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The findings on initial admission Chest CT scan of patients presenting with an Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD)

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disease that is irreversible and characterized by persistent airway obstruction and lung inflammation. Recently due to the advancements in imaging techniques we can have a better analysis of the lung parenchyma, airways, vascular and extrapulmonary manifestations of COPD.

Objectives: The primary objective of this study is to assess and classify abnormalities observed on chest CT scans in patients admitted with AECOPD. The aim of the study is to identify parenchymal, airway, and extrapulmonary abnormalities, and to assess their association with the severity of the disease and frequency of exacerbations.

Material and Methods: A retrospective analysis was conducted in Sulaimani city on 72 patients (54 male and 18 female), a mean age of 72.5 (56-104 years old), presented with AECOPD (GOLD group E) who underwent CT imaging at hospital admission. The CT scans were reviewed by a radiologist, and findings were categorized.

Results: Parenchymal abnormalities were the most common (94.4%), including emphysema (81.7%), bullae (40.8%), ground-glass opacity (33.8%). Airway abnormalities (56.9%) such as bronchial wall thickening (40.8%) and bronchiectasis (21.1%) were frequently observed. Extrapulmonary abnormalities (50%) included coronary artery calcifications (38%) and cardiomegaly (25.4%). There was a significant association between the frequency of exacerbations with severity of emphysema and older age (p-value 0.001 and < 0.001 respectively).

Conclusion: Parenchymal abnormalities were the most common findings, including emphysema as the most frequent abnormality. Half of patients had extrapulmonary abnormalities including cardiovascular abnormalities in a significant number of patients. These CT abnormalities had associations with clinical factors such as frequency of exacerbations and age of the patient..

Keywords: AECOPD, COPD, Chest CT scan, Cardiovascular abnormalities, Emphysema, Pulmonary abnormalities

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disease that is irreversible and characterized by persistent airway obstruction, chronic inflammation, and tissue damage in the airways and lung parenchyma.[1] It is one of the leading cause of morbidity and mortality worldwide, affecting over 300 million people globally.[2] The main risk factors for developing COPD include prolonged exposure to harmful particles or gases, such as tobacco smoke, biomass fuel, and occupational pollutants.[3]

Exacerbation of COPD is an acute worsening of respiratory symptoms associated with some degree of physiological deterioration.[4] Global Initiative for Chronic Obstructive Lung Disease (GOLD) define an exacerbation as an event in the natural course of the disease, characterized by a change in the patient's baseline dyspnea, cough, and/or sputum that is beyond normal day-to-day variations, that is acute in onset, and may lead to a change in regular medication use in a patient with underlying COPD.[5] Acute exacerbations of COPD (AECOPD) are associated with accelerated lung function decline, increased hospital admissions, and a higher risk of mortality.[3] The frequency and severity of AECOPD are strong predictors of disease progression, with patients experiencing frequent exacerbations are at higher risk of poorer outcomes.[6]

For many years, spirometry was used to confirm the diagnosis of COPD, but recently due to the advancements in the imaging techniques we can have a better analysis of the lung parenchyma, airways, vascular and extrapulmonary manifestations of COPD.[7] CT imaging has been shown to be an important tool in assessing the severity and extent of emphysema, bronchial wall thickening, and air trapping in COPD patients.[8] In the presence of AECOPD, chest CT scans are mainly useful for identifying complications such as pneumonia, pulmonary embolism, and pleural effusions, which can lead to worsening of symptoms of the patient and affecting clinical management.[9] Furthermore, CT scan imaging allow us to detect cardiovascular abnormalities, such as coronary artery calcifications and cardiomegaly, which are common comorbidities in COPD and can influence patient outcomes.[10]

Despite the growing evidence on the use of CT imaging in COPD, only a few studies have focused on the detailed categorization of imaging findings in patients presenting with AECOPD. Understanding the range of parenchymal, airway, and extrapulmonary abnormalities observed on chest CT scans during acute exacerbations is important for improving risk stratification, guiding treatment decisions, and predicting patient outcomes.[6]

2. MATERIALS AND METHODS

This study is a retrospective observational study that aims to assess and categorize abnormalities observed on chest CT scans in patients admitted with AECOPD. The study aims to identify parenchymal, airway, and extrapulmonary abnormalities, and to assess their association with disease severity and exacerbation frequency. The study was conducted at [Shar Hospital and German Hospital] between [January 2024] and [February 2025].

The study was approved by the Research Ethics Committee of the Kurdistan Higher Council for Medical Specialties (KHCMS) on February 27, 2023. Written informed consent was obtained from all participants prior to their inclusion in the study. Patient data were anonymized according to the ethical and regulatory standards.

Inclusion Criteria: Patients more than 40 years old who are diagnosed with COPD and presented with acute exacerbation (GOLD group E) and underwent chest CT scans during admission.

Exclusion Criteria: Patients less than 40 years old or those with incomplete clinical records, pre-existing conditions that significantly alter chest CT findings (e.g, interstitial lung diseases, lung cancer)

Data were collected retrospectively from medical records, including demographic information, clinical details, smoking history, and frequency of exacerbations. CT scans were independently reviewed by a radiologist beside a pulmonologist to evaluate the abnormalities. Discrepancies in interpretation were resolved by consensus. Inter-rater agreement was not formally quantified.

CT scans were done by using a 64-slice scanner with a slice thickness of 1.25 mm. Non-contrast CT scans were performed during full inspiration. Emphysema was classified according to visual scoring into mild, moderate, confluent, and advanced, based on distribution and density. Chest CT findings were categorized into three groups:

1. Parenchymal Abnormalities: Emphysema, bullae, ground-glass opacity, consolidation, fibrotic changes, interlobular septal thickening, pulmonary nodules, pulmonary mass, atelectasis, and cavitary lesion.
2. Airway Abnormalities: Bronchial wall thickening, bronchiectasis, centrilobular nodules, tree-in-bud pattern, mucous plugging, and saber-sheath trachea (SST).
3. Extrapulmonary Abnormalities: Coronary artery calcifications, cardiomegaly, pleural effusion, mediastinal lymphadenopathy, increase pulmonary trunk to aorta ratio, and empyema.

Descriptive statistics were used to summarize data. The prevalence of abnormalities was reported as frequencies and percentages. Comparisons were conducted using Chi-square tests for categorical variables, with p-values < 0.05 considered statistically significant. Analyses were performed using IBM SPSS Statistics Version 25. Fisher's exact test was used when expected cell counts were low (e.g., for empyema and cavitary lesions). No correction was applied for multiple comparisons; findings should be interpreted cautiously. Age was categorized for clinical relevance, but further analysis with continuous age data is suggested in future studies.

3. RESULTS

Among a total of enrolled 72 cases, 54 males (75%) and 18 female (25%), a mean age of 72.5±9, ranging from 56-104 years old, all of them were admitted with AECOPD and underwent chest CT imaging upon hospitalization. All of them had smoking history of more than 20 pack-year and based on GOLD 2023 classification, and all of patients were categorized as Group E (Exacerbation-prone), which means they have experienced ≥2 moderate exacerbations or ≥1 severe exacerbation (hospitalization) in the past year. 25 patients had one exacerbation per year that needed hospitalization and 47 patients had

more than one exacerbation per year.

The chest CT scans were analyzed for structural lung abnormalities, which were classified into three major groups, as shown in Figure (1). Parenchymal abnormalities were found in 94.4 % of patients, airway abnormalities were found in 56.9 % of patients, and extrapulmonary abnormalities were found in 50 % of patients.

Parenchymal changes were highly prevalent in AECOPD patients, with emphysema, bullae, and ground-glass opacity being the most frequently observed findings. Emphysema (Centrilobular subtype) was the most common abnormality, observed in 81.7% of patients. The percent of severity of centrilobular emphysema is shown in Figure (2).

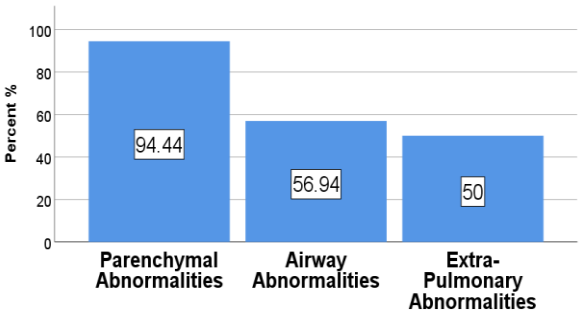

Figure (1) Percent of the group of abnormalities

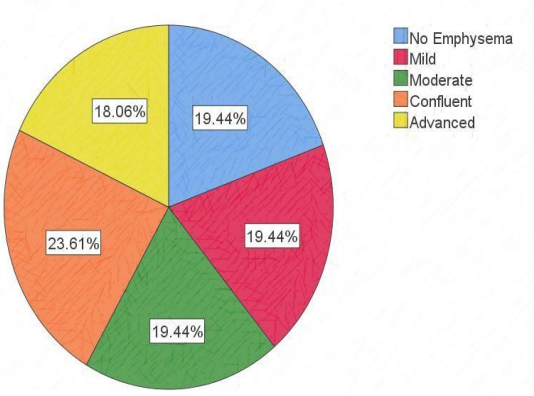

Figure (2) Percent of severity of Centrilobular emphysema

Other subtypes of emphysema including Paraseptal emphysema and Panlobular emphysema were found in 15.3% and 9.7% of patients respectively. There was a significant association between the severity of centrilobular emphysema and frequency of exacerbations with p value < 0.001. Bullae were present in 40.8% of cases that they had significant variation in the size and distribution. Ground-glass opacity (GGO), that suggest acute inflammatory processes, was found in 33.8% of patients. Consolidation, that often indicate presence of infection or worsening inflammatory response, was present in 25.4% of cases. Interlobular septal thickening, which indicate thickening of the connective tissue septa that separate lung lobules was found in 15.5% of cases. Fibrotic changes, which is indicative of chronic scarring of lung tissue, was present in 12.7% of cases. Other less common parenchymal abnormalities including Pulmonary nodules (14.1%), Pulmonary mass (4.2%), Atelectasis (5.6%), and Cavitary lesion (2.8%) were also noted.

Several airway abnormalities were also present, that indicating chronic airway remodeling and inflammation in COPD exacerbations. Bronchial wall thickening was detected in 40.8% of patients, consistent with chronic airway inflammation. Bronchiectasis was present in 21.1%, indicating irreversible bronchial dilation. Centrilobular nodules, suggestive of small airway disease, were seen in 16.9% of patients. Tree-in-bud opacities, associated with bronchiolar inflammation and mucus plugging, were observed in 12.7% of cases. Mucous plugging, leading to airway obstruction, was present in 12.7% of patients. Saber-sheath trachea (SST), that is the description given to a fixed deformity of the intrathoracic trachea characterized by a reduction in the coronal diameter and an increase in sagittal diameter of the intrathoracic trachea. The tracheal index (coronal to sagittal diameter ratio measured 1 cm above the aortic arch) is less than two-thirds. Its strongly associated with severe COPD and was found in 7% of patients.

Extrapulmonary abnormalities were also frequently detected, which indicate the systemic involvement in COPD patients. Coronary artery calcifications were found in 38% of cases, suggesting a high prevalence of cardiovascular disease in these patients. Cardiomegaly, indicative of possible pulmonary hypertension or heart failure, was seen in 25.4% of patients.

Pleural effusion was present in 14.1%, often associated with other cardiovascular abnormalities such as cardiomegaly, with p value 0.002 which indicate a significant correlation between them. Mediastinal lymphadenopathy was present in 11.3%, possibly indicating chronic inflammation or infection. Increase pulmonary trunk to ascending aorta ratio, which is a marker of pulmonary artery hypertension, commonly associated with severe COPD was found in 5.6% of patients.

Empyema, which refers to accumulation of pus within the pleural cavity, was found in 2.8% of patients. Only 2.8% of patients had a normal chest CT scan. All of the CT findings are shown in Table (1), and the association between the severity of centrilobular emphysema, age, gender and some CT findings with the frequency of exacerbations per year are shown in Table (2).

Table (1). Number and percent of CT findings

Chest CT findings	Number of cases	Percent
Emphysema	58	81.7%
Bullae	29	40.8%
Bronchial wall thickening	29	40.8%
Ground glass opacity (GGO)	24	33.8%
Consolidation	18	25.4%
Bronchiectasis	15	21.1%
Interlobular septal thickening	11	15.5%
Saber-sheath trachea (SST)	5	7.0%
Centrilobular nodules	12	16.9%
Tree-in-bud sign	9	12.7%
Fibrotic changes	9	12.7%
Cardiomegaly	18	25.4%
Coronary artery calcifications	27	38.0%
Pleural effusion	10	14.1%
Pulmonary nodules	10	14.1%
Pulmonary mass	3	4.2%
Mucous plugging	9	12.7%
Atelectasis	4	5.6%
Mediastinal lymphadenopathy	8	11.3%
Empyema	2	2.8%
Cavitary lesion	2	2.8%
Increase Pulmonary/Aorta ratio	4	5.6%
Normal	2	2.8%

Table (2). The association between the severity of centrilobular emphysema, age, gender and some CT findings with the frequency of exacerbations per year.

Variable		One exacerbation per year	Two or more exacerbations per year	Total	P-value
Severity of centrilobular emphysema	No Emphysema	13	1	14	< 0.001
	Mild	8	6	14	
	Moderate	4	10	14	
	Confluent	0	17	17	
	Advanced	0	13	13	
Gender	Male	21	33	54	0.25
	Female	4	14	18	
Age (in years)	50-60	3	2	5	< 0.001
	60-70	19	5	24	
	70-80	2	22	24	
	>80	1	18	19	
Cardiomegaly	Yes	3	15	18	0.05
	No	22	32	54	
Coronary artery calcifications	Yes	6	21	27	0.06
	No	19	26	45	
Pleural effusion	Yes	4	6	10	0.4
	No	21	41	62	

Increase pulmonary/aorta ratio	Yes	1	3	4	0.5
	No	24	44	68	
Fibrotic changes	Yes	2	7	9	0.3
	No	23	40	63	
Bronchiectasis	Yes	1	14	15	0.008
	No	24	33	57	
Bronchial wall thickening	Yes	4	25	29	0.002
	No	21	22	43	

4. DISCUSSION

This study analyzed chest CT findings in patients admitted with acute exacerbation of COPD (AECOPD) and categorized them into parenchymal, airway, and extrapulmonary abnormalities. CT imaging plays an important role in the assessment of lung damage and comorbidities in AECOPD. Emphysema and airway abnormalities such as bronchial wall thickening were the main findings in our study and was associated with the severity of the disease and frequency of exacerbations with p value of <0.001 and 0.002 respectively. The high prevalence of emphysema and bullae indicate that alveolar destruction and air trapping have an important role in AECOPD pathophysiology. Emphysema has been linked to; Reduced lung elastic recoil, leading to airflow limitation and hyperinflation.[8] Increased dyspnea and exercise intolerance, worsening quality of life.[11] Higher risk of pneumothorax, especially in bullous disease cases.[12] The severity of centrilobular emphysema and older age were significantly associated with exacerbation frequency with p value of <0.001 for both. Ground-glass opacity (GGO) and consolidation, while less frequent, may indicate acute inflammation, infection, or edema. Their presence in AECOPD may indicate secondary infections or inflammatory responses exacerbating lung injury.[9] Bronchial wall thickening and bronchiectasis were significantly more common in patients with frequent exacerbations with p value of 0.002 and 0.008 respectively. These findings suggest; Increased mucus production and impaired clearance, leading to recurrent infections.[3] also irreversible airway dilation in bronchiectasis, which may lead to bacterial colonization, increasing exacerbation frequency.[10]

Extrapulmonary findings indicate the systemic nature of COPD, that needs a multidisciplinary approach to management. The detection of coronary artery calcifications (38%) and cardiomegaly (25.4%) suggests that cardiovascular disease (CVD) plays an important role in COPD morbidity and mortality. There was significant association between the presence of cardiovascular abnormalities and frequency of exacerbations, including coronary artery calcifications and cardiomegaly with p value of 0.06 and 0.05 respectively. Although in our study the coronary artery calcifications showed a near-significant association (p value = 0.06), this does not meet the conventional threshold for statistical significance and should be interpreted cautiously.

Studies have demonstrated that; COPD patients have a higher prevalence of coronary artery disease, possibly due to systemic inflammation in COPD and presence of oxidative stress.[13] Pulmonary hypertension, as indicated by an increased pulmonary artery-to-aorta ratio, is a marker of poor prognosis and increased mortality.[14] Right heart strain and cardiomegaly in COPD are often associated with chronic hypoxia and pulmonary vascular remodeling, contributing to cor pulmonale.[6] These findings make us consider the need for combined COPD and cardiovascular risk management, including screening for cardiac complications in AECOPD patients.

Our findings are compatible with the previous researches that was done before, that supporting the importance of CT imaging in COPD as CT-based studies show increasing emphysema prevalence with COPD severity, particularly in GOLD 3-4 patients.[8,9] Airway abnormalities, particularly bronchial wall thickening, have been associated with higher exacerbation frequency and worse lung function.[8] also cardiovascular abnormalities (e.g., coronary artery calcifications) have been linked to increased mortality risk in COPD patients.[17]

Our study has several limitations that we should mention them. The retrospective design of the study and single-center involvement may lead to selection bias and limit the generalizability of the findings. The relatively small sample size may also reduce the statistical power, particularly for detecting associations with less common CT findings. Additionally, the study included only patients who underwent chest CT during admission, which may not represent all AECOPD cases. All patients had a smoking history of more than 20 pack-years, which may confound the associations between CT abnormalities and COPD severity. The uniform exposure limits our ability to assess its individual contribution. The absence of longitudinal follow-up restricts conclusions about long-term outcomes. Future studies should consider prospective, multicenter designs with larger sample sizes to validate these findings and better understand the prognostic significance of CT abnormalities in AECOPD.

5. CONCLUSION

AECOPD patients have a large number of CT abnormalities, parenchymal abnormalities were the most common including emphysema as the most frequent abnormality. Half of patients had extrapulmonary abnormalities including cardiovascular abnormalities in a significant number of patients. These CT abnormalities had associations with clinical factors such as frequency of exacerbations and age. However, due to the retrospective nature of the study, no causal relationships can be established. Further research is needed to determine the long-term impact of these imaging findings on patient outcomes.

Conflict of interest

The authors report no conflict of interest.

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