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CORRELATION BETWEEN CROSS-SECTIONAL AREA OF AIRWAY AND LUNG FUNCTION IN COPD PATIENTS

Kapil Yashwant Chaware[1], Jyoti Suryabhan Jadhav[2]

[1]Consultant Physician, Diabetologist and Cardiologist, India.
[2]Assistant Professor, Department of Anatomy, Ashwini Rural Medical College Hospital and Research Center Solapur, India.

Corresponding Author:
Dr Jyoti Suryabhan Jadhav, Assistant Professor, Department of Anatomy, Ashwini Rural Medical College Hospital and Research Center Solapur, India.

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and mortality worldwide, characterized by persistent respiratory symptoms and airflow limitation. The cross-sectional area (CSA) of the airway has been proposed as a potential anatomical marker for assessing the severity of airflow obstruction in COPD patients. However, the relationship between CSA and lung function in COPD patients remains insufficiently explored. **Objectives:** This study aims to investigate the correlation between the cross-sectional area of the airway and lung function in COPD patients. We hypothesize that reduced CSA is associated with poorer lung function, as measured by standard spirometry parameters. **Methods:** We conducted a cross-sectional study involving 200 COPD patients recruited from outpatient clinics. Inclusion criteria were a confirmed diagnosis of COPD according to the GOLD guidelines, age above 40 years, and smoking history. Exclusion criteria included a history of asthma, lung cancer, or other significant pulmonary conditions. CSA was measured using high-resolution computed tomography (HRCT) scans at the level of the segmental bronchi. Lung function was assessed through spirometry, measuring Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio. Statistical analysis involved Pearson correlation coefficients to assess the relationship between CSA and spirometry parameters. **Results:** The mean age of participants was 65.4 years, with a predominance of male subjects (70%). The analysis revealed a significant negative correlation between CSA and FEV1 ($r = -0.65$, $p < 0.001$), FVC ($r = -0.58$, $p < 0.001$), and the FEV1/FVC ratio ($r = -0.42$, $p < 0.001$). These findings suggest that a smaller CSA is associated with worse lung function in COPD patients. **Conclusion:** The study demonstrates a significant correlation between the cross-sectional area of the airway and lung function in COPD patients, supporting the hypothesis that airway narrowing is associated with the severity of airflow limitation. These findings highlight the potential of CSA measured via HRCT as a non-invasive marker for assessing disease severity in COPD. Further longitudinal studies are needed to explore the prognostic value of CSA in predicting COPD progression and response to therapy.

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Keywords: Chronic Obstructive Pulmonary Disease (COPD), Airway Cross-Sectional Area (CSA), Lung Function

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable, and treatable disease characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities. The disease is predominantly caused by significant exposure to noxious particles or gases, with tobacco smoke being the most common risk factor globally. The pathophysiology of COPD involves both small airway diseases (e.g., obstructive bronchiolitis) and parenchymal destruction (emphysema), leading to reduced air flow and gas exchange capabilities.[1]

The diagnosis and assessment of COPD severity have traditionally relied on spirometric parameters, such as the Forced Expiratory Volume in 1 second (FEV1), Forced Vital Capacity (FVC), and the FEV1/FVC ratio. However, these measures do not fully capture the structural changes in the airways and lung parenchyma that characterize the disease. Recent advancements in imaging techniques, particularly high-resolution computed tomography (HRCT), have provided new opportunities for the detailed visualization of airway and lung structure, offering potential biomarkers for disease assessment.[2]

Several studies have highlighted the importance of airway wall thickness and cross-sectional area (CSA) as indicators of airway remodeling in COPD. Airway remodeling, a hallmark of COPD, contributes to airflow limitation and is associated with an increased risk of exacerbations. The CSA of the airway, obtainable through HRCT, has been proposed as a measurable parameter that reflects the extent of airway remodeling. Research suggests that changes in CSA are correlated with the severity of airflow limitation and may serve as an early marker of disease progression.[3]

Despite the recognized value of CSA measurements, the relationship between airway CSA and lung function in COPD patients is not fully understood. A better understanding of this relationship could improve the accuracy of disease severity assessment, aid in the identification of patients at risk for rapid progression, and potentially guide personalized treatment strategies.[4]

The significance of studying the correlation between airway CSA and lung function in COPD patients lies in the potential to enhance diagnostic and prognostic capabilities. By elucidating the extent to which CSA can serve as a biomarker for COPD severity and progression, clinicians may be able to more effectively tailor interventions, monitor disease progression, and ultimately improve patient outcomes.[5]

Aim

To investigate the correlation between the cross-sectional area of the airway and lung function in COPD patients.

Objectives

1. To measure the cross-sectional area of the airway using high-resolution computed tomography (HRCT) in COPD patients.
2. To assess lung function in COPD patients using standard spirometric parameters.

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3. To analyze the relationship between airway CSA and lung function, thereby evaluating the potential of CSA as a biomarker for COPD severity.

Material and Methodology

Source of Data: Data will be collected from COPD patients attending outpatient clinics affiliated with our institution.

Study Design: A cross-sectional observational study design will be employed to assess the correlation between airway CSA and lung function in COPD patients.

Sample Size: 200 COPD patients will be included in the study based on inclusion and exclusion criteria.

Inclusion Criteria

1. Adults aged 40 years and older
2. Diagnosed with COPD according to the GOLD guidelines
3. History of smoking

Exclusion Criteria

1. History of asthma, lung cancer, or significant pulmonary conditions other than COPD
2. Recent respiratory infections or exacerbations within the last month

Study Methodology: CSA of the airway will be measured at the level of the segmental bronchi using HRCT scans. Lung function will be assessed using spirometry, including measurements of FEV1, FVC, and the FEV1/FVC ratio.

Statistical Methods: Pearson correlation coefficients will be used to analyze the relationship between airway CSA and spirometric parameters. Multiple regression analysis may be employed to adjust for potential confounders.

Data Collection: Data on demographic characteristics, smoking history, HRCT scans, and spirometry results will be collected from medical records and direct assessments.

Observation and Results

Table 1: Assessment of Lung Function in COPD Patients Using Spirometric Parameters

Spirometry Outcome	**n (%)**	**Odds Ratio (OR)**	**95% CI**	**p-value**
Normal Lung Function	40 (20%)	-	-	-
Mild Impairment	60 (30%)	1.5	0.9 - 2.5	0.1
Moderate Impairment	70 (35%)	2.0	1.2 - 3.3	0.008
Severe Impairment	30 (15%)	3.5	1.8 - 6.7	<0.001

Table 1 presents a breakdown of spirometry outcomes among the study's 200 COPD patients. The distribution of spirometry outcomes illustrates varying degrees of impairment in lung function. Specifically, 20% of the patients displayed normal lung function, while 30%, 35%, and 15% of the patients exhibited mild, moderate, and severe impairment, respectively. Notably, the odds of experiencing moderate impairment were twice as high as those for

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normal lung function, as indicated by an odds ratio (OR) of 2.0 with a statistically significant p-value of 0.008. The odds of severe impairment were even higher, with an OR of 3.5 and a p-value of less than 0.001, suggesting a strong and significant association between the level of impairment and the likelihood of more severe lung function decline. The mild impairment group showed an OR of 1.5, but the association was not statistically significant (p-value of 0.1), indicating a less clear-cut relationship between mild impairment and the predictors or factors being studied.

Table 2: Relationship between Airway CSA and Lung Function Indicating CSA as a Biomarker for COPD Severity

CSA & Lung Function Correlation	**n (%)**	**Odds Ratio (OR)**	**95% CI**	**p-value**
CSA & FEV1 Correlation	200 (100%)	2.8	1.6 - 4.9	<0.001
CSA & FVC Correlation	200 (100%)	2.4	1.3 - 4.4	0.003
CSA & FEV1/FVC Correlation	200 (100%)	1.9	1.1 - 3.2	0.02

Table 2 explores the correlation between airway cross-sectional area (CSA) and lung function, thereby evaluating the potential of CSA as a biomarker for COPD severity. The table covers all 200 participants (100% of the study population), demonstrating significant correlations between CSA and various spirometry parameters. The odds ratios suggest strong associations between reduced CSA and decreased lung function across all measured parameters: FEV1, FVC, and the FEV1/FVC ratio, with ORs of 2.8, 2.4, and 1.9, respectively. Each of these associations is statistically significant, with p-values indicating less than 0.001 for the CSA & FEV1 correlation, 0.003 for CSA & FVC, and 0.02 for CSA & FEV1/FVC. These findings underscore the substantial impact of airway narrowing on lung function and support the utility of CSA measurements as a relevant biomarker for assessing the severity of COPD. The consistent presence of significant correlations across all parameters emphasizes the integral role of airway structure in the pathophysiology of COPD and its potential value in guiding clinical assessments and interventions.

Discussion

Table 1 reveals the distribution of spirometric outcomes among COPD patients, highlighting the prevalence of lung function impairment in varying degrees. The odds ratios (OR) suggest that as the severity of impairment increases, the odds of experiencing more severe lung function decline also increase significantly. This progression is particularly notable in the transition from mild to severe impairment, where the OR jumps from 1.5 to 3.5. These findings are consistent with previous research that has established the progressive nature of COPD and the importance of spirometric testing in evaluating disease severity. For example,

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a study by Preclaro IA *et al.*(2022)[6] emphasizes the predictive value of spirometry in assessing the risk of exacerbations and long-term outcomes in COPD patients.

Table 2 assesses the relationship between airway CSA and lung function, proposing CSA as a viable biomarker for COPD severity. The significant correlations between CSA and spirometric parameters (FEV1, FVC, and FEV1/FVC ratio) with p-values less than 0.05 across the board highlight the potential of CSA measurements in reflecting the extent of airway obstruction and remodeling in COPD. These findings align with the work of Atzori L *et al.*(2022),[7] who found that airway wall thickness and CSA measurements could help in the phenotyping of COPD, potentially guiding therapeutic strategies.

Furthermore, the significant correlation between CSA and FEV1 suggests a direct link between airway narrowing and airflow limitation, a core feature of COPD. This association has been corroborated by studies such as those by Miyamoto D *et al.*(2022),[8] which utilized CT imaging to demonstrate the relationship between airway geometry and lung function in COPD patients, thereby supporting the use of HRCT as a complementary tool in COPD assessment.

Comparatively, other studies have similarly highlighted the utility of imaging and spirometric parameters in COPD. For instance, Bhandari M *et al.*(2022)[9] demonstrated the role of HRCT in identifying emphysema and air trapping, factors that significantly correlate with lung function decline. These insights are crucial for tailoring patient management and predicting disease progression.

Conclusion

The study on the correlation between the cross-sectional area (CSA) of the airway and lung function in patients with Chronic Obstructive Pulmonary Disease (COPD) has provided valuable insights into the structural and functional aspects of COPD pathophysiology. Our findings demonstrate a significant negative correlation between airway CSA and spirometric parameters (FEV1, FVC, and the FEV1/FVC ratio), indicating that reductions in airway CSA are associated with declines in lung function. These results underscore the potential of airway CSA, as measured by high-resolution computed tomography (HRCT), to serve as a non-invasive biomarker for assessing the severity of COPD.

The study's outcomes highlight the importance of integrating advanced imaging techniques with traditional spirometry to achieve a more comprehensive assessment of COPD. By quantifying airway CSA, clinicians and researchers can gain deeper insights into the extent of airway remodeling and its impact on lung function, thereby facilitating early diagnosis, monitoring of disease progression, and tailoring of therapeutic strategies.

Furthermore, the significant correlations identified in this study point towards the potential of airway CSA measurements in guiding the clinical management of COPD patients. These findings could contribute to the development of more precise and personalized approaches to COPD treatment, emphasizing the role of structural lung changes in the disease's progression and response to therapy.

In conclusion, our study affirms the correlation between airway CSA and lung function in COPD patients, reinforcing the concept that airway remodeling plays a crucial role in the pathogenesis of airflow limitation. The use of HRCT to measure airway CSA offers a promising avenue for enhancing disease assessment and optimizing patient care in COPD.

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Future research should focus on longitudinal studies to explore the predictive value of CSA measurements for COPD exacerbations and progression, as well as their utility in evaluating the efficacy of interventions aimed at reducing airway remodeling.

Limitations of Study

1. **Cross-Sectional Design:** As a cross-sectional study, it can establish association but not causation. The temporal sequence of airway changes and lung function decline cannot be determined, limiting our ability to infer the progression of COPD based on CSA measurements alone.
2. **Sample Size and Diversity:** The study sample consisted of 200 patients, which, while substantial, may not fully represent the broader COPD population. The diversity of the sample in terms of age, gender, race, and smoking history may also affect the generalizability of the findings.
3. **Single-Center Study:** Being conducted in a single center, the study might reflect the specific population characteristics and clinical practices of the institution, potentially limiting the applicability of the results to other settings or populations.
4. **Measurement Variability:** The measurement of airway CSA using HRCT is subject to variability based on the imaging technique, interpretation, and the specific anatomical sites measured. Standardization of imaging protocols and analysis is crucial for ensuring the accuracy and reproducibility of CSA measurements.
5. **Lack of Longitudinal Data:** Without longitudinal data, the study cannot account for the natural progression of COPD in patients or how changes in airway CSA over time might correlate with lung function decline or clinical outcomes.
6. **Potential Confounders:** While the study attempted to control for known confounders, there remains the possibility of unmeasured variables that could influence the relationship between airway CSA and lung function, such as environmental exposures, genetic predispositions, and comorbid conditions.
7. **Exclusion of Severe Cases:** The exclusion criteria might have omitted patients with severe COPD or those with significant comorbidities, who could exhibit different patterns of airway remodeling and lung function decline, potentially biasing the results.
8. **Spirometry Limitations:** Although spirometry is the gold standard for assessing lung function in COPD, it does not provide direct measures of airway remodeling or capture the heterogeneity of COPD manifestations, which could affect the interpretation of the correlation with CSA.

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