Optimization of Lung Imaging with Hyperpolarized 3Helium Using a 32 Channel Phased Array

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Introduction

Since two years first phased array coils for human lung imaging with hyperpolarized ^{3}He were presented [1]. So far besides general usage of parallel imaging no new concepts or improvements for functional imaging were discussed. To understand and analyse the possibilities of phased array usage in lung imaging a 32channel phased array coil for ^{3}He was designed and tested with several improved scan protocols to test out limitations of this technique. Compared to standard protocols high resolution 2D and 3D imaging was successfully realised as well as dynamic imaging with high temporal and spatial resolution. The results show up improved and new ways in functional lung imaging which can increase patient comfort as well as gain of information.

Methods

Coil: A 32 channel phased array coil was designed and build in an in-house-production process as described in Medical Devices Directive 93/42/EEC for an 1.5T Avanto TIM (Siemens Medical Solutions, Erlangen, Germany). **High resolution 2D:** For morphology imaging with high resolution a modified spoiled gradient echo sequence was used with the following parameters: *FOV=303x303 mm^2, 256x256 matrix, 5mm slice thickness. TR=7.1ms, TE=2ms, α=7.5°, 10 slices, TA=1.82sec*. 300ml ^{3}He (P=ca.65%) and 700 ml N_2 has been applied. Afterwards a second acquisition with R=2 and α=11° was performed. For reconstruction the standard GRAPPA reconstruction as provided by the scanner's software was used. **High resolution 3D:** 3D imaging was performed by using a 4x2 accelerated 3D sequence with *FOV=300x300 mm^2, 128x256 matrix, 8mm slice thickness. TR=3.2ms, TE=1.1ms, α=4°, 24 slices per slab, TA=3 sec*. 300ml ^{3}He (P=approx. 65%) and 700 ml N_2 was applicated. **High resolution dynamic imaging:** To meet normal forced ventilation manoeuvres which are commonly used in pneumology a time resolution of eight images per second with a resolution of 2.3x3.5mm^2 in coronal projection was achieved with the following parameters: *FOV= 294x294mm^2, 128x84 matrix, TR=2.2ms, TE=0.9ms, α=4°, 150 repetitions, R=2.* For reconstruction the standard GRAPPA reconstruction as provided by the scanner's software was used.

Results

All protocols show a sufficient SNR and never before seen details of human lung morphology. Acceleration factors up to 4x2 have been used successfully. Even in this case no acceleration artifacts reduced the image quality.

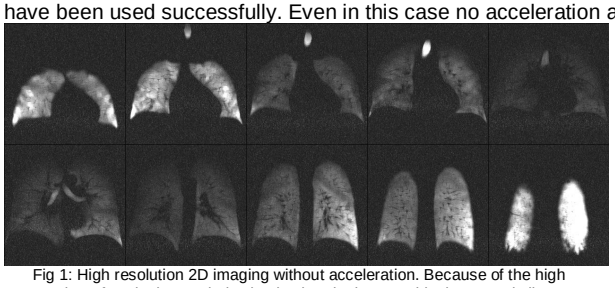

Fig 1: High resolution 2D imaging without acceleration. Because of the high number of excitations polarization is already destroyed in the central slices.

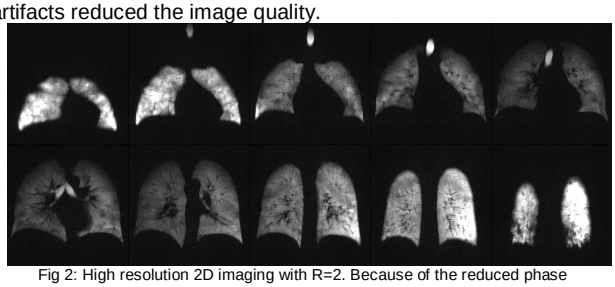

Fig 2: High resolution 2D imaging with R=2. Because of the reduced phase encoding steps all slices show a good SNR. To increase SNR in general a higher flipangle could be applied in the accelerated sequence because of reduced number of excitations.

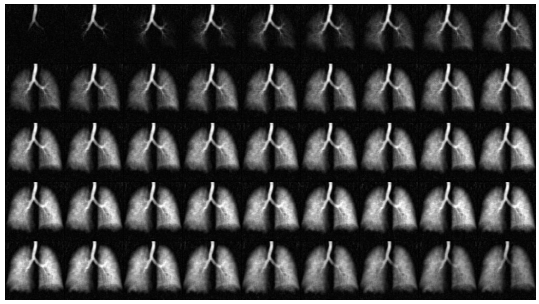

Fig 3. Dynamic imaging with high temporal (8 images per second) and spatial (2.3x2.5mm^2) resolution. This protocol could be used for imaging forced in- and expiration manoeuvres.

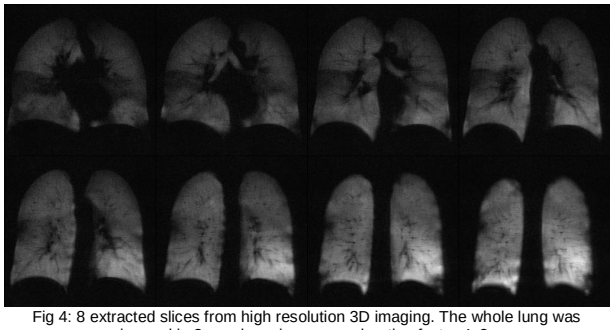

Fig 4: 8 extracted slices from high resolution 3D imaging. The whole lung was imaged in 3 sec. by using an acceleration factor 4x2.

Discussion

The presented results show the high potential of parallel imaging of the lung using hyperpolarized ^{3}He. High resolution 2D imaging could be used to observe even small ventilation defects in diagnostics or following studies for lung treatment. Another application would just be reducing the amount of ^{3}He and run the standard protocols for example the protocol which was established in the European PHIL study. Because ^{3}He prices are still very high a reduction of costs would be very welcomed especially for studies with a high number of subjects. For imaging real life ventilation manoeuvres the high temporal and spatial resolution dynamic imaging seems to be applicable. This could for example allow imaging the effect of ventilation therapeutics with respect to forced ventilation manoeuvres where common protocols so far only provided high temporal or spatial resolution. Another advantage is the reduction of breath hold time during 3D imaging techniques for patients with lung diseases. Even for a healthy volunteer a breath hold of more than 30sec is hard to realise when lying in the scanner. A reduction of imaging time to 3sec with accelerated 3D imaging would allow even patients with strong lung dysfunction to easily hold their breath. Combining this technique with functional methods like apparent diffusion coefficient or even tensor imaging would complete the presented improvement of human lung imaging by using phased array coils and parallel imaging.

Reference

1. Lee RF et al. Magn Reson Med 2006;55(5):1132-1141.

Acknowledgement

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