

Association between Forced Expiratory Volume in 1 second /Forced Vital Capacity ratio and Main Pulmonary Artery /Ascending Aorta ratio in Chronic Obstructive Pulmonary Disease Patients – A Hospital based Observational Study

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a condition marked by persistent airflow limitation with an enhanced inflammatory response in airways and alveoli. Key risk factors for COPD include smoking, exposure to environmental pollutants, and genetic predisposition. Low dose computed tomography (LDCT) chest offers valuable insights into structural and vascular abnormalities in COPD, contributing to better understanding of its phenotypes, severity and disease outcomes.

Objective: This study aims to evaluate the correlation between disease severity (FEV1/FVC) and MPA/AA ratio in LDCT chest.

Methods: This observational study included a total of 112 spirometry confirmed COPD patients. LDCT chest was performed to assess parenchymal abnormalities and vascular involvement. Statistical analyses were conducted to determine the significant association between disease severity (FEV1/FVC) ratio, MPA/AA ratio and frequency of exacerbations over one year.

Results: Patients with very severe and severe COPD disease exhibited elevated MPA/AA ratio and reduced FEV1/FVC ratio, with a significant negative correlation between FEV1/FVC and MPA/AA ($r = -0.533$, $p = 0.001$). A strong association was observed between increased MPA/AA ratio (>0.9) and higher risk of exacerbations ($p < 0.001$, OR = 2.42, 95% CI: 4.811–15.365). The most common parenchymal abnormality detected on LDCT chest was mosaic attenuation, observed in 38 patients.

Conclusion: This study focuses the utility of LDCT chest in COPD patients. The strong correlation between FEV1/FVC ratio, MPA/AA ratio and exacerbation frequency emphasises the disease severity in COPD patients, thus facilitating targeted interventions to improve disease condition.

Keywords: COPD, FEV1/FVC, LDCT, MPA/AA, Observational study.

1. INTRODUCTION

Highlights

This study highlights the relationship between COPD severity Forced Expiratory Volume in 1 Second / Forced Vital Capacity (FEV1/FVC), LDCT chest findings (MPA/AA ratio) and exacerbation frequency in COPD patients.

Background

Chronic obstructive pulmonary disease (COPD) is a heterogeneous condition with the abnormalities seen in the airways and alveoli ^[1]. Globally, COPD affects approximately 251 million people and is responsible for nearly 3 million deaths annually ^[2]. The predisposing factors are smoking, environmental pollutants, genetic predisposition, developmental defects and a history of respiratory infections which contribute to disease progression ^[3]. A key aspect in COPD disease is the frequent occurrence of exacerbations, which are worsening of symptoms that extend beyond normal daily variations. These exacerbations significantly increase disease burden by declining the lung function, reducing quality of life, and increasing healthcare utilization and hospitalizations ^[4]. Since frequent exacerbations are associated with increase in morbidity and mortality, their prevention and appropriate management remains key therapeutic goal in COPD patients ^[5]. However, exacerbations in COPD patients are difficult due to their heterogeneous nature, with contributing factors such as respiratory infections, smoking, environmental pollutants and comorbidities ^[6]. LDCT chest has emerged as a promising imaging tool in COPD patients, offering insights into disease phenotypes, severity and outcomes. Additionally, LDCT chest has been instrumental in evaluating pulmonary vascular changes, such as the main pulmonary artery-to-ascending aorta (MPA/AA) ratio ^[7].

2. MATERIALS AND METHODOLOGY

Study Design and Population

This observational cross-sectional study was conducted in the Department of Respiratory Medicine. A total of 112 spirometry-confirmed COPD patients were included in this study.

Inclusion and Exclusion Criteria

Patients aged 40 years and older with a clinical diagnosis of COPD, confirmed by spirometry (FEV1/FVC < 0.7), and a history of at least one exacerbation in the past year were included in the study. Patients with comorbid conditions such as type 2 diabetes mellitus, systemic hypertension, coronary artery disease and pre-existing pulmonary hypertension were excluded.

Demographic Data Collection

Demographic data, smoking history, Modified Medical Research Council (MMRC) scores and spirometry parameters—including forced expiratory volume in one second (FEV1), forced vital capacity (FVC), FEV1/FVC ratio. Patients were followed up and the number of exacerbations over one year was documented.

Imaging Protocol

LDCT chest imaging was performed. This imaging concentrated on parenchymal abnormalities and pulmonary vascular involvement such as mosaic attenuation, centriacinar emphysema, paraseptal emphysema, bullae, bronchiectasis, consolidation and measuring the main pulmonary artery (MPA) diameter at its bifurcation and the ascending aorta (AA) diameter at the same level ^[8] (FIG 1).

FIG 1: Study Flow Chart

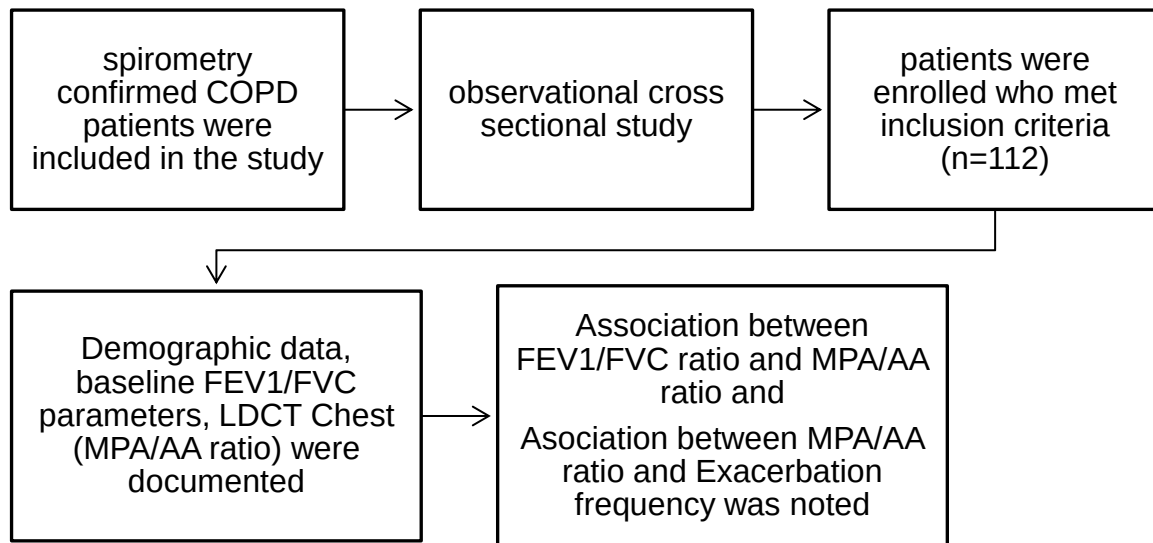


Figure 1 Footnote: (FEV1/FVC) Forced Expiratory Volume in 1 Second to Forced Vital Capacity, (MPA/AA) Main Pulmonary Artery to Ascending Aorta ratio, (LDCT) Low Dose Computed Tomography

Statistical Analysis

Statistical analysis was conducted using SPSS software. Continuous variables were presented as mean $\pm$ standard deviation and analysed using the student's t-test or Mann-Whitney U test, while categorical variables were evaluated using the Chi-square or Fisher's exact test. Binary logistic regression was performed to assess the association between the MPA/AA ratio and exacerbation risk, with the odds ratio (OR) and 95% confidence interval (CI) calculated. A p-value of <0.05 was considered statistically significant. Additionally, a linear regression model was used to examine the relationship between the FEV1/FVC ratio, MPA/AA ratio, and exacerbation frequency.

3. RESULTS

Patient Demographics and Clinical Characteristics

(Table 1) The study population had a mean age of 68.3 ± 9.4 years, with a male predominance of 75.3%. A smoking history of more than 10 pack-years was reported in 84.6% of participants. MMRC scores were distributed as follows: 38.4% of patients had Grade 2, 42.3% had Grade 3, and 19.3% had Grade 4 dyspnea. The mean FEV1 was $42.1 \pm 9.2\%$ of the predicted value. The average number of exacerbations in the past year were 2.4 ± 1.1 episodes.

Table 1: Demographic and Clinical Characteristics of Study Population

Variable	Mean $\pm$ SD / Percentage
Age (years)	68.3 ± 9.4
Male/female (%)	75.3/24.7
Smoking History (>10 pack-years)	84.6%
MMRC Dyspnea Score - Grade 2	38.4%

MMRC Dyspnea Score - Grade 3	42.3%
MMRC Dyspnea Score - Grade 4	19.3%
FEV1 (% predicted)	42.1 ± 9.2
Mean Exacerbations per Year	2.4 ± 1.1

Table 1 Footnote: SD = Standard Deviation; MMRC = Modified Medical Research Council; FEV1 = Forced Expiratory Volume in 1 second.

LDCT Chest Findings

In this study, clinical and imaging parameters were evaluated in 112 COPD patients, with a primary focus on CT pattern distribution and the MPA/AA ratio. The most common CT finding was mosaic attenuation (38 cases), followed by consolidation (28), centrilobular emphysema (24), paraseptal emphysema (16), bullae (4), and cystic bronchiectasis (2). Additionally, the MPA/AA ratio distribution showed that most patients had values greater than 0.9 (Table 2).

(Table 2) Elevated MPA/AA ratios were observed in patients with severe and very severe COPD, with mean values of 1.09 ± 0.08 and 1.21 ± 0.10 , respectively, along with lower FEV1/FVC ratios of 0.48 ± 0.02 and 0.27 ± 0.03 . In contrast, patients with mild COPD had lower MPA/AA ratios (0.89 ± 0.09) and higher mean FEV1/FVC ratios (0.67 ± 0.01) ($p < 0.001$ for both). The distribution of exacerbations also varied across different severity groups.

Table: 2 Comparison based on the severity among patients

Disease Severity	Very Severe, N = 20	Severe, N = 37	Moderate, N = 40	Mild, N = 15	p-value
MPA_AA	1.21 (0.08)	1.09 (0.10)	0.97 (0.12)	0.89 (0.09)	<0.001
FEV1_FVC	0.27 (0.03)	0.48 (0.02)	0.61 (0.03)	0.67 (0.01)	<0.001
Exacerbations					0.5
0	2 (10.0%)	8 (21.6%)	9 (22.5%)	6 (40.0%)	
1	3 (15.0%)	8 (21.6%)	14 (35.0%)	2 (13.3%)	
2	5 (25.0%)	10 (27.0%)	8 (20.0%)	5 (33.3%)	
3	6 (30.0%)	9 (24.3%)	6 (15.0%)	2 (13.3%)	
4	4 (20.0%)	2 (5.4%)	3 (7.5%)	0 (0%)	

Table 2 Footnote: Values are presented as mean (standard deviation) or number (percentage). MPA_AA = Main Pulmonary Artery to Ascending Aorta ratio; FEV1_FVC = Forced Expiratory Volume in 1 second to Forced Vital Capacity ratio. Disease severity classification based on Global Initiative for Chronic Obstructive Lung Disease criteria. p-values < 0.05 are considered statistically significant

(Table 3) Correlation analysis demonstrated a moderate negative correlation between FEV1/FVC and MPA/AA ($r = -0.533$, $p = 0.001$), indicating a significant inverse relationship between lower FEV1/FVC values and higher MPA/AA ratios. Patients with an MPA/AA ratio greater than 0.9 were 2.42 times more likely to experience frequent exacerbations (95% CI: 4.811–15.365, $p < 0.001$), while gender did not significantly impact exacerbation risk ($p = 0.61$, OR = 1.23, 95% CI: 0.57–2.64).

Table 3: Comparison of Clinical and Imaging Parameters in COPD Patients

Variable	AECOPD (n=92)	% AECOPD	p-value	Odds Ratio (OR)	95% CI
MPA:AA Ratio > 0.9	85	75.8%	<0.001	2.42	(4.811–15.365)
MPA:AA Ratio ≤ 0.9	27	24.1%		Reference	
Male	62	55.3%	0.611	1.23	(0.57–2.64)
Female	50	44.6%		Reference	

Table 3 Footnote: AECOPD = Acute Exacerbation of Chronic Obstructive Pulmonary Disease; MPA: AA = Main Pulmonary Artery to Ascending Aorta ratio; CI = Confidence Interval. p-values < 0.001 are considered statistically significant.

(Table 4) (Fig 2) The linear regression model further established that the MPA/AA ratio and FEV1/FVC ratio were significant predictors of exacerbations. FEV1/FVC showed a strong negative association with MPA/AA ($\beta = -1.109$, $p < 0.001$), whereas exacerbations were positively associated with the MPA/AA ratio ($\beta = 0.0488$, $p < 0.001$). The model intercept was 1.575 ($p < 0.001$), representing the baseline MPA/AA value when predictors equalled zero. These findings suggest that elevated MPA/AA ratios are associated with an increased risk of exacerbations in COPD patient.

Table 4. Association of FEV1/FVC Ratio and Exacerbations with MPA/AA

Variable	Estimate	Std. Error	t Value	P Value
Intercept	1.575	0.0997	15.797	<0.001 ***
FEV1/FVC	-1.109	0.1661	-6.679	<0.001 ***
Exacerbations	0.0488	0.0077	6.335	<0.001 ***

Table 4 Footnote: MPA/AA = Main Pulmonary Artery to Ascending Aorta ratio; FEV1/FVC = Forced Expiratory Volume in 1 second to Forced Vital Capacity ratio; Std. Error = Standard Error. *** indicates $p < 0.001$.

FIG 2: Correlation between MPA/AA ratio and FEV1/FVC in COPD patients

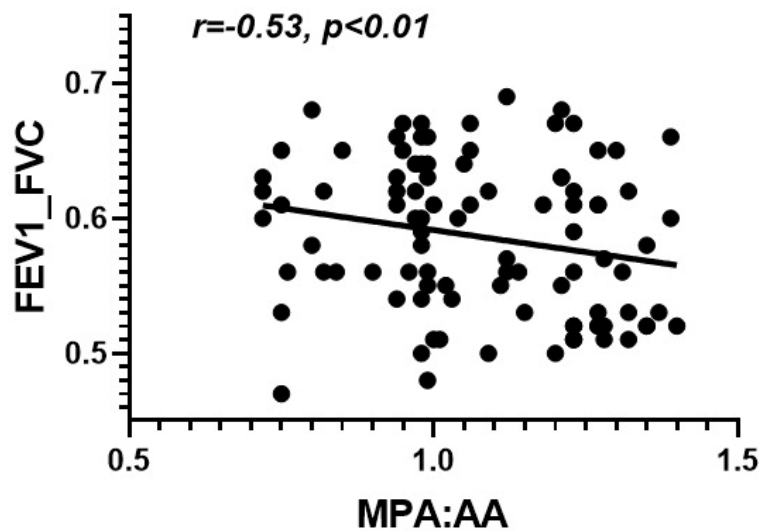


Figure 2 Footnote: (MPA/AA) Main Pulmonary Artery to Ascending Aorta ratio; (FEV1/FVC) Forced Expiratory Volume in 1 second to Forced Vital Capacity, (COPD) Chronic Obstructive Pulmonary Disease. $p < 0.01$."

4. DISCUSSION

The study examined the role of LDCT chest in assessing structural and vascular changes in COPD patients. The most common parenchymal finding on LDCT chest imaging was mosaic attenuation, observed in 70.8% of patients, indicating small airway disease involvement. These results align with previous studies identifying small airway disease as a key contributor to COPD exacerbations^[8,9]. Additionally, centrilobular and paraseptal emphysema were present in 64.6% and 30.8% of patients, respectively. Structural lung damage, including cystic bronchiectasis and bullae, was noted in a subset of patients, further emphasizing the long-term impact of COPD^[10,11].

This study shows association between MPA/AA ratio, FEV1/FVC ratio, and exacerbation frequency. The FEV1/FVC ratio demonstrated a strong inverse association with the MPA/AA ratio ($\beta = -1.109$, $p < 0.001$) and a positive association with exacerbation frequency ($\beta = 0.0488$, $p < 0.001$). An odds ratio of 2.42 was observed between an increased MPA/AA ratio and frequent exacerbations. Therefore, LDCT chest detects COPD patients at higher risk for disease progression and exacerbations.

Integrating LDCT chest into routine clinical practice could enhance risk stratification, allowing for earlier and more targeted interventions to reduce exacerbation frequency and improve overall patient outcomes. Identifying high-risk patients early may enable proactive management strategies to mitigate exacerbation risks.

Limitations:

- Sample size
- Follow up of the patients couldn't be done due to poor adherence.
- Repeat MPA/AA ratio, spirometry after 1 year was not addressed due to poor adherence of patients for follow up which would have helped in identifying whether MPA/AA ratio and spirometry parameters were improved with appropriate management

5. CONCLUSION

This study underscores the utility of LDCT chest in evaluating structural and vascular changes in COPD. The strong correlation between an increased MPA/AA ratio, disease severity (FEV1/FVC) and exacerbation frequency supports LDCT chest as a valuable non-invasive tool for risk assessment and disease management in COPD patients. Early identification of high-risk individuals could facilitate timely interventions, ultimately improving patient outcomes.

Ethical Considerations

Ethical approval was obtained from Institutional Human Ethics Committee for Student Research. The study adhered to the principles of the Declaration of Helsinki, 2013.

Data availability statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Financial support and sponsorship

NIL

Conflicts of interest

There are no conflicts of interest.

Reporting Guidelines

This original research article adheres to the STROBE reporting guidelines.

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