Structural Lung Parenchyma: Breath-hold isotropic imaging using 3D SSFP

P. Wielopolski[1], M. Lequin[1]
[1]Radiology, Erasmus MC, Rotterdam, ZH, Netherlands

Introduction:

Magnetic resonance imaging (MRI) of the lung has proven routinely difficult in the clinical setup but still carries the advantage that is free of ionizing radiation. A clinical scenario where MRI of the lungs could be included would make it possible for a better clinical follow-up and even the opportunity for monitoring therapy strategies. The possibility of better signal for a functional study using oxygen as contrast media could provide an equivalent ventilation scan, and therefore, show differences in ventilation and provide the differentiation of a segment or lobe that may be infected/involved in a specific lung disease. If good spatial resolution were possible with high signal-to-noise ratios (SNR), lung abnormalities like those found in cystic fibrosis patients, could be scored and would provide an alternative to the routinely performed x-ray computed tomogram (CT). Inspiration and expiration imaging could also show the trachea and bronchiomalacia.

Purpose:

In this study, we have focused on the possibilities of SSFP scanning for isotropic volumetric imaging of the lung using the inherent high SNR of the SSFP signal and the short TR/TE combinations that can be currently achieved in state-of-the-art MRI hardware.

Material and Methods:

Nine volunteers were scanned at 1.5T(General Electric Healthcare, USA) using software release 12 (Excite HD). After a 3-plane localizer and calibration scans for parallel imaging (ASSET) (collected generally at end-expiration), 20-24 second long breath-hold 3D SSFP scans were executed, both in the axial and coronal planes with a target voxel resolution of 1.6 mm^3. The 3D SSFP could perform with a TR/TE=1.8/0.9 ms combination for flip angles of 40° and less for the target voxel resolution. To assign the optimal flip angle for imaging parenchyma, the 3D SSFP was performed in the coronal plane for flip angles varying between 5° and 40° with scanning performed at end-expiration. An ASSET compatible 8-channel torso coil was used for signal reception. Shorter scanning was evaluated in both the axial and coronal using an ASSET acceleration factor of 2.

Results and Discussion:

Regions of interest were placed in the muscle, fat, lung parenchyma and trachea (air). A flip angle of 25° was selected for optimal visualization of the lung parenchyma, as evidenced on the plot shown in Figure 1. In general, the typical signal gradient across the lung (anterior-posterior direction) was appreciated with the highest signal intensity recorded towards the back of the lung (more dependent region); likewise, lung signal enhancement was evidently higher at end-expiration (even larger at forced expiration) than during inspiration (Figure 2). The signal from both pulmonary arteries and veins and aorta was better appreciated at a lower flip angle setting of 15° after reviewing the vascular structure using a maximum intensity projection (MIP). The higher signal of lung parenchyma against that of air in the airways could be used adequately for showing the bronchial tree using a minimum intensity projection (mIP) (Figure 3). The visualization of bronchia is variable in the subjects scanned but 4-5th order branches could be appreciated with the scanned voxel resolution. The ASSET calibration could only be used effectively for one predetermined breath-hold position. Axial scans were met with artifacts in the center of the lung, nonetheless, scans in the coronal plane were clean. With regards to ghosting from cardiac motion, axial scans projected ghosts in the anterior-posterior direction and were less obstructive than those in the coronal scan, running left-right. A multislab setup could be performed to enhance spatial resolution per unit time, nonetheless, the setup does support slab overlaps, leading to aliasing in the multiplanar reformations at the borders of each slab.

Conclusion:

Breath-hold, high SNR imaging with isotropic coverage of the lung parenchyma can be performed with 3D SSFP scans with ultrashort TR/TE on state-of-the-art systems with fast imaging gradients. This expands the role of MRI in the diagnosis of lung parenchyma for many diseases that were previously exclusive to CT scanning and without the use of ionizing radiation.

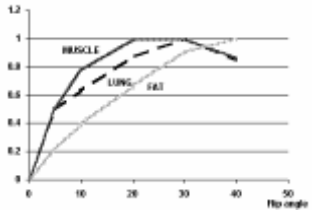

Figure 1: Signal from muscle, fat and lung parenchyma. 6 samples of lung parenchyma per volunteer were averaged in regions were major vessels were not appreciated. A flip angle of 25° was chosen for optimal scanning. Signals were normalized to the maximum found per tissue for the flip angle range evaluated.

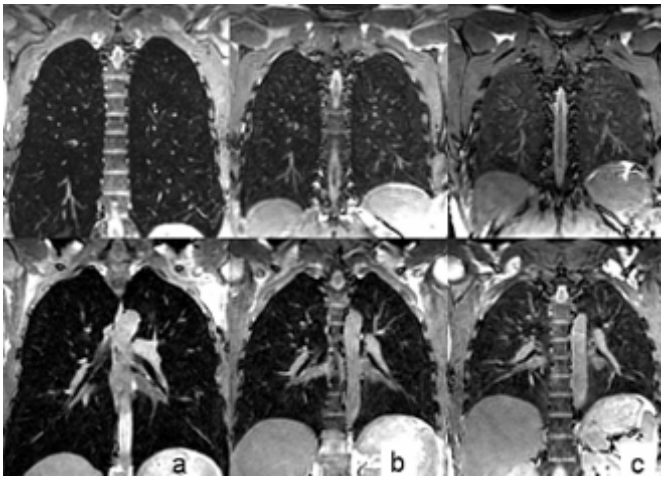

Figure 2: Inspiration (a), Expiration (b) and full forced expiration (c). The SSFP 3D scan used TR/TE/_=1.9/0.8 ms/15°. 128^3 matrix was collected with a voxel resolution of 1.8 x 1.8 x 1.6 mm^3 in 24 sec, BW=125 kHz, 0.71NEX in the slice select direction. Higher lung signal can be appreciated in (c). All panels show the higher signal intensity in the back of the lung as compared to the mid-portion.

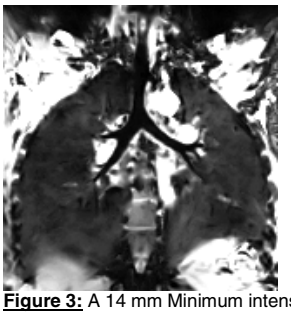

Figure 3: A 14 mm Minimum intensity projection (mIP) reconstruction along the trachea of a dataset collected in full forced expiration. The bronchia can be followed into 4-5th generation branching at the scanned resolution. Imaging parameters as in Figure 2.