Measurements of Regional Alveolar Oxygen Pressure and Oxygen Depletion Rate by Hyperpolarized 3He MRI in Small Animals

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Introduction: Hyperpolarized (HP) ^{3}He gas can be used to measure the alveolar oxygen partial pressure (P_AO_2) and oxygen depletion rate (ODR) in lungs. The measurement relies on the observation that ^{3}He depolarizes in the presence of oxygen with a rate that depends linearly on O_2 partial pressure. To separate the oxygen-induced depolarization from the depolarizing effect of the applied RF fields during the measurement, several acquisition techniques can be employed. The double-acquisition method [1], which requires two series of images with different inter-scan times, and single-acquisition methods [2,3], utilizing only one series of images, have been demonstrated to provide P_AO_2 and ODR in humans and large animals (pigs). However, the extraction of P_AO_2 and especially ODR requires a relatively high signal-to-noise ratio. This hindered the application of these techniques to small animals. Improvements in the acquisition sequence and hardware enabled us to acquire P_AO_2 and ODR in rabbit lungs.

Method : The experiments were conducted using an IACUC approved protocol. New Zealand rabbits were sedated with ketamine and kept under anesthesia. They were placed supine in a solenoidal coil inside a 1.5 T scanner (Siemens Sonata). HP ^{3}He gas was prepared in a prototype polarizer (General Electric Health System, Durham, NC). A tidal volume of 60 ml consisting of 12 ml O_2 and 48 ml HP ^{3}He gas was administered to the rabbits. A 2D gradient echo sequence with a modified scan loop structure was used to acquire images during breath hold. The key parameters were: FOV 160 mm; slice thickness 7 mm; T_R/T_E 6.2 s/2.8 s; resolution 64×64; scan delay $\Delta\tau/\tau$ 0.4 s/6 s.

Result and Discussion: Figure 1 shows the static images and the map of P_AO_2 and ODR values for 6 slices of the rabbit lung, covering almost the entire lung volume. Also shown in this figure are histograms of the measured parameters. The mean and standard deviations of the parameters within each slice are listed in Table 1. In the data a gradient of P_AO_2 and ODR from top to bottom in the supine direction is apparent.

Slice	P_AO_2 [mbar]	ODR [mbar/s]
1	101±23	0.7±0.7
2	118±19	0.8±0.6
3	130±12	1.1±0.4
4	138±18	1.3±0.4
5	141±11	1.6±0.4
6	135±13	1.6±0.4

Table 1: Average P_AO_2 and ODR values of 6 slices in the rabbit lung.

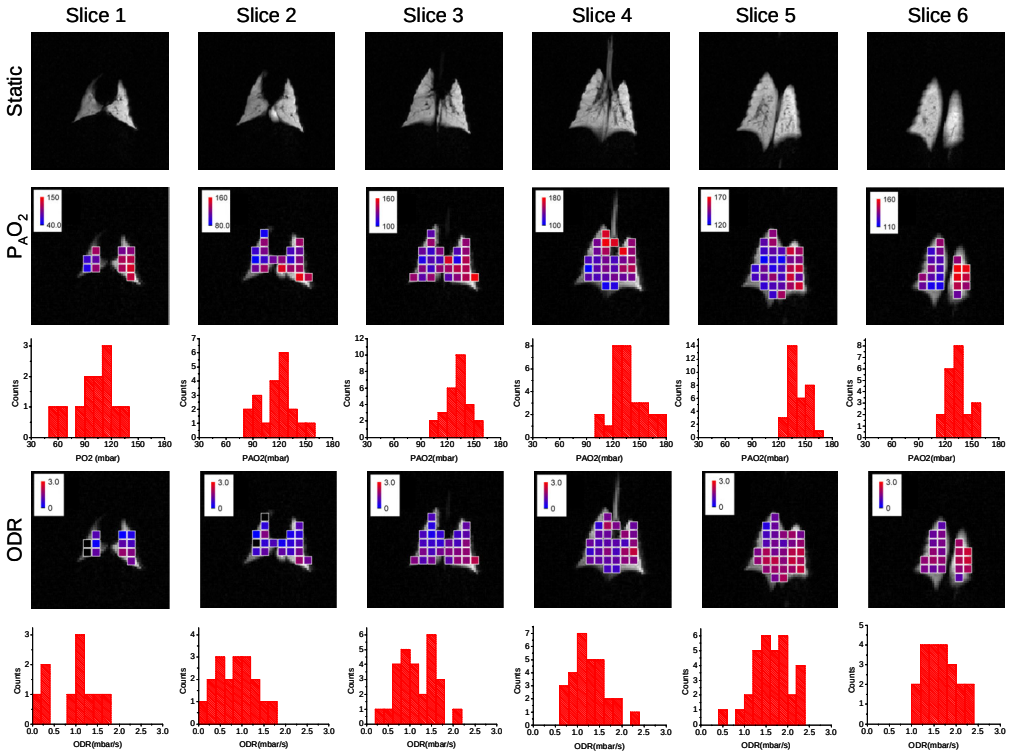

Fig. 1: Maps and histograms of P_AO_2 and ODR of 6 slices in the rabbit lung. Anatomy images are shown in the first row. The slice order (from left to right) corresponds to top-to-bottom direction in the supine position.

Conclusion: In this study we demonstrate the feasibility of measuring P_AO_2 and ODR in small animals. We present data obtained in healthy rabbits. Multiple slices covering almost the entire lung were acquired during a single breath hold.

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References: 1.) Deninger, A. J. *et al.*, *J Mag Res* **141**, 207 (1999). 2.) Deninger, A. J. *et al.*, *Mag Res Med* **47**, 105 (2002). 3.) Fischer, M.C. *et al.*, *Mag Res Med* **52**, 766 (2004).