Lung deposition of nanoparticles: Normalization of data to improve comparison between subjects

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The Airspace Dimension Test (ADT) is a unique and recently developed technique aiming at assessing pulmonary airway dimensions and possible pathological changes of the lungs, such as pulmonary emphysema, by measurement of lung deposition of nanoparticles in a single breath procedure. Nanoparticles with a mobility diameter <100 nm deposit in the lungs almost exclusively by diffusion. It is hypothesised that measurement of recovery of such particles could reflect anatomical properties such as average diffusion distances in the airspaces or available surface area in the lung tissue.

The ADT technique has been shown to have sensitivity to inter-subject variability, particle size and breath-holding time (Jakobsson et al., 2015). For a small group of young healthy subjects, the measured particle recovery had an inter-subject variability more than 10 times larger than the measurement uncertainty. However, comparison between subjects, especially for those with respiratory disease, is sometimes difficult due to differences in ability to follow the breathing procedure. Patients with a slow exhalation will have a decreased recovery due to the extended residence time of the aerosol particles in the respiratory tract. Here we investigate a procedure to normalize the particle residence times and thereby facilitate comparison between subjects.

ADT measurements were performed on a group of 147 volunteers. The particle recovery of 50 nm particles was measured after different diffusion times in the airways. Data were fitted to an exponential equation with a least-square-method (Figure 1). As a criteria of a successful fit a Pearson correlation above 0.95 was selected.

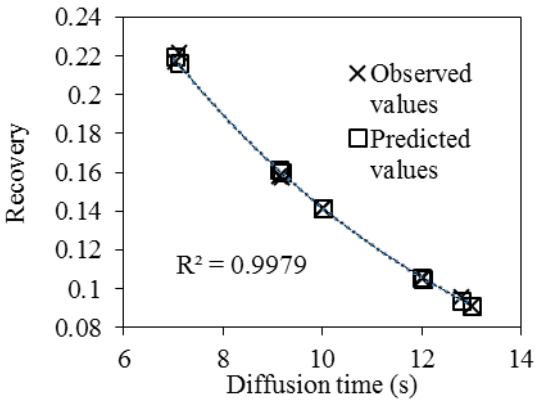

Figure 1. Comparison of observed values and values predicted by a curve fit for one subject.

In the group of 147 subjects, 131 fulfilled the criteria. The model was then used to estimate the values of recovery at 10, 12 and 13 s diffusion time.

The average Pearson correlation of the 131 included subjects was found to be 0.989. Of the remaining subjects, 10 had a Pearson correlation of 0.93-0.95 3 had a Pearson correlation of 0.73-0.86 and one subject had a Pearson correlation of 0.66.

It was also found that the slope of the fitted curves correlated with the observed recovery (r=0.696 at 13 s), which makes it plausible that a normalized value could be estimated from a single point measurement.

The distribution of the normalised ADT values for 131 subjects can be seen in figure 2.

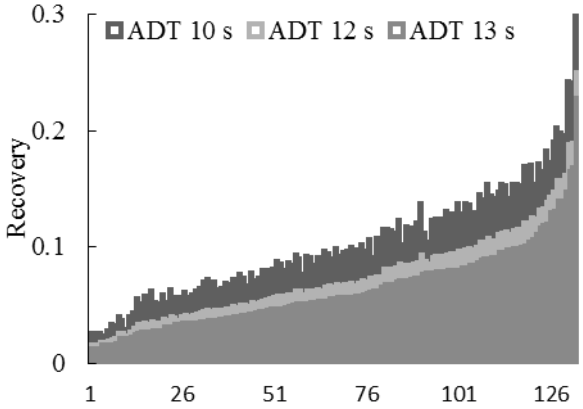

Figure 2. The distribution of ADT values for 131 subjects, normalised to 10, 12 and 13 s diffusion time.

The results show that a time normalization of recovery values is possible due to the high correlation with particle residence time. This may increase comparison between groups of subjects substantially. Data also suggest that normalization could be made based on a single measurement. The ADT values will be compared to clinical lung tests to evaluate the diagnostic capabilities for the technique.

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