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Characteristics for Airspace Dimension Test (ADT) – A novel technique for lung diagnosis with nanoparticles

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Chronic obstructive pulmonary disease (COPD) is the fourth most common cause of death globally. A general manifestation of COPD is emphysema, i.e. breakdown of lung tissue. Emphysema leads to enlargements of the peripheral airspaces that are difficult to observe without advanced and expensive tools such as X-ray computed tomography (CT) or magnetic resonance imaging with hyperpolarized ^{3}He. This work describes a novel technique, Airspace Dimension Test (ADT), for diagnosis of emphysema with aerosolized nanoparticles.

Nanoparticles in the size range < 300 nm are known to deposit in the airways almost exclusively by diffusion, a process determined by residence time and distance to nearby surfaces. Emphysema corresponds to enlarged alveoli and therefore increased mean diffusion distances in the peripheral lung, with decreased deposition of inhaled nanoparticles as a consequence (Löndahl et al., 2012).

The ADT-instrument, shown in Figure 1, measures the deposition fraction of monodisperse nanoparticles during a well-defined single breath procedure including a 3-20 s breath-hold. It consists of three main parts: 1) aerosol generation and conditioning, 2) inhalation system and 3) particle detection and analysis. The instrument was characterized and tested for sensitivity with respect to particle size, diffusion time and inter-subject variability on a group consisting of seven young, healthy volunteers.

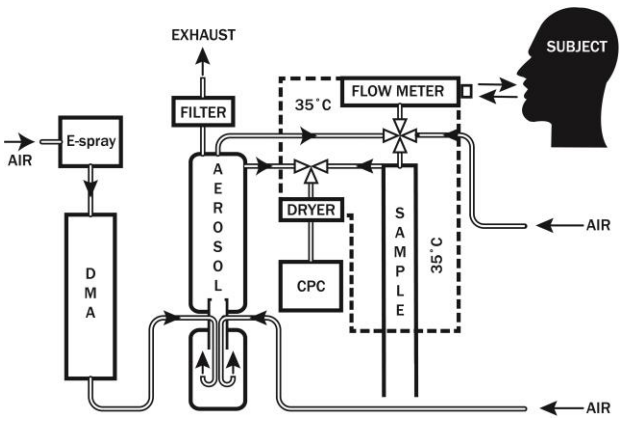

Figure 1. Instrumental set-up.

It was found that the ADT-instrument had a sensitivity of less than 0.3% in the measured lung deposition fractions (Figure 2). The deposition fraction increased with increased breath-hold time and decreased particle size as is expected according to diffusion theory. The inter-subject variability was significantly larger than the measurement uncertainty. The measured values were in accordance with values calculated with the multiple path particle dosimetry (MPPD) lung deposition model.

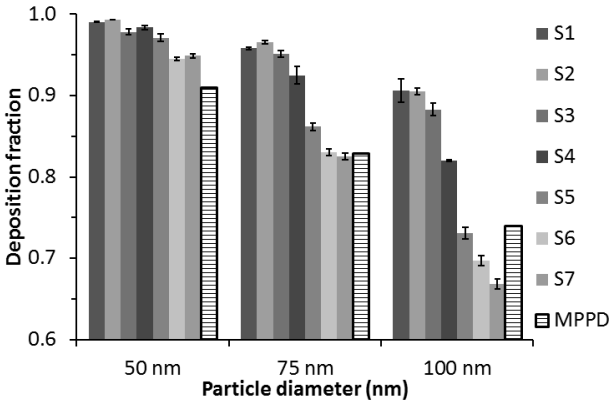

Figure 2. Deposition fractions for 7 young healthy individuals inhaling 50, 75 and 100 nm particles. Data from the simulation with the MPPD model are included.

From the theory of Brownian diffusion it is expected that the measured deposition fractions will correlate with the dimensions of the peripheral airspaces. ADT could then provide a fast, safe and cost-effective alternative for diagnosis of COPD.

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References

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