Quality Assessment of Hyperpolarized ^{129}Xe Magnetic Resonance Image (MRI) Data from Healthy and Asthmatic Patients With Varied Compressed Sampling

Mitra Tavakkoli[1,2] , Sarah Svenningsen[2,3] , Norman Konyer[2], Parameswaran Nair[3], Michael D. Noseworthy[1,2,4,5]

[1]Electrical and Computer Engineering, McMaster University, Hamilton ON; [2]Imaging Research Centre, St. Joseph's Healthcare Hamilton, Hamilton, ON;
[3]Firestone Institute for Respiratory Health, St. Joseph's Healthcare and Department of Medicine, Division of Respirology, McMaster University, Hamilton, ON;
[4]McMaster School of Biomedical Engineering, Hamilton ON; [5]Department of Radiology, McMaster University, Hamilton; ON

Introduction

- Hyperpolarized (HP) ^{129}Xe MRI has shown great promise in capturing pulmonary disease information. Hyperpolarization enhances the NMR signal or MR image quality, and it can be divided into two steps: 1) optical pumping and 2) spin exchange. Figure 1 represents a simple schematic of these two steps for ^{129}Xe hyperpolarization [1]. In this technique, the signal comes from the nuclear magnetic moment of spins from ^{129}Xe instead of the hydrogen spins of water, as in conventional MRI. Figure 2 shows an example of HP ^{129}Xe lung MRI compared to conventional ^{1}H MRI. However, this approach requires breath holding during acquisition, which is problematic in asthma patients [2,3].
- Accelerated imaging methods such as Compressed Sensing (CS) allow good quality image recovery from undersampled MRI data permitting faster data acquisition [4]. CS is now becoming routine for ^{1}H MRI. However, its application in HP ^{129}Xe lung ventilation MRI has not yet been optimized. Thus, our aim was to assess CS sampling schemes and their effect on image quality (SNR and resolution).

Proton Lung MRI **HP ^{129}Xe Lung MRI**

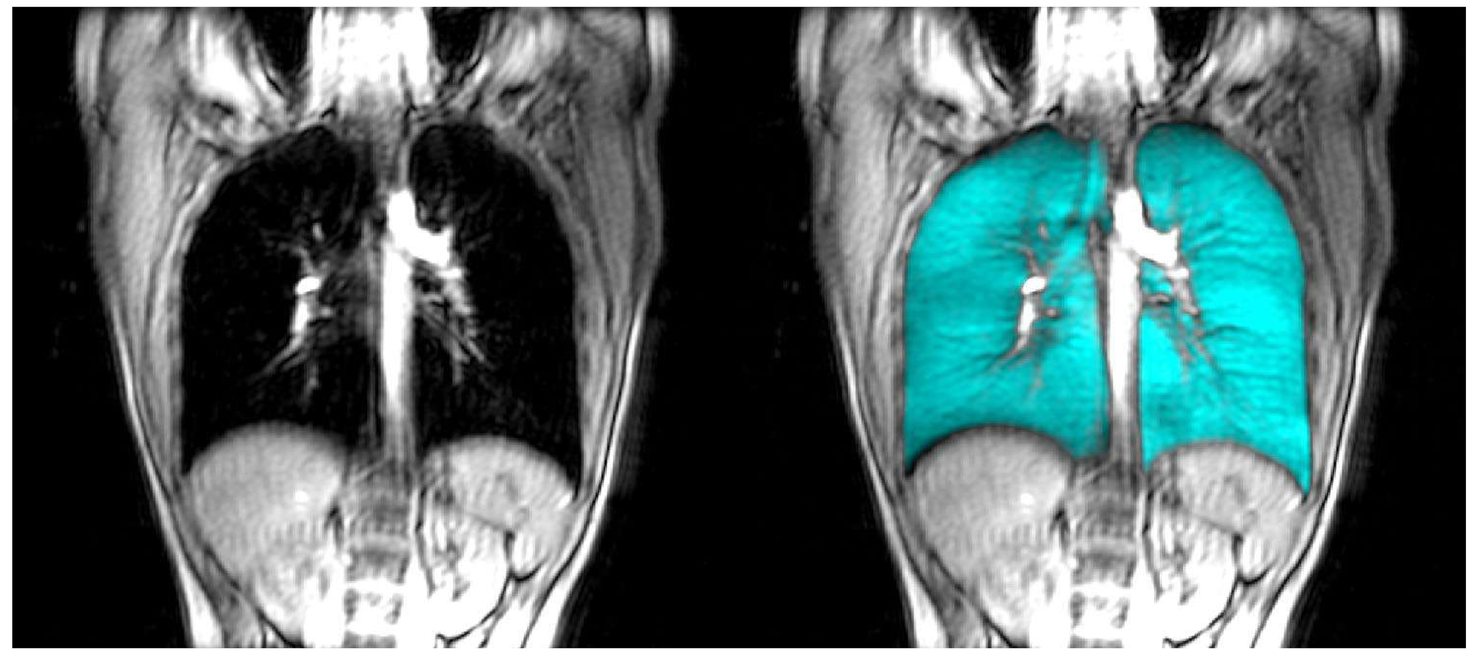

Figure 2 Left) ^{1}H lung MRI Right) HP ^{129}Xe lung MRI

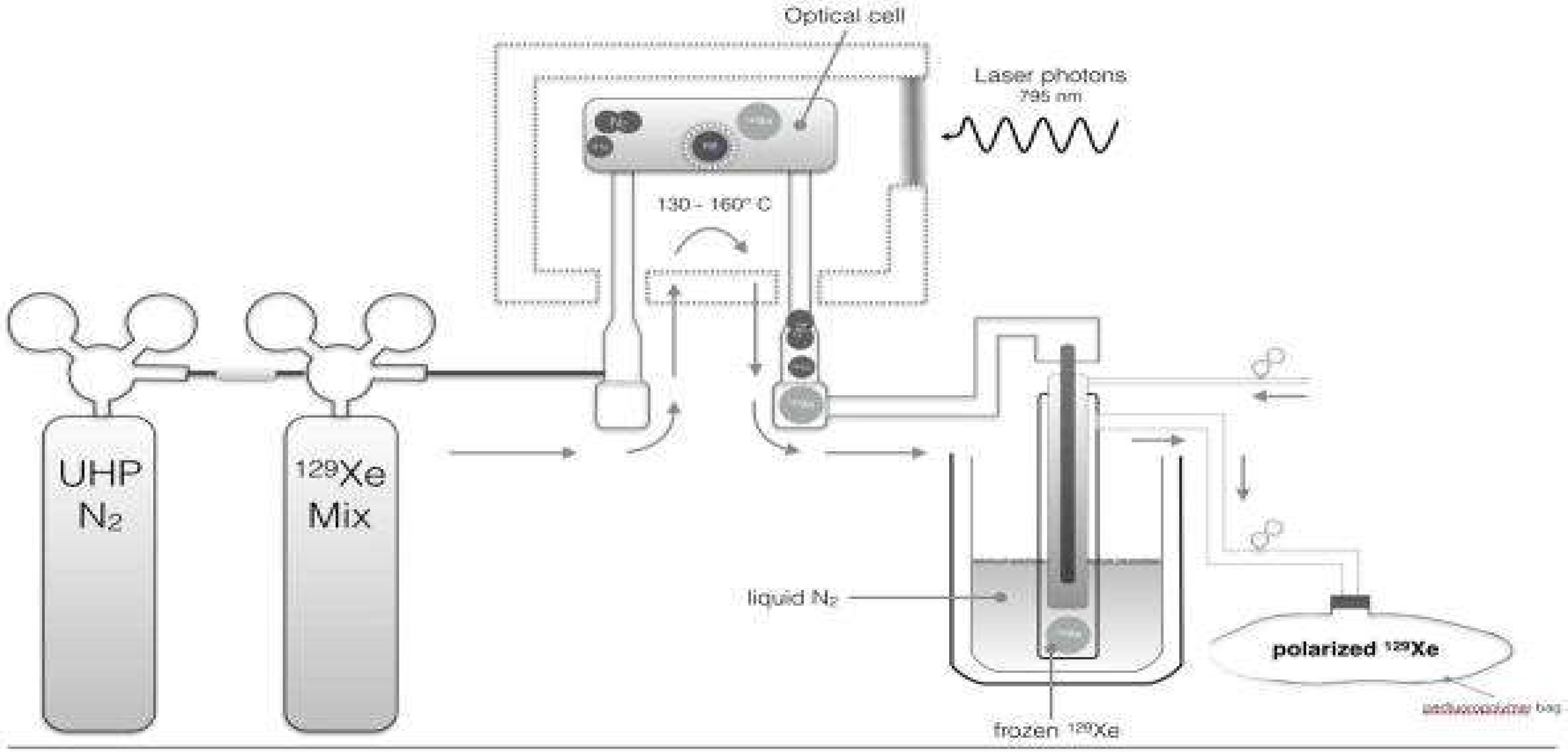

Figure 1 A simple representation of ^{129}Xe polarization [1]

Methods

- **Subjects:** Inhaled HP ^{129}Xe datasets from 10 subjects (5 healthy and 5 asthmatic) were used
- **Image Acquisition:** Images were acquired on a 3.0 T MRI (Discovery MR750, GE, acquiring fully sampled 3D multi-slice HP- ^{129}Xe lung ventilation images (128x80, 16 slices) [5].
- **Image Processing:** 200 masks were pseudo-randomly generated [6] each at 7 different sampling rates, (15% to 75% , step length = 10%). The Parallel Imaging Compressed Sensing (PICS) command from the Bart toolbox [7], with L1 wavelet optimization and 100 iterations, was used to reconstruct undersampled data. Resultant image quality (SNR, incoherence value, resolution, statistical similarity (SSIM)) for each was compared (figure 3).

Results

With greater undersampling, the degree of incoherence and SSIM decreased while the SNR increased. However, a high degree of variation in all quality metrics were noted for each of the undersampling rates. Relative Standard Deviation (RSD) values showed that SNR varied as much as 77.21% , SSIM 64.1%, and incoherence value 51.55%, depending on sampling scheme.

Discussion

These results indicate there is an optimized rate and pattern of undersampling. This needs thorough investigation to determine optimal CS accelerated HP 129Xe lung ventilation imaging and preserve fine image detail while reducing acquisition time.

Fully Sampled **Sampling Rate= 35%**

Severe Asthmatic

Healthy Volunteer

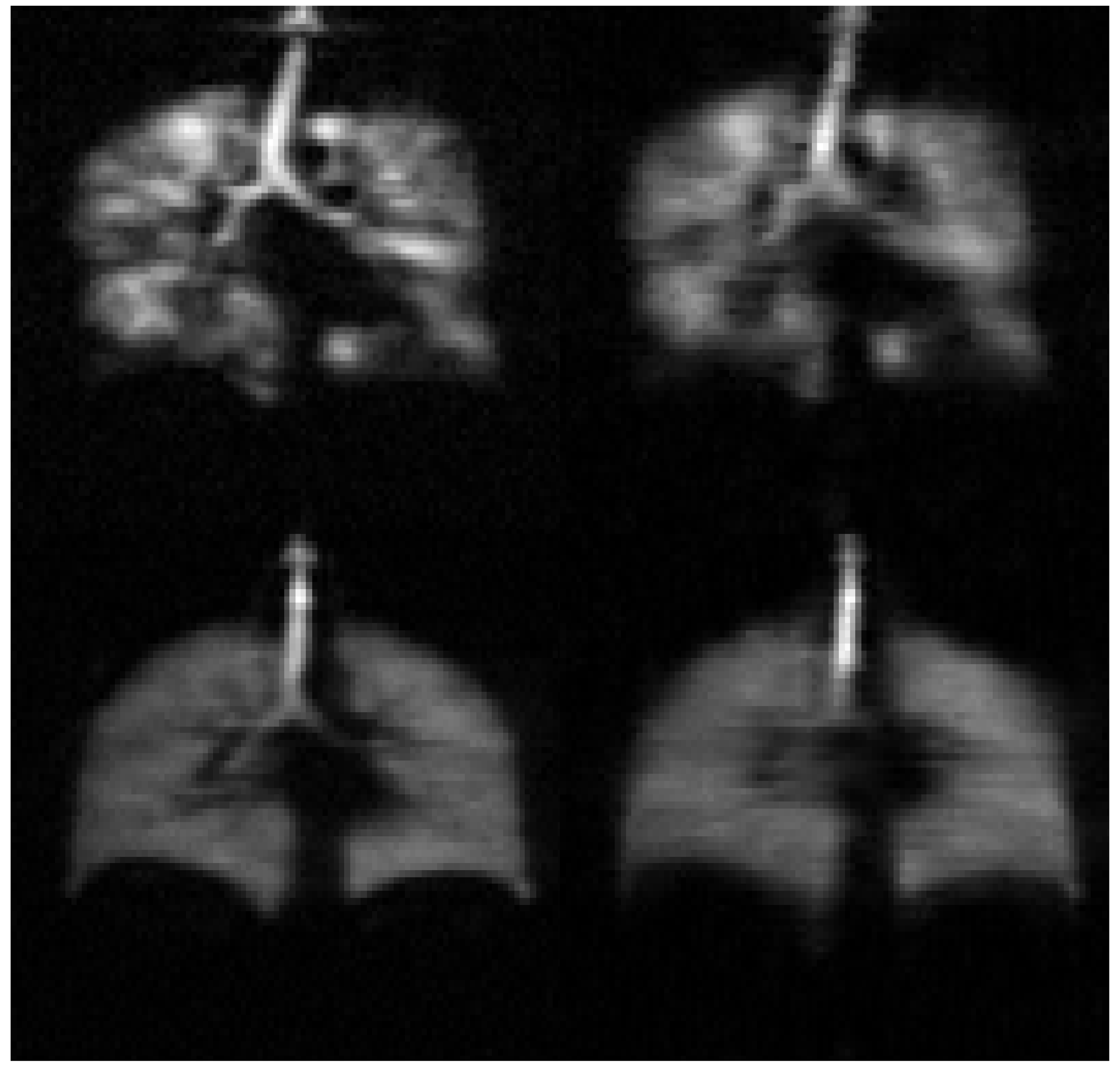

Figure 3. Comparing varying levels of undersampling in both asthmatic (top) and healthy (bottom) resultant lung images. The SNR values varies from 25.17 to 89.25 in the asthma case, and 65.84 for the healthy patient (fully sampled image SNR: 25.17)

References

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McMaster University

Electrical and Computer Engineering
Information Technology Building A111
1280 Main Street West
Hamilton, ON L8S 4L8

(905) 525-9140 x 24347
(905) 525-9140
tavakkm@mcmaster.ca
https://www.eng.mcmaster.ca/ece

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Mitra Tavakkoli received the B.Sc. degree in Computer Engineering in 2016 and M.Sc. in Electrical Engineering in 2019. She joined the Electrical Engineering Department of McMaster University, Hamilton, CA, in 2021, where she is studying as a P.h.D student under the supervision of Prof. Michael Noseworthy. Her research interests include Magnetic Resonance Imaging (MRI), Hyperpolarized (HP) gas MRI and Compressed Sensing (CS). Currently, she is trying to find the optimum MRI Xenon diffusion sampling scheme(s) for the best way to image lung diseases such as asthma, COPD and [long] SARS-CoV-2.

Mitra Tavakkoli
Ph.D. student
Department of Electrical and Computer Engineering
McMaster University

Email: tavakkm@mcmaster.ca
Phone: +1 (289)-253-8915
St. Joseph's Healthcare, Imaging Research Center (IRC)
50 Charlton Ave. E., Hamilton, ON, Canada, L8N 4A6