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Research Article

The importance of volumetric CT assessment of lung emphysema in COPD patients

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Abstract

Background: Volumetric CT is preferable to pulmonary function tests for evaluating the distribution and types of emphysema in COPD patients because it is more accurate and can be performed during an acute exacerbation of COPD as well as in some cases where pulmonary function tests are contraindicated (if there are large emphysematous bullae the patient can develop pneumothorax). COPD is a major cause of death. Due to the fact that not all patients with airway symptoms seek medical care, the number of individuals affected by the disease is frequently underreported. COPD requires increased focus on early diagnosis. **Methods**: This study was conducted in Minia university hospital- Radiology department during the period from May 2021 to March 2022. On 30 Patients known with COPD collected from the outpatient chest clinic. **Results**: patient's emphysematous changes on volumetric CT on the studied group in both lungs ranged between 5.6 – 48.0 % with mean value of 20.73±12.179 %. No statistically significant differences were found between current and ex-smoker and between pulmonary function test and volumetric CT findings. **Conclusion**: The findings of the present study indicate that in the diagnosis and follow-up of COPD patients with emphysema, volumetric CT assessment of lung emphysema plays a critical complementary role with spirometry.

Keywords: COPD, emphysema, pulmonary function tests, CT

Introduction

Chronic obstructive pulmonary disease (COPD) is characterized by the presence of airflow limitation that is caused by a combination of small airway remodeling and emphysema-induced loss of elastic recoil. It is defined by the Global Initiative for Chronic Obstructive Lung Disease as "a disease state characterized by airflow limitation that is not fully reversible". [1]

Pulmonary emphysema is defined as a lung disease characterized by "abnormal enlargement of the air spaces distal to the terminal nonrespiratory bronchiole, accompanied by destructive changes of the alveolar walls". These lung parenchymal changes are pathognomonic for emphysema. [2]

Generally, the diagnosis of emphysema is based on indirect methods, such as clinical examination, pulmonary function tests, and subjective visual evaluation of computed tomography (CT) scans. Many studies have assessed the use of CT in the quantitative analysis of those structural abnormalities in COPD. [3]

On volumetric CT, emphysematous lung destruction results in replacement of normal lung (which has a typical attenuation about -850 HU on inspiratory CT) by air-containing spaces, with CT attenuation

close to -1000 HU. From the early days of CT, it was apparent that measurement of CT attenuation values could help quantify the extent of emphysema. [4]

Assessment of pulmonary function is essential for the diagnosis and characterization of COPD. In general, spirometry is the method most used to detect airway obstruction; it is a relatively simple, repeatable, noninvasive, and inexpensive technique that allows a global assessment of functional changes. The primary parameters of diagnostic assessment at spirometry are forced expiratory volume in the 1st second (FEV1) and forced vital capacity (FVC). Reductions in FEV1, FVC, and the ratio of FEV1 to FVC (hereafter, FEV1/FVC ratio) are hallmarks of airway obstruction. The criterion for a diagnosis of COPD is an FEV1/FVC ratio of less than 70%. In addition to these parameters, measurement of the diffusing capacity of the lung for carbon monoxide allows the detection of emphysema in patients with airflow obstruction. However, spirometry does not provide regional information about the distribution of emphysema.[1,3]

In contrast, CT allows a regional assessment of each lung compartment, including the airways, parenchyma, and vasculature. In addition, CT is more sensitive than spirometry for detecting extent of emphysema. Yet, it is subjective tool. Therefore, emphysema quantification on CT scans may be an important complimentary tool for the diagnosis and staging of COPD as an objective tool.[5]

Computed tomography (CT) allows visualization of pathologic changes in the lung parenchyma and classification of patients into different phenotypes according to the presence of bronchitis or emphysema. CT analysis of lung attenuation is commonly used to quantify the extent of emphysema in the lungs by computing the emphysema score. [6]

There are currently two computerized methods for identifying emphysema.:

The first approach finds areas of low attenuation (a sign of emphysema) based on a single density index threshold or a range of density index thresholds. The second method computes the average lung density as an emphysema defining parameter.
These studies have reported good correlation with some pulmonary function tests.[6]

Aim of the work

The aim of this work is evaluation of the role of volumetric CT examination in patients with COPD.

Patients and Methods

Study type and region:

This study was conducted in Minia university hospital- Radiology department during the period from May 2021 to March 2022.

Study population:

This study was conducted on 30 Patients known with COPD collected from the outpatient chest clinic of Minia university hospital.

Inclusion criteria:

All patients with known COPD.

Exclusion criteria:

1- Patients with previous pulmonary surgical interference.
2- Patients with history of pulmonary TB.
3- Patients with history of lung abscess.
4- Patients with known IPF.

Methods

Initial assessment:

Full history taking, including: age, gender, history of dyspnea, cough, wheeze and chest pain, pre-existing respiratory disease (e.g., asthma, TB) and family history of respiratory disease (e.g., cystic fibrosis, alpha-1 antitrypsin deficiency, TB)

Investigations:

A- Imaging studies:

CT protocol:

The patient lied supine.
The CT systems used in this study included: MDCT, Phillips brilliance 16 slice scanner, GE bright Speed 16 slice scanner & GE VCT 128 slice.
Conventional examination:

FOV=350mm.
Slice thickness=5mm.
120 KV and 30 mA.

Post processing:

Using Philips intel space portal version 9
There is dedicated automated volumetric lung assessment with calculation of each lung separately as well as air-ways.
By using lung attenuation density, cut-off value of -950 HU areas of low density, FEV1/FVC ratio.
below this value were considered emphysematous changes.
Tables of results output was created include the volume of each

B-Pulmonary function tests:

Forced vital capacity (FVC).
Forced expiratory volume in the first one second (FEV1).

Sample result of calculations:

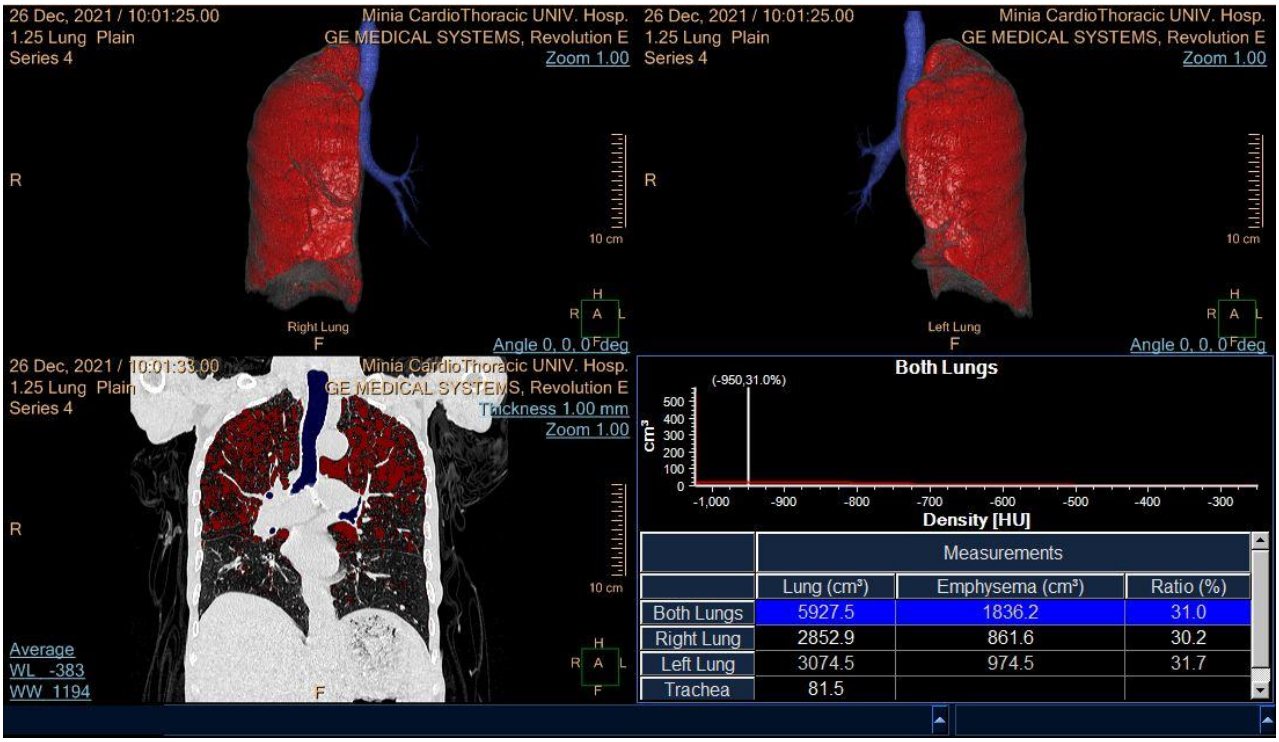

Figure (1) the case is for male patient 70 years old, ex smoker for 10 years, volumetric CT shows emphysematous changes on both lung fields about 31%, more affecting both upper lung lobes.

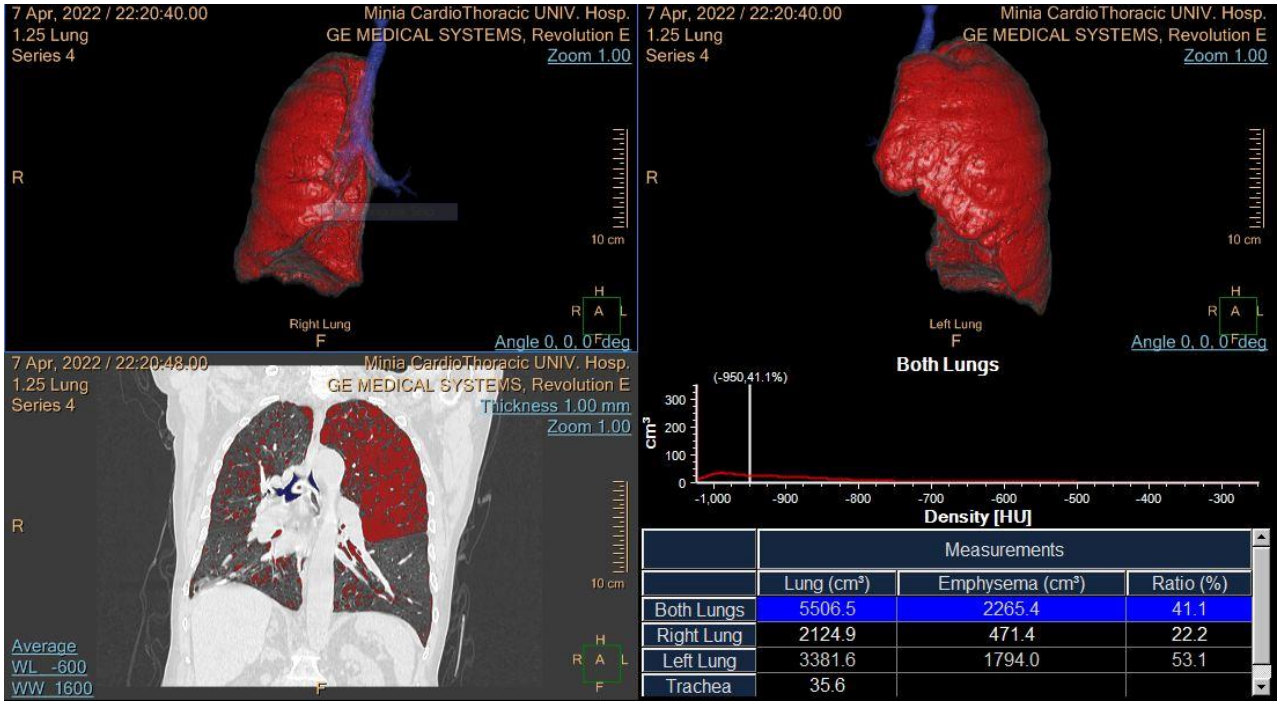

Figure (2) the case is for male patient 50 years old, current smoker, volumetric CT shows emphysematous changes on both lung fields about 41%, it affects more the left upper lung lobe.

Ethical consideration:
Approval of Ethics committee of Faculty of Medicine was obtained. Informed consent was obtained from each participant of the study.

Statistical analysis
Statistical package of social science (SPSS V.20) was used to analyze the data. Chi-square test: For categorical variables, to compare between separate groups. Student t-test: For normally quantitative variables, to compare between two studied groups two studied groups. P value is considered significance at cut of value < 0.05.

Results
Table (1) shows patient's Emphysematous changes on volumetric CT of the studied.

Mann-Whitney test: For abnormally quantitative variables, to compare between group. Right lung ranged between 7.0 – 50.0 % with mean value 20.97±12.316 %. Left lung ranged between 7.3 – 60.0 % with mean value 20.48±14.454 %. Both lungs ranged between 5.6 – 48.0 % with mean value 20.73±12.179 %.

There are no statistically significant differences between current smoker and ex-smoker regarding pulmonary function tests (table 2). As shown in table (3) shows Relation between smoking status and Emphysematous changes on volumetric CT and it shows no statistically significant differences between current smoker and ex-smoker.

Table (1): Distribution of studied sample according to patient's Emphysematous changes on volumetric CT.

Emphysematous changes on volumetric CT (%)	Range	Mean ±S.D.
Right Lung	7.0 – 50.0%	20.97±12.316
Left Lung	7.3 – 60.0%	20.48±14.454
Both Lung	5.6 – 48.0%	20.73±12.179

Table (2): Relation between smoking status and pulmonary function tests.

	Current Smoker	Ex-smoker	t	P value
FVC				
Range	70-99	67-100	0.983	0.334
Mean ±S.D.	84.17±7.685	87.17±8.501		
FEV1				
Range	30-71	26-73	0.926	0.362
Means	51.33±11.032	55.72±13.693		
FEV1/FVC				
Range	43-72	39-74	0.758	0.455
Mean± S.D.	60.42±7.868	63.11±10.487		

Table (3): Relation between smoking status and Emphysematous changes on volumetric CT.

	Current Smoker	Ex-smoker	U	P value
Right lung				
Range	7.3-55.9	8.2-60.0	73.00	0.138
Mean± S.D.	25.03±15.889	17.46±12.991		
Left lung	6.9-48.0		83.00	0.290
Range	24.13±13.632	5.6-39.9		
Mean± S.D.		18.46±10.915		
Both lungs			72.00	0.127
Range	7.0-49.8	8.0-50.0		
Mean ±S.D.	25.33±13.379	18.07±10.985		

Discussion

COPD is a preventable and treatable disorder that is characterized by persistent respiratory symptoms and airflow limitation that is due to lower airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles and/or gases. Besides these risk exposures, host factors (genetic factors, altered childhood lung growth, and accelerated premature aging) predispose individuals to develop COPD. The most common respiratory symptoms include breath-lessness and chronic cough with or without sputum production. [7]

Emphysema is visible on computed tomography (CT) scans as areas of low attenuation (LAA). However, to enable the detection of lesions smaller than 5 mm, thin slice reconstructions, such as high-resolution computed tomography (HRCT) scans, are preferred.[8]

The present study was conducted to evaluate the role of volumetric CT changes in COPD patients. This study comprised thirty patients with known COPD collected from the outpatient clinic of the Minia university hospital and multi centers.

Regarding COPD patient's pulmonary function tests in the current study, mean FVC value was 85.97±8.185% (67 – 100 %), mean FEV1 value was 53.97±12.683% (26 – 73%) and mean FEV1/FVC value 62.03±9.474% (39 – 74%). Our result agreed with Gomes et al., study [9] which reported -hat COPD patients also showed a reduced FEV1 of 51.3 ± 23%. However, mean FEV1/FVC value of COPD in El-behairy et al., study [10] was slightly lower than in our study (59.5±5.1 %).

Our result was comparable to Bodduluri et al., study[11] which showed that COPD patient's pulmonary function tests reported that FEV1 was 53.2± 22.0% and FVC was 80.0± 21.3%.

Among COPD patients in the present study, emphysematous changes on volumetric CT were reported in 20.97±12.316% (7.0 – 50.0%) of the right lung, 20.48±14.454% (7.3–60.0%) of the left lung and 20.73±12.179% (5.6–48.0%) of both lungs.

Our result was comparable to Loh et al., study[12] which examined COPD-associated mortality using a novel approach of phenotyping COPD based on computed tomography (CT)-emphysema index from quantitative CT (QCT) and post-bronchodilator (BD) forced expiratory volume in 1 second (FEV_1) in a local Malaysian cohort. CT-emphysema index (LAA%) of COPD patients was 19.7±14.39.

However, our emphysematous changes result was higher than reported in Bodduluri et al., study[11] which showed that CT emphysema was 12.4±12.1 %. Similarly, the percent emphysema lung (Emph%) was 8.5±7.5 among COPD patients in Ho et al., study [13]

Conclusion

The findings of the present study indicate that in the diagnosis and follow-up of COPD patients with emphysema, the volumetric CT assessment of lung emphysema in these patients plays a critical complementary role with spirometry.

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