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Correlation between pulmonary function and low attenuation area (LAA) on HRCT in patients with asthma in relation to smoking

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Abstract : The influence of smoking on pulmonary function and emphysematous changes of the lung (percentage of attenuation area < -950 HU (%LAA) on high resolution computed tomography (HRCT) was examined in 49 patients with bronchial asthma. 1. In patients with asthma, the %residual volume (RV) in many nonsmokers was less than 129%, in contrast, the %RV in many smokers was between 130% and 189% , which was higher than that in nonsmokers. 2. Significant correlations between %RV and %LAA value, and between %RV and CT number were observed both in nonsmokers and smokers with asthma, in which as %RV more increased, %LAA value was larger, and CT number was lower. 3. %DLco value was lower in smoking patients with asthma, whose %RV was between 130% and 189% and larger than 190%, however, the %DLco value did not change in nonsmoking patients despite of higher valure in %RV. 4. A significant correlation was also observed between %FEV1.0 value and %RV both in smoking and nonsmoking patients with asthma ; as %RV value more increased, %FEV1.0 value was lower. 5. Any correlation between %FVC value and %RV was not observed. These results suggest that smoking affects the %LAA of the lung on HRCT and %DLco in patients with asthma.

Key words : asthma, smoking, %LAA of the lungs, FEV1.0, DLco

Introduction

Asthma is characterized by transient or sometimes persistent narrowing of the airways. The disease sometimes shows emphysematous changes of the lung evaluated by %low attenuation area (%LAA) <-950 HU on high resolution computed tomography (HRCT)[1]. In contrast, it has been suggested that the diagnosis of emphysema by pathologic examination is correlated with high resolution computed tomography (HRCT) scan findings[2, 3]. The low attenuation area (LAA) < -950 Housfield Unit (HU) of the lungs on HRCT scans at full inspiration is an objective measure of the extent of pulmonary emphysema[4, 5]. However, the influences of hyperinflation and of nonemphysematous expiratory airflow limitation on the CT quantification of pulmonary emphysema are still unclear[6].

High resolution CT has been also used to study asthmatic patients. It has been observed that asthmatic patients manifest more abnormalities related to permanent airways remodelling, such as bronchial dilatation, and bronchiectasis, than do healthy subjects[7, 8]. Furthermore, emphysematous changes of the lung on HRCT have been observed in patients with asthma in relation to smoking and severity of the disease[1, 9, 10].

In this study, influences of smoking on the percent of low attenuation area (%LAA) <-950 HU of the lungs by HRCT and on pulmonary function particularly %DLco, residual volume (RV), and FEV1.0.

Subjects and Methods

The subjects in this study were 49 patients (21 females and 28 males) with asthma. Twenty patients were previous and current smokers with an average smoking history of 49.1±32.5 pack-year. The remaining 29 patients were nonsmokers. Seven (35.0%) of the 20 smoking patients had severe intractable asthma with lomg-term glucocorticoid therapy. In contrast, 9 (31.0%) of the 29 nonsmoking patients had severe asthma being treated with glucocorticoids. Asthma was evaluated according to the criteria of the International Consensus of Diagnosis and Management of Asthma[11]. All patients revealed reversible airway response with a difference between prebronchodilator and postbronchodilator values of FEV1 exceeding 15%. An informed consent for study protocol was obtained from all study patients.

CT scans were performed on a TOSHIBA Xpeed scanner (2.7s, 200 mAs, 120 kVp) without infusion of contrast medium, using 2-mm collimation (HRCT) in patients breathholding at full inspiration. The lungs were scanned as preselected three anatomic levels ; (1) top of the aortic arch, (2) origin of the lower lobe bronchus, (3) three cm above the top of the diaphragm, as reported by Miniati M, et al.[12]. Inspiratory HRCT scans were evaluated qunantitatively by measuring the percentage of lung area with CT number < -950 HU (%LAA) and the mean CT number in HU. In this study, the mean %LAA between the two anatomic levels of the lung : origin of the lower lobe bronchus and three cm above the top of the diaphragm, was expressed as representative %LAA in each patient with asthma. The LAA on HRCT can be evaluated by two aspects : severity and extent. The severity is graded on a 4-point scale ; 0. no emphysema, 1. low attenuation areas <5 mm in diameter, 2. circumscribed low attenuation areas>5 mm in diameter, 3. diffuse low attenuation areas without

intervening normal lung. However, in this study, LAA of the lung <-950HU was evaluated refardless of the severity. The CT number was calculated from the CT numbers of the three anatomic levels.

Pulmonary function tests, %forced vital capacity (FVC), %forced expiratory volume in one second (FEV1, %predicted), %residual volume (RV, %predicted) and %DLco (%predicted), were carried out in all patients using a CHESTAC 33 (Chest Co) linked to a computer, when they were attack-free. The subjects were classified into three groups by the degree of %RV : <129%, 130-189%, and 190%<.

IgE antibodies against house dust mite (HDm), cockroach, and Candida were estimated by radioallergosorbent test (RAST) and serum level of total IgE was measured by radioimmunosorbent test (RIST).

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

Results

Table 1 represents the characteristics of smoking and nonsmoking patients with asthma. Mean age was higher in smokers than in nonsmokers with asthma. The level of serum IgE was higher in smoking patients than in nonsmoking patients. However, the difference was not significant.

The positive rate of RAST scores for HDm was not different between smokers and nonsmokers with asthma (Table 1).

Nonsmoking patients with asthma showed the %RV less than 129% most frequently (65.6%), in contrast, the %RV between 130 and 189% was most often observed in smoking subjects with asthma (Fig. 1).

Table 1. Characterristics of patients with asthma studied

Subjects	No of patients	Mean age (years)	Serum IgE (IU/ml)	RAST score (HD2+<)
Smoker	20	68.1	474 (19-2562)	9/20 (45.0%)
Nonsmoker	29	61.0	355 (20-1124)	12/29 (41.4%)

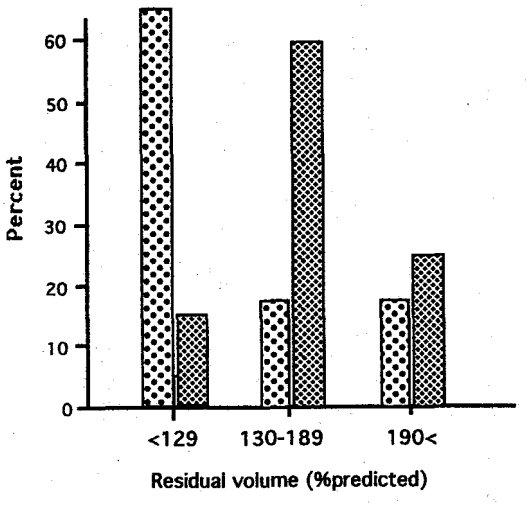

Fig.1. Frequency of asthmatics with three different degrees of residual volume inrelation to smoking ; smoker (▩) and non smoker (▩)

A significant correlation between %RV and %LAA on HRCT was observed both in nonsmoking and smoking patients with asthma. In nonsmokers with asthma, the mean of %LAA was 10.2 ±7.7% (mean ± SD) in subjects with %RV less than 129%, 29.5±11.4% in those with %RV between 130 and 189%, and 37.0±4.7% in those with %RV more than 190%. The %LAA was larger as the %RV increased, and the %LAA was significantly

lower in the subjects with %RV<129% than in those with %RV of 130-189% ($p<0.001$), and 190%< ($p<0.001$). Smoking patients with asthma showed a same tendency as nonsmoking subjects. The mean %LAA was significantly lower in patients with %RV<129% than in subjects with %RV of 130-189% ($p<0.01$) and 190%< ($p<0.01$) (Fig. 2).

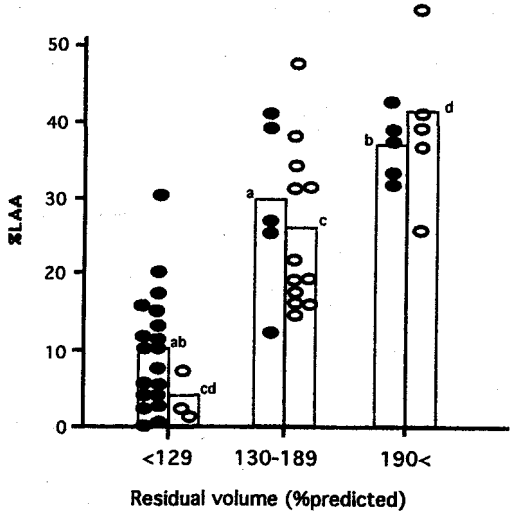

Fig.2. Correlation between residual volume (RV) and %LAA on HRCT in patients with asthma : smoker (●) and nonsmoker (o).
a and b ; $p<0.001$, c and d ; $p<0.01$.

A significant correlation was also found between mean CT number and %RV both in nonsmoking and smoking patients with asthma, as shown in Fig. 3. The %DLco value was to a certain extent correlated with %RV in smokers with asthma. A marked decrease in %DLco was found in smoking patients of %RV between 130 and 489%, and those of %RV more than 190%, however, decrease in %DLco was not found in the patients of %RV less than 129% (Fig 4).

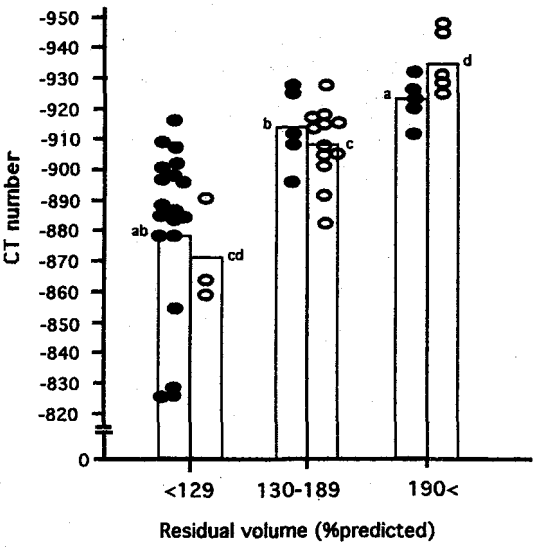

Fig.3. Correlation between residual volume (RV) and CT number in patients with asthma : smoker (o) and nonsmoker (●).
a and b ; $p<0,02$, c and d ; $p<0,001$.

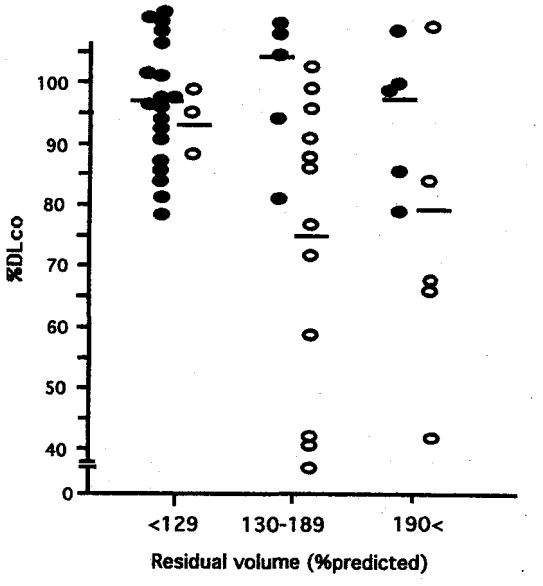

Fig.4. Correlation between residual volume (RV) and %DLco in patients with asthma : smoker (o) and nonsmoker (●).

Regarding ventilatory function, any significant correlation was not observed between %FVC and %RV both in nonsmoking and smoking patients with asthma (Fig. 5). In contrast, %FEV1.0 value was significantly correlated with the degree of %RV both in patients with and without smoking. In nonsmokers with asthma, the %FEV1.0 in patients with %RV less than 129% was significantly higher than the values in subjects with %RV between 130 and 189% ($p<0.001$), and more than 190% ($p<0.01$). Regarding smokers with asthma, the %FEV1.0 value was significantly larger in subjects with %RV <129% than in those with %RV 190%< ($p<0.01$) (Fig. 6).

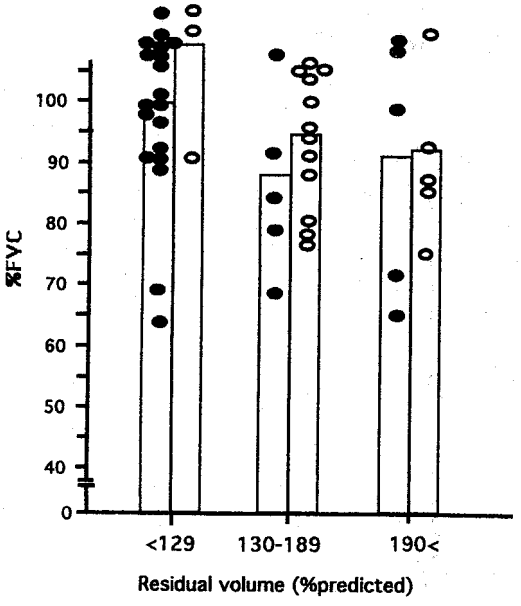

Fig.5. Correlation between residual volume (RV) and %FVC in patients with asthma : smoker (o) and nonsmoker (●).

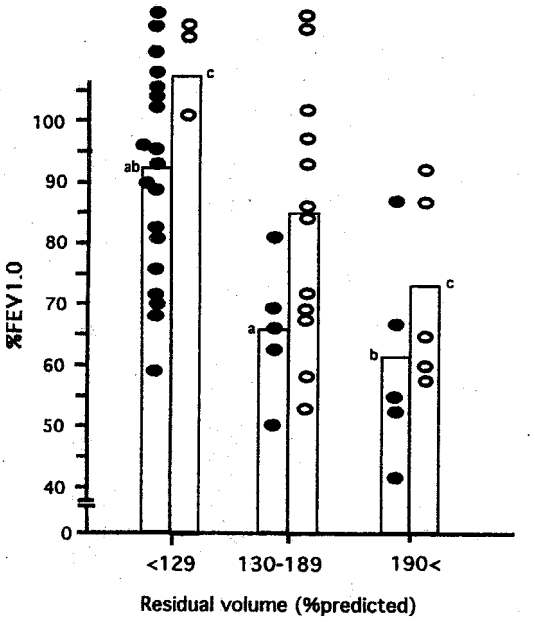

Fig.6. Correlation between residual volume (RV) and %FEV1.0 in patients with asthma : smoker (o) and nonsmoker (●).
a ; $p<0.001$, b and c ; $p<0.01$.

Discussion

It is generally agreed that CT scanning is a sensitive technique of detecting emphysematous lesions in patients with chronic obstructive pulmonary disease (COPD). It has been shown that the relative lung area with low attenuation values < -950 HU on HRCT scans at full inspiration is a sensitive imaging method to measure the extent of pulmonary emphysema[4, 5]. However, the influences of hyperinflation and of nonemphysematous expiratory airflow limitation on HRCT has not been investigated in pulmonary emphysema[6].

Regarding the percentage of low attenuation area (%LAA) of the lung, Newman KB, et al. have reported that there was no significant difference between asthmatic patients and control subjects for the inspiratory

HRCT scans obtained in the lower lung areas (<-900 HU), whereas difference was significant for the upper lung areas[13]. They concluded that hyperinflation and airflow obstruction without emphysematous lung destruction would not influence densitometric measurements obtained from inspiratory scans.

A close correlation between pulmonary emphysema and smoking has been extensively suggested. Smoking patients with asthma have significantly more emphysema than nonsmoking patients[14, 15]. In this study, to clarify the influence of smoking on %LAA of the lungs, and %RV in patients with asthma. A significant correlation was found between %RV and %LAA, between %RV and mean CT number, and between %RV and %FEV1.0 both in nonsmoking and smoking patients with asthma; as %RV increased, %LAA showed a tendency to increase, and mean CT number and %FEV1.0 value decreased in the two groups (nonsmoking and smoking group). However, marked differences were observed in patients with asthma between nonsmokers and smokers. The %RV was less than 129% in many of nonsmokers with asthma (65.6%), in contrast, the %RV was between 130 and 189% in many of smokers with asthma (60.0%). A marked decrease in %DLco was found in smoking patients with asthma with %RV larger than 130%, however, not found in nonsmoking patients with asthma. These results suggest that smoking influences an increase in %RV, relating to an increase in %LAA of the lungs, and also shows that smoking leads to a marled decrease in %Dlco in patients with asthma.

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気管支喘息患者における肺機能と ＨＲＣＴ 上の low attenuation area に対する喫煙の影響

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気管支喘息49例を対象に、肺機能および High-resolution computed tomography (HRCT) 上の Low attenuation are (LAA) <-950 HUで示される肺気腫様変化に及ぼす喫煙の影響について検討した。1．気管支喘息患者のうち、非喫煙例では%残気量 (%RV) は多くの症例 (65.6%) で129%以下であったが、一方喫煙症例では130%から189%を示す症例が最も多く見られた (60.0%)。非喫煙例および喫煙例いずれにおいても、2．%RV と %LAA、%RV と CT number 間に有意の相関が見られた：%RV が上昇するにつれて、%LAA 値は増加し、CT number は低下する傾向が見られた。3．喫煙例では、%RV が 130-189% あるいは 190% 以上の症例で、%DLco 値が明かに低値を示す症例が見られたが、非喫煙症例では%RV が高い値を示しても %DLcoの低下はみられなかった。4．喫煙例、非喫煙例いずれにおいても、%FEV1.0 値と %RV 値の間には有意の相関が見られ、%RV値 が上昇するにつれて、%FEV1.0 値は低下する傾向が見られた。5．%FVC と %RV の間には相関は見られなかった。

以上の結果より、喫煙は気管支喘息患者の HRCT 上の %LAA および %DLco に影響を与えることが示唆された。