

Alveolar oxygen partial pressure and oxygen depletion rate mapping in rats using ^3He -MRI

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INTRODUCTION: Oxygen partial pressure ($p\text{O}_2$) in lungs varies both spatially and temporally due to regional differences in oxygen delivery and oxygen uptake. During the initial period of apnea linear decrease of $p\text{O}_2$ can be assumed (1). Two parameters: initial $p\text{O}_2$ (p_0) and depletion rate R can be used to characterize ventilation and perfusion in the lungs. In ^3He -MRI of the lungs, there are two main factors resulting in the decay of the signal, namely depolarization due to the presence of oxygen and RF excitation. It is important to separate those two effects. This problem has been addressed in variety of ways (1-3). In this work a novel protocol is presented with spiral acquisition and sliding window technique used for RF flip angle correction. The first maps of initial $p\text{O}_2$ and R in rats are demonstrated using this protocol.

SUBJECTS AND METHODS: The experiments were performed on a 2T magnet. ^3He was polarized using a home-built spin-exchange polarizer. Male Sprague-Dawley rats were anesthetized by intraperitoneal injection of sodium pentobarbital and tracheotomized. Animal's lungs were insufflated with ^3He and oxygen in various proportions (total mixture volume of 10 ml, concentration of oxygen ranging from 20% to 40%). Spiral sequence with 12 interleaved spirals per image and 1024 samples/spiral was used (flip angle = 6 deg, TE = 2 ms, TR = 27.3 ms, FOV = 80 mm). Series of 12 coronal or transverse projections were acquired with delay time $\tau=2.3$ s between consecutive images except for the first two images acquired without any delay (Fig. 1).

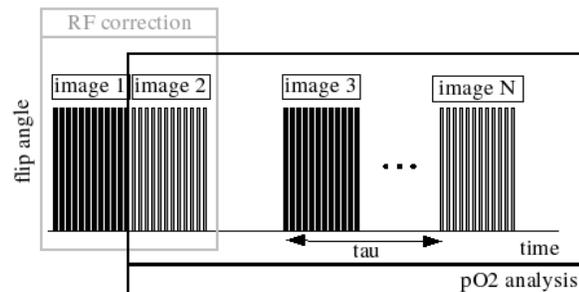


Fig. 1. Schematic of the acquisition sequence.

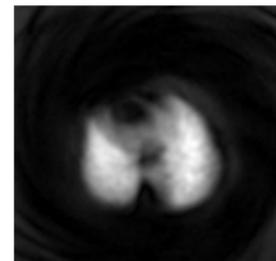


Fig. 2. Transverse projection of rat lungs.

RESULTS: The first two images in every series were used for RF flip angle correction. Using sliding window technique, 13 images with delay time of 328 ms were reconstructed and the flip angle was determined for every pixel of the image. Figure 2 presents transverse projection of the rat lungs filled with pure helium. Exemplary parametric maps of initial $p\text{O}_2$ and depletion rate with bin size of 3.5mm^2 are shown in Fig. 3. The $p\text{O}_2$ values were found to vary in conformance with our experimental parameters and the R values were measured to be in good agreement with the literature data.

CONCLUSIONS: We show that it is possible to map initial $p\text{O}_2$ and depletion rate R in healthy rats using a single-acquisition method based on spiral sequence with satisfying signal to noise ratio and spatial resolution of 3.5mm^2 . This method carries a great potential since it can be used to assess disturbances in ventilation and perfusion in well established animal models of various diseases.

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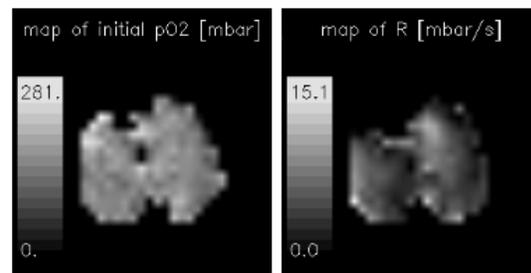


Fig. 3. Parametric maps of initial $p\text{O}_2$ and R .