# Multi-Slice Measurements of Ventilation to Perfusion Ratios by Hyperpolarized Gas MRI

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**Introduction:** To achieve comprehensive assessment of pulmonary function and sensitivity to regional disease, an imaging method is required that can measure functional parameters for the entire lung. We have recently reported the regional measurement of the ventilation to perfusion ratio for a single slice of the lung in a pig model using hyperpolarized (HP) $^3$He MRI [1]. For the alveolar oxygen measurements we utilized the double acquisition method of Deninger [2]. More recently, we have developed a single-acquisition method [3], which requires only one breath hold, as opposed to the two breath holds necessary for the double acquisition technique. Our single-acquisition method eliminates the need for one of the two breath holds without sacrificing performance. The main objective of the present study was to develop a multi-slice, MRI-based method for calculating V/Q for the entire lung. This is an important extension of our previous work. Furthermore, the development and validation of such a method is critically important before applying these measurements to human studies.

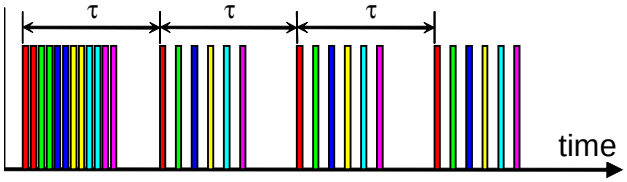


**Fig.1:** Schematic of the imaging acquisition sequence. Different colors indicate different slices.

**Method:** Figure 1 shows the employed multi-slice technique used to acquire the data for the alveolar oxygen partial pressure ($P_AO_2$). The sequence derives from the single acquisition method [3] and consists of interleaved sets of the single slice measurement sequence that are displaced in time by twice the single slice acquisition time. The first two images in each slice are used to extract the regional flip angle and are acquired without inter-scan delay. The slices were stacked without overlap and inter-slice gap. The analysis of the multi-slice sequence proceeds in a manner analogous to the single slice case. Each slice is analyzed separately. Care must be taken to take into account the fact that the first picture in each slice sequence starts at a different time. From the obtained $P_AO_2$ values a map of V/Q was calculated.

Experiments were conducted under an IACUC approved protocol. Yorkshire pigs were induced, intubated, paralyzed, and maintained on isoflurane anesthesia. Vital signs were monitored during the procedure. The pigs were placed supine in a birdcage coil and positioned in a 1.5 T whole-body imager (Sonata, Siemens). The hyperpolarized $^3$He used for imaging was generated using a commercial polarizer (Amersham Health, Durham, NC). MRI imaging began immediately after administration of a gas mixture consisting of 100 ml $O_2$, 200 ml $N_2$ and 200 ml of $^3$He that was polarized to a level of about 30%. We used a 2D fast gradient-echo pulse sequence with the following imaging parameters: flip angle 2°; TR/TE 6.4/2.9 ms; FOV 24×24 cm; matrix size 128×128; slice thickness 2 cm; interscan delay (τ) 6 s.

**Result and Discussion:** Figure 1 shows the static images and the map of V/Q values for 3 slices in the pig lung, covering the lung volume. Also shown in this figure are the histograms of the measured V/Q values. The mean and standard deviations of V/Q within each slice are listed in Table 1.

| Slice | V/Q |
|---|---|
| 1 | 1.15 ± 0.65 |
| 2 | 0.84 ± 0.27 |
| 3 | 0.74 ± 0.21 |

**Table 1:** Average V/Q values for 3 slices in the pig lung.

**Conclusion:** We present a multi-slice technique for measuring regional V/Q from HP $^3$He MRI lung images. Using this technique we can obtain V/Q maps of the entire lung using only one breath hold.

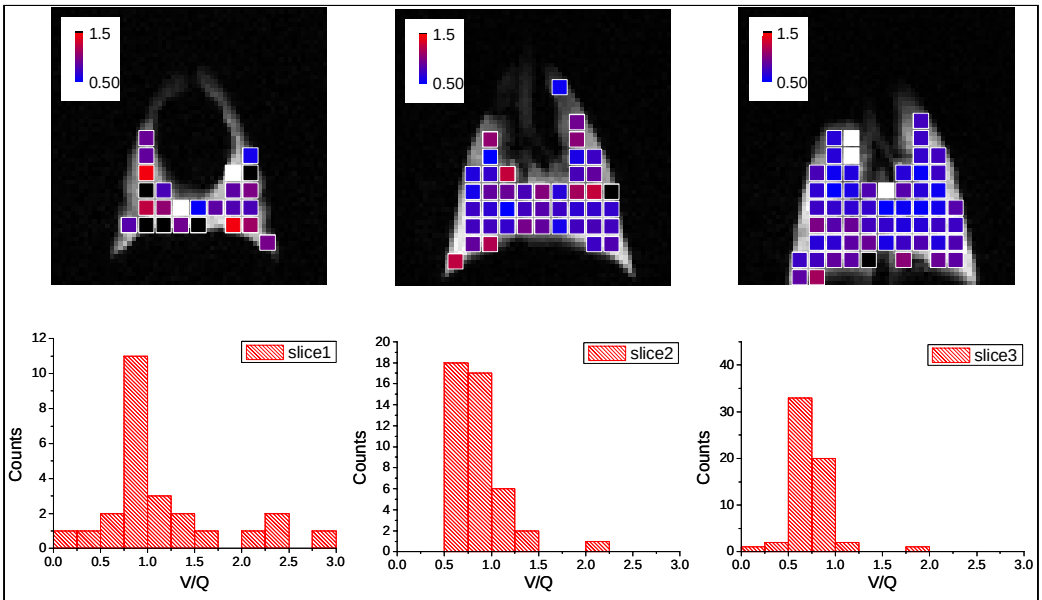


**Fig. 1:** Maps and histograms of V/Q for 3 slices in the pig lung. Anatomy images are shown in

## Acknowledgments

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**References:** 1.) Rizi, R.R., *et al.*, *Mag. Res. Med.*, **52,** 65 (2004). 2.) Deninger, A. J. *et al.*, *J Mag Res* **141**, 207 (1999). 3.) Fischer, M.C. *et al.*, *Mag Res Med* **52**, 766 (2004).