

Brain Diffusion and Perfusion Alterations in Chronic Obstructive Pulmonary Disease (COPD)

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Introduction:

Cognitive impairment which has been documented as one of the important extrapulmonary problems is common in patients with chronic obstructive pulmonary disease (COPD) (1). Despite of their potential importance, understanding of cognitive impairment in COPD remains incomplete. Also, there is no proper diagnostic tool for the early detection of neurologic decline in COPD patients. The correlation between the cognition function and cerebral perfusion function of COPD patients by using brain single-photon emission computed tomography (SPECT) demonstrated that regional perfusion can be altered in COPD patients (2, 3). Brain CBF imaging can be used to map perfusion reserve in brain. Diffusion tensor imaging (DTI) can be used to evaluate the microstructural change of white matter in vivo. The purpose of this study was to evaluate regional microstructural and perfusion changes in subjects with COPD, by comparing with cognitively normal (CN) elderly controls by using voxel-based morphometry (VBM) analyses of 3D T1WI, DTI indices, and CBF maps.

Materials and Methods:

The subjects were classified in three groups: moderate COPD groups, severe COPD groups and normal control. Six subjects with severe COPD (6 men, mean age, 69.80 years), 13 with moderate COPD (12 men, 1 women; mean age, 65.23 years), and 12 CN subjects (12 men, mean age, 63.92 years) were enrolled in this study. There was no significant difference of demographic characteristics among groups. All patients and controls underwent a standard neuropsychologic test.

MR imaging was performed on a 3.0-T MR system (Achieva, Philips Medical system, Best, The Netherlands). For volumetric analysis, the isometric sagittal structural volumetric T1-weighted (T1W) images were acquired. In addition, T2-weighted axial images and fluid attenuation inversion recovery (FLAIR) axial images were also acquired to evaluate any pathological changes. For DTI data, a single-shot spin-echo echo-planar imaging (EPI) sequence was used with voxel = $2.2 \times 2.2 \times 2.2$ mm³; b = 0 and 800 sec/mm² applied along 32 diffusion-encoding directions. For CBF data, STAR arterial spin labeling (ASL) technique was used.

All processing steps were performed with using Statistical Parametric Mapping program version 5 (SPM5, Wellcome Department of Cognitive Neurology, London, UK). Group comparisons were performed with analysis of covariance (one-way ANOVA) for the GM volumes, FA and trace, and CBF with covarying for subject's age. We used multiple comparisons using a false discovery rate (FDR) of 5% with a threshold looking for clusters with at least 10 contiguous voxels for all maps.

Results :

For the 3D T1WI, GM volumes did not present any significant regional difference among the three groups. For the DTI index of FA, FA in moderate COPD group reduced mainly both frontal cortices, right occipital subcortical white matter, and left angular gyrus compared with CN. Also, FA in severe COPD significantly decreased FA values in gray matter of brain as well as white matter. Finally, FA in severe COPD reduced in bilateral medial temporal cortices, frontal subcortical white matter, occipitofrontal fasciculus, and corticospinal tract compared with moderate COPD. For the DTI index of trace, the trace value in moderate COPD was significantly higher in bilateral occipital cortices, left hippocampus and left superior frontal cortex than the CN group. Also, trace in severe COPD significantly increased in frontal, temporal and occipital lobes, frontal subcortical white matter, occipitofrontal fasciculus, and corticospinal tract. Finally, trace in severe COPD was significantly high in multiple brain regions compared with moderate COPD. For the CBF data, severe COPD patients had decreased CBF in lentiform nucleus compared with CN and moderate COPD.

Discussions:

The main finding of this study was significant change of axonal integrity in multiple brain regions in COPD. Severe COPD showed extensive regions with significantly lower FA and higher trace in gray and white matter than control groups. Although there have been many neuropsychologic evaluations for COPD patients, little is known of structural change of the brain in COPD patients. A previous study of VBM analysis between COPD and control groups presented significant gray matter losses in the left intraparietal sulcus, inferior frontal gyrus, basal ganglia and the right inferior frontal gyrus (4). In contrast to previous study, our results did not show any difference of regional brain volume between COPD and control groups. Based on cerebral perfusion measures using brain SPECT, it was suggested that the decrease of the cerebral perfusion in bilateral anterior frontal, left middle frontal and left parietal of COPD might resulted in cognition impairment (2). We only found decreased CBF in severe COPD at lentiform nucleus, lateral globus pallidus. COPD could affect the diffusion and perfusion changes in brain.

Conclusion:

Regional microstructural changes of brain in COPD were confirmed by using VBM analysis of DTI data for the first time. The result of this study presented the severity of COPD and the cognitive function might be correlated with the extent of microstructural change in brain. Voxel-based evaluation by DTI and CBF may be useful for preclinical detections of the cognitive dysfunction in patients with COPD.

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References: (1) Grant I, et al. Arch Gen Psychiatry 1987; 44:999-1006; (2) Antonelli IR, et al. J Neurol 2003; 250:325-332; (3) Ortapamuk H, et al. Ann Nucl Med 2006; 20:99-106; (4) Giesel FL, et al. ASNR 44th 2006 Proceedings 287-288 San Diego California May, 2006

Fig. (A) FA, (B) Trace, (C) CBF

A. CN>Severe

B. CN<Severe

C. CN<Mild

