Hyperpolarized Helium-3 ventilation imaging under spontaneous breathing conditions in mice

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Introduction

Mouse models are becoming more and more popular in different fields of basic research. Hyperpolarized ^{3}He ventilation imaging studies in mice reported in the literature have been performed using either animal tracheotomy or intubation protocols combined with assisted ventilation using respirator devices [1, 2]. These approaches are invasive and traumatic for the animals and might not be suited for multiple, longitudinal assessments of animal lung function. In recent studies, the possibility to obtain HP ^{3}He ventilation imaging was demonstrated in rabbits and rats under free breathing conditions [3, 4]. This approach is more challenging in mice because of small lung tidal volume (0.2 ml) and high respiratory rates (100-150 breaths/min). 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 mouse breathing conditions.

Methods

MRI experiments were performed on a 2 Tesla magnet and ^{3}He was polarized using a home-built spin-exchange polarizer. Male C57BL/6 mice ranging from 25 to 30 g were anesthetized by intraperitoneal injection of 12 mg/kg xylazine and 90 mg/kg ketamine in 0.9% NaCl (100 mL/10 g body weight). 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 ^{3}He. 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=15ms, TE=40µs, FOV=35mm, flip angle 11°. Retrospective Cine ventilation image reconstructions were based on the NMR signal variations induced by the animal breathing [3].

Results

The ventilation images were reconstructed at different moments of the breathing cycle using retrospective synchronisation [3]. Figure 1 shows the time evolution of the ^{3}He NMR signal intensity in the mouse lungs following every RF pulse. Representative ventilation images, obtained during respiratory window of 150 ms, are shown in Figure 2.

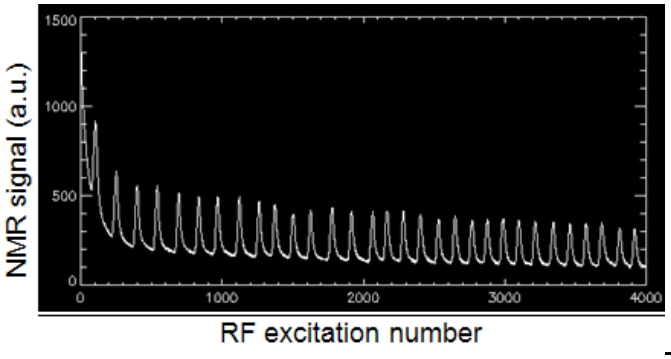

Figure 1: ^{3}He NMR signal at the centre of k-space

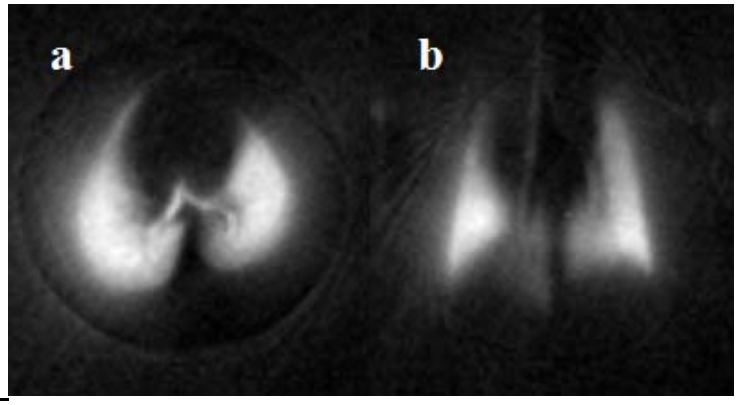

Figure 2: Free breathing ^{3}He ventilation images (transversal (a) and coronal (b)) of mice

Conclusion

In this study, the feasibility of free-breathing ^{3}He ventilation imaging was demonstrated on mouse lungs. 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.

Reference

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