Lung deposition of nanoparticles in COPD patients and healthy subjects compared to clinical lung function tests and computed tomography

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Keywords: Lung-particle interaction, nanoparticles, COPD, diagnosis, AiDA

Introduction

Airspace Dimension Assessment (AiDA) is a technique aimed at assessing airspace dimensions in the distal lung by measuring lung deposition of inhaled nanoparticles. The aim of this work is to evaluate AiDA as a potential diagnostic technique by comparison with currently used lung function tests and medical imaging.

Pulmonary emphysema is one of the main components of COPD and the condition that the AiDA technique is primarily targeted at. Current clinical techniques with sensitivity for emphysema are computed tomography (CT) and measurement of lung diffusion capacity for carbon monoxide, $D_{L,CO}$. $D_{L,CO}$ is affected by several variables other than emphysematous changes of the lung and CT is expensive and entails exposure to radiation.

Methods

A group of 23 patients with diagnosed COPD and a group of 37 healthy subjects, performed AiDA measurements with inhalation of 50 nm and 100 nm PSL particles. Particle deposition was determined for breath samples from alveolar air at 1800 ml and 1300 ml volumetric lung depth after 10 s breath holding time.

Both groups performed clinical lung function tests including $D_{L,CO}$ and the study group underwent a CT scan of the lungs including densitometry analysis, which is a technique for assessing and quantifying pulmonary emphysema. A comparison between the groups is shown in Table 1.

Table 1. *Comparison between the groups of COPD patients and healthy subjects. FEV_1 and $D_{L,CO}$ expressed in % of predicted. The lung deposition is reported as the recovery (R) of nanoparticles in exhaled breath samples from a defined volumetric lung depth. (Mean ± std).*

	COPD patients	Healthy volunteers
N	23	37
♂/♀	10/13	16/21
Age	67.6 ±7	63.5±5
FEV_1 % pred.	52±20%	107±15%
$D_{L,CO}$ % pred.	60±20%	91±11%
$AiDA_{1300\ ml,\ 50\ nm}$	.123 ± .064	.087 ± .065
$AiDA_{1800\ ml,\ 50\ nm}$	.086 ± .060	.059± .047
$AiDA_{1800\ ml,\ 100\ nm}$	.376 ± .126	.301 ± .112

Results

As shown in Table 1, the measured lung deposition is lower for the group of patients than for the healthy control group ($p < 0.046$, 50 nm, 1300 ml). This is in concordance with our hypothesis and previous results. Nanoparticles deposit in the lungs almost exclusively by diffusion, and as emphysema causes enlarged airspace dimensions (= longer average diffusion distances) and loss of available surface area, thus lung deposition is predicted to decrease.

Correlation was also found between CT densitometry measurements and particle deposition both as 15th percentile lung density (PD15, $p= 0.001$) and low attenuation volume (LAV%, $p=0.003$), as shown in Figure 1. Particle recovery also correlated with $D_{L,CO}$ but not to spirometry.

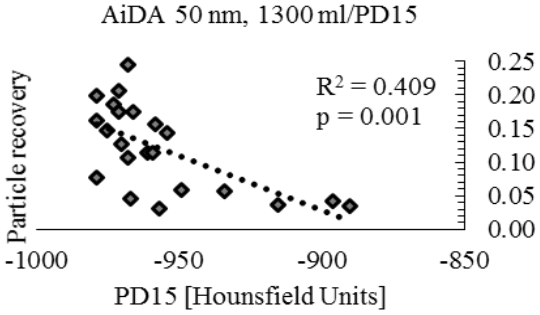

Figure 1. *The correlation between PD15 (CT measurement of emphysema) and particle deposition for N=23 COPD patients.*

Conclusion

CT has high specificity to emphysema, $D_{L,CO}$ has sensitivity for emphysema but is also affected by other factors such as blood values and membrane diffusion resistance. Compared to CT, AiDA is less time consuming, considerably cheaper, simpler to use, has no radiation exposure and is easier to interpret. In contrast to $D_{L,CO}$, AiDA is not disturbed by blood flow, haemoglobin concentration, CO inhibition or alterations of the alveolar membranes. Once further investigated, AiDA may prove to be a useful tool to diagnose emphysema in the future.

This work was supported by Swedish Research Council, Vinnova, EU EuroNanoMed, The Swedish Heart and Lung Foundation, the Crafoord foundation and the Sten K Johnsson foundation.