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The Evidence of Hyperinflation on Chest X Ray and its Correlation with Air Flow Obstruction in COPD Patients

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ABSTRACT

Introduction: According to the latest statistical and epidemiological studies, chronic obstructive pulmonary disease (COPD) will become the fourth leading cause of death in 2030 worldwide. Scientists are studying on methods to diagnose COPD in the patients in early stages, because it is a curable and preventable disease in early stages. In this study, evidences of hyperinflation on chest X- ray (CXR) of COPD patients were compared with pulmonary function test (PFT) finding.

Materials and Methods: This cross-sectional study was done on 100 patients who were referred to the pulmonary clinic with symptoms of chronic cough and dyspnea. After taking history and performing physical examination, demographic information, history of smoking and bakery and frequency of exacerbations were recorded. Standard spirometry was performed and the severity of COPD was determined by GOLD (Global initiative for chronic Obstructive Lung Disease) staging. Additionally, they underwent CXR examination (PA and lateral). Collected data were analyzed in SPSS ver. 18.

Results: In this study, there were 79 male and 21 female**.** The patients, 64% of whom were urban and 36% were rural dwellers. There was significant correlation between forced expiratory flow (FEF) 50% predict with sterno-diaphragmatic angle and retro-sternal lucency (p=0.01, r=-0.26 and p=0.01, r=-0.25 respectively). Also there were significant correlations between the forced expiratory volume/forced vital capacity (FEV1/FVC) with retro-sternal lucency (p=0.006, r=-0.27) and FEV1%predict with sterno-diaphragmatic angle (p=0.002, r=-0.31).

Conclusion: The study showed some evidences of lung hyperinflation on CXR which significantly associated with PFT parameters. Sterno-diaphragmatic angle and retro-sternal lucency can be used to predict the severity of airway obstruction in patients with COPD, although the CXR finding cannot be substituted for PFT and CT data.

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive disease with airflow limitation associated with abnormal inflammatory response of the lungs in response to different types of particles and gases. It is one of the major causes of morbidity and mortality worldwide (1, 2). Among COPD patients, smoking is considered as a major risk factor

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associated with reduced lung function (3). COPD is associated with smoking in 90% of cases (4). COPD also occurs in 10-20% of smokers or ex-smokers (5).

Airways obstruction during exhalation progressively traps air and causes hyperinflation at rest and dynamic hyperinflation during activity. Hyperinflation, reduces inspiratory capacity and causes reduced functional residual capacity. These features can cause shortness of breath and reduced exercise capacity in COPD. Airflow obstruction in COPD is best measured by spirometry an early diagnostic instrument (6).

Airways obstruction is an essential diagnostic criterion in COPD which is diagnosed by Spirometry. CT scan shows more details of the lung parenchyma in areas affected by emphysema (7). Chest X-ray (CXR) has a benefit in COPD patients and it should be performed to rule out other causes (8). Characteristics of COPD in CXR are hyperinflation of the lungs with flattened diaphragm, the hyperleucent lungs, enlargement of the pulmonary arteries, bula, and areas of damaged pulmonary tissue that makes up the large air sacs (9). Although CXR is an insensitive and nonspecific procedure to diagnose COPD (10) and it is not a substitute for spirometry, but it is inexpensiveness, accessibile and it can benefit physicians in evaluating patients with COPD.

In a study by Miniati M *et al*, CXR scores on indices of airflow obstruction and hyperinflation were comparable with those obtained using quantitative and qualitative data of HRCT (11). A study by Ravindran C, and colleagues has concluded that the CXR can identify pulmonary artery hypertension in patients with COPD. This study also reported a positive relationship between the diameter of the pulmonary artery and the hilar-thoracic ratio and other findings, such as smoking rates, symptoms and sign duration, and electrocardiographic (ECG) evidence of Right Ventricular Hypertrophy (RVH). There was also an inverse relationship with Forced Expiratory Volume in one second (FEV1)%predict (12).

Study of the Komatsu S, on diagnostic radiology by CXR, chest CT and MRI is shown that; CXR was not a useful tool to detect early-stage COPD; however in the advanced stages of COPD following signs can be seen: pulmonary hypo-vascularity, increasing radiolucency of the lung, depression and flattening of the diaphragm, and increasing retro-sternal lucency (13).

Another study by Shaker SB, *et al* on imaging findings in COPD especially in advanced disease reported a hyperinflation in the CXR (14). In contrast, other study by Maury G, *et al* found limited role for CXR in diagnosis of lung hyperinflation while pulmonary function test was reported as the gold standard (15).

The purpose of this study was to evaluate patients with COPD with an easy and accessible way, and comparisons the evidence of lung hyperinflation on CXR with pulmonary function test parameters.

Materials and Methods

This study is a cross-sectional study. A total of 100 patients referred to the lung clinic with symptoms of chronic productive cough and dyspnea with obstructive pattern without reversibility in Pulmonary Function Test (PFT) according to the American Thoracic Society were enrolled. The demographic data including age, gender, location, occupation, educational level, smoking history, bakery period, the frequency of hospitalization were asked.

The severity of airway obstruction was determined according to the Global initiative for chronic Obstructive Lung Disease (GOLD) guideline including: mild; FEV1/Forced Vital Capacity (FVC) < 70%, FEV1>80%, moderate; FEV1/FVC < 70%, 50% ≤ FEV1 < 80%, severe; FEV1/FVC < 70%, 30% ≤ FEV1 < 50%, very severe; FEV1/FVC < 70%, FEV1< 30%.

The severity of dyspnea was determined according to the Modified Medical Research Council (MMRC) and graded between 0 and 4 based on the patient's response. The subjects, quality of life was assessed by COPD assessment test (CAT). The CAT score was classified into four groups of impact levels: low (CAT score<10), medium (CAT score 10-20), high(CAT score 21-30) and very high(CAT score 31-40). Hemoglobin saturation by pulse oximetry (SPO2) evaluated in all patients. They underwent CXR examination (PA and lateral). In addition, information of hyperinflation in PA and lateral CXR were included in the questionnaire by pulmonologist.

Evidence of lung hyperinflation on CXR

Standard CXR at full inspiration position was performed in all the patients. The seven parameters were evaluated as follows.

Height of Right Lung: Lung apex along an imaginary line perpendicular to the upper inner to the margin of the right diaphragm in PA chest radiography measured by mm.

Right Pulmonary Diameter: Maximum diameter of descending pulmonary artery in PA chest radiography measured by mm.

Retro-Sternal Lucency: Maximum retro-sternal lucency in Lewis angle in PA chest radiography measured by mm.

Right Diaphragmatic Height: Distance between an imaginary line connecting internal and external sides and peak of right diaphragm measured in mm. in the PA chest radiography.

Sterno-Diaphragmatic Angle: The angle between the sternum bone and right diaphragm in lateral chest radiography.

Cardio-Thoracic Ratio: The ratio of maximum length of heart to maximum thoracic length in PA chest radiography.

Mediastinal-Thorax Ratio: The maximum length of the mediastinum in lower edge of the aortic arch to the maximum thorax length on an imaginary line in PA chest radiography.

Statistical analysis of the data

The data were analyzed using SPSS version 18. Descriptive and analytical methods for data classification, and the average frequency of use of descriptive statistics in the form of diagrams and tables were set up. To examine the differences between groups, ANOVA and Independent-Samples T Test and Parametric (Pearson) was used to determine the correlation between variables. Less than 0.05 was considered significant in all tests. Written consent was obtained from all the patients in admission. This study was approved by the Ethics Committee of the Ardabil University of Medical Sciences.

Results

The study included 100 patients referred to the pulmonary clinic with symptoms of dyspnea and chronic productive cough in years 2012-2013. The mean age of the patients was 65.16±11.27 years of whom 79% male and 21% female. The majority of the patients, 64% were urban dweller. Eighty-one percent of the patients had a history of smoking and 19% bakery workers. Average CAT score was 24.78±6.45, and 50% of the patients were in the severe group. Eighty-one percent of patients did not mention history of exacerbation during the last year. The mean SPO2 was 92.4±64.41. Demographic and Paraclinical findings of the patients are listed in Table 1.

A weak inverse relationship between Forced Expiratory Flow (FEF) 50% with retro-sternal lucency and sterno-diaphragmatic was angle observed (r = -0.25, *P* = 0.01, and r = -0.26, *P* = 0.01 respectively). A weak but direct statistical relationship was also observed between the height of the right diaphragm with FEF 50% (r = +0.22, *P* = 0.02)

A weak and inverse association was observed between FEV1% predict and sterno-diaphragmatic angel (r = -0.31, *P* = 0.002). In addition, a weak statistical relationship was found between retro-sternal lucency and FVC/FEV1 (r = -0.27, *P* = 0.006). The results of the CXR evidence and its relationship with PFT findings are listed in Table 2.

Table1. Demographic characteristics and Para clinical results.

	Subjects (Number)	Mean±SD
Age(years)	100	65.16±11.27
Sex(M/F)	79/21	
Residency(Urban/Rural)	64/36	
Smoking history (M/F)	81(79/3)	26.71±16.11
Baking History	19(1/18)	4.84±10.81
FEV1/FVC%	100	57.82±10.82
FEV1% predict	100	49.05±16.45
FVC% predict	100	63.79±18.19
FEF50% predict	100	19.82±12.50
MMRC(dyspnea scale)	100	1.72±0.77
SPO2%	100	92.46±4.41
CAT score	100	24.78±6.45
Exacerbation Rate		
No exacerbation	81	
One exacerbation	15	
Two exacerbation	4	

Information about the number of patients according to the GOLD classification, the intensity of dyspnea using MMRC scale and impact of the disease on quality of life assessed by CAT tests are listed in Table 3.

The results of CXR of patients are listed in Table 4. And the relationship between the results of the CXR with MMRC, GOLD, CAT is listed in Table 5.

Table 2. Correlation between evidences of CXR hyperinflation and PFT parameters

Air Trapping Evidence on CXR	FEV1/FVC		FEV1%predict		FEF50%predict	
	P Value	Correlation	P Value	Correlation	P Value	Correlation
Height of Right Lung	0.23	-0.12	0.10	-0.17	0.08	-0.17
Right Pulmonary Diameter	0.45	-0.08	0.11	-0.16	0.41	-0.08
Retro-Sternal Lucency	0.006	-0.27	0.08	-0.18	0.01	-0.25
Right Diaphragmatic Hieght	0.19	+0.13	0.12	+0.16	0.02	+0.22
Sterno-Diaphragmatic Angle	0.08	-0.18	0.002	-0.31	0.01	-0.26
Cardio-Thoracic Ratio %	0.17	+0.14	0.73	-0.03	0.94	+0.007
Mediastinal-Thorax Ratio %	0.55	+0.06	0.15	-0.15	0.26	-0.11

Table 3. Subjects distribution by GOLD, MMRC, CAT.

	Gold Classification	MMRC(dyspnea scale)	CAT Impact Level
Normal	0	1	0
Mild	3	43	3
Moderate	48	40	22
Severe	42	15	50
Very severe	7	1	25

Table 4. CXR findings.

	Subjects(Number)	Mean±SD
Height of Right Lung *	100	270.73±32.85
Right Pulmonary Diameter *	100	13.15±2.79
Retro-Sternal Lucency *	100	66.28±17.83
Right Diaphragmatic Hieght *	100	24.79±6.37
Sterno-Diphragmatic Angle (Degree)	100	64.74±13.79
Cardio-Thoracic Ratio %	100	0.48±0.05
Mediastinal-Thorax Ratio %	100	0.25±0.04

*** Values are presented as millimeter**

Table 5. Association between CXR and parameters of MMRC and CAT Group.

Air Trapping Evidence on CXR	MMRC	Impact Level (CAT)	GOLD Classification
	P Value	P Value	P Value
Height of Right Lung	0.53	0.71	0.06
Right Pulmonary Diameter	0.14	0.84	0.27
Retro-Sternal Lucency	0.34	0.55	0.75
Right Diaphragmatic Hieght	0.75	0.88	0.58
Sterno-Diaphragmatic Angle	0.65	0.11	0.01
Cardio-Thoracic Ratio %	0.45	0.67	0.10
Mediastinal-Thorax Ratio %	0.19	0.29	0.16

These findings did not support the correlation between the CXR parameters and intensity in dyspnea and patients' quality of life, however our findings confirm previous findings on the association between severity of the disease according to The GOLD classification and sterno-diaphragmatic angle ($p = 0.01$).

Statistical correlation was observed between the SPO2 with right descending pulmonary artery diameter and sterno-diaphragmatic angle ($r = -0.21$, $P = 0.03$, and $r = -0.22$, $P = 0.02$ respectively) (Table 6).

Table 6. Association between SPO2 and CXR.

Air Trapping Evidence on CXR	SPO2	
	P Value	Correlation
Height of Right Lung	0.01	-0.24
Right Pulmonary Diameter	0.03	-0.21
Retro-Sternal Lucency	0.15	-0.14
Right Diaphragmatic Hieght	0.19	-0.13
Sterno-Diaphragmatic Angle	0.02	-0.22
Cardio-Thoracic Ratio %	0.66	+0.04
Mediastinal-Thorax Ratio %	0.91	+0.01

Discussion

This study shows a weak correlation between FEV1 and sterno-diaphragmatic angle (Figure 1). There is also a weak correlation between FEV1/FVC and retro-sternal lucency. A statistical association was shown between FEF 50% with retro-sternal lucency and right diaphragmatic height.

COPD patients have air trapping in chest. Diaphragm widening is the most important measure of air trapping and it may be seen as increasing sterno-diaphragmatic angle and retro-sternal lucency in CXR. Komatsu S, did not also find CXR as accurate diagnostic method to evaluate early-stage COPD, but CXR shows an increased retro-sternal lucency and diaphragmatic widening in the advanced stages of the disease (13). An association was also reported between the height of the diaphragm in CXR and FEV1 by Petrukhin (16). In the present study retro-sternal lucency had a significant inverse correlation with FEV1/FVC which is in accordance with reported findings of Siafakas N, (17).

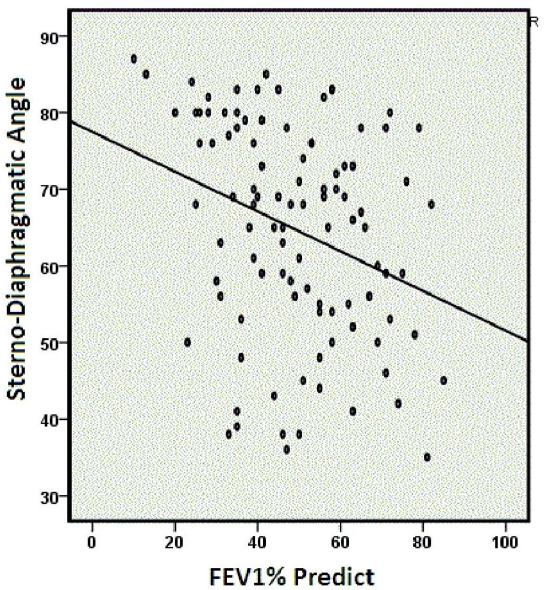

Figure 1. Correlation between FEV1 with sterno-diaphragmatic angle.

Although low sensitivity and specificity are the limitations of CXR (especially in mild emphysema), availability is the main benefit of this method in the evaluation of lung disease (18). Most authors recommend to perform CXR in patients with suspected pulmonary disease should be performed. CXR is often the first imaging assessment of lung diseases including COPD to rule out other causes in patients with cough and dyspnea. CXR is also used to diagnose those factors flaring up COPD (19).

Imaging has limited value in the evaluation of patients with COPD (15) and CT scan findings in the evaluation of asymptomatic smokers are better than CXR (8), in fact the results of CXR findings was comparable with lung CT scan in a study (11). The availability of CXR made it as the first diagnostic method in the evaluation of emphysema. The relationship between PFT parameters and severity of airflow obstruction and radiographic findings of CXR for pulmonary physicians is of great importance. The majority of studies have shown that in the advanced stage of disease, CXR is useful for evaluating hyperinflation (10, 14) therefore can be used in the assessment of lung hyperinflation.

The CXR is also used to assess the magnitude of cardiomegaly secondary to pulmonary disease and pulmonary artery hypertension (12). In this study the correlation between the magnitudes of cardiomegaly (Corpulmonal), the diameter of the right descending pulmonary artery (as an index of pulmonary hypertension) with the severity of airway obstruction and values of FEV1 was checked and found no significant relationship, although a weak statistical association was observed between SPO2 and the right descending pulmonary artery diameter. (Figure 2) ($r = -0.21$, $P = 0.03$).

An association was reported between the size of descending pulmonary artery and hillar-thorax ratio (C-Ravindran *et al*). There was also observed an association between the pulmonary artery diameter and smoking status, duration of symptoms and evidence of RVH in ECG (12). In our study, an association was not observed between the pulmonary artery and hilar-thorax ratio. This result was found because high number of the samples were in mild or moderate stages (based on the GOLD classification). Although this finding is indicative of the fact that other factors including alveolar hypoxia, systemic inflammation, abnormal pulmonary vascular beds and endothelial cell dysfunction play a role in the occurrence of pulmonary hypertension and cor-pulmonale instead of airflow obstruction.

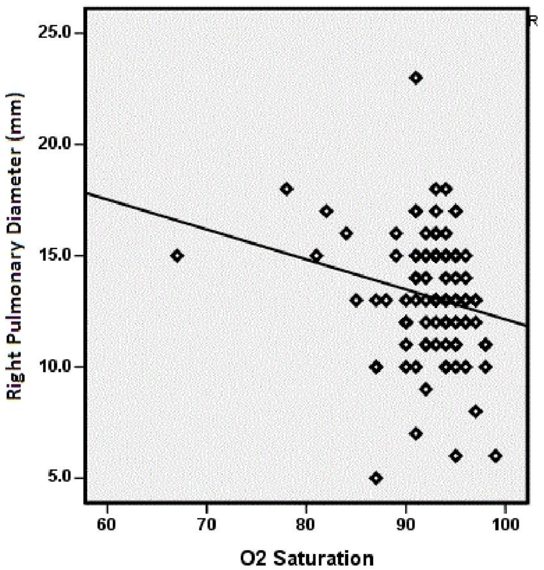

Figure 2. Correlation between SPO2 with right descending pulmonary diameter.

In the present study, there was significant association between smoking status and evidence of hyperinflation on CXR (i.e. correlated with right lung height, sterno-diaphragmatic angle and retro-sternal lucency, and an inverse association with hilar-thoracic ratio). This indicates the effect of smoking as an independent risk factor for the disease and the severity of airway obstruction.

Our findings did not support result of a study by Watz H, *et al*, in which an inverse association was found between Cardio-thoracic ratio and GOLD Stage (20). In our study there was a significant association between the GOLD Stage and sterno-diaphragmatic angle. The current finding may also indicate association of diaphragatic widening in COPD patients by severity of airway obstruction.

Bellemare J-F. reported an association between diaphragmatic height and the age of COPD patients, but our findings did not support their findings. Diaphragmatic height which indicates pulmonary hyperinflation increases by age and it occurs mostly in ages above 65 years old. However, in our study, probably due to the lower age of the patients, the height of diaphragm is not significantly associated with age. In present study, age only was associated with cardio-thoracic ratio. There was not any other association between age and other evidence of CXR hyperinflation (21). This shows that the severity of disease is not related only to the age of the patient and smoking is the main risk factor of the disease.

Our study had some limitations. The first limitation was the relatively small sample size, that may be altered the study finding. Secondly, some subjects had not full inspiration in CXR which alter the results, although researchers tried to minimize the effect of confounding by patients learning.

Conclusion

This study showed some evidences of lung hyperinflation on CXR are significantly associated with PFT parameters. In patients with COPD, some parameters in CXR (sterno-diaphragmatic angel and retro-sternal lucency) can be used to predict the severity of airway obstruction. Although CXR is not the optimal technique for the diagnosis, it can be utilized in the assessment of COPD severity and to rule out other causes in patients with pulmonary symptoms (dyspnea, cough, and sputum).

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Conflict of interests

None of the authors have a conflict of interest to declare in relation to this work.

References

1. Mannino DM, Kiri VA. Changing the burden of COPD mortality. Int J COPD. 2006;1:219-33.
2. Kim V, Criner GJ. Chronic Bronchitis and Chronic Obstructive Pulmonary Disease Am J Respir Crit Care Med 2013;187:228-37.
3. Ramsey SD, Hobbs FDR. Chronic obstructive pulmonary disease, risk factors, and outcome trials: comparisons with cardiovascular disease. Proc Am Thorac Soc 2006; 3:635-40.
4. Kałucka S. The occurrence of chronic obstructive pulmonary disease (COPD) in cigarette smoking families. Przegl Lek 2006;63:848-57.
5. Lam DC, Hui CK, Ip MS. Issues in pulmonary function testing for the screening and diagnosis of chronic obstructive pulmonary disease. Curr Opin Pulm Med 2012; 18: 104-11.
6. MacNee W. ABC of chronic obstructive pulmonary disease: pathology, pathogenesis and pathophysiology. BMJ 2006; 332: 1202-4.
7. de Torres JP, Bastarrika G, Wisnivesky JP, Alcaide AB, Campo A, Seijo LM, *et al* Assessing the relationship between lung cancer risk and emphysema detected on low-dose CT of the chest. Chest 2007;132:1932-8.
8. Aydın Ö, Dursun AB, Kurt B, Aloğlu V, Alpar S, Uçar N, et al. Correlation of Functional and Radiological Findings of Lung in Asymptomatic Smokers. TRJ 2008;9: 15-9.
9. Wallace G, Winter J, Winter J, Taylor A, Taylor T, Cameron R. Chest X-rays in COPD screening: Are they worthwhile? Respir Med 2009;103:1862-5.
10. Muller N, Coxson H. Chronic obstructive pulmonary disease : Imaging the lungs in patients with chronic obstructive pulmonary disease. Thorax 2002;57:982-5.
11. Miniati M, Filippi E, Falaschi F, Carrozzi L, Milne E, Sostman HD, et al. Radiologic evaluation of emphysema in patients with chronic obstructive pulmonary disease. Chest radiography versus high resolution computed tomography. Am J Respir Crit Care Med 1995;151:1359-67.
12. Ravindran C, Padmanabhan K, Sreedhar R. A study of correlation between transhilar diameter and P pulmonale in COPD patients. Lung India 2008;25:145-7.
13. Komatsu S. Radiological diagnosis--diagnosis and evaluation by chest X ray, chest CT and chest MRI. Nihon Rinsho 2007;65:670-4.
14. Shaker SB, Dirksen A, Bach KS, Mortensen J. Imaging in chronic obstructive pulmonary disease. COPD 2007;4:143-61.
15. Maury G, Marchand E. Thoracic hyperinflation and COPD. Beyond respiratory mechanics and dyspnea. Rev Mal Respir 2009;26:153-65.
16. Petrukhin IS, Sorokin IK, Nechaev VI. The x-ray functional characteristics of chronic bronchitis. Probl Tuberk 1993;6:22-5.
17. Siafakas N, Vermeire P, Pride Na, Paoletti P, Gibson J, Howard P, et al. Optimal assessment and management of chronic obstructive pulmonary disease (COPD). Eur Respir J 1995;8:1398-420.
18. Washko, G R. Diagnostic Imaging in COPD. Semin Respir Crit Care Med 2010; 31: 276-85.
19. Cardinale L, Volpicelli G, Lamorte A, Martino J, Veltri A. Revisiting signs, strengths and weaknesses of Standard Chest Radiography in patients of Acute Dyspnea in the Emergency Department. J Thorac Dis 2012;4:398-407.
20. Watz H, Waschki B, Meyer T, Kretschmar G, Kirsten A, Claussen M, et al. Decreasing Cardiac Chamber Sizes and Associated Heart Dysfunction in COPD, Role of Hyperinflation. Chest 2010;138:32-8.
21. Bellemare J-F, Cordeau M-P, Leblanc P, Bellemare F. Thoracic dimensions at maximum lung inflation in normal subjects and in patients with obstructive and restrictive lung diseases. Chest 2001;119:376-86.