Real-time Production and *in vivo* Imaging of Hyperpolarized ^{129}Xe

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Introduction: MRI using hyperpolarized ^{3}He and ^{129}Xe is challenging due to the non-renewable magnetization and single gas batches generally available for imaging. However, the polarization physics of ^{129}Xe, lends itself to real-time and continuous production which could fundamentally alter the way hyperpolarized gas MRI is implemented. Continuous ^{129}Xe polarization has been demonstrated for *in vitro* NMR spectroscopy applications [1]. However, *in vivo* imaging requires gas pressures to be stepped down to physiologic levels, and ^{129}Xe to be polarized faster. Here, we demonstrate the capability to perform *in vivo* imaging using hyperpolarized ^{129}Xe flowing directly and continuously from the polarizer to the subject.

Methods: A prototype commercial polarizer (IGI.9800.Xe, MITI, Durham, NC) was modified to eliminate cryogenic accumulation, stepping down the 5atm Xe/N_2/He (1% Xe) mixture flowing out of the optical cell using an all Teflon regulator (Partek, Tuscon, AZ). This gas stream took the place normally occupied by the hyperpolarized gas reservoir in the ventilator [2] where it was mixed with O_2 and delivered continuously to the animal. Five Fischer 344 rats (Charles River, Raleigh, NC) weighing 170-200g were used for imaging. Three of the rats had unilateral pulmonary fibrosis in the left (n=2) or right (n=1) lung. Rats were anesthetized with ketamine and diazepam, perorally intubated and ventilated at 60 bmp with 2 ml tidal volume. Animals were imaged in a 23.639MHz linear bird cage coil (L=8cm, ϕ=7cm) in a 2.0T horizontal 15cm clear bore magnet (Oxford Instruments, Oxford, UK) with shielded gradients (18G/cm), controlled by a GE Excite console (GE Healthcare, Milwaukee, WI). Animals were also scanned using fully concentrated hyperpolarized ^{129}Xe (0.5 liter, P=8%) mixed 75/25% with O_2. All studies used 83% enriched ^{129}Xe (Spectra Gases, Alpha, NJ). Standard images were acquired at 128×128 matrix, 4cm FOV, no slice, 8kHz bandwidth, 400 radial projections, 10 views per breath, TR=20ms and a variable flip angle. Direct flow images used a 64×64 matrix, 7cm FOV, no slice, 4kHz bandwidth, 200 radial projections, 4 views per breath, TR=50ms, and variable flip angle.

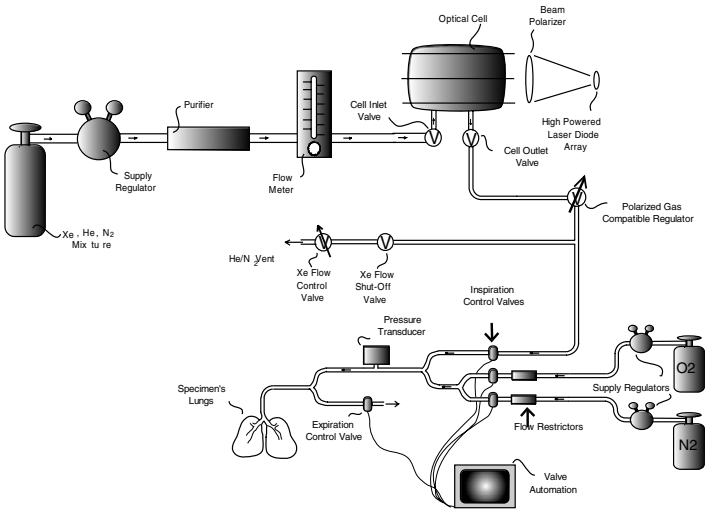

Figure 1 Continuous production and animal delivery of hyperpolarized ^{129}Xe

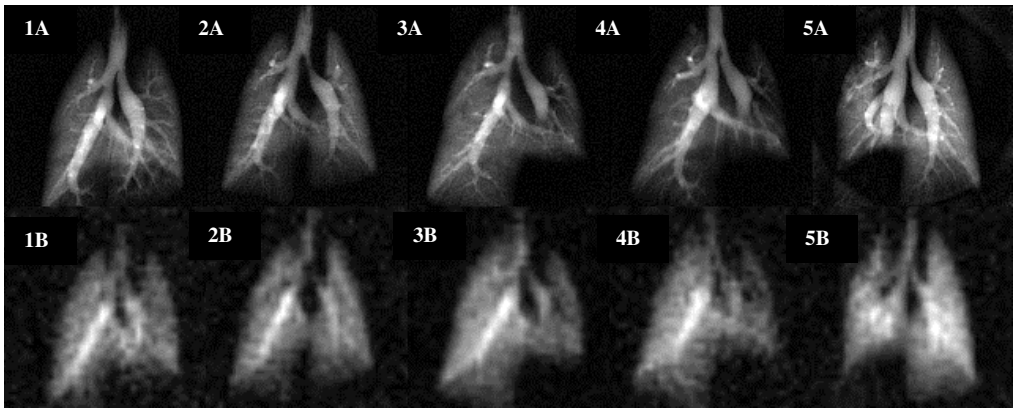

Figure 2 Images of rats using standard ventilation (1A-5A) and continuous delivery (1B-5B).

Results and Discussion: For standard versus direct delivery, we achieved resolutions of 0.31×0.31mm^2 with SNR of 10-21 versus 1.09×1.09mm^2 with SNR of 7.5-15, reflecting a factor of 23 signal difference. Most notably, the direct flow images were acquired in 0.83min using only 0.8ml of Xe, whereas the standard images were acquired using 64ml Xe. The direct-flow images are of sufficient quality to delineate the major airways and observe the shrunken ventilated volume in the fibrotic lungs (3B-5B).

Conclusion: In its current form, this technique is very useful for performing some of the standard pre-scan activities such as localizing, shimming, setting flip angle and frequency, or pulse sequence testing. More interesting, however, is the possibility of concentrating the ^{129}Xe to 100% in real time, gaining a further factor of 100 and enabling high-resolution^{129}Xe imaging beyond the lung to become practical.

References

1. M. Haake, A. Pines, J. A. Reimer *et al.,* Journal Of The American Chemical Society 119 (48), 11711-11712 (1997).
2. B. T. Chen, A. C. Brau, and G. A. Johnson, Magnetic Resonance in Medicine 49 (1), 78-88 (2003).

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