Molecular Flow Sensing for Early Detection of Lung Abnormalities in Young Smokers

J. L. Redmond1, F. Kendall1, N. M. J. Smith1, S. R. M. Magor-Elliot2, R. J. Hallifax3, G. A. D. Ritchie1, P. A. Robbins2, N. Petousi3, N. P. Talbot3,4

1Department of Chemistry, University of Oxford; 2Department of Physiology, Anatomy and Genetics, University of Oxford; 3Nuffield Department of Clinical Medicine, University of Oxford; 4Oxford NIHR Biomedical Research Centre, University of Oxford

Chronic Obstructive Pulmonary Disease (COPD) affects 50% of lifelong smokers1. COPD is the 4th leading cause of death worldwide and costs the NHS £1.9 billion per year2. Progress in treating COPD described as ‘woefully inadequate’ by recent Lancet commission3.

Need a sensitive technique to detect abnormal lung function at an early stage.

Increased inhomogeneity of the lungs is an early sign of damage so we propose a 15 min test to assess this.

Study compared lung model parameters of 23 smokers vs. 23 never-smokers aged 18-35.

Cumulative smoking history was quantified using pack years (py). No. of pack years did not significantly predict the currently used lung function metric FEV1. However, no. of pack years did significantly predict σCL. For all smokers with more than 5 pack years, σCL exceeded the healthy range. No other technique demonstrates this level of sensitivity.

Greater absorption of light means we have a higher concentration of a molecule.

We can then fit the expired gas profiles to a mathematical model of the lung. The lung model consists of 125 compartments like the three in Fig. 6. This gives us useful parameters of lung function, including σCL, the inhomogeneity of lung compliance (lung elasticity).

This technique:
- Is more sensitive to early stage lung abnormalities
- Uses no ionizing radiation
- Uses no scarce or expensive consumables
- Is easy for patients and clinicians to perform and could allow earlier diagnosis/assess risk of COPD
- Evaluate effectiveness of treatment
- Improve efficiency of clinical trials for COPD


Tiny lasers inside the measurement cell emit light at very specific wavelengths that are absorbed by the molecules of interest. Greater absorption of light means we have a higher concentration of a molecule.

From the concentration and flow measurements we can calculate gas consumption rates as a subject breathes air for 10 minutes followed by 5 minutes of oxygen breathing.

This gives us useful parameters of lung function, including σCL, the inhomogeneity of lung compliance (lung elasticity).

Fig. 1: Volunteer performing test

Fig. 2: Measurement cell

Fig. 3: Optical paths of laser beams within measurement cell

Fig. 4: Sample spectra from which the concentrations of oxygen, carbon dioxide and water can be determined

Fig. 5: Measured gas consumption data from a 15 min test

Fig. 6: Simplified version of the lung model with 3 compartments instead of 125

Fig. 7: Sample distributions illustrating inhomogeneity: a broader distribution means a higher value of σCL and a more inhomogeneous lung

Fig. 8: Comparison of existing measure of lung function (a) with our parameter (b) for smokers with varying numbers of pack years (py) vs. never-smokers (NS)