Original Research

ROLE OF SPIROMETRY IN THE EARLY DETECTION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE AMONG ASYMPTOMATIC SMOKERS

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ABSTRACT

Background: Chronic Obstructive Pulmonary Disease (COPD) is a major cause of morbidity and mortality worldwide. Structural and functional changes in the airways often precede the onset of symptoms, resulting in delayed diagnosis. Early identification of airflow limitation among smokers may facilitate timely intervention and smoking cessation. Spirometry is a simple, non-invasive, and reliable tool for detecting early airflow obstruction.
Aim: To evaluate the role of spirometry in the early detection of Chronic Obstructive Pulmonary Disease among asymptomatic smokers.
Methods: A hospital-based cross-sectional study was conducted among 72 asymptomatic smokers aged 30 years and above with a smoking history of at least 10 pack-years. Demographic details and smoking characteristics were recorded using a structured questionnaire. All participants underwent spirometric evaluation according to American Thoracic Society and European Respiratory Society guidelines. Airflow obstruction was defined as a post-bronchodilator FEV_1/FVC ratio of less than 0.70. Data were analyzed using SPSS software, and associations were assessed using appropriate statistical tests.
Results: The mean age of the participants was 46.8 ± 10.7 years, and 91.7% were males. Spirometry detected airflow obstruction suggestive of COPD in 10 (13.9%) participants despite the absence of respiratory symptoms. Among those with airflow obstruction, 60% were classified as GOLD stage I and 40% as GOLD stage II. The mean FEV_1/FVC ratio was 75.8 ± 7.1%. A significant association was observed between smoking exposure and airflow obstruction, with smokers having ≥30 pack-years showing a higher prevalence of COPD compared to those with lower smoking exposure ($p = 0.018$).
Conclusion: Spirometry is an effective screening tool for the early detection of COPD among asymptomatic smokers. Routine spirometric assessment in high-risk smokers may facilitate early diagnosis, smoking cessation counseling, and timely intervention, thereby reducing future disease burden.

Keywords: Chronic Obstructive Pulmonary Disease, COPD, Spirometry, Asymptomatic Smokers, Airflow Obstruction, Pulmonary Function Test, Early Detection, Smoking.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a common, preventable, and treatable respiratory disorder characterized by persistent airflow Limitation and chronic inflammatory changes in the airways and lung parenchyma. It develops gradually over several years and is strongly associated with exposure to noxious particles and gases, particularly tobacco smoke. The disease encompasses pathological changes seen in chronic bronchitis and emphysema and is a leading cause of chronic morbidity, disability, and mortality worldwide. Although COPD is traditionally diagnosed after the onset of symptoms such as chronic cough, sputum production, and dyspnea, substantial structural and

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functional lung damage may occur long before clinical manifestations become evident[1].

Globally, COPD represents a major public health challenge. According to the Global Burden of Disease Study 2021, COPD affects hundreds of millions of individuals and remains among the leading causes of death worldwide. The World Health Organization estimates that COPD accounts for more than three million deaths annually, representing approximately 5% of all global deaths. The burden is particularly high in low- and middle-income countries, where tobacco use, biomass fuel exposure, occupational pollutants, and limited access to healthcare contribute significantly to disease prevalence. India bears a disproportionately large share of the global COPD burden, with smoking remaining one of the most important risk factors among adults[2].

Cigarette smoking is the single most important modifiable risk factor for COPD. Long-term tobacco exposure induces chronic airway inflammation, oxidative stress, mucus hypersecretion, and progressive destruction of alveolar structures. Studies have demonstrated that a significant proportion of smokers develop measurable airflow limitation before the appearance of respiratory symptoms[3]. Consequently, many smokers remain undiagnosed until the disease reaches a more advanced stage, when substantial loss of lung function has already occurred. Spirometry is considered the gold standard for the diagnosis of COPD. It provides an objective assessment of airflow limitation by measuring forced expiratory volumes and capacities[4]. Several studies have highlighted the utility of spirometry as a screening tool among asymptomatic smokers. Bednarek et al[5]. reported that active case-finding using spirometry among smokers identified a substantial number of previously undiagnosed COPD cases. Van Schayck and colleagues similarly demonstrated that early spirometric screening could facilitate timely diagnosis and smoking cessation interventions[6]. More recently, Somnath V[7]. observed airflow obstruction in approximately 12% of asymptomatic smokers, emphasizing the presence of occult disease in apparently healthy individuals.

Early detection of COPD offers important clinical and public health benefits. Identification of airflow obstruction during the asymptomatic stage allows implementation of smoking cessation strategies, risk-factor modification, patient education, and appropriate follow-up before irreversible lung damage progresses[8]. Despite these advantages, spirometric screening of high-risk smokers remains underutilized in routine clinical practice, particularly in resource-limited settings. Data regarding the prevalence of undiagnosed COPD among asymptomatic smokers in the local population are also limited. Therefore, the present study was undertaken to evaluate the role of spirometry in detecting early COPD among asymptomatic smokers and to assess the relationship between smoking exposure and spirometric abnormalities. The findings may contribute to the development of targeted screening strategies aimed at reducing the burden of COPD through earlier diagnosis and intervention.

Aim and Objectives

Aim

To evaluate the effectiveness of spirometry in detecting early chronic obstructive pulmonary disease (COPD) among asymptomatic smokers.

Objectives

1. To determine the prevalence of spirometric abnormalities suggestive of COPD among asymptomatic smokers.
2. To assess the relationship between smoking exposure (pack-years/smoking index) and spirometric parameters (FEV_1, FVC, FEV_1/FVC ratio).
3. To identify demographic and smoking-related factors associated with early airflow obstruction detected by spirometry.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional observational study was conducted in the Department of Pulmonary Medicine of a tertiary care teaching hospital over a period of ____months from _____ to _____. The study was undertaken after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population

The study included asymptomatic smokers attending the outpatient department, accompanying patients, hospital staff, and individuals from the community who fulfilled the eligibility criteria.

Sample Size Calculation

The sample size was calculated based on the prevalence of spirometrically detected airflow obstruction among asymptomatic smokers reported in a previous study by Somnath V[7]. which demonstrated a prevalence of 12.2%.

The sample size was estimated using the formula:

$n = Z^2PQ/d^2$

Where:

- n = required sample size
- Z = standard normal deviate corresponding to 95% confidence level (1.96)
- P = prevalence of airflow obstruction among asymptomatic smokers (12.2% or 0.122)
- Q = 1 – P = 87.8% or 0.878
- d = absolute precision (8% or 0.08)

Substituting the values:

$n = (1.96)^2 \times 0.122 \times 0.878 / (0.08)^2$
$n = 3.84 \times 0.107 / 0.0064$
$n = 64.2$
The minimum required sample size was calculated as 65 participants. To compensate for possible non-response, incomplete spirometry, or withdrawal from the study, an additional 10% was added.
Adjusted sample size:
$n = 65 + 6.5 = 71.5$
Thus, the final sample size was rounded off to 72 participants.

Sampling Technique

Eligible participants were recruited using consecutive sampling until the required sample size of 72 subjects was achieved.

Inclusion Criteria

1. Adults aged 30 years and above.
2. Current smokers with a smoking history of at least 10 pack-years.
3. Individuals without respiratory symptoms such as chronic cough, sputum production, wheezing, breathlessness, or chest tightness.
4. Individuals willing to provide informed written consent.

Exclusion Criteria

1. Previously diagnosed cases of COPD, bronchial asthma, interstitial lung disease, bronchiectasis, or pulmonary tuberculosis.
2. Individuals with acute respiratory tract infection within the preceding four weeks.
3. Subjects with severe cardiovascular disease contraindicating spirometry.
4. Pregnant women.
5. Individuals unable to perform acceptable spirometry according to standard guidelines.
6. Former smokers who had quit smoking for more than one year.

Data Collection Procedure

After obtaining informed consent, participants were interviewed using a structured proforma. Demographic information including age, sex, occupation, educational status, and socioeconomic status was recorded.
Smoking history was assessed in detail, including:

- Duration of smoking (years)
- Number of cigarettes/bidis smoked per day
- Type of smoking product
- Smoking index
- Pack-years of smoking

Pack-years were calculated using the formula:
Pack-years = (Number of cigarettes smoked per day × Duration of smoking in years) / 20
A detailed clinical examination was performed to exclude symptomatic respiratory disease and identify any significant comorbid conditions.

Spirometric Assessment

Pulmonary function testing was performed using a calibrated computerized spirometer according to the recommendations of the European Respiratory Society (ERS) and the American Thoracic Society (ATS). Prior to testing:

- Participants were advised to avoid smoking for at least one hour before the procedure.
- Vigorous exercise was avoided for at least 30 minutes before testing.
- Measurements were conducted in a seated position using a nose clip.

Each participant performed a minimum of three acceptable forced expiratory manoeuvres. The highest values meeting reproducibility criteria were recorded. The following spirometric parameters were obtained:

- Forced Vital Capacity (FVC)
- Forced Expiratory Volume in one second (FEV_1)
- FEV_1/FVC ratio
- Peak Expiratory Flow Rate (PEFR)
- Forced Expiratory Flow between 25% and 75% of FVC (FEF25–75%)

Definition of Airflow Obstruction

Airflow obstruction suggestive of COPD was defined according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria as:
FEV_1/FVC ratio < 0.70 following bronchodilator administration.
Participants identified with airflow obstruction were classified according to GOLD severity staging based on post-bronchodilator FEV_1 percentage predicted.

Outcome Measures

Primary Outcome

- Prevalence of spirometrically detected airflow obstruction among asymptomatic smokers.

Secondary Outcomes

- Association between smoking exposure and spirometric parameters.
- Correlation between pack-years and severity of airflow limitation.
- Identification of demographic and smoking-related risk factors associated with early COPD.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. Participation was voluntary, and confidentiality of all collected information was maintained. Participants diagnosed with airflow obstruction were counselled regarding smoking cessation and referred for further pulmonary evaluation and management.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using Statistical Package for Social Sciences (SPSS) version 25. Continuous variables were expressed as mean ± standard deviation or median with interquartile range as appropriate. Categorical variables were expressed as frequencies and percentages. The Chi-square test or Fisher's exact test was used to compare categorical variables.

Independent Student's t-test or Mann–Whitney U test was used for comparison of continuous variables between groups. Correlation between smoking exposure and spirometric parameters was assessed using Pearson's or Spearman's correlation coefficient. A p-value less than 0.05 was considered statistically significant.

RESULTS

A total of 72 asymptomatic smokers were enrolled in the study. The mean age of the study participants was 46.8 ± 10.7 years. Spirometry revealed airflow obstruction suggestive of COPD in 10 (13.9%) participants despite the absence of respiratory symptoms.

Table 1. Demographic Characteristics of the Study Participants (n = 72)

Variable	Frequency (N)	Percentage (%)
Age Group (Years)		
30–39	18	25.0
40–49	24	33.3
50–59	20	27.8
≥60	10	13.9
Gender		
Male	66	91.7
Female	6	8.3
Occupation		
Manual Laborer	29	40.3
Farmer	17	23.6
Office Worker	15	20.8
Others	11	15.3

Interpretation: Most participants belonged to the 40–49 years age group (33.3%). Males constituted the majority (91.7%) of the study population.

Table 2. Smoking Characteristics of the Study Participants (n = 72)

Variable	Frequency (N)	Percentage (%)
Duration Of Smoking (Years)		
10–19	25	34.7
20–29	28	38.9
≥30	19	26.4
Pack-Years		
10–19	22	30.6
20–29	31	43.1
≥30	19	26.3
Type Of Smoking		
Cigarette	48	66.7
Bidi	20	27.8
Mixed	4	5.5

Interpretation: The majority of participants (43.1%) had a smoking exposure of 20–29 pack-years.

Table 3. Spirometric Findings among Asymptomatic Smokers (n = 72)

Spirometric Parameter	Mean ± Sd
Fvc (% Predicted)	89.4 ± 11.2
Fev_1 (% Predicted)	84.7 ± 13.5
Fev_1/Fvc Ratio (%)	75.8 ± 7.1
Pefr (% Predicted)	81.5 ± 12.8
Fef25–75 (% Predicted)	72.6 ± 14.3

Interpretation: Reduction in small airway flow rates (FEF25–75) was observed even among asymptomatic smokers, suggesting early airway involvement.

Table 4. Prevalence and Severity of Airflow Obstruction Detected by Spirometry (n = 72)

Spirometry Result	Frequency (N)	Percentage (%)

Normal Spirometry	62	86.1
Airflow Obstruction (Copd)	10	13.9

GOLD Classification among Subjects with Airflow Obstruction (n = 10)

Gold Stage	Frequency (N)	Percentage (%)
Gold I (Mild)	6	60.0
Gold Ii (Moderate)	4	40.0
Gold Iii/Iv	0	0

Interpretation: Spirometry identified previously undiagnosed airflow obstruction in 13.9% of asymptomatic smokers. Most cases were classified as mild COPD (GOLD I).

Table 5. Association between Smoking Exposure and Airflow Obstruction

Pack-Years	COPD Present N (%)	COPD Absent N (%)	P-Value
10–19 (N=22)	1 (4.5)	21 (95.5)	
20–29 (N=31)	3 (9.7)	28 (90.3)	
≥30 (N=19)	6 (31.6)	13 (68.4)	
Total	**10 (13.9)**	**62 (86.1)**	**0.018***

*Chi-square test; $p < 0.05$ considered statistically significant.

Interpretation: A significant association was observed between cumulative smoking exposure and airflow obstruction. Participants with ≥30 pack-years had a substantially higher prevalence of COPD compared to those with lower smoking exposure.

DISCUSSION

The present study evaluated the role of spirometry in detecting early chronic obstructive pulmonary disease (COPD) among asymptomatic smokers. A total of 72 asymptomatic smokers underwent spirometric assessment, and airflow obstruction suggestive of COPD was identified in 13.9% of participants. The findings highlight the importance of spirometry as a screening tool for identifying occult airflow limitation before the development of overt respiratory symptoms. In the present study, the mean age of the participants was 46.8 ± 10.7 years, with the majority belonging to the 40–49-year age group. This observation is consistent with the findings of Bednarek et al[5]., who reported that undiagnosed COPD was most commonly identified among middle-aged smokers with prolonged tobacco exposure. Similarly, Padila and Menezes[9] observed that the prevalence of airflow obstruction increased progressively with advancing age, reflecting the cumulative effects of smoking-related airway injury. The predominance of male participants (91.7%) in our study is also comparable to previous Indian studies, where smoking habits remain significantly more common among males than females.

The majority of participants in the present study had a smoking exposure of 20–29 pack-years, while approximately one-fourth had smoked for more than 30 pack-years. Similar smoking patterns were reported by Somnath V[7]., who found that longer duration and higher intensity of smoking were strongly associated with impaired pulmonary function among asymptomatic smokers. These findings reinforce the established dose-dependent relationship between tobacco exposure and progressive decline in lung function. Spirometric evaluation revealed a mean FEV_1/FVC ratio of 75.8 ± 7.1%, with evidence of reduced expiratory airflow among a subset of participants. In addition, lower mean FEF25–75 values were observed, indicating early small-airway involvement. These findings are supported by the work of Tager et al[10]., who demonstrated that small-airway dysfunction often precedes clinically apparent COPD and may serve as an early marker of smoking-induced lung injury. Similar observations were reported by Hoesterey et al[11]., who noted that reductions in mid-expiratory flow rates could be detected in smokers before significant reductions in FEV_1 become evident.

A major finding of the present study was the detection of airflow obstruction in 13.9% of asymptomatic smokers. This prevalence closely parallels the results reported by Somnath V[7], who identified airflow obstruction in 12.2% of asymptomatic smokers using spirometry. Bednarek et al[5]. similarly demonstrated that systematic spirometric screening among smokers identified a considerable proportion of previously undiagnosed COPD cases. The slight variation in prevalence between studies may be attributed to differences in age distribution, smoking exposure, sample size, and diagnostic criteria. Nevertheless, all studies consistently indicate that a substantial proportion of smokers harbor undetected airflow limitation despite the absence of symptoms. Among participants diagnosed with airflow obstruction, 60% were classified as GOLD stage I and 40% as GOLD stage II. No severe cases were identified. These findings are in agreement with the

observations of Zielinski and Bednarek[12], who reported that most newly detected COPD cases identified through screening programs were in the mild-to-moderate stages. Detection at these early stages is particularly important because smoking cessation and preventive interventions have the greatest impact before significant irreversible lung damage occurs.

The present study also demonstrated a statistically significant association between smoking exposure and airflow obstruction ($p = 0.018$). Participants with smoking exposure of 30 or more pack-years exhibited a markedly higher prevalence of COPD compared with those having lower smoking exposure. Similar findings were reported by Lundbäck et al[13]. and Mannino and Buist[14]., who showed that increasing pack-years significantly increased the risk of developing airflow limitation and COPD. The biological plausibility of this relationship is well established, as cumulative tobacco smoke exposure promotes chronic inflammation, oxidative stress, airway remodeling, and destruction of lung parenchyma. Overall, the findings of the present study are consistent with previous international and Indian studies demonstrating that a significant proportion of asymptomatic smokers already have measurable airflow limitation. The study emphasizes the value of spirometry as a simple, non-invasive, and cost-effective tool for early detection of COPD. Routine spirometric screening of high-risk smokers may facilitate earlier diagnosis, encourage smoking cessation, and potentially reduce the long-term burden of COPD.

Limitations

The present study has certain limitations that should be considered while interpreting the findings. First, the study was conducted at a single tertiary care center with a relatively small sample size of 72 participants, which may limit the generalizability of the results to the broader population of smokers. Second, the cross-sectional study design allowed assessment of spirometric abnormalities at a single point in time and did not permit evaluation of disease progression or long-term outcomes. Third, smoking exposure was assessed based on self-reported history, which may be subject to recall bias and underreporting. Fourth, the study included only asymptomatic smokers and did not evaluate the influence of other important risk factors such as passive smoking, occupational dust exposure, environmental pollution, biomass fuel exposure, or genetic susceptibility. Additionally, advanced investigations such as diffusion capacity measurements and high-resolution computed tomography were not performed, which could have detected subclinical structural lung abnormalities in participants with normal spirometry. Therefore, larger multicentric prospective studies are required to further validate these findings and establish the role of routine spirometric screening in high-risk populations.

CONCLUSION

The present study demonstrated that a significant proportion of asymptomatic smokers had previously undiagnosed airflow obstruction detectable by spirometry. Approximately one in seven smokers showed evidence of COPD despite the absence of respiratory symptoms, with most cases being identified in the early stages of the disease. A significant association was observed between cumulative smoking exposure and the presence of airflow limitation, highlighting the detrimental effect of prolonged tobacco use on pulmonary function. The findings emphasize that spirometry is a simple, non-invasive, and effective tool for the early detection of COPD among high-risk smokers. Incorporating spirometric screening into routine clinical evaluation of chronic smokers may facilitate timely diagnosis, promote smoking cessation, enable early therapeutic interventions, and ultimately reduce the long-term burden of COPD and its associated complications.

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