Bronchodilatation Effect on Alveolar Oxygen Partial Pressure and Gas Exchange Rate of Asthma Patients: First Results of Clinical Study

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Target audience

Scientists working with hyperpolarized gases, clinical researchers (pulmonologists and radiologists) specialized in obstructive lung deceases

Purpose

Hyperpolarized ^{3}He-MRI is known to be an efficient tool to visualize and quantify pulmonary function. The spatiotemporal kinetics of ^{3}He MRI distribution can be assessed und used to obtain information about lung function. This makes the ^{3}He-MRI particularly attractive for the diagnostics of the obstructive lung disease, e.g. asthma and COPD. In particular, to characterize the spatial distribution and temporal variation of the alveolar oxygen partial pressure (aPO2) the measurement of the ^{3}He T_1 relaxation rate in presence of O_2 is used [1]. However, the relevance of the determined parameters for diagnostic purposes and statistical significance of its changes with the respiratory function is still not established firmly. Therefore, correlating variations of these parameters with clinically proven tests of lung function is a question of significant interest. In the present work HP-^{3}He-MRI measurements were performed in bronchial asthma patients before and after bronchodilatation (BDL). The particular aim of this study was to investigate the effect of BDL using functional parameters obtained with ^{3}He-MRI, and to correlate the variation of these parameters with the changes observed with pulmonary function tests (PFT)

Method

In an open clinical trial performed after approval of the local Ethics Committee 8 (of 12) patients with clinically confirmed asthma were examined using HP ^{3}He MRI in the first visit. 4 patients finished the study with the 2nd visit (interval 1 year). Each visit comprised two 3He-MRI examinations, as well as PFT before and after BD (250µg Salbutamol). The MRI measurements were performed on a 1.5T Magnetom Avanto scanner (Siemens) using a dual-tune ^{3}He/^{19}F birdcage (Rapid Biomedical). The HP-^{3}He (polarization level p=70±2%) was provided by centralized large scale polarization facility [2]. The 200ml of ^{3}He from Tedlar bag was administered to the patient following the inhalation of ambient air to the total lung capacity (TLC). Coronal 2D-projections images were acquired (matrix 128x64 at FOV=400mm). The images were acquired in 2 series (5+5) separated by t_1=1 sec and t_2=5 sec delay respectively, yielding ^{3}He T_1 vs time dependence. The $aPO_2(t)$ was determined at t=3,6,9,12 and 15 sec. In this work we analyzed changes in “initial” aPO2(t=3s sec)=P_0 and “average” P_a=<aPO2> (t=3..15 sec) values of aPO2 before and after patients obtained BDL. Additionally, the decay rate $R=P_0/P_a$ was considered as the characteristic of oxygen consumption rate. The analysis was done on a pixel basis with subsequent calculation of descriptive statistic parameters of histograms for both lungs, and left and right lung separately.

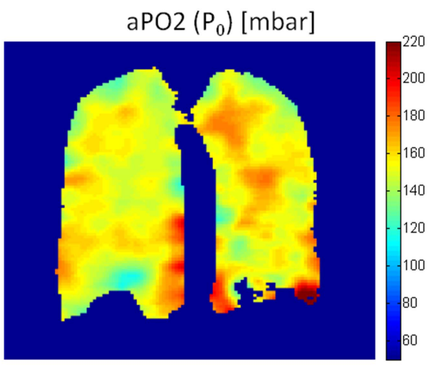

Fig. 1 Exemplary map of P_0 of asthma patient (after BDL).

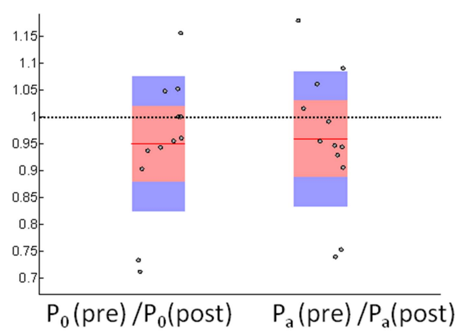

Fig. 2 Ratio of mean aPO2 values in both lungs before to after BDL. The increase in mean value on ≈0.05 after BDL is observed with standard error s≈0.04 both for a P_0 and P_a. Points are laid over a 1.96 standard error of mean (95% confidence interval) in red and a 1 standard deviation in blue.

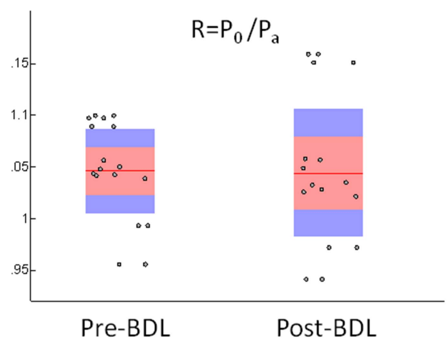

Fig. 3 Decay ratio of aPO2 before and after BDL. The standard deviation after BDL is essentially increased that correlates with decrease of non-ventilated volume. Points are laid over a 1.96 standard error of mean (95% confidence interval) in red and a 1 standard deviation in blue.

Results

Figure 1 show exemplary map of initial aPO2 value P_0. One can clearly observe certain difference in aPO2 enhancements and depressions in left and right lung. The measured histogram median values of for 12 measurements was P_0≈(140-150) mbar (105-112 mmHg) and P_a≈(135-145) mbar. Figure 2 shows changes of PO2 values after BDL for both aPO2 values. The tentative upward trend (≈5%) for both P_0 and P_a after BDL is observed basing on current amount of experimental data. Figure 3 show the decay rate of aPO_2. With same mean and median value the post-BDL oxygen consumption rate R demonstrates essentially broader distribution over the measured data.

Conclusion

Although the trial is not yet finished, several trends can be observed at this time. For the patient data analyzed up to now we confirmed tentatively the increase of aPO2 after BDL on about ≈5% both for P_0 and P_a. With the standard error of pre- to post-BDL aPO_2 ratios distribution ≈4% the additional data is required for confirming this observation. This finding, however, correlates with the increase of ventilated lung volume after BDL measured using static ventilation 3He MR-images and grows of FEV1 detected by PFT as it was reported previously for this study data. The slightly increased initial aPO2 is probably explained by forced inhalation to the TLC during administration. After the BDL this increase would be even more pronounced. The median value of oxygen consumption rate appears to be unchanged after BDL. However, the heterogeneity of variation over the patients increases by at least 50% (Fig. 3). This also may be explained by increase of ventilated volume after BDL and recruitment the lung areas non-ventilated before BDL. The statistical significance of the both findings should be confirmed in course of the Clinical Study competition.

References:

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