

“Constant repetition time” imaging protocols for high resolution lung proton MR Imaging in mice

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Purpose: The fundamental spatial resolution of in vivo MR lung imaging is limited by motion in thoracic cavity [1]. This problem is particularly evident in microscopic lung imaging of rodents because of their high cardiac (400-700 bpm) and breathing rate (100-150 breaths/min). To overcome these limitations several methods have been proposed, including scan-synchronous ventilation [2] and cardiac gating approach [3]. However, cardiac and ventilation triggered techniques do not allow predetermined and constant repetition time of the sequence, resulting in variable image contrast. In this study, we investigate the potential of two “constant repetition time” approaches based on retrospective self-gating (RSG) and signal averaging (SA) [4]. Associated imaging sequences were based on very short echo time for visualization of lung structures and parenchyma.

Materials and Methods: Experiments were performed on a 4.7 T MR scanner. C57BL/6 mice (n=6) were anesthetized with isoflurane. RSG and SA acquisitions were carried out using short echo time radial sequence (400 radials/image, TE=630 μ s, TR=80ms, flip angle=30deg, FOV=35mm, slice thickness = 1.2mm). For RSG and SA procedures, 20 k-space sweeps were scanned continuously resulting in 10 minutes total acquisition time. As a reference, cardio-respiratory gated (CRG) acquisitions were performed using ECG signal. The typical repetition time for CRG acquisition was equal to 400 ms resulting in 3 minutes total acquisition time.

Results: The signal intensity at the center of k-space for each view of radial acquisition is shown in Fig.1. The signal variations are due to the respiratory and cardiac cycle. Radial projections within user-defined range were selected and used for retrospective image reconstruction. Typical coronal lung images obtained with three approaches are shown in Fig.2. Although overall image qualities are comparable, RSG images provide more detailed visualizations of pulmonary structures than SA images. Due to signal averaging, higher SNR is obtained with SA acquisitions. To illustrate the potential of RSG technique in relation to cardiac cycle, examples of retrospective-gated axial images corresponding to systolic and diastolic phases are presented in Fig.3. Averaged image of the same slice is shown for comparison.

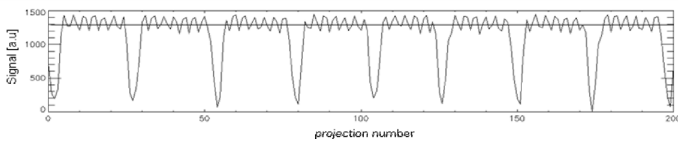


Fig1. Signal from the center of k-space. The line indicates the threshold chosen for the self-gating procedure.

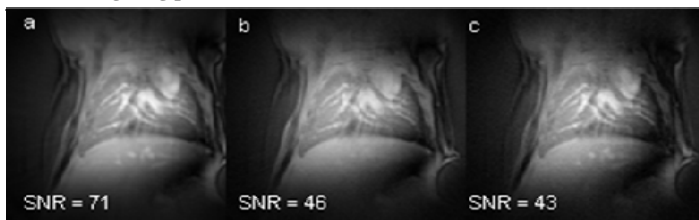


Fig2. Typical images of mice thorax acquired with 20 averages (a), ECG-triggered approach (b) and after self-gated procedure (c).

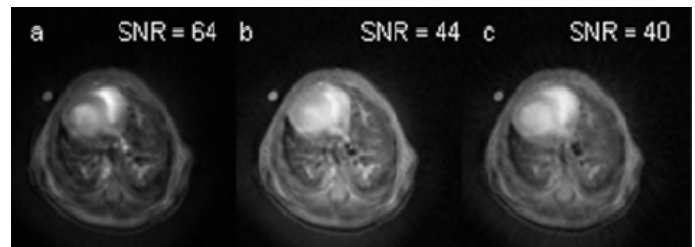


Fig3. Comparison of averaged (a) and self-gated transverse pulmonary images triggered in the systolic (b) and diastolic (c) phases of cardiac cycle.

Conclusions: Parenchyma and vascular structures in mouse lung can be visualized with satisfactory spatial resolution and SNR using “constant repetition time” sequences associated with short echo time. These two approaches facilitate the implementation of studies where quantification of changes in signal amplitude is required. The SA technique provides the highest SNR at the expense of slightly compromised spatial resolution. The RSG procedure allows for sharp visualization of pulmonary vasculature at different phases of the cardiac cycle. In the future, both techniques will be applied for the investigation of lung structural and functional changes in mice models of lung diseases.

References: [1] Maï et al., Magn Reson Med 53:858-865 (2005), [2] Hedlund et al., Invest Radiol 21:18-23 (1986), [3] Cassidy et al., J Magn Reson Imaging 19:229-237 (2004), [4] Beckmann et al. NMR Biomed. 14:297-306 (2001).