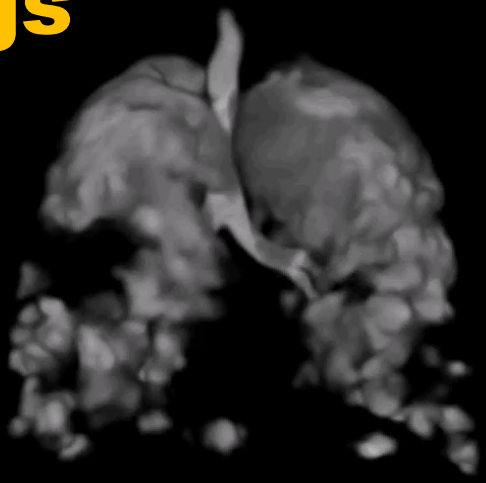
Functional Lung MRI Using Inhaled Hyperpolarised Xenon-129 for Personalised Radiotherapy Planning and Longitudinal Treatment-induced Lung Injury Assessment: Preliminary Findings



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Clinical Supervisor: Prof. Matthew Hatton

University of Sheffield

POLARIS
Pulmonary, Lung and Respiratory Imaging Sheffield
Polarised Imaging Systems

NHS
Sheffield Teaching Hospitals
NHS Foundation Trust

Yorkshire Cancer Research

جامعة الملك عبدالعزيز
KING ABDULAZIZ UNIVERSITY

Lung Cancer: Global and Regional Burden

Global Perspective

- **Incidence:** 2nd most common cancer

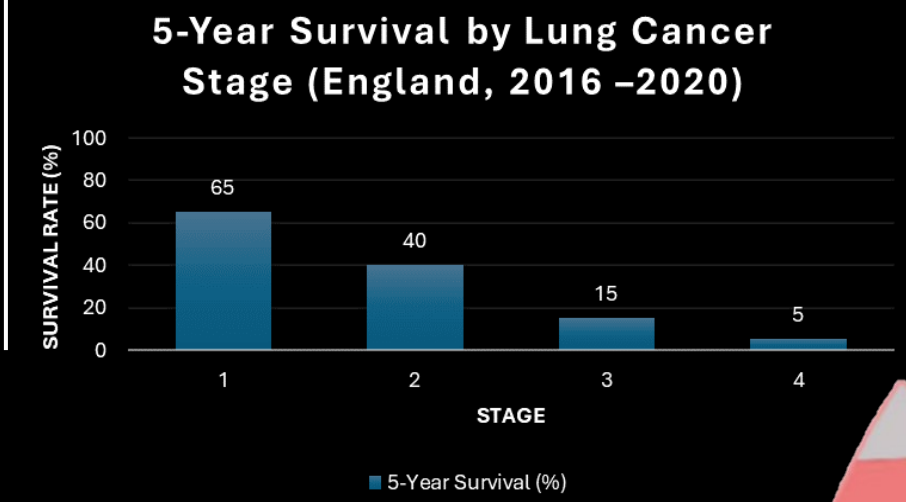
(2.48 million new cases in 2022).

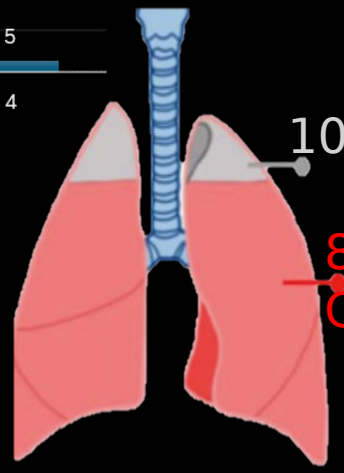
- **Mortality:** 1.8 million deaths were linked to lung cancer.
- If trends continue → by 2050:
  - 4.62 million new cases.
  - 3.55 million deaths.

UK / Yorkshire

- 4,300 new cases diagnosed annually.

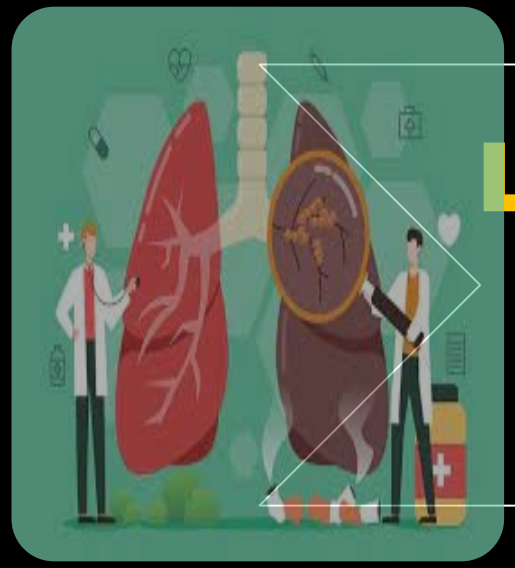
Most cases are diagnosed at late stages (III–IV) → poor treatment outcomes



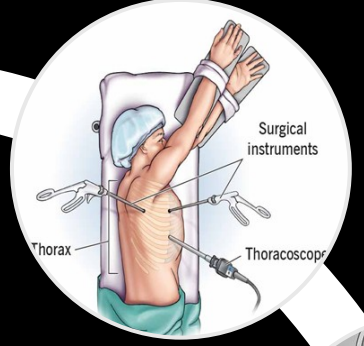


Cigarette smoking → is the primary risk factor for lung cancer worldwide.

(WHO, 2023), (NHS, 2022), (CRUK, 2022),(Oh et al., 2024), (Li *et al.*, 2023), (Leiter, 2023), (Z



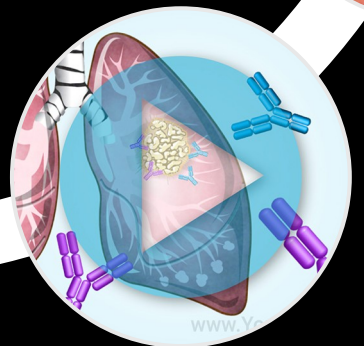
Lung Cancer Treatment Modalities



Surgery

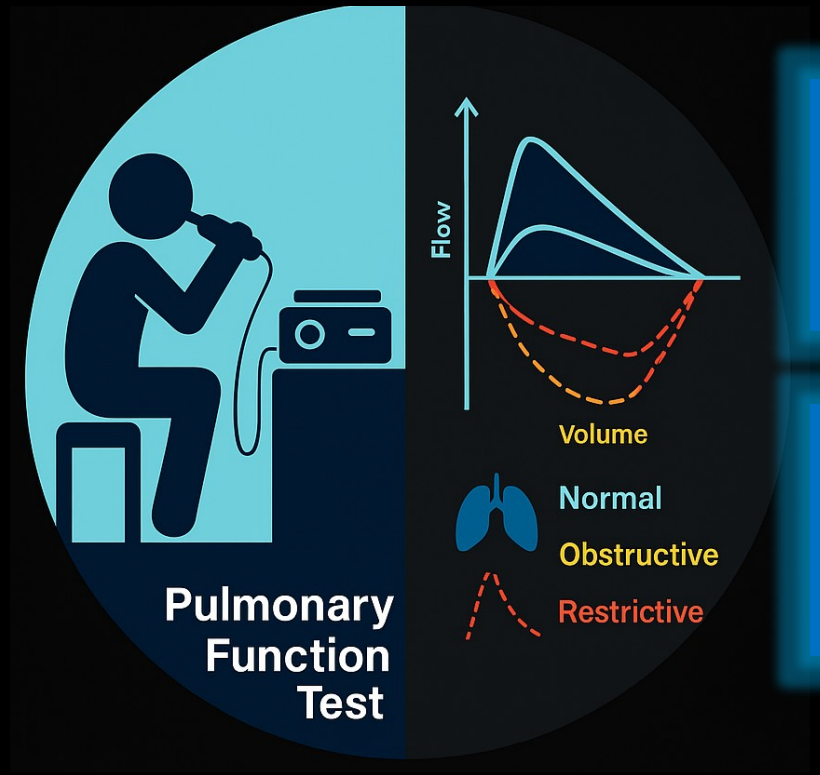
Radiotherapy

Chemotherapy



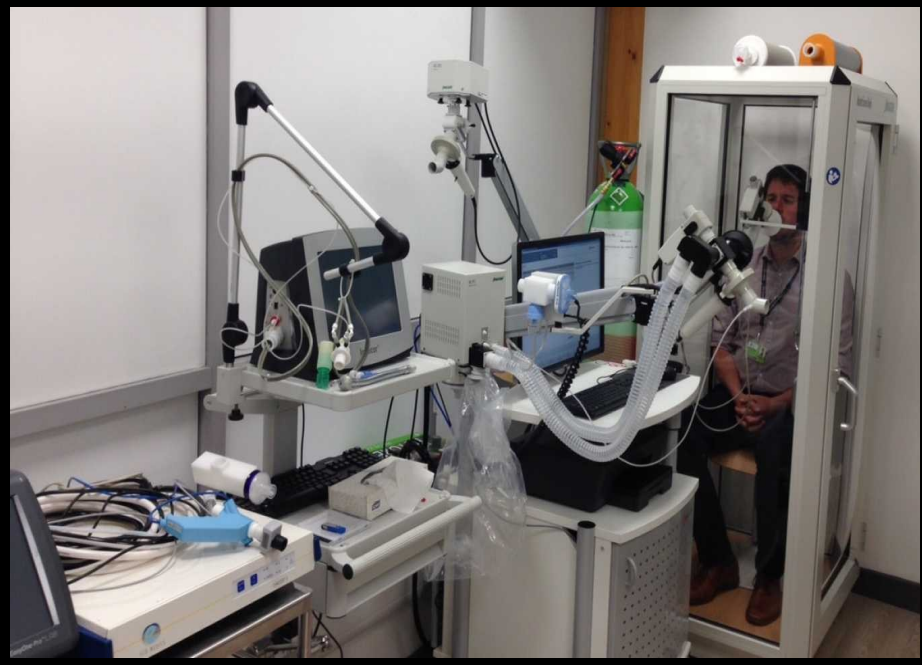
Immunotherapy

Pulmonary Function Tests



FEV1
Forced expiratory volume in one second

FVC
Forced vital capacity



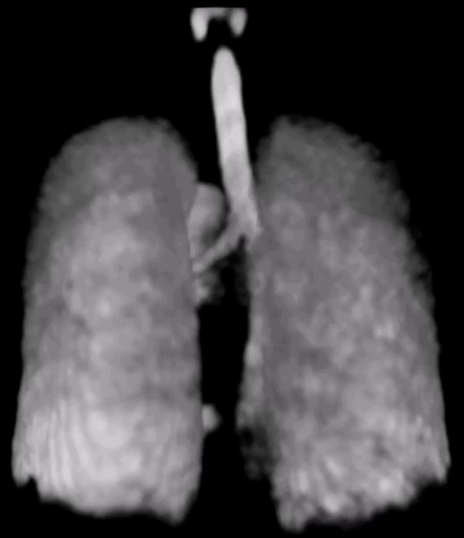
University of Sheffield Lung Function Lab

FEV1 measurements below 40% deem an increased peri-operative risk and mean radiotherapy may be more suitable

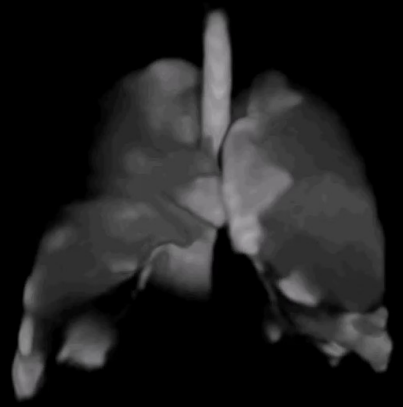
(Ponce et al., 2023)

Aim of the Study

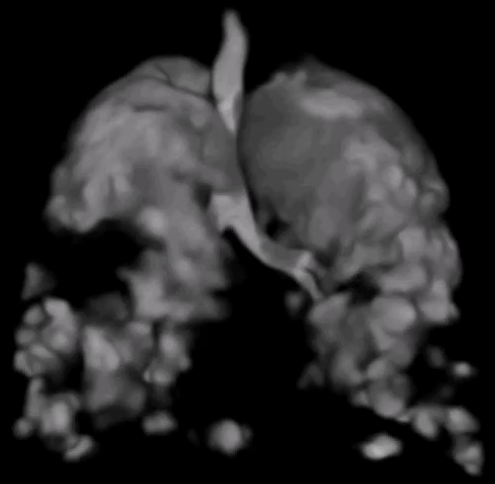
To evaluate Hyperpolarised Xenon-129 (HP ^{129}Xe) MRI-derived **ventilation**, **diffusion**, and **gas-exchange** metrics in patients with early-stage NSCLC undergoing surgery or radiotherapy



Healthy



COPD



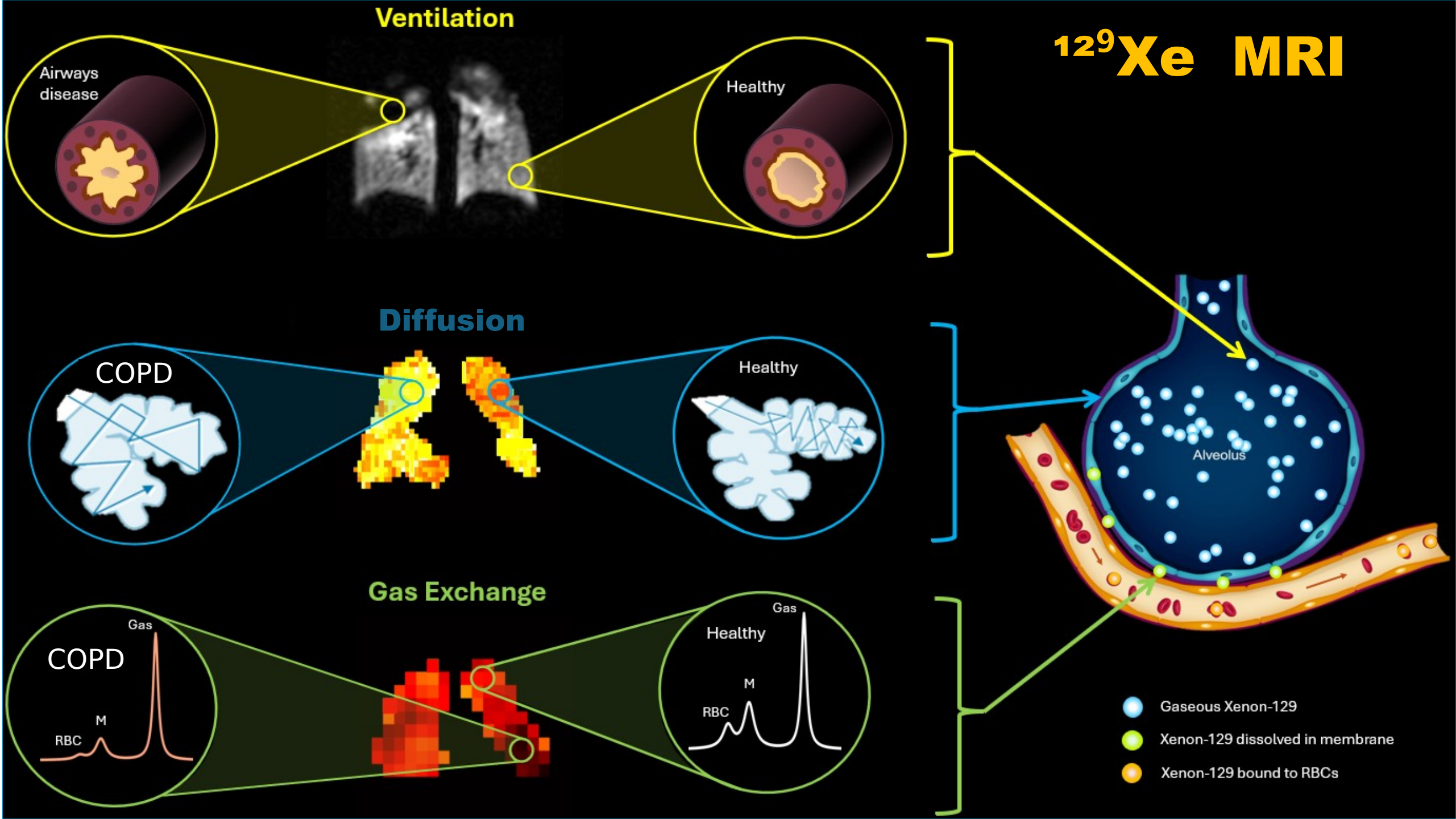
Lung cancer (+

Patient Experience During HP ^{129}Xe MRI Imaging

Polariser

Tedlar bag

RF coil


Ventilation
Airways disease
Healthy
^{129}Xe MRI
Diffusion
COPD
Healthy
Gas Exchange
COPD
Gas
M
RBC
Healthy
Gas
M
RBC
Alveolus
Gaseous Xenon-129
Xenon-129 dissolved in membrane
Xenon-129 bound to RBCs

LUMRIS Data Acquisition

Yorkshire Cancer Research

LUng **M**RI for **RI**sk **S**tratification to select non-small cell lung cancer patients for radical treatment

Inclusion:

Radically treatable NSCLC
Borderline lung function
Able to undergo MRI scanning

PFTs
^{129}Xe MRI
Dynamic Contrast-Enhanced MRI
CT

Visit 1:
Pre-treatment

→

Visit 2:
3 months post-treatment

→

Visit 3:
12 months post-treatment

Summary of Patient Characteristics

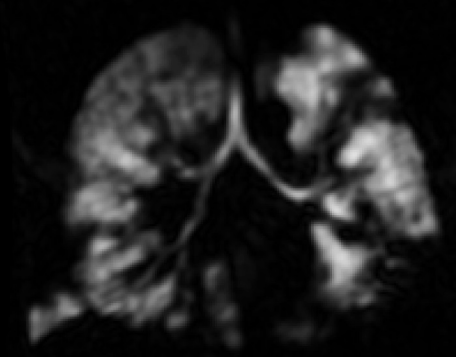
Clinical Characteristic		RT Group	Surgery Group
		Number (%) or mean ± SD	Number (%) or mean ± SD
Gender	Male	11 (55.0%)	1 (16.7%)
	Female	9 (45.0%)	5 (83.3%)
Age	Age	72.2±7.7	72.5±8.1
Treatment regime	S or RT	20 (76.9%)	6 (23.1%)
Smoking Cigarette Status	Current smoker	8 (40.0%)	3 (50.0%)
	Former smoker	9 (45.0%)	3 (50.0%)
	Alternative tobacco product user	2 (10.0%)	0
	Non-smoker	1 (5.0%)	0
Respiratory	COPD	11 (55.0%)	2 (33.3%)
	Asthma	1 (5.0%)	1 (16.7%)
	Emphysema	2 (10.0%)	0

MRI Acquisition and Analysis

Imaging	**^{129}Xe Ventilation**	**^{129}Xe Diffusion**	**^{129}Xe Gas Exchange**
Biomarker	Ventilation Defect Percentage (VDP)	Lung Microstructure: apparent diffusion coefficient (ADC) & mean	Signal ratios of ^{129}Xe in physicochemical compartments
Analysis	Heterogeneity of lung ventilation	Whole lung morphometry measurements	Ratio Maps (RBC:Tissue, RBC:Gas, Tissue:Gas)

Workflow of image segmentation to calculate the VDP

^{129}Xe MRI

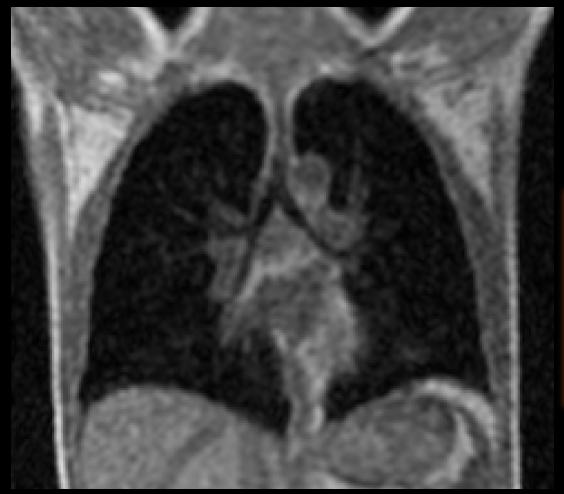


Deep learning + manual editing

Ventilated volume

$$(1 - \frac{VV}{TLV}) * 100 = VDP$$

Proton MRI

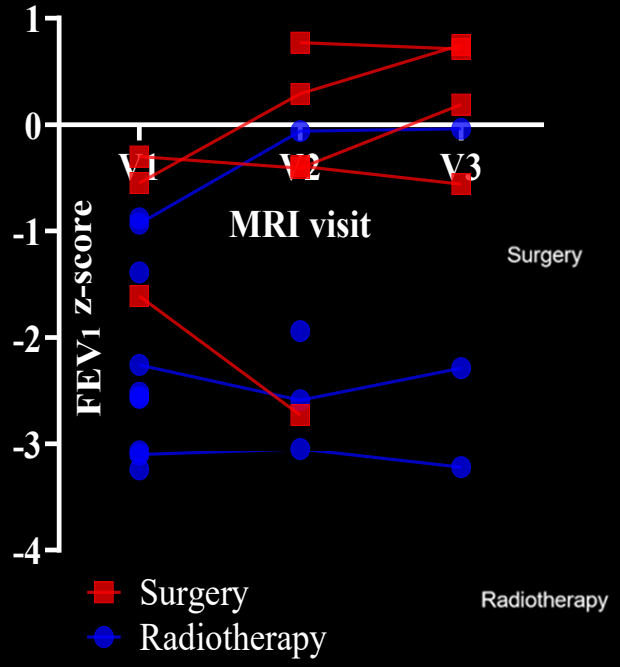


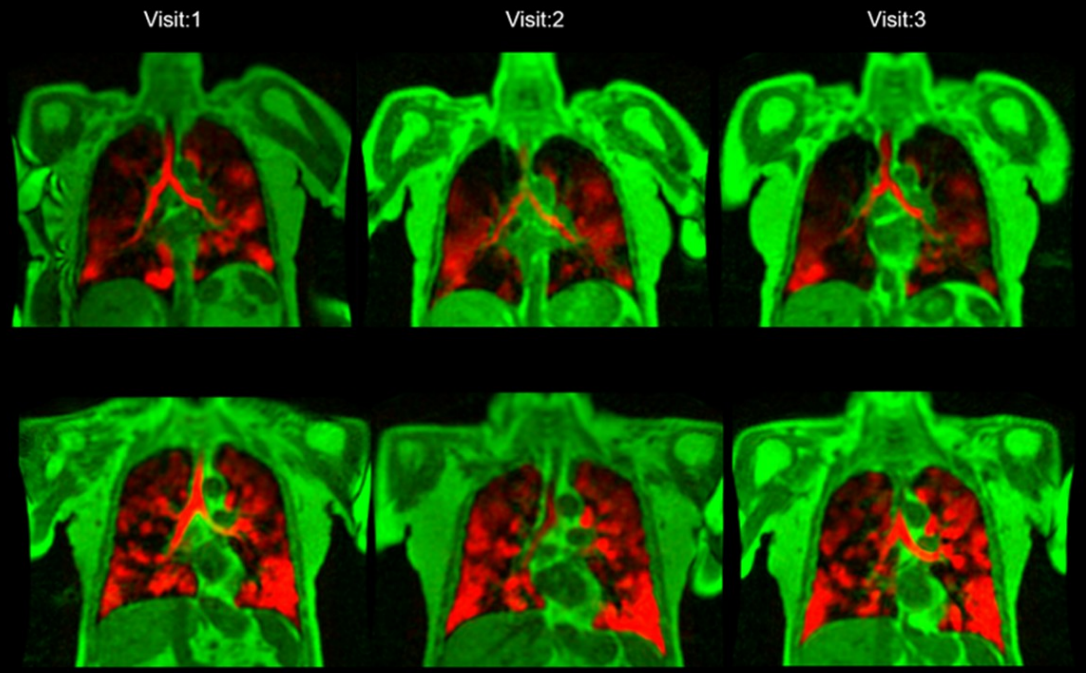
Deep learning + manual editing

Total lung volume

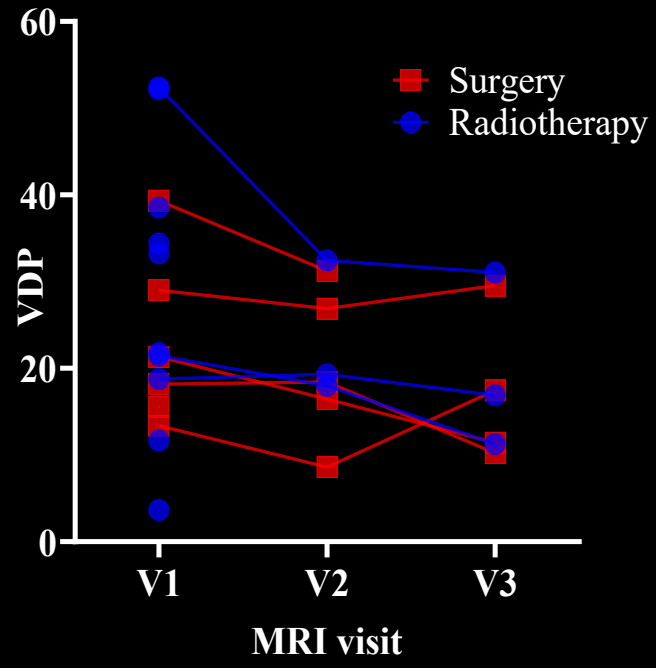
Longitudinal Changes Between Lung **Ventilation** Defect Percentage and Lung Function Measures In Patients with Early-stage NSCLC

Lung function measures (FEV_1)



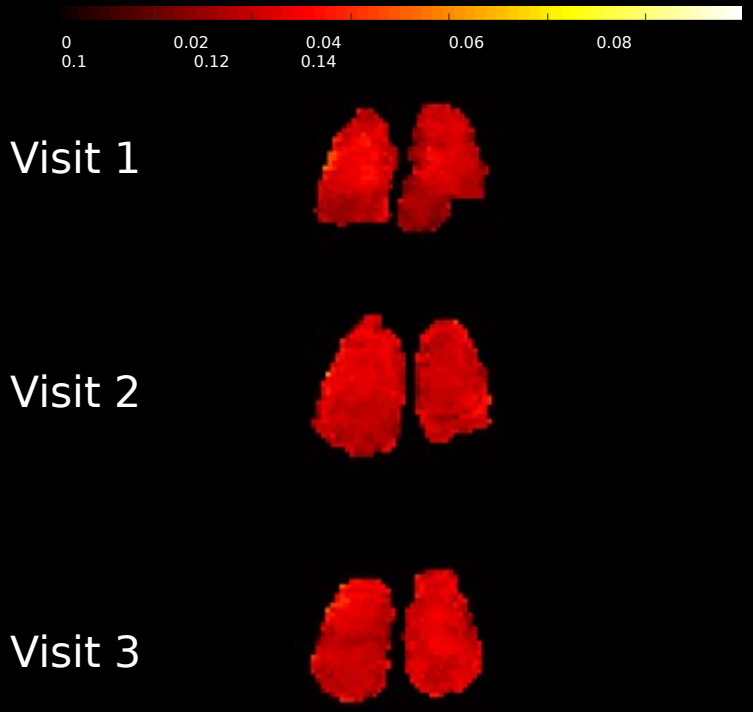


Ventilation defect percentage (VDP)

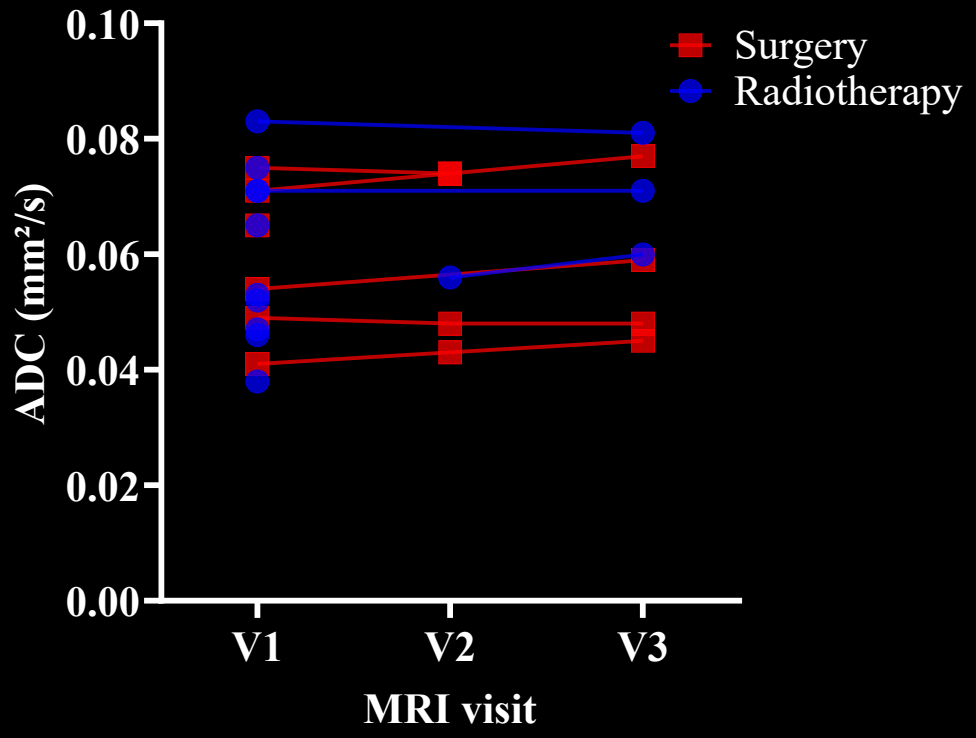


Hyperpolarised ^{129}Xe gas ventilation MRI (red) overlaid on anatomical proton MRI in two NSCLC patients who underwent **surgery** (top) and **radiotherapy** (bottom) over three visits

Longitudinal Changes In **Diffusion** Among Early-stage NSCLC Patients with Surgery and Radiotherapy

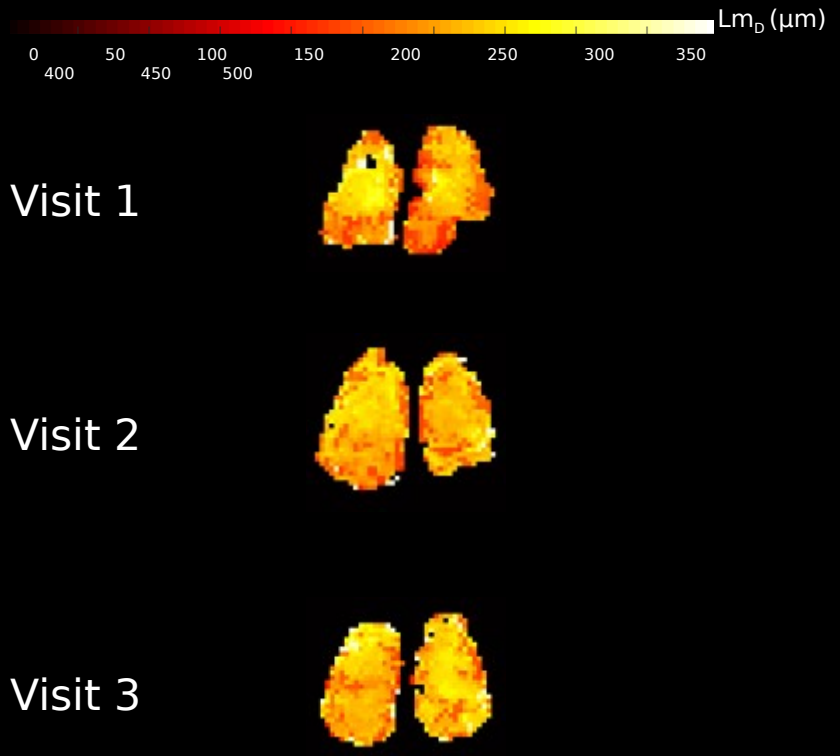


Longitudinal changes in the diffusion of a patient undergoing **surgery**

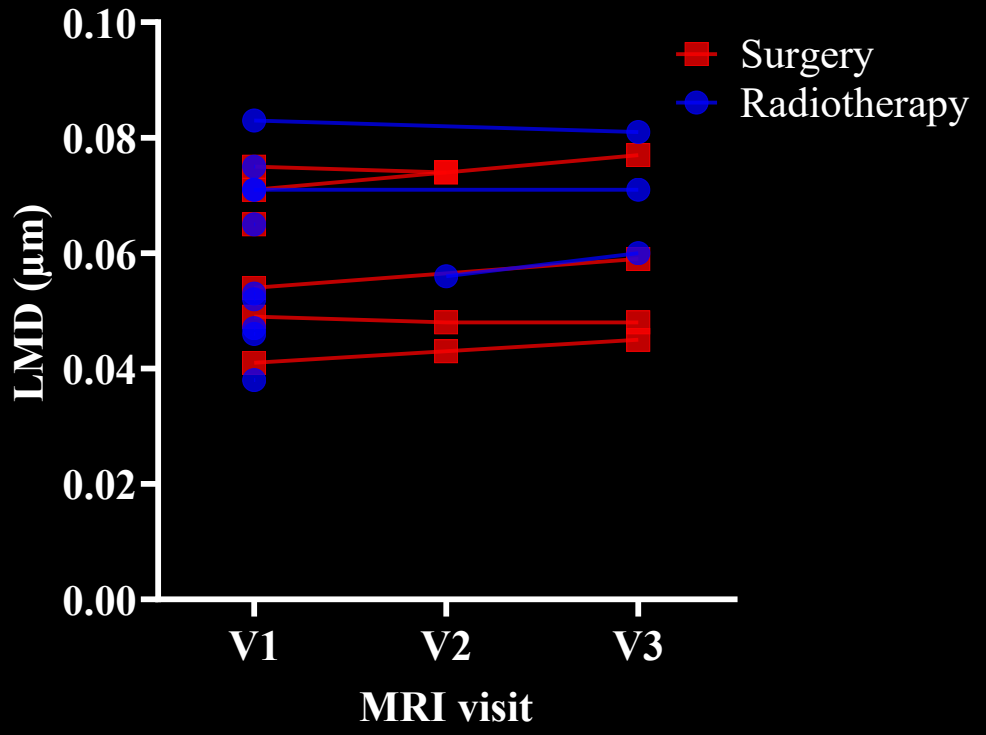


Apparent diffusion coefficient (ADC)

Longitudinal Changes In **Diffusion** Among Early-stage NSCLC Patients with Surgery and Radiotherapy

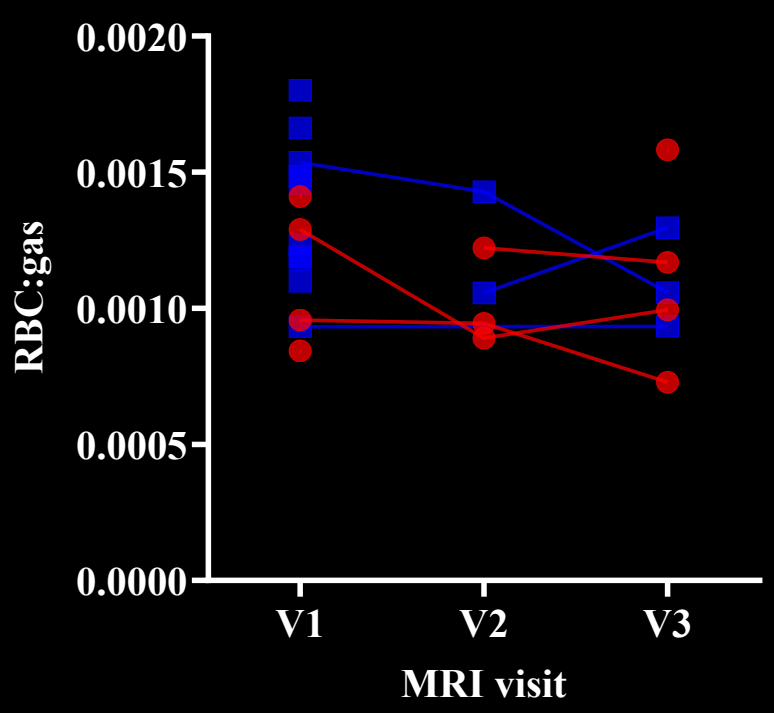


Longitudinal changes in the diffusion of a patient undergoing **surgery**

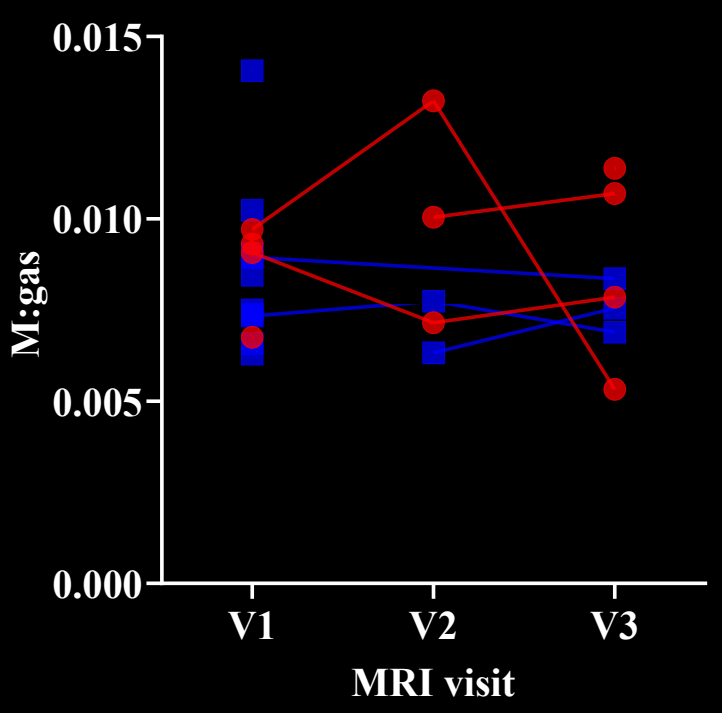


Diffusive length scale (LMD)

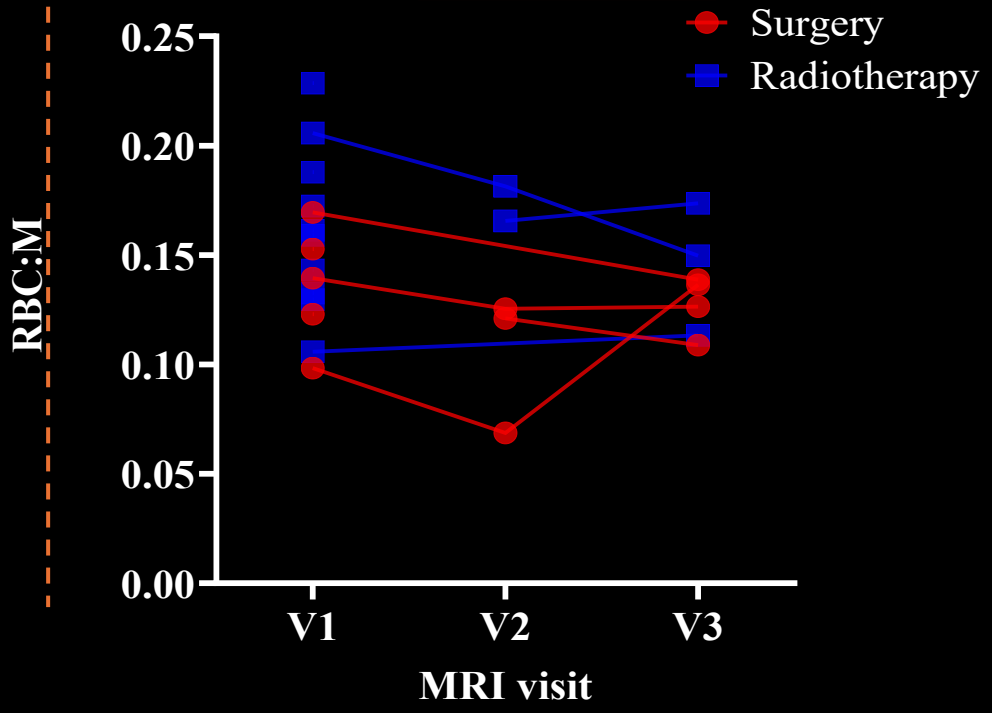
Longitudinal Changes in **Gas Exchange** in Lung Cancer Patients With Surgery and Radiotherapy



red blood cell to gas ratio (RBC:

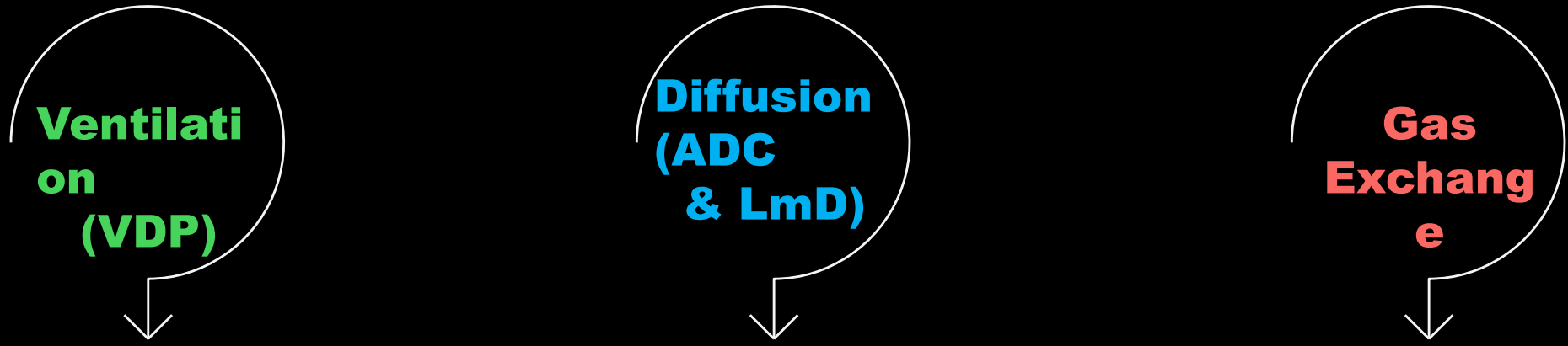


membrane to gas ratio (M:

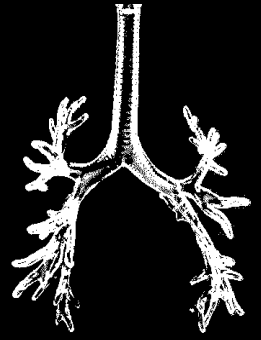


red blood cell to membrane ratio

Conclusion



- HP ^{129}Xe is feasible and show promise for monitoring regional changes in lung function for early-stage NSCLC patients
- Advanced functional MRI could guide personalised radiotherapy and post-surgical follow-up to improve patient outcomes



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- Dr Joshua R. Astley
- William Clark
- Fred Smith
- Patients who have participated in the study

Polaris Lung Imaging Group
(www.shef.ac.uk/polaris)

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