

# Functional Lung MRI Using Inhaled Hyperpolarised Xenon-129 for Personalised Radiotherapy Planning and Longitudinal Treatment-induced Lung Injury Assessment: Preliminary Findings

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## Introduction

Current motion-management strategies in radiotherapy mitigate positional error but do not typically incorporate regional lung function information, which can facilitate functional lung-avoidance radiotherapy planning and longitudinal evaluation of treatment-induced lung injuries, including radiation-induced lung injury (RILI). Inhaled hyperpolarised xenon-129 (HP <sup>129</sup>Xe) gas MRI provides a sensitive, non-invasive, radiation-free assessment of regional ventilation, microstructure, and gas exchange, offering richer functional characterisation than conventional techniques.

## Aim

This study evaluates HP <sup>129</sup>Xe MRI-derived ventilation, diffusion, and gas-exchange metrics in patients with early-stage non-small cell lung cancer (NSCLC) to assess the feasibility of multi-parametric functional imaging for functional lung-avoidance radiotherapy planning and longitudinal monitoring.

## Materials and Methods

Seventeen patients with early-stage NSCLC undergoing radiotherapy or surgery were recruited from a prospective, ongoing observational study that images patients using HP <sup>129</sup>Xe MRI pre-treatment and at 3- and 12-months post-treatment, with concurrent pulmonary function tests acquired. For this preliminary study, we analysed the pre-treatment scans only. HP <sup>129</sup>Xe gas was polarised on-site and delivered via volitional breath-hold from a Tedlar bag at functional residual capacity plus bag volume titrated according to the patient's height. 3D volumetric <sup>129</sup>Xe ventilation and proton MRI structural images were acquired at 1.5T. Ventilation defect percentage (VDP) was calculated from co-registered images. Apparent diffusion coefficient (ADC) maps and mean diffusivity length ( $L_{mD}$ ) were derived from multi-b-value diffusion-weighted imaging. Gas-exchange ratio maps (RBC: Membrane, RBC: Gas, Membrane: Gas) were produced using in-house MATLAB processing workflows.

## Results

As patient recruitment is ongoing, only descriptive statistics have been calculated for the cohort to date. Pre-treatment median VDP values between radiotherapy and surgery groups were 27.50% (n=11) and 19.74% (n=6), respectively. Median ADC values were comparable (RT: 0.061, n=10; surgery: 0.059, n=6), as were median  $L_{mD}$  estimates (RT: 384 $\mu$ m, n=10; surgery: 384 $\mu$ m, n=6), indicating similar baseline ventilation and microstructure measurements between treatment groups. For gas-exchange metrics, median RBC: Membrane (RT: 0.160, n=10; surgery: 0.139, n=5), RBC: Gas (RT: 0.0013, n=10; surgery: 0.0012, n=5) and Membrane: Gas ratios (RT: 0.008, n=10; surgery: 0.009, n=5) were comparable.

## Conclusion

These pilot findings demonstrate the feasibility of acquiring multi-parametric HP <sup>129</sup>Xe MRI via volitional breath-holds in lung cancer patients undergoing treatment. Future work will assess the efficacy of HP <sup>129</sup>Xe MRI for functional lung-avoidance radiotherapy planning and longitudinal RILI assessment.

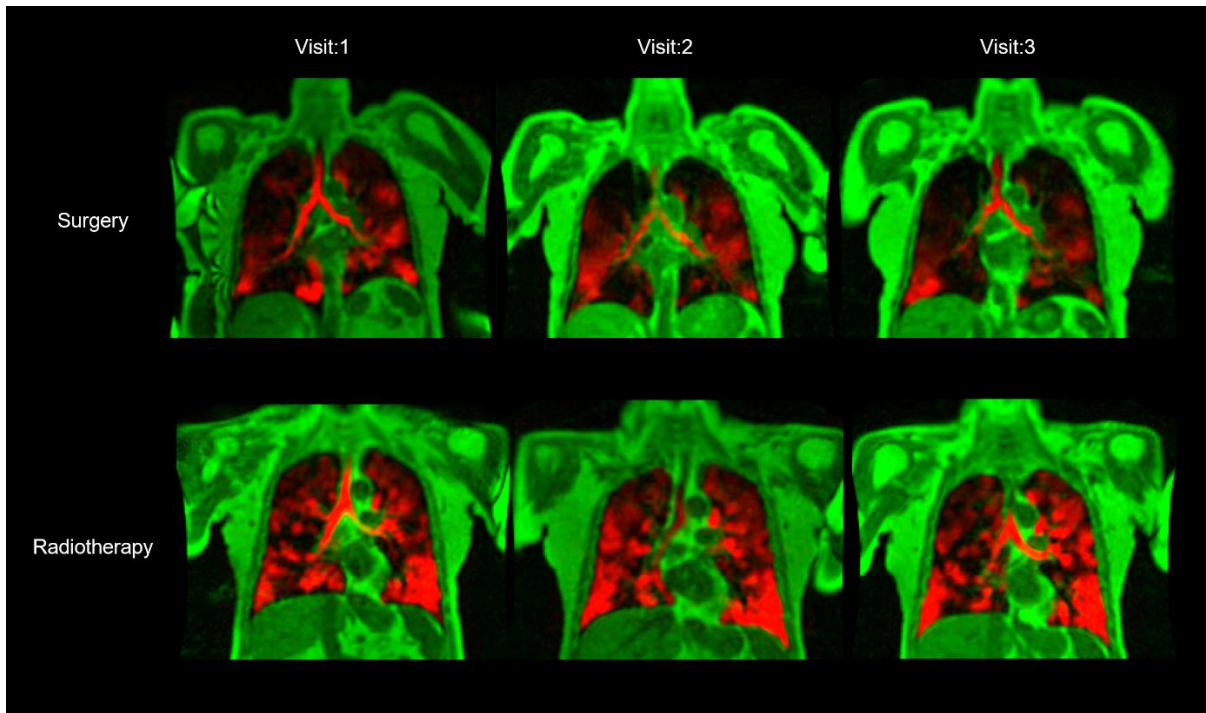


Figure 1: Hyperpolarised  $^{129}\text{Xe}$  gas ventilation MRI (red) overlaid on anatomical proton MRI in two NSCLC patients who underwent surgery (top) and radiotherapy (bottom) over three visits.