Oxygen-enhanced MR Imaging: Compared Efficacy of Pulmonary Functional Loss Assessment and Clinical Stage Classification in Asthmatics with Quantitatively Assessed CT

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INTRODUCTION: Asthma is a chronic inflammatory disorder that predominantly involves the small and medium airways in the peripheral lungs and characterized by airflow limitation, which reverse spontaneously or in response to treat. Currently, pulmonary function test is considered as the most important and widely utilized method in diagnosis and management of asthmatics. In the last decade, several investigators have suggested that thin-section CT and hyperpolarized noble gas MR imaging (HP-MRI) have been also useful procedures for assessment of regional morphological and functional changes in asthmatics (1-3). In addition, O_2-enhanced MRI is suggested as useful for regional ventilation and oxygen transfer assessments in the lung (4, 5). However, there are no reports about assessment of O_2-enhanced MRI in asthmatics. We hypothesized that O_2-enhanced MRI has potential for functional loss assessment and clinical stage classification in asthmatics as well as quantitatively assessed thin-section CT. The purpose of the study reported here was to prospectively and directly compare the efficacy of O_2-enhanced MRI and quantitative CT for functional loss assessment and clinical stage classification in asthmatics.

MATERIALS AND METHODS: A total of 34 consecutive asthmatics (14 men and 20 women; age rang 21-79 years), who were classified severity by using National Asthma Education and Prevention Program guideline, underwent O_2-enhanced MRI, thin-section MDCT and pulmonary function test. All asthmatics were classified into four stages ('Mild Intermittent [n=7]', 'Mild Persistent [n=8], 'Moderate Persistent [n=14]' and 'Severe Persistent [n=5]') according to the guideline. O_2-enhanced MR images were obtained by means of a respiratory synchronized half-Fourier acquisition centrically-reordered inversion recovery single-shot turbo spin-echo (HASTE) pulse sequence and three 1.5 T scanners. For quantitative assessment of morphological changes on thin-section CT in asthmatics, mean lung density (MLD), airway wall area (WA), ratio between WA and total area (WA%) and WA normalized by body surface area (WA/BSA) in the third generation of bronchus were automatically determined by using commercially available software. All O_2-enhanced MR images were expressed as the percentage change between the oxygen-enhanced and baseline images by using commercially available software, and the mean relative enhancement ratio (MRER) for every subject was determined as the average of the relative enhancement ratio measured from regions of interest (ROIs) drawn over both lungs on the coronal section.

To compare the efficacy of two methods for pulmonary functional loss assessment in asthmatics, MLD, WA, WA%, WA/BSA and MRER were correlated with $\%FEV_1$, FEV_1/FVC and $FEF_{25-75\%}$ in asthmatics. To determine the efficacy of the two methods for clinical stage classification in asthmatics, MLD, WA, WA%, WA/BSA and MRER of subjects at all stages were statistically compared each other.

RESULTS: Results of correlation among pulmonary functional parameters on the one hand and MLD, WA, WA%, WA/BSA and MRER on the other are shown in Table 1. FEV_1/FVC had significantly positive and fair correlation with MLD ($p<0.05$), and moderate correlations with MRER ($p<0.05$). FEV_1/FVC had significantly negative and fair correlation with WA, WA% and WA/BSA ($p<0.05$). $\%FEV_1$ had significantly positive and fair correlation with MLD ($p<0.05$), and moderate correlation with MRER ($p<0.05$). $\%FEV_1$ had significantly negative and moderate correlations with WA and WA/BSA ($p<0.05$), and fair correlation with WA% ($p<0.05$). $FEF_{25-75}\%$ has significantly positive and moderate correlation with MRER ($p<0.05$). $FEF_{25-75\%}$ has significantly negative and fair correlations with WA and WA% ($p<0.05$), and moderate correlation with WA/BSA ($p<0.05$).

Detailed characteristics of the four clinical stage groups and the results of the statistical comparison of MLD, WA, WA%, WA/BSA and MRER for clinical stage classification are shown in Table 2. On comparison of quantitative CT parameters, WA of 'Severe Persistent' group was significantly larger than that of others ($p<0.05$). In addition, WA of 'Moderate Persistent' group was significantly larger than that of 'Mild Intermittent' group ($p<0.05$). WA% of 'Moderate persistent' and 'Severe Persistent' groups were significantly higher than that of 'Mild Intermittent' group ($p<0.05$). WA/BSA of 'Severe Persistent' group was significantly higher than that of others ($p<0.05$). On comparison of O_2-enhanced MR parameter, MRER of 'Severe Persistent' group was significantly lower than that of others ($p<0.05$). In addition, MRER of 'Moderate Persistent' group was significantly lower than that of 'Mild Intermittent' and 'Mild Persistent' groups ($p<0.05$).

CONCLUSION: O_2-enhanced MRI was found to be effective for pulmonary functional loss assessment and clinical stage classification of asthmatics as well as quantitative thin-section CT.

Table 1. Correlations among pulmonary functional parameters, quantitatively assessed CT parameters and O_2-enhanced MR parameter in asthmatics.

	FEV_1/FVC			$\%FEV_1$			$FEF_{25-75\%}$		
	r	r^2	p value	r	r^2	p value	r	r^2	p value
MLD	0.36	0.13	0.04	0.39	0.15	0.02	0.18	0.03	0.32
WA	-0.43	0.18	0.01	-0.54	0.29	0.001	-0.48	0.23	0.004
WA%	-0.43	0.18	0.01	-0.44	0.19	0.009	-0.41	0.17	0.02
WA/BSA	-0.44	0.19	0.009	-0.52	0.27	0.002	-0.52	0.27	0.002
MRER	0.55	0.30	<0.001	0.55	0.30	<0.001	0.55	0.30	<0.001

r: Correlation coefficient, MLD : Mean lung density, WA : Wall area, WA% : Ratio between wall area and total airway area, WA/BSA: WA normalized by body surface area, MRER: Mean relative enhancement ratio

Table 2. Characteristics and statistical results of quantitatively assessed CT and O_2-enhanced MR parameters for all groups.

	Mild Intermittent (Mean± SD)	Mild Persistent (Mean± SD)	Moderate Persistent (Mean± SD)	Severe Persistent (Mean± SD)
Age (year old)	59.3± 11.6	56.3± 14.6	55.4± 12.2	61.8± 8.9
Gender				
Male (cases)	3	4	5	2
Female (cases)	4	4	9	3
BSA (m^2)	1.63± 0.10	1.54± 0.11	1.62± 0.08	1.55± 0.05
FEV_1/FVC (%)	84.3± 8.3	78.9± 6.3	65.9± 6.1*, **	50.4± 7.6*, **, ***
$\%FEV_1$ (%)	91.9± 8.7	86.6± 5.1	71.0± 6.4*, **	48.4± 8.0*, **, ***
$FEF_{25-75\%}$ (%)	72.3± 9.0	63.9± 5.7*	45.0± 6.3*, **	32.6± 6.7*, **, ***
MLD (HU)	-888.6± 24.1	-907.5± 28.2	-913.6± 19.8	-914.5± 20.7
WA (mm^2)	22.0± 4.2	22.7± 3.6	25.9± 12.2*	29.8± 3.7*, **, ***
WA% (%)	57.9± 6.6	60.4± 4.5	63.4± 4.1*	65.6± 4.2*
WA/BSA (mm^2/m^2)	14.0± 2.3	14.2± 2.2	16.1± 2.3	19.3± 2.5*, **, ***
MRER	0.25± 0.03	0.23± 0.04	0.19± 0.03*, **	0.15± 0.05*, **, ***

All values represent mean ± standard deviation. SD: Standard deviation, BSA: Body surface area, MLD : Mean lung density, WA : Wall area, WA% : Ratio between wall area and total airway area, WA/BSA: WA normalized by body surface area, MRER: Mean relative enhancement ratio

*: Significant difference with 'Mild Intermittent' group ($p<0.05$).
**: Significant difference with 'Mild Persistent' group ($p<0.05$).
***: Significant difference with 'Moderate Persistent' group ($p<0.05$).

References:

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