examined. All images were acquired during one breath-hold in end-expiration. Neither ECG triggering nor contrast enhancement was required. For measurement a 2D radial sequence was used with the following parameters: TR = 9.0 ms, FOV = 480^2 mm², in-plane resolution = 0.8^2 mm², slice thickness = 5.0 mm, FA = 9.0°, BW = 303 kHz, radial samples S = 600, radial projections N = 1200, pulse duration = 520 µs, TA = 22 s per slice. On both MR systems, one measurement was performed with conventional (full) RF pulses using TE = 0.77 ms, averages = 2 and a second measurement was performed with half RF (VERSE [4]) pulses using TE = 0.02 ms, no averages. For each measurement, the minimal echo time was chosen which was stipulated by the duration of the slice-selective pulse and the transmit/receive switching time of the coils. Images were reconstructed using Kaiser-Bessel gridding (W = 4.0), Hanning filter and zero-filling from matrix size 600 x 600 to 1200 x 1200.

Results

Fig. 1 shows the comparison between 1.5 T and 3.0 T with TE = 0.77 ms. Eight regions of interest were distributed (upper and lower lobes of both lungs) in the lung parenchyma separated from observable vessels. Average signal-to-noise ratio (SNR) resulted in 6.1 ± 34% for B_0 = 1.5 T and in 5.6 ± 38% for B_0 = 3.0 T. This is an average decrease in SNR of 8% in lung parenchyma using 3.0 T compared to 1.5 T with TE = 0.77 ms. Fig. 2 shows the comparison between 1.5 T and 3.0 T with TE = 0.02 ms (half RF pulses). Average SNR in the same regions as above resulted in 5.2 ± 13% for B_0 = 1.5 T and in 8.1 ± 30% for B_0 = 3.0 T. This is an average increase in SNR of 56% in lung parenchyma using 3.0 T compared to 1.5 T with TE = 0.02 ms.

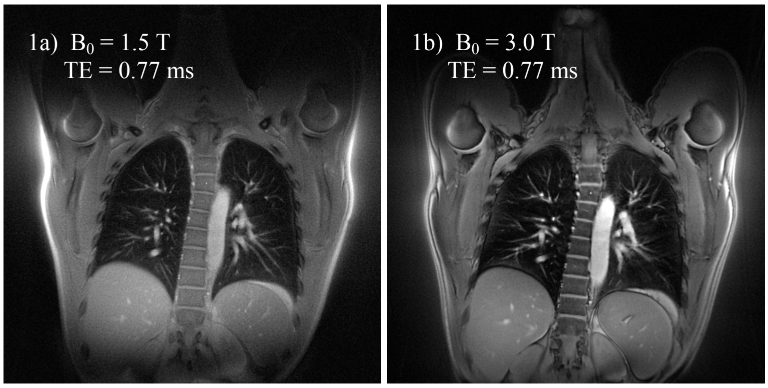

***Fig. 1**: 2D radial acquisition with full RF pulses (TE = 0.77 ms) at B_0 = 1.5 T **(a)** and B_0 = 3.0 T **(b)**. Images were acquired in 22 seconds during a single breath-hold with a resolution of 0.8 x 0.8 x 5.0 mm³. Visibility of lung vasculature is increased at 3.0 T.*

Discussion

The results show that SNR in proton MRI of human lung at 3.0 T is superior to 1.5 T when using a 2D radial sequence with ultrashort echo time. Images of lung parenchyma with sub-millimeter in-plane resolution can be obtained in a single breath-hold with no contrast enhancement and no ECG triggering needed. The signal from lung parenchyma is not significantly different for 3.0 T compared to 1.5 T with TE = 0.77 ms. However, the visibility of lung vasculature at 3.0 T is increased. With TE = 0.02 ms, SNR of lung parenchyma is higher at 3.0 T than at 1.5 T. Only half RF pulses with ultrashort echo time show a gain in SNR at 3.0 T. The results suggest that lung imaging with a 2D radial sequence at higher field strengths than 3.0 T might be feasible or even beneficial in terms of SNR and/or resolution. Studies in patients with lung diseases are necessary to validate the clinical impact of the findings presented.

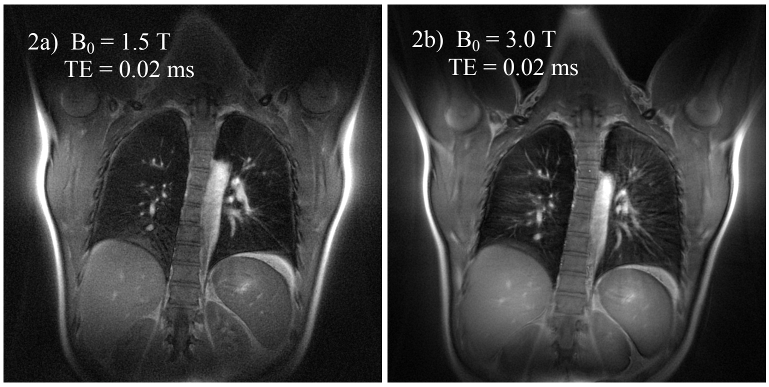

***Fig. 2**: 2D radial acquisition with half RF pulses (TE = 0.02 ms) at B_0 = 1.5 T **(a)** and B_0 = 3.0 T **(b)**. Images were acquired in 22 seconds during a single breath-hold with a resolution of 0.8 x 0.8 x 5.0 mm³. Visibility of lung vasculature and parenchyma is increased at 3.0 T.*

References

[1] Stock et al., MRI 17:997-1000 (1999).
[2] Glover et al., MRM 28:275-289 (1992).
[3] Kveder et al., MRM 7:432-441 (1988).
[4] Conolly et al., JMR 78:440-458 (1988).