◎原　著

Difference in low attenuation area (LAA) of the lungs on high resolution computed tomography (HRCT) between asthma and pulmonary emphysema in relation to cigarette smoking

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Abstract : The low attenuation area (LAA) of the lungs on high resolution computed tomography (HRCT) was evaluated in 20 asthmatics (10 ex-smokers and 10 never-smokers) and 10 patients with pulmonary emphysema (all ex-smokers) by ventilatory function, lung volume, DLco, and a ratio of expiratory LAA/inspiratory LAA. 1. The %LAA of the lungs on HRCT was significantly larger in patients with pulmonary emphysema (PE) than in those with asthma, but there was not significant difference in %LAA between ex-smokers and never-smokers of asthmatics. 2. A ratio of expiratory LAA/inspiratory LAA was significantly higher in patients with PE than in those with asthma , and the ratio was significantly higher in ex-smokers of asthmatics than in never-smokers ($p<0.05$). 3. The difference in %residual volume and %DLco was significant between asthma and PE, and between ex-smokers and never-smokers of asthmatics (%RV : $p<0.05$, DLco : $p<0.05$). 4. The difference in the values of %FVC, %FEV1.0, and FEV1.0% was significant between asthma and PE, but not significant between ex-smokers and never-smokers of asthmatics. The results suggest that the difference in a ratio of expiratory LAA/ inspiratory LAA, %RV and %DLco was significant between ex-smokers and never-smokers of asthmatics, and cigarette smoking induces more irreversible changes of the lungs.

Key words : low attenuation area, asthma, pulmonary emphysema, cigarette smoking, residual volume, DLco

Introduction

Asthma is a disease characterized by transient wheezing and dyspnea elicited by narrowing of the airways due to bronchoconstriction, edema of mucous membrane, and hypersecretion. The main pathogenesis of onset mechanisms of the disease is well known to be airway inflammation, in which IgE-mediated allergy play an important role, and an increase in muscle mass, mucous gland hypertrophy, and reorganization of the extracellular matrix, have been found in the inflammatory process.

Furthermore, airway reconstruction such as bronchial wall thickening, bronchiectasis, emphysematous changes[1-3], and mosaic patterns of lung attenuation has been found by high resolution computed tomography (HRCT) in patients with asthma[4,5]. It has been shown that asthmatics with abnormal HRCT findings demonstrate poorer lung function and less hyperresponsive bronchi than those with normal HRCT findings[6].

In contrast, low attenuation area (LAA) $<$-950 Hounsfield Units (HU) of the lungs on HRCT scans obtained at full inspiration is an objective measure of pulmonary emphysema[7,8]. A previous study suggested that the percentage of pixels below -900 HU is significantly correlated with pulmonary function, and reflects air trapping in patients with asthma[9]. However, the significance of the %LAA of the lungs on HRCT scans in asthma has not been determined.

In the present study, the significance of %LAA of the lungs on HRCT in asthma was examined by comparing the %LAA of asthmatics with the %LAA in patients with pulmonary emphysema, and further by comparing the %LAA of never-smokers of asthmatics with the %LAA of ex-smokers in relation to pulmonary function.

Subjects and Methods

The subjects of this study were 20 asthmatics and 10 patients with pulmonary emphysema (PE). Of 20 asthmatics, 10 were never-smokers (5 females and 5 males, mean age 66.3 years), and the residual 10 were ex-smokers (all males, mean age 71.2 years with a smoking history of 28.6 pack-years). Ten patients with PE were all ex-smokers (all males, 68.8 years with a smoking history of 46.7 pack-years). Diagnosis of PE was made by clinical symptoms, pulmonary function, chest radiography and CT findings[10].

All subjects had a modified HRCT scan of the lungs with a Toshiba Xpeed scanner (Toshiba Co) using the thin section (2 mm collimation) technique and a high-resolution reconstruction algorithm. An intravenous contrast medium was not administered. The scanning time was 2.7 seconds, tube current was 200 mA, and voltage was 120 kVp. Maximal inspiratory and maximal expiratory HRCT scans were obtained at the following three selected anatomic levels as described by Miniati et al.[10]: (1) top of the aortic arch, (2) origin of the lower lobe bronchus, and (3) 3cm above the top of the diaphragm. In this study, the relative area of the lungs with an attenuation value lower than -950 HU at the second level (origin of the lower lobe bronchus) was obtained both at full inspiration (inspiratory LAA) and full expiration (expiratory LAA). The ratio of expiratory LAA to inspiratory LAA was also calculated.

Spirometry was performed by means of a CHESTAC 33 (Chest Co) linked to a computer when their symptoms were stable. The following measurements were performed in all subjects: forced vital capacity (FVC), forced expiratory volume in one second (FEV1.0), and FEV1.0/FVC (FEV1.0%). Residual volume (RV) was measured by body plethysmography (Autobox 2800, Chest Co). The diffusing capacity for carbon monoxide (DLco) was measured by the single breath technique using a CHESTAC 33. The actual DLco values were corrected for hemoglobin and carbon monoxide levels. The FVC, FEV1.0, RV, and DLco measurements for each patient were expressed as a percent of the predicted values.

Serum IgE was measured by radioimmunosorbent test (RIST), and serum IgE antibodies specific to aeroallergens including house dust mite, pollens. Moulds, and animal danders were measured using the Pharmacia CAP system (Pharmacia Diagnostics SAB).

Statistically significant differences of the mean were estimated using the unpaired Student's t test. A p value of <0.05 was regarded as significant.

Results

The mean serum IgE level was 298 IU/ml (range 30-925 IU/ml) in never-smokers, 279 IU/ml (33-839 IU/ml) in ex-smokers of asthmatics, and 580 IU/ml (15-2298 IU/ml) in patients with PE. A positive RAST score against inhalant allergens was observed in 3 of 10 never-smokers, 7 of 10 ex-smokers of asthmatics, and 6 of 10 patients with PE.

The %LAA of the lungs on HRCT, ratio of expiratory LAA to inspiratory LAA, %FVC, %FEV1.0, FEV1.0%, %RV, and %DLco, were significantly different between asthmatics and patients with PE. The %LAA of the lungs on HRCT was significantly larger in patients with PE than in asthmatics, however, the difference in the %LAA was not significant between never-smokers and ex-smokers of asthmatics (Fig. 1). In contrast, a ratio of expiratory LAA to inspiratory LAA was significantly higher in ex-smokers than in never-smokers of asthmatics ($p<0.05$) (Fig. 2).

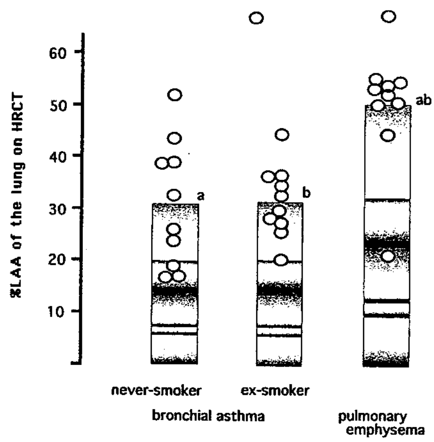

Fig.1. %Low attenuation area (LAA) of the lung on high-resolution computed tomography (HRCT) in patients with asthma and in those with pulmonary emphysema. a:$p<0.02$, b:$p<0.001$.

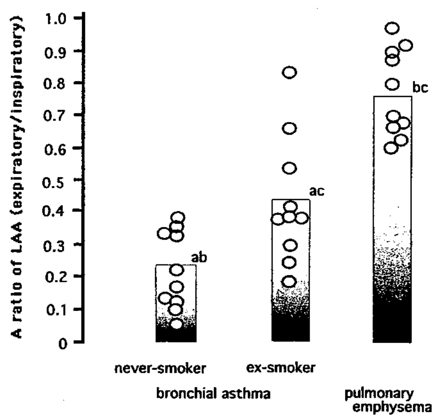

Fig.2. A ratio of LAA (expiratory/inspiratory)in patients with asthma and in those with pulmonary emphysema. a:$p<0.05$, b:$p<0.001$.

A significant difference between never-smokers and ex-smokers of asthmatics was observed in %RV ($p<0.05$) (Fig. 3) and %DLco ($p<0.05$) (Fig. 4). However, a difference in %FVC, %FEV1.0 and FEV1.0% values was not significant between never-smokers and ex-smokers in asthma (Fig. 5, 6, 7).

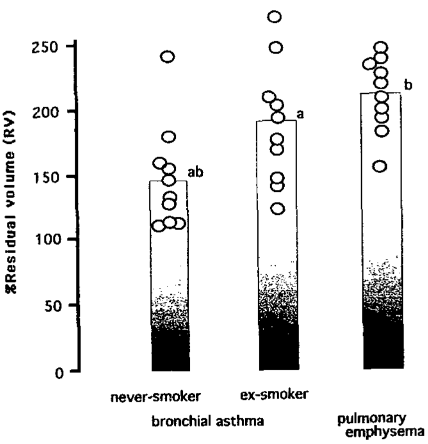

Fig.3. %Residual volume (%RV) in patients with asthma and in those with pulmonary emphysema. a:p<0.05, b:p<0.001.

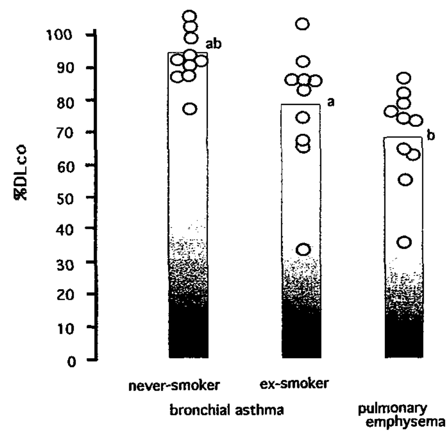

Fig.4. %DLco in patients with asthma and in those with pulmonary emphysema. a:p<0.05, b:p<0.001.

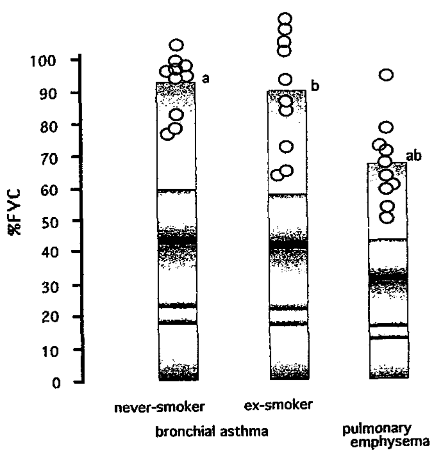

Fig.5. %FVC in patients with asthma and in those with pulmonary emphysema. a:p<0.001, b:p<0.01.

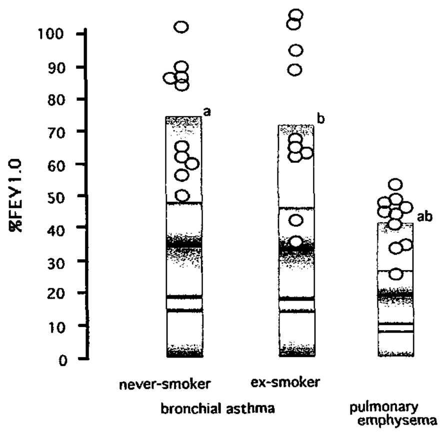

Fig.6. %FEV1.0 in patients with asthma and in those with pulmonary emphysema. a:p<0.001, b:p<0.01.

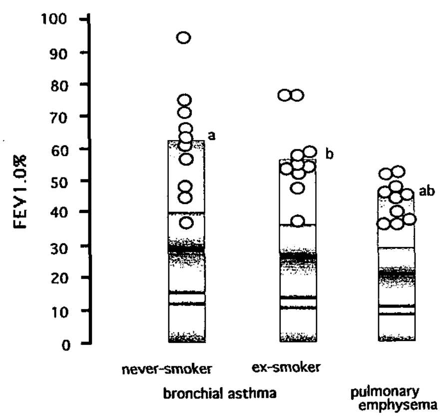

Fig.7. FEV1.0% in patients with asthma and in those with pulmonary emphysema. a:p<0.01, b:p<0.01.

Discussion

Pulmonary emphysema is defined in structural terms as 'a condition of the lung characterized by abnormal, permanent enlargement of the airspaces distal to the terminal bronchiole, accompanied by destruction of their walls'[11]. Regarding the evaluation of PE, it has been suggested that the diagnosis of PE by pathologic examination is correlated with HRCT scan findings[12-14].

The LAA <-950 HU of the lungs on HRCT scans at full inspiration is an objective measure of the extent of PE[7,8,15]. The qualitative analysis of emphysema has been carried out according to a visual score introduced by Sakai, et al.[16] based on the assessment of two aspects of emphysema : severity and extent. Severity was graded on a 4-point scale : 0, no emphysema ; 1, low attenuation areas < 5 mm in diameter (type 1) ; 2, circumscribed low attenuation areas > 5 mm in diameter with intervening normal lung (type 2) ; 3, diffuse low attenuation areas without intervening normal lung (type 3) as shown in Fig. 8. The extent of emphysema was on a 4-point scale : 1, <25% of the lung involvement ; 2, 25% to 50% lung involvement ; 3, 50 to 75% lung in-volvemment ; 4, >75% lung involvement.

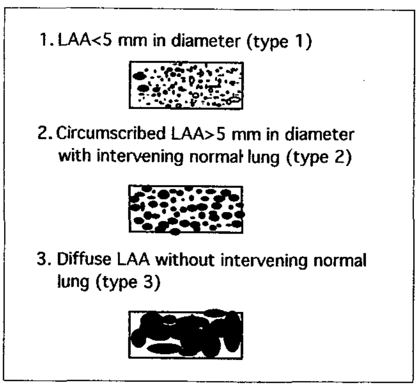

Fig. 8. Severity of low attenuation area (LAA) < -950 HU of the lung on HRCT

The extent of %LAA of the lungs on HRCT was significantly larger in patients with PE than in those with asthma, however, a significant difference in the extent of %LAA was not found between never-smokers and ex-smokers of asthmatics. Regarding the severity of emphysema, all asthmatics showed low attenuation areas <5 mm in diameter of the lungs (type 1). In contrast, diffuse low attenuation areas without intervening normal lung (type 3) were observed in many patients with PE, and circumscribed low attenuation areas < 5 mm in diameter with intervening normal lung (type 2) were in some.

In addition to different severity of LAA between asthmatics and patients with PE, the ratio of expiratory LAA to inspiratory LAA was significantly different between asthmatics and patients with PE. Furthermore, a significant difference in the ratio of expiratory LAA to inspiratory LAA was observed between never-smokers and ex-smokers of asthmatics : the ratio was significantly higher in ex-smokers than in never-smokers of asthmatics. The results obtained here suggest that cigarette smoking induces more irreversible changes of the lungs compared with never-smoking. The higher ratio of expiratory LAA to inspiratory LAA of the lungs was closely correlated with %RV and %DLco, but not with %FVC, %FEV1.0 and FEV1.0%.

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肺気腫と喘息のHRCT上のlow attenuation are（LAA）の性質の差。喫煙との関連を含めて

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気管支喘息20例（10例：喫煙例，10例非喫煙例）および肺気腫10例（全例喫煙例）を対象に，high resolution computed tomography（HRCT）上の肺のlow attenuation area（LAA）の臨床的意義について検討を加えた。1．HRCT上の肺の%LAAは，肺気腫において気管支喘息に比べ有意に高い値を示したが，気管支喘息の喫煙例と非喫煙例の間には有意に差は見られなかった。2．呼気LAA／吸気LAA比は，喘息症例に比べ肺気腫症例で有意に高い値を示した。また，喘息の中では，喫煙例で非喫煙例に比べ有意に高い値が示された。3．%RVおよび%DLcoは，肺気腫と喘息症例との間で，また喘息症例では，喫煙例と非喫煙例の間で有意の差が見られた。4．%FVC，%FEV1.0およびFEV1.0%値はいずれも肺気腫と喘息の間では有意の差が見られたが，喘息の喫煙例と非喫煙例の間には有意の差は見られなかった。以上の結果より，肺気腫と喘息の間では全てのパラメーターで有意差が，また喘息の喫煙例と非喫煙例の間では，呼気LAA／吸気LAA比，%RV，%DLcoで有意差が見られることが示唆された。