

Exhaled Breath Particles – a Biomarker for Detection of Lung Disease?

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MOTIVATION

Besides gaseous compounds the exhaled breath of humans contains particles providing information on pulmonary status directly from the airways and alveoli. Up to now, it is unclear, to which extent the biochemical analysis of these particulates could be used for detection and monitoring of airway disease, mainly due to lack of systematic data correlating emission rates with respiratory variables.

RATIONALE

Identification of the relevant parameters determining the number and mass flux of exhaled breath particles.

MATERIAL AND METHODS

An experimental set-up (Fig.1) was designed to measure the exhaled particle flow, the size distribution and the airflow simultaneously with high time resolution (Fig.2). The particle concentration was determined by means of a condensation nuclei counter (TSI 3760) and the size distribution by a laser spectrometer (PMT Lasair II 110).

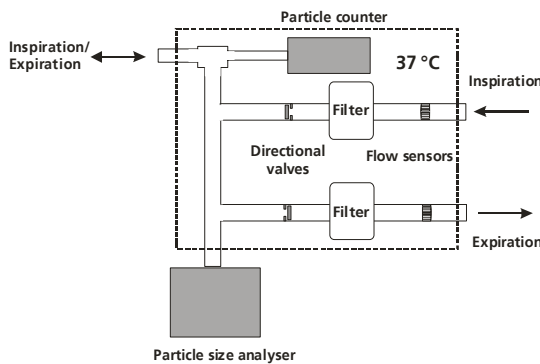


Fig.1: Experimental set-up for time-resolved measurement of the exhaled particle concentration, the size distribution and the airflows

For healthy volunteers (n = 16, 20 – 63 years) the particle properties were measured for different tidal volumes.

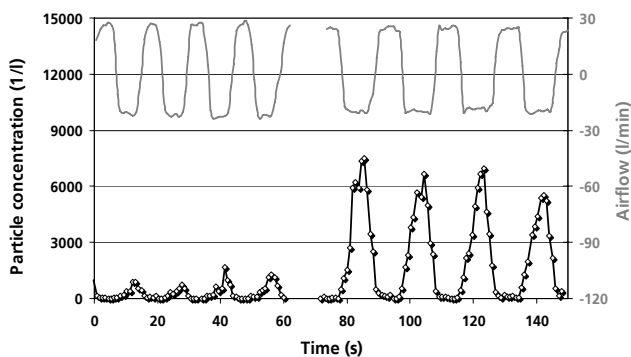


Fig.2: Air flow (upper curve) and particle concentration (lower curve) during several complete breathing cycles for two different tidal volumes of 2.4 (left) and 3.1 l (right)

RESULTS

For all subjects, the number of particles, N , emitted per breath rose exponentially with increasing tidal volume, V_T ,

$$N = A \exp(\beta V_T)$$

with a mean value of β of 1.9 with low inter-individual variation.

However, there was a large variability for the exhaled particle number between the different subjects covering about two orders of magnitude (Fig.3). A high interday and intraday reproducibility exists for the number of exhaled particles.

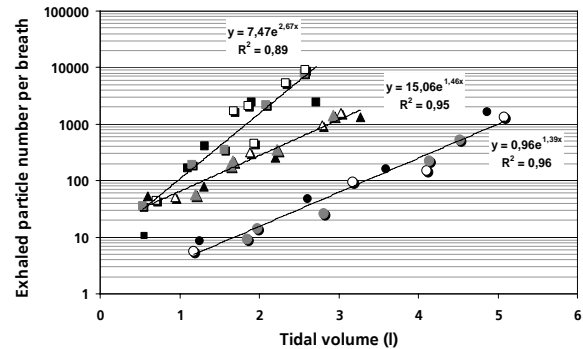


Fig.3: Number of exhaled particles per breath plotted against the tidal volume

The data were further analysed using an emission-index, defined as the number of exhaled particles at a tidal volume of 2.5 l. The index shows a decrease with increasing expiratory reserve volume, representing the expiratory position referred to the vital capacity (Fig.4).

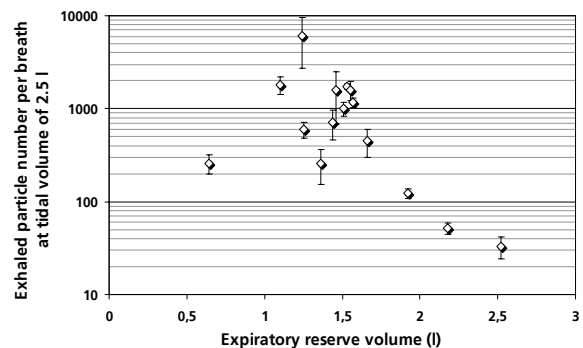


Fig.4: Particle number per breath at V_T of 2.5 l plotted against expiratory reserve volume

The number of exhaled particles is determined by the particle generation rate in the lung and the rate of redeposition in the airways during exhalation, mainly due to diffusive and gravitational deposition. For all subjects the particle size is predominantly in the submicron range, with count median diameter at 0.4 μm . Larger particles will be deposited by gravitational settling.

CONCLUSION

The tidal volume turned out to be the most important variable determining the exhaled particle flux of the individual subject. The exponential behaviour suggests that reopening of collapsed terminal airways linked with the break-up of the surfactant film is the main mechanism for particle generation in the lung. It is known from the literature that airway disease can lead to premature airway closure. We suppose that these alterations could result in a change of the exhaled particle number compared to healthy subjects. Thus breath particle analysis might serve as a convenient non-invasive method for detection of lung disease.

Further investigations will be carried out to identify other relevant respiratory variables for the exhaled particle flux and to evaluate the usefulness of breath particle analysis as a biomarker.

CONTACT AND FUNDING

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