

# Differentiation of Vasculopathy from Normal Pulmonary Vasculature Using Hyperpolarized Helium-3 MRI in Humans

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## Introduction

Many lung pathologies manifest themselves as alterations in the pulmonary vasculature bed. We hypothesized that by determining regional lung oxygen concentrations and regional ventilation and perfusion ratios using hyperpolarized helium-3 MRI, we could non-invasively differentiate pulmonary disease caused by vasculopathy, from normal subjects. We chose patients with sickle cell disease (SCD) as our vasculopathy model group. Sickle cell disease is a disorder characterized by red blood cell hemolysis, and vaso-occlusion. Over time, recurrent red blood cell occlusive episodes in the lung lead to lung injury, restrictive lung disease, hypoxemia, pulmonary hypertension, and vasculopathy. We demonstrate that hyperpolarized helium-3 MRI can be used to non-invasively differentiate patients with vasculopathy from normal subjects.

## Methods

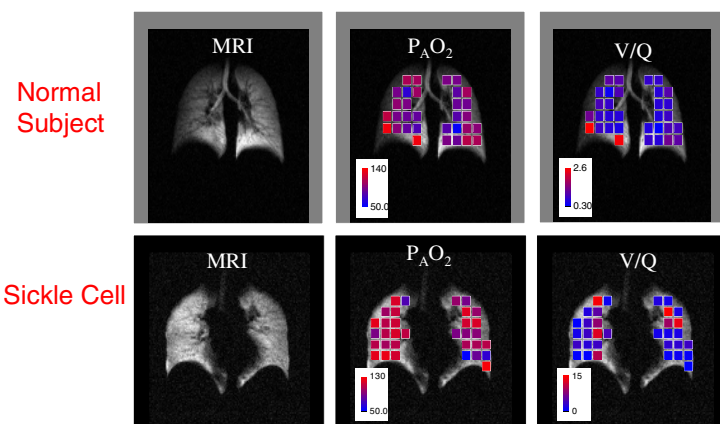
Work was performed under an approved FDA IND and IRB protocol. Subjects were imaged in a 1.5 T MRI scanner (GE Signa, Milwaukee, WI) configured for broadband operation for imaging. The subjects inhaled 500 cc of a mixture of 80% HP <sup>3</sup>He gas (9 mmol/L) and N<sub>2</sub>, and 20% O<sub>2</sub>. Hyperpolarized <sup>3</sup>He gas was prepared through spin exchange collisions with optically pumped rubidium atoms using a commercial prototype noble gas hyperpolarization system (GE, Fairfield, CT). The hyperpolarized <sup>3</sup>He gas was polarized for approximately 14 hours to achieve an average polarization of 38%. A double tuned (proton, <sup>3</sup>He) coil was used for MR image acquisition. TR: 7.3 msec; TE: 1.9 msec; matrix size: 256x128; FOV 26 cm x 26 cm; slice thickness 2 cm; Flip angle 4°. Measurements of regional alveolar oxygen pressure were performed using a double pulse acquisition technique. The MR images were analyzed by first calculating PAO<sub>2</sub> and then deriving the VA/Q ratio for 32 ROIs over the entire lung volume. Regional PAO<sub>2</sub> information is then used to derive regional VA/Q ratios by using accepted gas exchange equations.

## Results and Discussion

Helium gas was homogeneously distributed throughout the lungs of normal subjects (n=6) and those with vasculopathy (n=2). Table 1 reveals mean blood values, pulmonary function values, regional oxygen values and regional VA/Q values in the normal subjects and those with vasculopathy. In the normal subjects regional P<sub>A</sub>O<sub>2</sub> averaged 100.15 mbar. The mean V<sub>A</sub>/Q ratio was 0.969. In patients with known vasculopathy the mean P<sub>A</sub>O<sub>2</sub> was 127mbar. The mean VA/Q ratio was 3.9. Figure 1 demonstrates regional PAO<sub>2</sub> (mbar), and regional VA/Q ratios in a healthy human subject and in a patient with SCD. Figure 2 reveal the data in histogram form.

	HGB	FEV <sub>1</sub>	DL <sub>CO</sub>	TLC	P <sub>A</sub> O <sub>2</sub>	V <sub>A</sub> /Q
<b>Normal</b>	<b>14.06</b>	<b>105 %</b>	<b>108 %</b>	<b>105 %</b>	<b>100.15</b>	<b>0.969</b>
<b>SCD</b>	<b>9.65</b>	<b>68 %</b>	<b>59.5 %</b>	<b>72.5 %</b>	<b>127</b>	<b>3.9</b>

**Table 1:** Selected mean values in the subjects.



**Figure 1:** <sup>3</sup>He MR, regional PAO<sub>2</sub> (mbar), and regional VA/Q ratios in a healthy human and in a patient with vasculopathy.

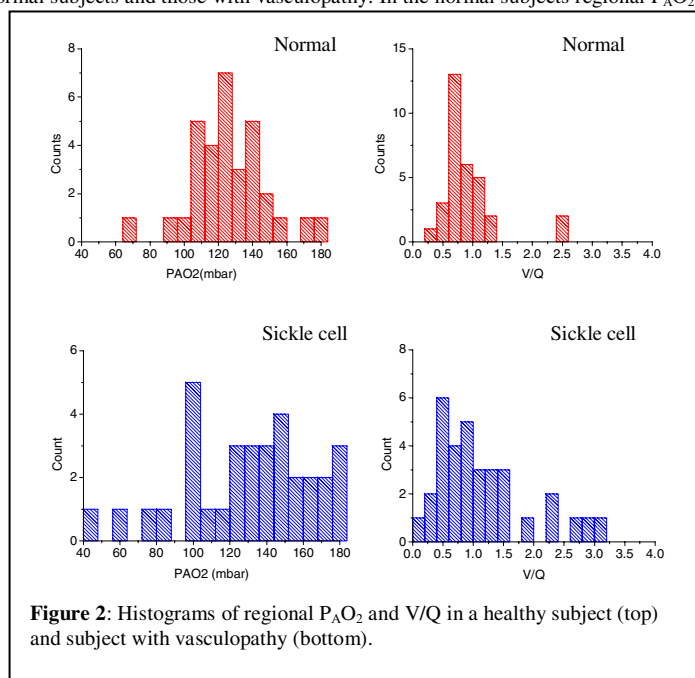
## Conclusions

Hyperpolarized helium-3 MRI may be used to non-invasively differentiate normal subjects from those with vasculopathy based on differences in regional oxygen concentrations and regional ventilation and perfusion relationships. Patients with vasculopathy have higher alveolar oxygen concentrations than normal subjects because of decreased uptake of oxygen from the alveolar space. Elevations in regional VA/Q values represent an increased number of lung units with high ventilation to perfusion ratios due to vascular destruction.

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## References

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**Figure 2:** Histograms of regional P<sub>A</sub>O<sub>2</sub> and V/Q in a healthy subject (top) and subject with vasculopathy (bottom).