Influence of Oxygen Administration on Pulmonary Vascular Resistance in Patients with Emphysema: Evaluation with Cine Phase Contrast MR Imaging

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PURPOSE: Oxygen therapy is widely utilized for management of pulmonary emphysema patients with or without secondary pulmonary hypertension (PH)(1). Currently, the therapeutic effect and influence of oxygen administration in emphysema patients have been predicted and evaluated by pulmonary function test, blood oxygen saturation, morphological changes in the lung and cardiac function(2,3). In addition, severity of secondary PH has been assessed by catheterization. Recently, cine phase contrast MR imaging (PC-MRI) has been proposed as a non invasive method for evaluation of pulmonary vascular resistance (PVR) in PH patients(4). We hypothesize that administration of oxygen affect the PVR, and the changes of PVR by administration of O_2 correlate with the disease severity of emphysema. The purpose of this study was to evaluate the relationship between influence of O_2 administration on PVR assessed by PC-MRI and disease severity of emphysema evaluated by air-flow limitation, oxygen saturation, morphological changes of the lung and cardiac function in pulmonary emphysema patients.

MATERIALS AND METHODS: Forty-eight pulmonary emphysema patients (42 males and 6 females; mean age, 67.2 yr.; range 41-82yr.) underwent PC-MRI, chest thin-section CT and pulmonary function test. In the present study, disease severity of emphysema in each patient was assessed by measured FEV1.0%, resting oxygen saturation measured by pulse oximetry (SpO_2), low attenuation areas of the lung (%LAA) assessed by density-masked CT and cardiac index (CI) calculated from PC-MRI data. All PC-MRI were performed in a double oblique section perpendicular to the main pulmonary artery by cine 2D phase contrast method (TR 5.4 ms/ TE 3.0 ms, a constant 15° flip angle, VENC 150cm/sec, 32 frames/ R-R interval) with SENSE technique at 1.5 T scanner (Gyroscan Intera T-15; Philips Medical Systems) using 4-channel cardiac phased array surface coil. To evaluate the influence of administration of oxygen on PVR, PC-MRI data were acquired during inhalation of room air, followed by administration of 100% oxygen (3 L/min). Regions of interest outlining the pulmonary trunk on the magnitude image were copied to the corresponding phase image, and the time-velocity curve was reconstructed automatically by using commercially available software (Segment v1.471) (Figure 1). For non-invasive assessment of PVR in patients with pulmonary emphysema, the ratio of maximal change in flow rate during ejection to acceleration volume (MCFR/AV) was calculated from the time-velocity curve in each patient. In the past literature(4), MCFR/AV was the most sensitive indicator of PVR (Figure 2). To determine the influence of O_2 on PVR, MCFR/AV was statistically compared between without and with O_2. To assess the relationship between the changes of PVR by administration of O_2 and the disease severity of emphysema, the difference in MCFR/AV was correlated with FEV1.0%, SpO_2, %LAA and CI.

RESULTS: MCFR/AV with O_2 (0.18±0.05 sec^{-2}: mean ± standard deviation) was significantly lower than without O_2 (0.20±0.07 sec^{-2}) ($p<0.05$). Table 1 shows correlation coefficient and p value between difference in MCFR/AV and the disease severity of emphysema. Figure 3 shows relationship among FEV1.0%, SpO_2 and difference in MCFR/AV. The difference in MCFR/AV significantly correlated with FEV1.0% ($r=0.49$, $p<0.05$) and SpO_2 ($r=0.45$, $p<0.05$).

CONCLUSIONS: Administration of O_2 reduced PVR in pulmonary emphysema patients with low FEV1.0% and SpO_2. Morphological changes of the lung and cardiac function had no correlation with changes of PVR by administration of O_2.

Table 1. Correlation coefficient and p value between difference in MCFR/AV and the disease severity of emphysema

r (p value)	FEV1.0% [%]	SpO_2 [%]	%LAA [%]	CI [L/min/m^2]
Diff. MCFR/AV [sec^{-2}]	0.49 ($p<0.05$)	0.45 ($p<0.05$)	-0.31 (NS)	0.04 (NS)

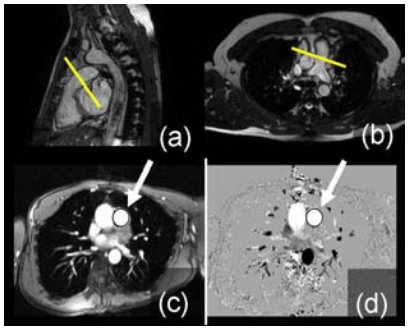

Figure 1. ROIs were planned perpendicular to the main pulmonary (a,b), and those on the magnitude image (c) were copied to the corresponding phase image (d).

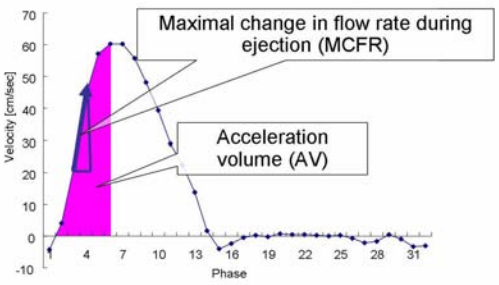

Figure 2. The ratio of maximal change in flow rate during ejection to acceleration volume (MCFR/AV) was calculated as an indicator of pulmonary vascular resistance.

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Figure 3. FEV1.0% ($r=0.49$, $p<0.05$) and SpO_2 ($r=0.45$, $p<0.05$) had poor but significant correlation with the difference in MCFR/AV by administration of O_2.