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High Resolution Computed Tomography Findings in Patients with Persistent Asthma

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ABSTRACT

Background: Structural changes of airways can be detected by high-resolution computerized tomography (HRCT) in asthmatics especially those with persistent asthma. The aim of this study was to detect these airways changes and their relationship with the duration and severity of the disease. **Methods:** This cross-sectional study enrolled 80 patients with persistent asthma. The patients were classified into two groups; severe and non-severe persistent asthma. HRCT scan was done for all patients, and radiological changes were classified into reversible (mucoid impaction, consolidation and lobar collapse) and irreversible changes (bronchiectasis, bronchial wall-thickening and emphysema). The Statistical Package for Social Sciences (SPSS, version 18) was used for data entry and analysis with appropriate statistical tests. P value of less than 0.05 was considered statistically significant. **Conclusion:** In this study, 28 patients out of 80 patients (35%) had severe and 52 patients (65%) had non-severe persistent asthma. Irreversible changes were detected in 100% of patients with severe, and 57.7% of patients with non-severe persistent asthma, (P = 0.0001). Reversible changes were found in 42.9% of patients with severe and 42.3% of patients with non-severe persistent asthma (p=0.9732). In asthmatic patients, radiological changes on HRCT scan correlates directly with the severity and the duration of the disease.

Key wards: Asthma, high resolution computed tomography, reversible and irreversible changes.

Introduction

Asthma is a chronic respiratory disorder characterized by hyper-responsiveness of the airways that leads to recurrent episodes of wheezing, shortness of breath, chest tightness and cough, mainly at night and in the early morning. These episodes are usually reversible, either spontaneously or with treatment [1]. Asthma is a common disorder that affects about 300 million people worldwide, about 10–12% of adults and 15% of children affected by the disease with about 250,000 deaths/year [2], according to GINA criteria asthma is classified according to the frequency of symptoms, forced expiratory volume in the first second (FEV1), and peak expiratory flow rate into intermittent, mild persistent, moderate persistent and severe persistent asthma as shown below.

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Table 1: Clinical classification of asthma according to GINA [3]

Severity*	Symptom frequency	Night time symptoms	%FEV1 of predicted	Drug use**
Intermittent	≤2 per week	≤2 per month	≥80%	≤2 days per week
Mild persistent	>2 per week but not daily	3–4 per month	≥80%	>2 days / week but not daily
Moderate persistent	Daily	>1 per week but not nightly	60–80%	Daily
Severe persistent	Throughout the day	Frequent (often7×/week)	<60%	Several times per day
*In patients ≥ 12 years of age. **Use of short-acting beta2 agonist for symptom control.				

Asthma can be diagnosed clinically depending on a typical history of recurrent episodes of wheeze, cough, chest tightness and shortness of breath plus either [1]:

1- 15% (200 ml) increase in FEV1 after administration of a bronchodilator or a trial of corticosteroids, or
2- 20% diurnal variation in peak expiratory flow rate (PEFR) on 3 days or more / week for 2 weeks, or
3- Reduction in FEV1 more than 15% after 6 minutes of exercise.

Airway remodeling occurs in both large and small airways in asthmatics regardless the severity of the disease. Structural changes include loss of epithelial integrity, thickening of basement membrane, sub epithelial fibrosis, goblet cell and submucosal gland enlargement, increased smooth muscle mass, decreased cartilage integrity and increased airway vascularity. These changes result from chronic inflammation with activation of inflammatory cells including $CD4^+$ T cells, eosinophil, Neutrophils and mast cells. With time these changes can cause reduced lung function, increased airway hyper-responsiveness [4]. Airway remodeling can be detected by histological examination; however, high resolution computed tomography (HRCT) scan can be used to detect these changes although it is not accurate as histological examination, but it is less invasive [5]. HRCT scan provides anatomical examination of the lung parenchyma. In asthma HRCT scan can identify the associated conditions as bronchopulmonary aspergillosis and conditions that mimic asthma as hypersensitivity pneumonitis [6]. HRCT scan studies in asthmatic patients may reveal abnormal radiologic findings, such as bronchial wall thickening (BWT), bronchiectasis (BE), emphysema, mucus plugging, consolidation, and lobar collapse [4]. The detection of airway remodeling in severe asthma and finding of the relation between airway structure using CT scan, and the clinical outcome may help to treat the patients more effectively [6].

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Aim of the study

This study was done to detect the airways changes in patients with persistent asthma by HRCT scan and their relationship with the duration and severity of the disease.

Patients and Methods

This cross-sectional study included 80 patients with persistent asthma attended the emergency department of AL- Sadder teaching hospital in AL-Najaf city/Iraq, from 20thApril to 30th October 2019, their ages ranged from (20–54) years and the duration of disease ranged from (4–38) years. Detailed history was taken including the age, sex, job, and smoking, duration of asthma, time of occurrence of symptoms (day, night, or both), frequency of symptoms, past medical and drugs history including use of inhalers, after stabilization of the patients spirometry was done by (spirolab-III-MIR) before and 15 – 20 minutes after administration of salbutamol nebulization 5 mg in 2 ml of normal saline. The patients were classified into two groups; severe and non-severe (mild to moderate) persistent asthma depending on GINA criteria. HRCT scan of the chest was done for the patients by (Toshiba Aquilion 64 slices) after adequate therapy and control of the symptoms, all scans were obtained at full inspiration, thin CT sections of 1 mm were obtained through the lungs at 20 mm intervals using a scan time of 1.2 seconds, the scans were reconstructed by using a high resolution algorithm and a matrix size of 512x512. The images were obtained and viewed at window levels of 700 Hounsfield units (HU) and window width of 1500 HU. Bronchial wall thickness was measured at five sites; the superior margin of the aortic arch, 1 cm above the carina, the carina, at the level of the inferior pulmonary vein, and 2 cm above the diaphragm. Bronchiectasis was diagnosed by lack of bronchial tapering, visibility of airways within 1 cm of the pleural surface, abutting the mediastinal pleural surface, beaded appearance, signet ring sign, gross bronchial dilation with appearance of cysts, or tram-track appearance of the parallel bronchial walls. Centrilobular emphysema was diagnosed by irregular, small, round or confluent areas of low attenuation interspersed with a normal lung. Panacinar emphysema was diagnosed by diffuse areas of low attenuation with little normal lung tissue between the lesions. The following changes were taken into consideration for analysis: reversible changes (mucus impaction, consolidation and lobar collapse) and irreversible changes (bronchial wall thickening, bronchiectasis, and emphysema). In this study, patients with past history of smoking, old tuberculosis, and chronic obstructive airways diseases were excluded.

Statistical analysis

The Statistical Package for Social Sciences (SPSS, version 18) was used for data entry and analysis with appropriate statistical tests. P value of less than 0.05 was considered statistically significant.

Results:

From 80 patients included in this study, 32 (40%) patients were male and 48 (60%) were female. The mean age of the patients and standard deviation were (36.1±11.7) years and a mean duration

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of disease was (16.35±10.61) years. According to GINA classification 52 (65%) of these patients had non-severe (mild or moderate), and 28 (35%) patients had severe persistent asthma. Radiological changes on HRCT scan were found in 72.5% of the patients (58 out of 80 patients), these changes were significantly higher in patients with severe persistent asthma in comparison with non-severe persistent asthma (100% versus 57.7%), P values = 0.0001. HRCT scan was normal in 22 (42.3%) patients, all of them with non-severe asthma, as shown in table (2)

Table (2): High resolution computed tomography scan changes according to the severity of persistent asthma

HRCT scan	Patient group		P value
	Severe persistent asthma (n=28)	Non-severe persistent asthma (n=52)	
Abnormal	28 (100%)	30(57.7%)	0.0001
Normal	0 (0%)	22(42.3%)	_

Irreversible changes were more common in patients with severe persistent asthma as compared with non-severe persistent asthma as shown in table (3). Bronchial wall thickening was significantly higher in severe than non-severe persistent asthma (100% versus 38.4%), p =0.0001. The second irreversible radiological finding was bronchiectasis, which was also significantly higher in severe than non-severe persistent asthma (71.4% versus 19%), p=0.0021. Emphysema was found in (57%) of patient with severe persistent asthma, but it wasn't recorded in non-severe persistent asthma.

Table (3): Irreversible high-resolution computed tomography scan changes in relation with severity of asthma

Radiological changes	Number of patients (%)		Total (n=80)	P value
	Severe (n=28)	Non-severe (n=52)		
BWT	28 (100%)	20 (38.4%)	48 (60%)	0.0001
Bronchiectasis	20 (71.4 %)	10 (19%)	30 (37.5%)	0.0021
Emphysema	8 (57%)	0	8 (20%)	_

There were no significant differences in occurrence of reversible changes between severe and non-severe persistent asthma. Reversible changes were found in (42.9%) of patients with severe and (42.3%) of patients with non-severe persistent asthma (p=0.9732). Mucus impaction, consolidation and lobar collapse were found in (14%, 21.4% and 7%) of patients with severe persistent asthma and (11.5%, 23% and 7.7%) of patients with non-severe persistent asthma respectively, as shown in table (4). Some patients had two or more of these reversible and irreversible changes at the same time.

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Table (4): Reversible high-resolution computed tomography scan changes in relation with severity of asthma

HRCT scan Changes	Patients groups		P value
	Severe persistent asthma (n=28)	Non-severe persistent asthma (n=52)	
Mucus impaction	4 (14%)	6 (11.5%)	0.7051
Consolidation	6 (21.4 %)	12 (23%)	0.8708
Lobar collapse	2 (7%)	4 (7.7%)	0.9100
Total	12 (42.9%)	22 (42.3%)	0.9732

As shown in table (5), the radiological changes were significantly higher in patients with long standing disease. Forty-four patients gave history of asthma for 15 years or more, 42 of them (95.4%) had radiological changes on HRCT scan, and 36 patients gave history of asthma for less than 15 years, 16 of them (44.4%) had radiological changes on HRCT scan, P value = 0.0007.

Table (5): Relationship between duration of asthma and high resolution computed tomography scan finding

HRCT changes	Duration of asthma		P value
	≥ 15 years	< 15 years	
Abnormal	42(95.4%)	16 (44.4%)	0.0007
Normal	2 (4.6%)	20 (55.6%)	_
Total	44 (100%)	36 (100%)	

Discussion

In the current study of 80 patients with persistent asthma 52 patients (65%) had non-severe persistent asthma (mild or moderate) and 28 (35%) had severe persistent asthma. Machado et al found that (30%) of patients with persistent asthma had mild, (43%) moderate, and (27%) had severe persistent asthma, (81.8%) of patients with persistent asthma, and (100%) of patients with severe persistent asthma had abnormal HRCT scan [7]. Abnormal HRCT scans in this study was found in (72.5%) of patients. Mousa et al reported that (32.1 %) of the asthmatics had normal and (67.9%)) had abnormal chest HRCT scan [8], and Sumit et al found HRCT abnormalities in (80%) of the patients [9]. On the other hand, Dan et al found HRCT scan abnormalities in (85.4%) of asthmatics [10]. This discrepancy was possibly because of differences in sample size, patient population, scanning technique. In our study bronchial wall thickening (BWT) was detected in (100%) of patients with severe persistent asthma versus (38%) of patients with non-severe asthma. This finding agree with the results of other studies, where this lesion was the most common irreversible HRCT scan finding, but with different prevalence, Kim et al reported that (81.3%) of patients with asthma had BWT [11], Dan et al reported that bronchial wall thickening was the most common irreversible change in asthmatics (57.7%) [10], this difference in prevalence of BWT is probably because there is no clear definition of BWT on HRCT scan.

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Bronchiectasis which is an important cause of respiratory morbidity was found in (37.5%) of patients with persistent asthma, a similar result was reported by Carolina et al (40%) [6]. And Mousa K et al found bronchiectasis in (28.6%) of the patients [8], but this percentage was lower than that obtained by other studies; Dan et al found bronchiectasis in (51.2%) [10], and Kim et alin (44%) of asthmatic patients [11]. This disagreement was probably because the risk of bronchiectasis increase with severity and duration of asthma, in our study 18 patients had history of asthma for less than 15 years and 10 patients of them had non-severe asthma and gave history of asthma for only 4 – 6 years, and all of them had normal HRCT scan. The least frequent irreversible lesion was emphysema; which was detected in (20%) of the patients. Dan et al reported emphysematous changes in (22%) of the patients [10], and Ki Young et al in (12%) of patients with asthma [12], Yilmaz et al reported that (21.6%) of patients with late onset asthma developed emphysema [13], while Sumit et al found emphysema in (8%) of severe asthmatics [9]. These differences in the prevalence of emphysema in asthmatic patients are due to variation in severity and duration of asthma. In this study irreversible HRCT scan changes were more frequent in severe asthmatics and in patients with longer duration of disease. The same results were reported by previous studies [10]. Lee Y et al found that the parenchyma and airway structural changes can occur early in the disease and become irreversible during the long course of the disease [14]. Other studies reported clinical correlations between the severity of asthma, sub epithelial fibrosis and increased airway wall thickness [15-17]. Sumit et al reported that HRCT scan abnormalities are common in patients with severe and long standing asthma [9]. Other studies found that severe asthmatics have relatively higher rates of bronchiectasis and bronchial wall thickening, and these findings have been associated with longer disease duration [4, 6]. Reversible HRCT scan changes were not common in our study, because all the patients were on intensive treatment for their asthmatic attacks. Treatment especially steroids reduce inflammation, mucus and tensin secretion which are responsible for mucoid impaction, lobar collapse and subsequent infection.

Conclusions and Recommendations

In patients with persistent asthma, the irreversible HRCT scan changes were more common in severe than non-severe persistent asthma, and these changes correlate directly with the duration of asthma, so HRCT scan is recommended for all patients with persistent asthma for early detection of these changes for proper therapeutic approach.

Conflict of interest: none of the authors have any conflict of interest relevant to this research subject.

Ethical clearance

The present study was approved by the Ethics Committee of Kufa University, college of medicine No.3 15/2/2018, and the research followed the tenets of the Declaration of Helsinki. The patients were free to refuse the study.

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