

## T2\* Measurements of 3.0 T MRI with Ultra-Short TE: Capabilities of Pulmonary Functional Assessment and Clinical Stage Classification in Smokers

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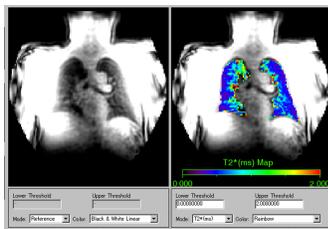
**Introduction:** Chronic obstructive pulmonary disease (COPD) is currently the fourth-leading cause of mortality and the twelfth-leading cause of disability, and by 2020 it is expected to be the third-leading cause of death and the fifth-leading cause of disability worldwide (1, 2). The diagnosis of COPD largely relies on a history of exposure to noxious stimuli (mainly cigarette smoke) and abnormal lung function test results. Currently, CT is most widely used for radiological disease severity assessment in COPD, and in clinical and academic practice, and hyperpolarized noble gas MR imaging and O<sub>2</sub>-enhanced MR imaging have been suggested as new techniques in this setting in the last decade. Recently, several investigators have tried to determine the utility of regional T2\* measurement in the lung for assessment of pulmonary diseases in animal studies (3, 4). We hypothesized that direct T2\* measurement in the lung at 3.0 T MR system has a potential role to play as a method for pulmonary functional loss assessment and clinical stage classification as well as thin-section MDCT. The purpose of this study was to determine the capability of pulmonary MR imaging with ultra-short TEs (UTES) in a 3.0 T system for pulmonary functional assessment and clinical stage classification in smokers.

**Materials and Methods:** 40 smokers without and with COPD (24 men and 16 women; mean age 68 years) underwent thin-section MDCT, MRI with UTE (UTE-MRI) for quantitative T2\* measurement at 3T MRI (Gyroscan Achieva 3T, Best, the Netherlands) and pulmonary functional measurements (FEV<sub>1</sub>/FVC%, FEV<sub>1</sub>% and %DL<sub>CO</sub>/V<sub>A</sub>). All subjects were classified into five groups according to the results of the pulmonary function test and the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines (5): 'smokers without COPD (n=9)', 'with mild COPD (n=12)', 'with moderate COPD (n=15)', and 'with severe or very severe COPD (n=4)' groups.

All UTE MRI were obtained by using a 3D rephased radial sampling sequence with UTES (TR 10ms/ TE 0.2, 0.7, 1.2, 1.7, 2.2, 2.7, 3.2, 3.7, 4.2, 4.7 ms/ Flip angle 8 degree/ voxel size 3.52x3.52x3.52 mm/ 64x64 matrix, 128x128 reconstruction matrix, 1 NEX, 70 slices). The multi-echo UTE MR data were analyzed using the manufacture-provided software (Philips Healthcare) (Figure 1), and mean T2\* value in the lung was calculated in each subject. For quantitative assessment of thin-section MDCT, all MDCT data were transferred to a workstation (Fujin; AZE Ltd, Tokyo, Japan), followed by determination of CT-based functional lung volume (CT-based FLV) and ratio of wall area to total airway area (WA%). Then, all CT- and MR-based indexes were correlated with lifetime smoking exposure, FEV<sub>1</sub>/FVC%, FEV<sub>1</sub>% and %DL<sub>CO</sub>/V<sub>A</sub> were examined. To determine the capability of each index for differentiating all groups, Tukey's HSD test was used to compare CT-based FLV, WA% and mean T2\* values for non-smokers with those for smokers at all stages of COPD. A p value less than 0.05 was considered significant for all statistical analyses.

**Results:** Correlations for all CT- and MR-based indexes, lifetime smoking exposure, FEV<sub>1</sub>/FVC%, FEV<sub>1</sub>% and %DL<sub>CO</sub>/V<sub>A</sub> are shown in Table 1. Lifetime smoking exposure, FEV<sub>1</sub>/FVC%, FEV<sub>1</sub>% and %DL<sub>CO</sub>/V<sub>A</sub> showed significant but moderate correlation with CT-based FLV (p<0.01) and mean T2\* value (p<0.001). In addition, lifetime smoking exposure, FEV<sub>1</sub>/FVC% and FEV<sub>1</sub>% showed significant but moderate correlation with WA% (p<0.01). Statistical results for CT- and MR-based indexes in non-smokers and smokers without and with COPD at all stages are shown in Table 2. Statistical results for CT- and MR-based indexes in smokers without and with COPD at all stages are shown in Table 3. Comparison of CT-based FLV among all groups disclosed that the values for 'smokers without COPD' and 'smokers with mild COPD' were significantly different from those for 'smokers with moderate COPD' and 'smokers with severe or very severe COPD' (p<0.05). Comparison of WA% among all groups showed that the values for 'smokers without COPD', 'smokers with mild COPD' and 'smokers with moderate COPD' were significantly different from those for 'smokers with severe or very severe COPD' (p<0.05). Comparison of mean T2\* values among all groups demonstrated a significant difference between 'smokers without COPD' and 'smokers with mild COPD' on the one hand and 'smokers with moderate COPD' and 'smokers with severe or very severe COPD' on the other (p<0.05). Moreover, mean T2\* value of the 'smokers with moderate COPD' group was also significantly different from that of 'smokers with severe or very severe COPD' (p<0.05).

**Conclusion:** UTE MRI on a 3T MR system was useful for pulmonary functional loss assessment and clinical stage classification in non-smokers and smokers without and with COPD.



**Figure 1. Examples of source image and calculated regional T2\* map**  
(L to R: Source image to T2\* map) Calculated regional T2\* map demonstrates regional difference of T2\* value within the lung.

**Table 1. Correlations among life time smoking exposure, pulmonary functional parameters and CT- and MR-based indexes**

	CT-based FLV		WA%		Mean T2* value	
	r	p value	r	p value	r	p value
<b>Lifetime smoking exposure</b>	-0.44	0.0045	0.46	0.0028	-0.52	0.0006
<b>FEV<sub>1</sub>/FVC%</b>	0.50	0.0011	-0.54	0.0004	0.60	<0.0001
<b>FEV<sub>1</sub>%</b>	0.58	<0.0001	-0.54	0.0004	0.70	<0.0001
<b>%DL<sub>CO</sub>/V<sub>A</sub></b>	0.60	<0.0001	-0.29	0.0711	0.72	<0.0001

**Table 3. Statistical results for pulmonary functional parameters and CT-based and MR-based indexes for smokers without and with all stages of COPD**

	Smokers without COPD (Mean ± SD)	Smokers with mild COPD (Mean ± SD)	Smokers with moderate COPD (Mean ± SD)	Smokers with severe or very severe COPD (Mean ± SD)
<b>CT-based FLV (%)</b>	76.3 ± 5.8	73.6 ± 6.7	60.1 ± 8.5*, **	51.8 ± 10.0*, **
<b>WA% (%)</b>	63.1 ± 4.0	64.3 ± 4.9	66.6 ± 4.8	75.5 ± 2.9*, **, ***
<b>Mean T2* value (ms)</b>	0.82 ± 0.09	0.74 ± 0.07	0.61 ± 0.07*, **	0.46 ± 0.11*, **, ***

SD: Standard deviation

CT-based FLV: CT-based functional lung volume

WA%: Ratio of WA to total airway area

T2\*: T2 Star

\*: Significant difference with smokers without COPD (p<0.05).

\*\*: Significant difference with smokers with mild COPD (p<0.05).

\*\*\*: Significant difference with smokers with moderate COPD (p<0.05).

### References:

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