◎原 著

Low attenuation area on computed tomography in asthma. Comparison between smoking and nonsmoking subjects.

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Summary : The percentage of attenuation area < −950HU (%LAA) on high resolution computed tomography (HRCT) was compared between 17 smoking and 24 nonsmoking patients with asthma. 1. FEV1/FVC value was lower in smoking patients (56.4%) than in nonsmoking patients (66.0%), however, the difference was not significant. 2. The percentage of LAA of the lung was larger in smoking patients compared with that in nonsmoking patients in all the three anatomic levels : the %LAA was 14.4% in nonsmoking and 20.3% in smoking patients at lower lung level (3 cm above the top of the diaphragm). However, this was not significant. The maximal %LAA among the three lung levels on HRCT was 21.6±12.5% in smoking, and 15.7±11.9% in nonsmoking patients. This suggested that the maximal %LAA was larger in smoking patients, however, this was not significant. 3. The mean CT number of the lung on HRCT was smaller in smoking patients (−897.3HU) than in nonsmoking patients (−884.7HU). 4. Three of 4 nonsmoking patients whose %LAA was more than 30% had severe intractable asthma with long-term glucocorticoid therapy.

The results suggest the possibility that smoking influences the %LAA of the lung on HRCT in asthma. It could be also speculated that %LAA is influenced by severity of asthma.

Key words : bronchial asthma, FEV1, %LAA, mean CT number, HRCT,

Introduction

It has been suggested that the diagnosis of emphysema by pathologic examination is correlated with high resolution computed tomography (HRCT) scan findings[1-3]. 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 ob-

served that asthmatic patients manifest more abnormalities related to permanent airways remodelling, such as bronchial dilatation, and bronchiectasis, than do normal 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[9, 10].

In this study, the percent of low attenuation area (LAA) $<$ −950HU of the lungs on HRCT was compared between smoking and nonsmoking patients with asthma, and the significance of %LAA of the lungs in asthma was discussed in relation to smoking and severity of the disease.

Subjects and Methods

The subjects in this study were 41 patients (15 females and 26 males) with asthma. Seventeen patients were previous and current smokers with an average smoking history of 36.1 ± 20.6 pack-year. The remaining 24 patients were nonsmokers. Nine (52.9%) of the 17 smoking patients had severe intractable asthma with lomg-term glucocorticoid therapy. In contrast, 5 (20.8%) of the 24 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, 200mAs, 120KVp) without infusioin of contrast medium, using 2-㎜ 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 ㎝ 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 $<$ −950HU (%LAA)(Fig. 1) and the mean CT number in HU. The maximal %LAA among the three anatomic levels of the lung was expressed as representative %LAA in each patient with asthma.

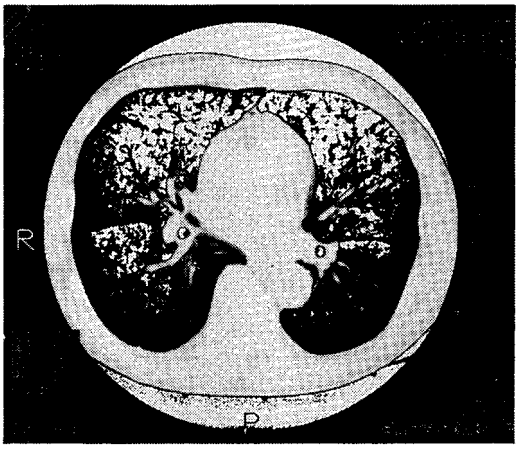

Fig. 1. Low attenuation area (LAA) of the lung $<$ −950HU on high resolution CT in patients with asthma (71 years old, male, smoker)(maximal %LAA, 33.7%)

The mean CT number was calculated from the CT numbers of the three anatomic levels.

Pulmonary function tests, forced vital capacity (FVC) and forced expiratory volume in one second (FEV1), were carried out in all patients using a Chestac 33 (Chest Co) linked to a computer, when they were attack-free.

IgE antibodies against house dust mite (HDm), cockroach, and Candida were esti-

mated 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. Ap value of < 0.05 was regarded as significant.

Results

Table 1 represents the characteristics of smoking and nonsmoking patients with asthma. Mean age and age at onset of the disease were not different between smoking and nonsmoking patients. Family history with asthma was frequently observed in the two groups. The level of serum IgE was higher in smoking patients than in nonsmoking patients.

Table 1. Characteristics of smoking and nonsmoking patients with asthma studied

Smoking	No of patients	Age (years)	Age at onset (years)	Family* history	Serum IgE (IU/ml)
+	17	65.4	45.4	11/17 (64.7%)	594 (33-2298)
−	24	66.1	49.4	13/24 (54.2%)	235 (8-929)

*Family histoly of asthma

The positive RAST scores for inhalant allergens were more frequently observed in smoking patients compared to that in nonsmoking patients, and the difference in RAST score for Candida was significant between the two groups ($p<0.02$)(Fig. 2).

The value of %FVC was not different between smoking and nonsmoking patients, as shown in Fig. 3. The value of FEV1/FVC (FEV1%) was higher in nonsmoking patients ($66.0\pm13.6\%$)(mean ± 1SD) than in smoking patients ($56.4\pm12.3\%$), however, this difference was not significant (Fig. 4).

The %LAA of the three anatomic levels of the lung on HRCT was compared between the two groups. The %LAA of each level of the lung was larger in smoking patients than in nonsmoking patients, however, the difference was not significant (Fig. 5). The maximal %LAA among the three anatomic levels of the lung was also higher in smoking patients ($21.6\pm12.5\%$) than in nonsmoking patients ($15.7\pm11.9\%$), but this was not significant (Fig. 6). The mean CT number was -897.3 ± 19.4HU in smoking, and -884.7 ± 28.6HU in nonsmoking patients, and the difference between the two groups was not significant (Fig. 7).

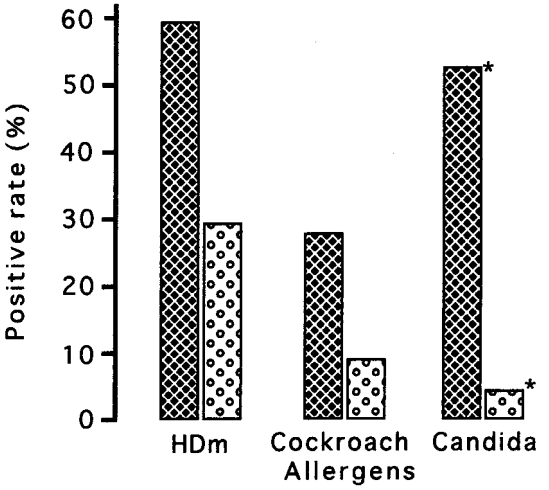

Fig. 2. Positive RAST score for inhalant allergens in smoking (▩) and nonsmoking patients with asthma (▩). HDm ; house dust mite. *$p<0.02$

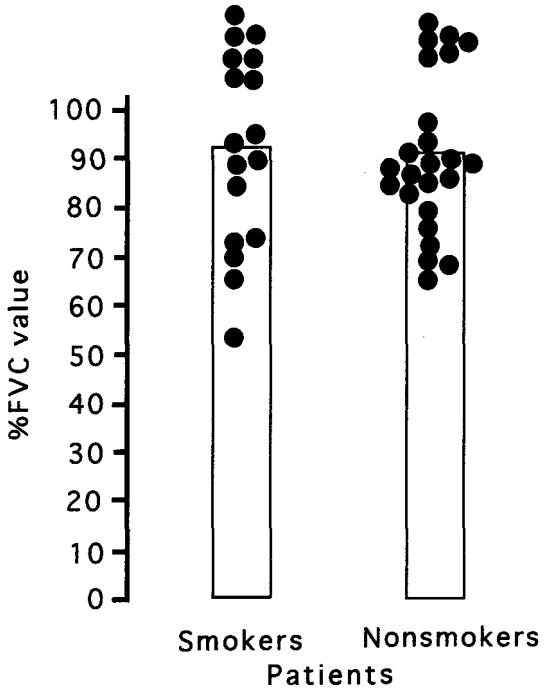

Fig. 3. %FVC value in smoking and nonsmoking patients with asthma

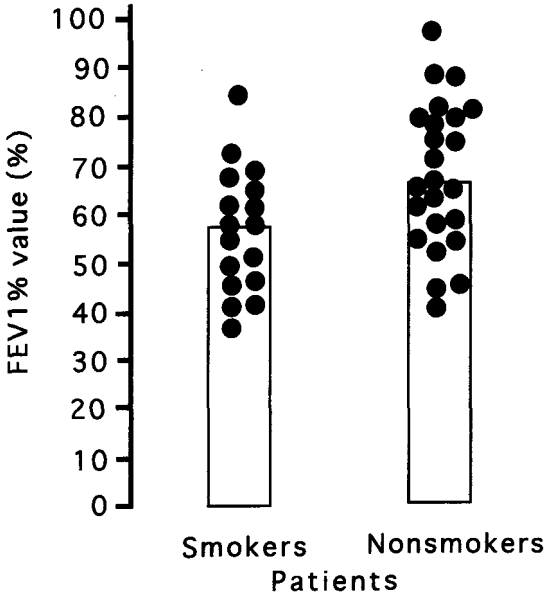

Fig. 4. FEV1% value in smoking and nonsmoking patients with asthma

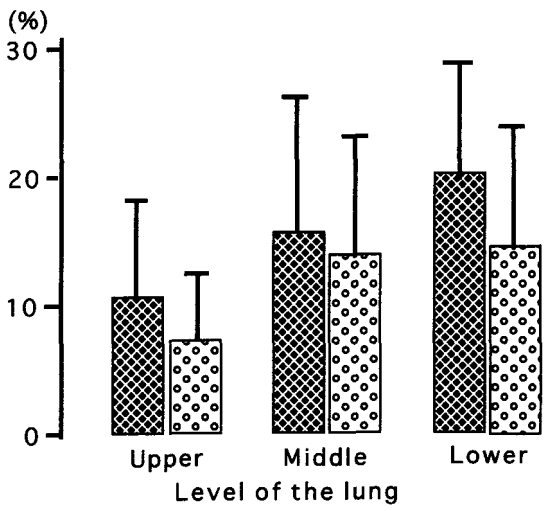

Fig. 5. %LAA of three anatomic levels of the lung on HRCT in smoking (▩) and nonsmoking patients with asthma (▩)

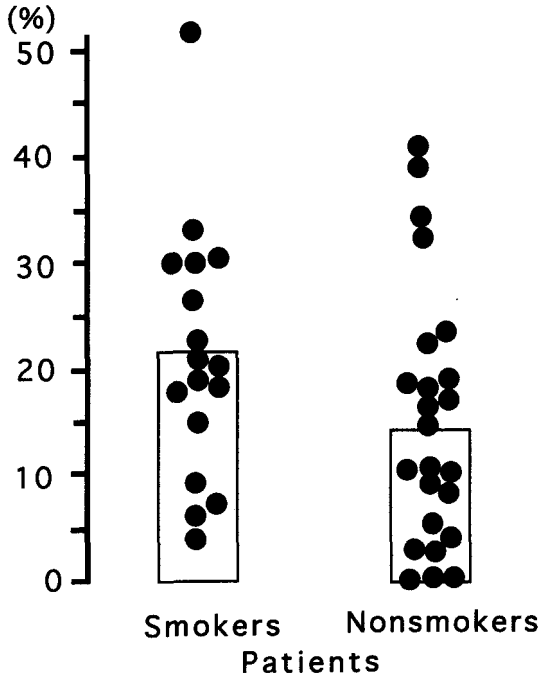

Fig. 6. Maximal %LAA among three anatomic levels of the lung on HRCT in smoking and nonsmoking patients with asthma

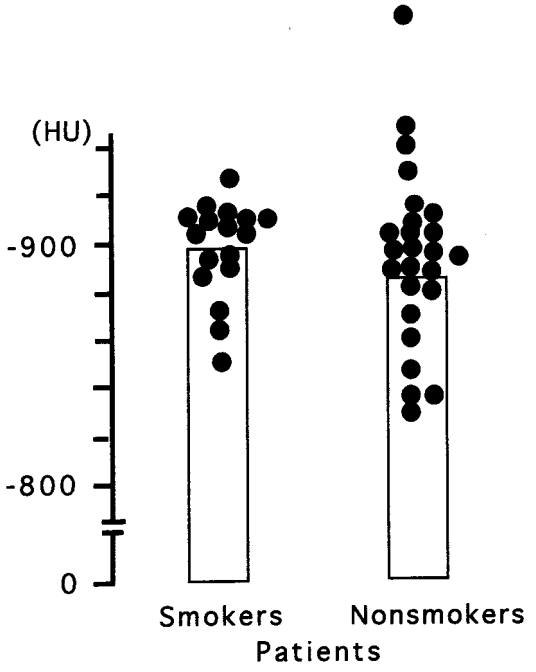

Fig. 7. Mean CT number on HRCT in smoking and nonsmoking patients with asthma

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 <-950HU 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].

HRCT has been also used to study asthmatic patients. Asthmatic patients show more abnormalities related to permanent airways remodelling, such as bronchial dilatation and bronchiectasis, than do normal subjects[7,8]. It is suggested that airways remodelling, which is a feature of long-standing asthma, may differ in patients with allergic and nonallergic asthma. Paganin F, et al. have revealed that patients with nonallergic asthma have a more extensive remodelling of the airways than those with allergic asthma[10].

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 (<-900HU), 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 do nonsmoking patients[14]. In this study, to clarify the influence of smoking on airways remodelling in asthma, inspiratory HRCT scans were analyzed quantitatively by measuring the mean CT number in HU and the percentage of lung area with CT number <-950HU. The results obtained here demonstrated that the %LAA of the lung was larger and the mean CT number was smaller in smoking patients than in nonsmoking patients, however, these differences were not significant. The results might suggest that smoking would not largely influence airways remodelling in some patients with asthma. In fact, it has been shown that emphysematous

lesions on HRCT could be found in nonsmoking, nonallergic patients with severe asthma[10]. In our study, 3 of 4 nonsmoking patients with %LAA more than 30% on HRCT had severe intractable asthma with long-term glucocorticoid therapy. Aging might also influence the mean CT number and %LAA of the lung in asthma, as reported by Gevenois PA, et al[9]. Thus, it can be speculated that asthma severity, aging and smoking might influence airways remodelling in asthma.

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気管支喘息におけるCTによる気腫性変化。喫煙症例と非喫煙症例の比較。

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HRCT（high resolution computed tomography）による－950HU以下の肺野のlow attenuation area（LAA）について，17例の喫煙喘息症例と24例の非喫煙喘息症例で比較検討した。1．FEV1.0%値は，喫煙症例（56.4%）で非喫煙症例（66.0%）に比べ低い値が示されたが，両群間に有意の差は見られなかった。2．%LAAは，肺野のいずれの高さにおいても，非喫煙症例に比べ喫煙症例で高い傾向が見られたが，有意の差ではなかった。Maximal %LAAは，喫煙症例で21.6%，非喫煙症例15.7%であり，同様に喫煙症例で高い傾向が見られたが，有意の差は見られなかった。3．平均CT値は，非喫煙症例（－884.7HU）に比べ，喫煙症例（－897.3HU）で低い値であった。4．%LAAが30%以上を示す4例の非喫煙症例のうち，3例がステロイド依存性の重症難治性喘息であった。

これらの結果より，喫煙が肺野の%LAAに影響をあたえる可能性もあるものの，疾患の重症度がより影響が強い可能性が示唆された。