

Retrospective Cine ^3He ventilation imaging under spontaneous breathing conditions: a non invasive imaging protocol for small animal lung function imaging.

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Introduction

Up to date, hyperpolarized ^3He ventilation imaging studies in small animals were performed using either animal tracheotomy or intubation protocols combined with assisted ventilation using respirator devices (1,2). These approaches are obviously invasive and traumatic for the animals and are not suited for multiple, longitudinal assessments of animal lung function. In this work, we developed and applied a fully non-invasive imaging protocol based on retrospective radial Cine imaging and sliding window technique under spontaneous animal breathing conditions.

Methods

MRI experiments were performed on a 2 Tesla magnet and ^3He was polarized using a home-built spin-exchange polarizer. Male Sprague-Dawley rats ranging from 300 to 350 g were anesthetized by intraperitoneal injection of sodium pentobarbital. A non-invasive ^3He breathing system was designed for the ventilation imaging protocol. The device was composed of two separate screwable components: a home-built mask fitting the animal head and a latex gas reservoir aimed at containing the HP ^3He . Before each imaging protocol, 40 ml of polarized gas was extracted from the optical pumping cell with a plastic syringe, and the polarized gas was transferred from the syringe to the gas reservoir. This was then rapidly screwed on the animal mask and the image acquisition was started immediately. A projection-reconstruction sequence with the following imaging parameters was used: 128 acquired samples, 200 radial directions per image, TR=5ms, TE=40 μ s, FOV=80mm, flip angle ranging from 3° to 15°. Total acquisition time was equal to 20 s. Retrospective Cine ventilation image reconstructions were based on the NMR signal variations induced by the animal breathing.

Results

Figure 1 shows the time evolution of the ^3He NMR signal intensity in the animal lungs following every RF pulse. This signal evolution curve was obtained by plotting the magnitude of the first sampled point of each radial acquisition. The signal amplitude oscillation corresponds to the animal breathing cycle with maxima and minima coinciding respectively with the end-inspiration and end-expiration phases. The decrease of the maxima is due to helium T_1 relaxation and RF depolarization. In most of the acquisitions, the breathing pattern was very regular and suitable for retrospective cine imaging. Typically, Cine images were reconstructed using a 100 ms image window. Figure 2a represents the ventilation image obtained during the animal maximal lung inflation. Figure 2b shows lung image obtained at end-expiration. The complete breathing cycle was imaged by shifting (5ms time shift) the acquisition window.

Conclusion

To our knowledge, this study reports the first helium3 ventilation images acquired on spontaneously breathing rats without using any traumatic procedure such as intubation or tracheotomy. The ventilation imaging protocol is very easy to perform and can be completed in a few minutes allowing a high throughput suitable for ventilation studies involving large animal series. This imaging protocol makes possible the implementation of longitudinal studies for the investigations of pulmonary physiological or physio-pathological processes in small animals.

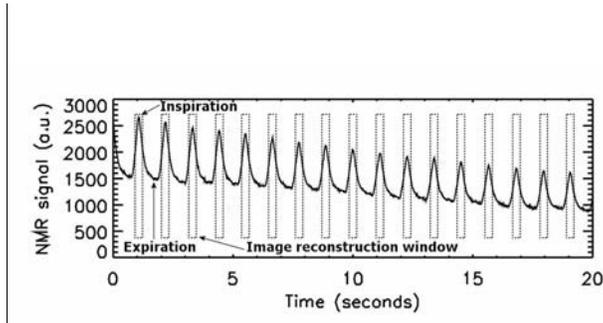


Figure 1. Evolution of total ^3He NMR signal.

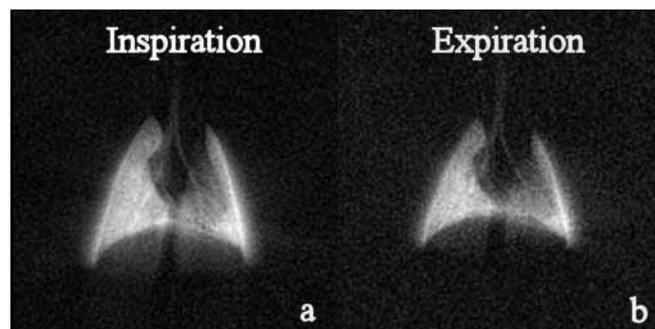


Figure 2. Lung images of spontaneously breathing rat.

References:

1. Hedlund LW et al. *Ilar J* 2002 ;43(3) :159-174.
2. Dupuich D et al. *Magn Reson Med* 2003;50(4):777-783.