Quantitative regional lung ventilation- results in 15 single lung transplanted patients

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Introduction

During the ISMRM2004 (4) we presented data on real time ventilation imaging at 0.2 Tesla (Siemens Magnetom Open). At the ISMRM 2005 (5) we have demonstrated a new mode of imaging making this approach available for the widespread mid- and –high field strength MRI systems, using a cardiac triggered HASTE sequence. Non linear registration of the pictures theoretically allows us to calculate the quantitative regional pulmonary ventilation by a simple technique (3, 4). Presented are measurements in 15 lung transplanted patients. The measured values and the regional color coded ventilation maps were in concordance to the clinical expectations. The fact that only on side of the lung was transplanted and the other side was kept allows to compare healthy and pathological lung tissue at the same time. The MRI data provide additional information to spirometry, wich represents the mix of healthy and pathological lung airflow, in these patients.

Methods and patients: We used a HASTE sequence (TE 30ms, TR 2000ms, FOV 128x128). The strong perfusion signal at high magnetic field strength was compensated (equalized) by ecg triggering. Each individual image in the sequence is registered to the reference image. The algorithm computes a dense deformation field by composition of small displacements. These displacements are designed to maximize the local correlation between the intensity values of the current (floating) image and the reference image. This local similarity measure allows coping with nonstationary behaviours in the intensity profiles of MR images. Regularization is achieved by low-pass filtering of the resulting displacement fields (2). Using the previously released formulas according to our former attempts (4) a cardiac triggered HASTE sequence (using every third cardiac cycle) at 1.5 Tesla (Avanto) was used.

We took a cohort of 15 people (male and female, age ranging from 53 to 76) who underwent lungtransplantation. Only one side was transplanted and the other side was kept. Patients were investigated at spontaneous breathing over 50 acquisitions, depending on the heart rate taking up to 3 min.

Afterwards manually regions of interest (ROI) were chosen and the mean signal values and the background noise were determined during the ventilatory cycle for both upper (uF) middle (mF) and lower lung fields (lF). According to the theoretical considerations the absolute and the actual values for the local pulmonary ventilation were calculated. The quadratic ROI's (9x9cm) were placed in the center of the upper, middle and lower third of the longitudinal lung diameter. For computation of the ventilation data and the colour coded maps each individual image in the sequence was registered to a reference image. The registration algorithm computed a dense deformation field by composition of small displacements. Regularization was achieved by low-pass filtering of the resulting displacement fields (2). Using the previously released formulas the values for the local pulmonary ventilation were calculated for each ROI and each voxel. Inspirational and expirational changes in air content are coded red and green in the ventilation maps.

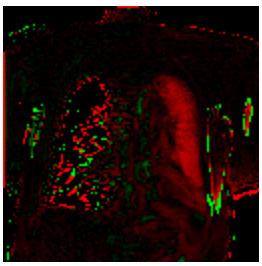

Fig.1: Left lung transplanted Right lung with emphysema Red indicating ventilation

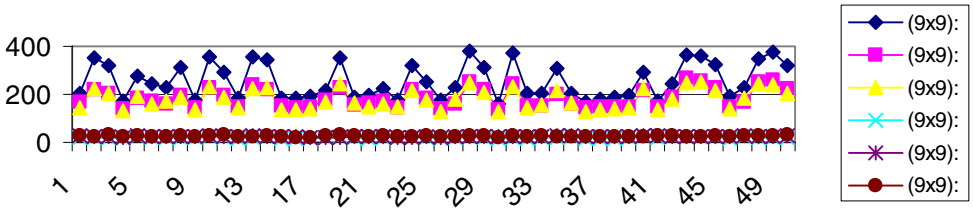

Fig 2: signal intensity curves of the ROIs during breathing cycle upper curves transplanted lung, lower curves lung with emphysema

Results: In all patients the registration procedure was successful. The investigation of the mean ventilation in the transplanted lungs revealed a mean lung ventilation of 0,55ml air/ml parenchyma which is identical to our previous results in healthy patients, the pathological lung ventilation depended on the indication for transplantation. The difference between transplanted and pathological lung was highly significant in all patients.

Discussion: In this study we demonstrate a new clinical application of a novel technique for quantitative calculation of regional pulmonary ventilation. The measured values were in concordance to the previous experiments, the clinical expectations and the lung function studies. In our opinion the great advantage of this approach is the possibility to do repeated measurements without x ray exposure. The data won sometimes are more helpful than the spirometry data. There is no need to apply any external contrast agents, which may influence the pulmonary ventilation. Ventilation maps demonstrate local ventilation. The registration has been optimized and the application is now applicable for a larger group of researchers and clinics. In all cases of transplantation a host versus graft reaction and loss of transplant function is feared. Loss of local ventilation could be used as an early indicator of a possible immunological problem. Although further studies are undoubtedly necessary our data suggest that the AVI-method could become a promising alternative method for functional lung MRI in other areas as well.

Bibliography:

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