Velocity Encoding MRI with SENSE: Utility for Assessment of Disease Severity in Pulmonary Emphysema Patients

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PURPOSE: Pulmonary emphysema is one of the important diseases of chronic obstructive pulmonary disease, and its severity increase the risk of secondary pulmonary hypertension (cor pulmonale) and respiratory failure. Currently, severity of pulmonary emphysema has been assessed according to functional information using pulmonary function test, morphological information using thin-section CT or perfusion scan and hemodynamic information using echocardiography or cardiac catheterization. Recently, velocity encoding MR imaging (velocity MRI) has been proposed as a substitute for cardiac echocardiography or catheterization for assessment of hemodynamic information in cardio-pulmonary disease [1, 2]. We hypothesize that parameters from velocity-MRI can assess severity of pulmonary emphysema according to functional and morphological information, and may play an important role for management of pulmonary emphysema. The purpose of present study was to determine the utility of velocity-MRI for quantitative assessment of severity of pulmonary emphysema.

MATERIALS AND METHODS: Thirty pulmonary emphysema patients (25 males and 5 females; mean age, 68.0 yr.; range 40-84yr.) underwent velocity-MRI, chest thin-section CT and pulmonary function test. Cardiac echocardiography performed for all the assessed patients to rule out the other causes of right ventricular failure, including congenital heart disease, mitral valve stenosis or left ventricular failure. In the present study, gold standard of lung disease severity in each patient was assessed by 5-point visual scoring system of thin-section CT according to the National Emphysema Treatment Trial criteria (NETT score) (3-5) and measured FEV1.0%. All velocity 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) with SENSE technique at 1.5 T scanner (Gyroscan Intera T-15; Philips Medical Systems) using 4-channel cardiac phased array surface coil. Manual 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 (Figure 1). For assessment of disease severity of pulmonary emphysema by using velocity-MRI, following hemodynamic indices, 1) the regurgitation fraction (RF, retrograde to antegrade flow volumes); 2) the acceleration time (AT, time from the onset of the flow to the peak velocity); 3) the maximal change in flow rate during ejection (MCFR); 4) the acceleration volume (AV, integrating the flow rate of acceleration time); 5) the ratio of 3 and 4 (MCFR/AV); and 6) the stroke volume (SV) were calculated from the time-velocity curve in each patient (Figure 2). Then, each pulmonary homodynamic index was statistically compared with disease severity of pulmonary emphysema that determined by NETT score and FEV1.0%.

RESULTS: MCFR (r=-0.57, p<0.05) and stroke volume (r=-0.50, p<0.01) had good negative correlation with NETT score, and stroke volume had good positive correlation with FEV1.0% (r=0.57, p<0.01) (Table 1 and Figure 3).

CONCLUSIONS: MCFR and stroke volume of the right ventricle from velocity-MRI have a potential for assessment of disease severity of pulmonary emphysema assessed by destruction of lung parenchyma and airway obstruction. In conclusion, velocity-MRI is useful for quantitative assessment of disease severity of pulmonary emphysema.

Table 1. Correlation coefficient and p value between assessed hemodynamic indices and NETT score or FEV1.0%.

r (p value)	RF	AT	MCFR	AV	MCFR/AV	SV
NETT score	0.09 (p=NS)	-0.01 (p=NS)	-0.57 (p<0.05)	-0.28 (p=NS)	-0.26 (p=NS)	-0.50 (p<0.01)
FEV1.0%	0.16 (p=NS)	0.03 (p=NS)	0.32 (p=NS)	0.32 (p=NS)	0.16 (p=NS)	0.57 (p<0.01)

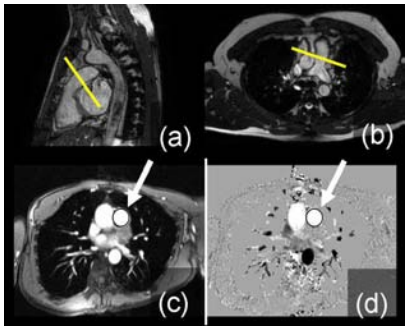

Figure 1. ROIs were planned perpendicular to the main pulmonary (a,b), and those on the magnitude image (c) were copied to the corresponding phase image (d).

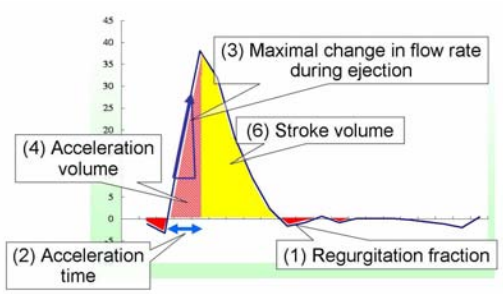

Figure 2. Assessed hemodynamic indices from the time velocity curve

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Figure 3. MCFR (r=-0.57, p<0.05) and stroke volume (r=-0.50, p<0.01) had good negative correlation with NETT score, and stroke volume had good positive correlation with FEV1.0% (r=0.57, p<0.01).