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The Airspace Dimension Test (ADT): A novel technique for lung diagnosis with Nanoparticles

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Introduction

The Airspace Dimension Test (ADT) is a novel technique to examine the lungs by measurement of deposition of nanoparticles in distal airspaces under controlled conditions (Jakobsson et al., in manuscript).

Nanoparticles in the size range <300 nm are known to deposit in the airways almost exclusively by diffusion, a process depending on time and distances. By measuring the deposition of inhaled nano particles during a well-controlled residence time in the lungs of a human subject, information about the average diffusion lengths and thus the state of the lungs can be obtained.

The primary aim of the technique is to be able to detect pulmonary emphysema at an early stage, a much demanded technology for battling the rising global threat of chronic obstructive pulmonary disease (COPD).

Method

An ADT instrument was constructed for measurement of the deposition of nanoparticles in the peripheral airspaces (Figure 1). In the technique a monodisperse aerosol of polystyrene latex nanospheres is produced by electrohydrodynamic atomization. A differential mobility analyzer is used to select a specific particle size, and the aerosol is diluted to 2000-3500 p/cm³.

A high-speed computer-controlled valve system is used to conduct highly reproducible measurements of lung deposition in a single breath procedure.

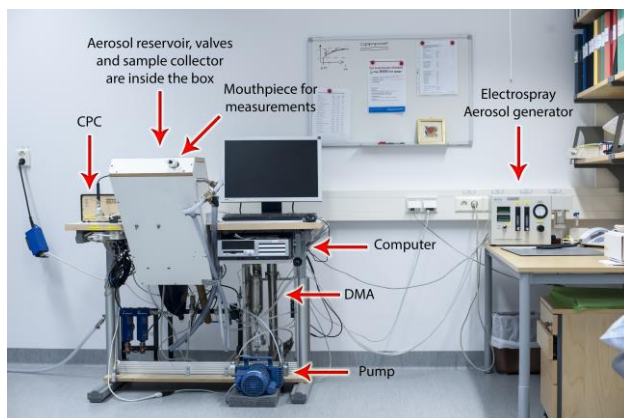


Figure 1. The final system in the clinical setting at the department of Clinical Sciences, Malmö, Sweden.

The system was tested on a group of 23 healthy individuals and 45 patients referred to clinical lung function tests for diagnosis of respiratory disease. The most common diagnosis in the group was COPD.

Results

The ADT instrument was found to be capable of producing measurements with a standard deviation of $\pm 0.3\%$ for three consecutive measurements on the same subject and showed sensitivity to particle size, diffusion time in the lungs and individual parameters in accordance with theoretical expectations. (Löndahl et al., 2014)

As shown in Table 1, the deposition fractions observed for the healthy subjects were similar (± 0.02).

Table 1. Comparison between the group of normal subjects and the group of lung patients.

	FEV ₁ (%pr)	VC (%pr)	FEV ₁ / VC	D _{L,CO} (%pr)	ADT
Normal subjects	93±13	93±13	.79±.05	97±14	.97±.02
Patients	83±23	92±16	.63±.16	72±21	.91±.08

The deposition fractions for patients were found to be lower and more diverse. This is believed to reflect enlargement of distal airspaces in the patient group and correspondingly longer average diffusion lengths, and is in accordance with the theory of particle diffusion. The diversity reflects that the pathological changes are of various severity.

Conclusions

The ADT technique is in its infancy, but the initial results are promising. However, much work is needed to achieve a more fundamental understanding of the anatomical background reflected by the measurements and future possible applications in the field of clinical physiology.

Acknowledgements

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