Parallel Lung Imaging

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The lung is the most challenging organ to image with MRI due to several technical and methodological constraints.

(i) the low signal-to-noise ratio (SNR) given by the inherently low lung proton density
(ii) the presence of cardiac and respiratory motion artifacts
(iii) the presence of large magnetic field gradients arising from magnetic susceptibility effects
(iv) the presence of extremely short transverse relaxation times and significant diffusion yielding short T2's of 30-70msec, short T2*'s of 1-3 msec accompanied by rather long T1-relaxation times of 1300-1500 msec.

However, these qualities make the lung a perfect target for improved imaging using parallel MRI (pMRI), since the benefits of faster imaging with parallel MRI (pMRI) have the potential to overcome several of these restrictions and thus impact significantly on lung imaging.

Impact on depiction of lung morphology with pMRI

In particular, lung MRI based on single-shot sequences, such as TSE or HASTE imaging, benefit from parallel imaging techniques due to reduced relaxation time effects during the echo train and therefore reduced image blurring as well as reduced motion artifacts [1]. In the human lung parenchyma, apparent T2 values of 30 ms or less have been reported at 1.5 T. These very short T2 values are responsible for a fast signal decay during a single-shot readout, resulting in significant blurring. This effect can be reduced by reducing the acquisition time. In particular, in ^{1}H imaging of the human lung the combination of single-shot imaging techniques with pMRI methods allows one to obtain significantly increased resolution in the same or reduced imaging time. The ability to decrease the effective interecho spacing and to increase the image matrix size in a single shot HASTE acquisition with pMRI provides e.g. a dramatic increase in the visibility of small lung vessels.

Impact on depiction of lung function with pMRI

pMRI techniques imply the great advantage of a significant increase in temporal and spatial resolution which can be successfully exploited for high resolution 3D contrast-enhanced MR lung angiography, dynamic contrast enhanced MR perfusion imaging [2-4] and oxygen enhanced multislice imaging [5] in lung patients. In these applications the speed of pMRI is mainly exploited to increase the spatial resolution (increase in spatial coverage and/or in plane resolution) or the temporal resolution at fixed spatial resolution and fixed breath-hold duration. In addition, the breath-hold duration of the imaging protocols might be reduced at constant spatial resolution.

In conclusion, lung imaging is a perfect application field for pMRI exploiting all well known advantages of the parallel imaging world.

References

1. R, M. Heidemann et al, Resolution Enhancement in Lung 1H Imaging Using Parallel Imaging Methods. Magnetic Resonance in Medicine 49:391–394, (2003).
2. O. Dietrich et al, iPAT: Applications for fast Cardiovascular MR Imaging. Electromedica 70, no. 2, page 133, (2002).
3. K. Nikolaou et al, Quantification of Pulmonary Blood Flow and Volume in Healthy Volunteers by Dynamic Contrast-Enhanced Magnetic Resonance Imaging Using a Parallel Imaging Technique. *Investigative Radiology* 39(9): 537-545 (2004).
4. E. van Beek et al, MRI for the Diagnosis of Pulmonary Embolism. Journal of Magn. Reson. Med., 18:627 (2003)
5. O. Dietrich et al, Fast oxygen-enhanced multi-slice MR imaging of the human lung using integrated parallel acquisition techniques (iPAT), Proc. Intl. Soc. Mag. Reson. Med. 11, p 669, (2004).