Highly Constrained Backprojection (HYPR) for ^{3}He-MRI spontaneous breathing and insufflation protocols in rats

K. CIESLAR[1], A. AL FARAJ[1], V. STUPAR[1], S. GAILLARD[1], and Y. CREMILLIEUX[1]
[1]Creatis-LRMN, UMR CNRS, Université Lyon 1, LYON, France

Purpose: Due to the high breathing rate of rodents, imaging of rats lung function requires temporal resolution of the order of tens of milliseconds. In small animal studies, sliding window technique is routinely used resulting in pseudo-temporal resolution of one TR. However, this technique has the drawback of averaging the temporal dynamics of the gas flow. One can increase the temporal resolution by undersampling but this results in poor image quality. In order to preserve high image SNR despite angular undersampling HighlY constrained backPRojection (HYPR) reconstruction can be used [1]. We present the result of HYPR reconstruction applied for spontaneous breathing and insufflation protocols in rats.

Materials and Methods: Experiments were performed on a 2T magnet (Oxford Instruments) using an MRRS console. ^{3}He was polarized using a home-built spin-exchange polarizer. Male Sprague-Dawley rats were anesthetized using intramuscular injection of a ketamine-xylazine-atropine mixture (1.2ml/kg body weight). Insufflation protocol required tracheotomisation of the animals. The rats were placed supine in the coil and their lungs were insufflated with ^{3}He at the rate of 2 ml/s. For spontaneous breathing protocol, a custom-designed mask was attached on animals head. After placing the animal in the coil a bag containing 40 ml of polarized gas was screwed onto the mask. Projection images were obtained using radial sequence (128 points, 200 directions, flip angle=10deg, TE=40us, TR=5ms, FOV=80mm). The k-space was continuously scanned during insufflation (total imaging time=10s) and spontaneous breathing (total imaging time=20s) protocols.

Results: The images were reconstructed using HYPR algorithm. In case of insufflation protocol, sliding window composite images containing 200 directions (1 s duration) were reconstructed. For spontaneous breathing protocol, retrospective cine reconstruction [2] was used to obtain 10 composite images (131-144 directions/composite image) in each breathing cycle (Fig. 1). The duration of each cine composite image was about 50 ms. For both protocols, HYPR images corresponding to different phases of the breathing maneuvers were reconstructed using 32 radial projections (angular undersampling factor of 12.5 as compared to Nyquist criterion). Exemplary images of rat's lungs during insufflation and spontaneous breathing protocols are shown in the upper rows of Fig. 2 and 3, respectively. For comparison, undersampled filtered back-projection images formed from 32 projections are shown (bottom rows of Fig 2 and 3). HYPR images exhibit less streak artifacts and a two-fold SNR increase as compared to undersampled filtered back-projection images.

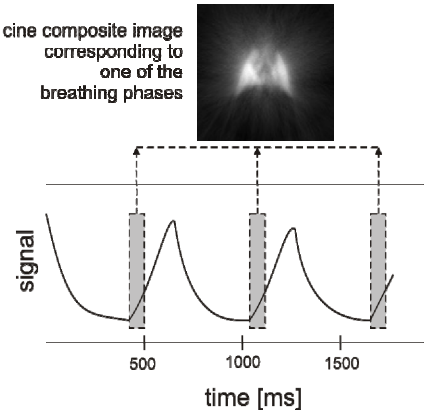

Fig. 1. Formation of the retrospective cine composite images. Signal measured in the center of k-space allows to identify different phases of the breathing cycle.

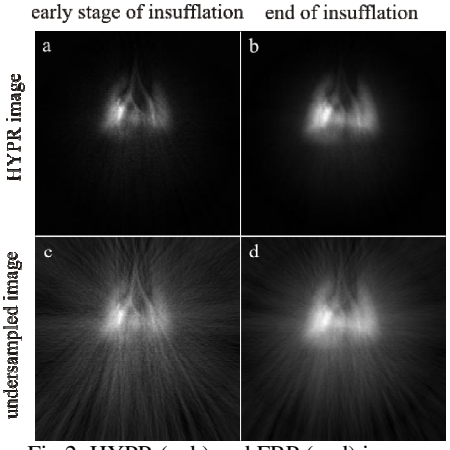

Fig 2. HYPR (a, b) and FBP (c, d) images corresponding to different phases of insufflation protocol.

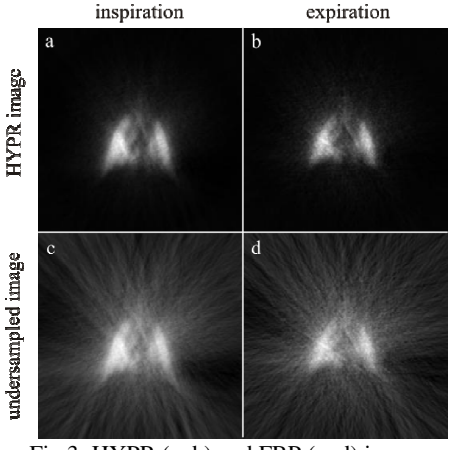

Fig 3. HYPR (a, b) and FBP (c, d) images corresponding to different phases of spontaneous breathing protocol.

Conclusions: Using HYPR reconstruction the quality of the undersampled images was improved, allowing for the visualization of respiratory dynamics. Further studies are needed in order to decrease the number of projections required to form a good quality time frame image. This technique could be used to improve the temporal resolution in studies of ventilation defects in animal models of lung diseases.

References: [1] Mistretta CA et al., MRM 55:30 (2006), [2] Stupar V et al., NMR Biomed, 20:104 (2007)