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Silent but Significant: Uncovering Early Chronic Obstructive Pulmonary Disease (COPD) in Asymptomatic Male Smokers

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Abstract

Background

Chronic obstructive pulmonary disease (COPD) is an important cause of illness and death worldwide. Airflow limitation, however, may develop before noticeable respiratory symptoms appear. Since cigarette smoking is a major modifiable risk factor, spirometry may help identify early airflow obstruction in smokers who otherwise consider themselves healthy. This study evaluated the prevalence of spirometric airflow obstruction among apparently asymptomatic male smokers in Northern India and examined its association with smoking exposure, smoking duration, body mass index (BMI), and biomass exposure.

Methods

This prospective observational study included 1,000 male smokers aged ≥ 30 years who had no significant respiratory symptoms. Participants were recruited from hospital and community-based settings. Individuals with asthma, chronic respiratory or cardiac disease, previous bronchodilator or corticosteroid use, or smoking cessation for more than one year were excluded. Demographic characteristics, BMI, smoking history, and biomass exposure were recorded. Spirometry was performed according to standardized procedures, with post-bronchodilator measurements obtained after 400 μ g of salbutamol. Airflow obstruction was defined as a post-bronchodilator forced expiratory volume in one second (FEV1)/forced vital capacity (FVC) ratio < 0.70 and classified according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria.

Results

The mean age of participants was 43.9 ± 12.73 years. Spirometric airflow obstruction was identified in 125 (12.5%) participants. Of these, 121 (96.8%) had GOLD stage 1, and 4 (3.2%) had GOLD stage 2 disease. Obstruction was substantially more frequent among participants with a smoking index > 200 than those with a smoking index < 200 (43.7% vs. 1.4%). Mean smoking index and smoking duration were also higher among participants with obstruction. BMI and biomass exposure were not significantly associated with airflow obstruction.

Conclusions

Spirometric airflow obstruction was present in a notable proportion of apparently asymptomatic male smokers and was predominantly mild. Greater cumulative smoking exposure and longer smoking duration were associated with airflow obstruction. Targeted spirometric assessment of smokers with substantial tobacco exposure may facilitate earlier recognition of airflow limitation and reinforce opportunities for smoking cessation and preventive care.

Categories: Public Health, Pulmonology, Internal Medicine

Keywords: airflow obstruction, biomass, chronic obstructive pulmonary disease (copd), smoking and cancer, spirometry

Introduction

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable respiratory disorder characterized by persistent airflow limitation and respiratory symptoms resulting from abnormalities of the airways and/or alveoli, usually caused by significant exposure to noxious particles or gases. The disease is generally progressive and may be associated with acute exacerbations and multiple comorbidities [1].

COPD represents a major global health burden. It is associated with substantial morbidity, mortality,

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healthcare utilization, and loss of productivity. Global estimates have consistently demonstrated that COPD is among the leading causes of death worldwide, with tobacco smoking being one of the most important modifiable risk factors [2,3]. The burden is expected to remain substantial because of population aging, continued exposure to tobacco smoke, and other environmental and occupational exposures.

India contributes substantially to the global burden of COPD. Epidemiological studies conducted in different parts of the country have reported considerable geographical and population-level variation in prevalence. The Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis in Adults (INSEARCH), which included more than 169,000 adults from multiple urban and rural sites, reported a prevalence of chronic bronchitis of approximately 3.5% among adults aged ≥ 35 years [4].

The Burden of Obstructive Lung Disease (BOLD) study demonstrated considerable variation in the prevalence of COPD between populations and highlighted the importance of standardized post-bronchodilator spirometry in epidemiological studies [5]. In a BOLD study conducted in Kashmir, Koul et al. reported a substantial prevalence of chronic airflow limitation among adults, demonstrating the significant respiratory disease burden in Northern India [6].

Smoking is one of the most important established risk factors for COPD. The risk of persistent airflow limitation increases with cumulative exposure to tobacco smoke, although susceptibility varies considerably between individuals. Importantly, physiological impairment may develop before individuals recognize respiratory symptoms. Smokers may therefore have clinically relevant reductions in pulmonary function while considering themselves asymptomatic.

Spirometry is the principal objective test used to demonstrate persistent airflow limitation. The major parameters measured are forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio. The American Thoracic Society and European Respiratory Society have established standardized technical recommendations for the performance and interpretation of spirometry [7,8]. Current Global Initiative for Chronic Obstructive Lung Disease (GOLD) recommendations require post-bronchodilator spirometry to confirm persistent airflow obstruction.

The identification of airflow limitation at an early stage may provide an opportunity for preventive intervention. Smoking cessation is the most important intervention for smokers at risk of COPD and has been shown to reduce the subsequent rate of decline in lung function [9]. Identification of airflow obstruction may therefore provide an additional opportunity to reinforce smoking cessation and other risk reduction measures [10].

The present study was undertaken to determine the prevalence of spirometric airflow obstruction among apparently asymptomatic male smokers in Northern India and to evaluate its relationship with cumulative smoking exposure, smoking duration, BMI, and biomass exposure.

Materials And Methods

Study design and setting

This cross-sectional observational study was conducted in the Department of Medicine, Government Medical College, Srinagar, between August 2017 and July 2020, over a period of 35 months. Participants were recruited from hospital and community-based settings within the study area. Institutional ethical approval was obtained before commencement of the study.

Study population

Male smokers aged ≥ 30 years who did not report significant respiratory symptoms and were willing to undergo spirometry were eligible for participation.

Inclusion criteria

Participants were included if they were male, were aged ≥ 30 years, were current smokers, had no significant respiratory symptoms at the time of enrollment, and were willing to undergo spirometric evaluation.

Exclusion criteria

Participants were excluded if they had discontinued smoking for more than one year before enrollment, a previous diagnosis of bronchial asthma, a history of regular bronchodilator or corticosteroid use, a known chronic respiratory disease, a known cardiac disease likely to influence respiratory function, or any other condition that could significantly interfere with spirometric assessment.

Sample size calculation

The sample size was calculated using the single population proportion formula:

$$n = \frac{Z_{1-\alpha/2}^2 p(1-p)}{d^2}$$

where n is the required sample size, $Z_{1-\alpha/2}$ is the Z-score corresponding to a 95% confidence level (1.96), p is the expected prevalence of spirometric airflow obstruction (0.125), and d is the absolute precision (0.025). Assuming an expected prevalence of 12.5%, a 95% confidence level, and an absolute precision of 2.5%, the minimum required sample size was calculated to be 673 participants. After adjusting for a potential 10% non-response rate or unusable spirometry results, the required sample size was increased to 748 participants. A total of 1,000 participants were included in the study to assess the prevalence of spirometric airflow obstruction.

Clinical and anthropometric assessment

A structured history was obtained from each participant. Demographic characteristics and smoking history were recorded. Height and weight were measured using standardized procedures, and BMI was calculated as weight in kilograms divided by height in meters squared.

Waist and hip circumferences were measured, and the waist-to-hip ratio was calculated. Baseline pulse rate was also recorded.

Smoking exposure was quantified using the smoking index. For cigarettes, the smoking index was calculated by multiplying the number of cigarettes smoked per day by the number of years of smoking. Participants were categorized into two groups according to a smoking index <200 or >200.

Information regarding household and biomass smoke exposure was also recorded, including exposure to liquefied petroleum gas, kerosene, and household smoke.

Spirometry

Participants were instructed to withhold bronchodilator medication for at least 12 hours before testing. Spirometry was performed by a trained technician using an RMS Helios Series 401/702 spirometer (Recorders & Medicare Systems Pvt. Ltd., Panchkula, India), in accordance with standardized American Thoracic Society (ATS)/European Respiratory Society (ERS) recommendations. The spirometer was calibrated daily using a certified 3-L syringe with an accuracy of ± 15 mL, following standard volume calibration techniques and the guidelines of the National College of Chest Physicians (NCCP) [7,8].

FVC, FEV1, and the FEV1/FVC ratio were recorded. At least three acceptable spirometric maneuvers and two reproducible measurements were obtained.

Post-bronchodilator spirometry was performed 15 minutes after administration of 400 μ g of salbutamol.

A post-bronchodilator FEV1/FVC ratio <0.70 was considered indicative of persistent airflow obstruction, in accordance with the GOLD diagnostic criterion [1].

Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 20.0 (Released 2011; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation, whereas categorical variables were expressed as frequencies and percentages.

The Student's t-test was used for comparison of continuous variables. The chi-square test or Fisher's exact test was used for categorical variables, as appropriate. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated where applicable. A p-value < 0.05 was considered statistically significant.

Airflow obstruction was graded according to GOLD spirometric criteria: GOLD 1 (mild), FEV1 $\geq 80\%$ predicted; GOLD 2 (moderate), FEV1 50%-79% predicted; GOLD 3 (severe), FEV1 30%-49% predicted; and GOLD 4 (very severe), FEV1 <30% predicted [1].

Results

This study highlighted the importance of early COPD diagnosis, as clinical features may be absent in the early stages of the disease. Therefore, a high index of suspicion is essential to facilitate early detection, as demonstrated by the findings presented below.

Age distribution

The study included 1,000 male smokers. The mean age was 43.9 ± 12.73 years. Of the total participants, 414 (41.4%) were aged 30-40 years, 341 (34.1%) were aged 40-50 years, 181 (18.1%) were aged 50-60 years, and

64 (6.4%) were aged >60 years (Table 1).

Age group	Number (%)
30-40 years	414 (41.4)
40-50 years	341 (34.1)
50-60 years	181 (18.1)
>60 years	64 (6.4)
Total	1,000 (100)

TABLE 1: Age distribution of study participants

Smoking exposure

A smoking index <200 was recorded in 737 (73.7%) participants, whereas 263 (26.3%) had a smoking index >200 (Table 2).

Smoking index	Number (%)
<200	737 (73.7)
>200	263 (26.3)
Total	1,000 (100)

TABLE 2: Distribution according to smoking index

Spirometric pattern

Among the 1,000 participants who underwent spirometry, 125 (12.5%) demonstrated an obstructive pattern and 875 (87.5%) had a non-obstructive pattern (Table 3).

Spirometric pattern	Number (%)
Obstructive	125 (12.5)
Non-obstructive	875 (87.5)
Total	1,000 (100)

TABLE 3: Spirometric pattern among study subjects

The prevalence of an obstructive spirometric pattern was therefore 12.5% (95% CI, 10.5%-14.6%).

Severity of airflow obstruction

Of the 125 participants with airflow obstruction, 121 (96.8%) had GOLD stage 1 airflow obstruction, and 4 (3.2%) had GOLD stage 2 airflow obstruction. No GOLD stage 3 or stage 4 cases were reported (Table 4).

GOLD stage	Number (%)
GOLD 1	121 (96.8)
GOLD 2	4 (3.2)
GOLD 3	0
GOLD 4	0
Total	125 (100)

TABLE 4: GOLD severity among participants with airflow limitation

GOLD: Global Initiative for Chronic Obstructive Lung Disease.

Association between smoking index and airflow obstruction

A marked difference in spirometric pattern was observed according to smoking index. Among participants with a smoking index <200, 10 (1.4%) had an obstructive pattern. Among participants with a smoking index >200, 115 (43.7%) had an obstructive pattern (Table 5).

Smoking index	Obstructive, n (%)	Non-obstructive, n (%)	Total	χ² (df)	p value
<200	10 (1.4)	727 (98.6)	737		
>200	115 (43.7)	148 (56.3)	263		
Total	125 (12.5)	875 (87.5)	1,000	318.13	<0.001

TABLE 5: Association between smoking index and spirometric pattern

The Pearson's chi-square test demonstrated a statistically significant association between smoking index and spirometric pattern (χ² = 318.13, df = 1, p < 0.001). The association was large in magnitude, with a phi coefficient of 0.564.

The mean smoking index among participants with an obstructive pattern was 334.7 ± 91.85 compared with 167.4 ± 68.43 among participants with a non-obstructive pattern.

Smoking duration

The mean duration of smoking among participants with an obstructive pattern was 27.61 ± 9.83 years compared with 23.74 ± 12.75 years among those with a non-obstructive pattern (Table 6). The statistical analysis reported this difference as statistically significant.

Variable	Obstructive (n = 125)	Non-obstructive (n = 875)	p-value
Smoking duration, years	27.61 ± 9.83	23.74 ± 12.75	0.006

TABLE 6: Relation between smoking duration and obstruction

Body mass index

Out of the 125 participants with obstruction, 9 (7.2%) had a BMI <18.5 kg/m², 89 (71.2%) had a BMI of 18.5-25 kg/m², and 27 (21.6%) had a BMI >25 kg/m². Among the 875 participants without obstruction, 34 (3.9%) had a BMI <18.5 kg/m², 636 (72.7%) had a BMI of 18.5-25 kg/m², and 205 (23.4%) had a BMI >25 kg/m² (Tables 7, 8).

BMI category	Obstructive, n (%)	Non-obstructive, n (%)
<18.5 kg/m²	9 (7.2)	34 (3.9)
18.5–25 kg/m²	89 (71.2)	636 (72.7)
>25 kg/m²	27 (21.6)	205 (23.4)
Total	125 (100)	875 (100)

TABLE 7: BMI distribution according to spirometric pattern
Pearson's chi-square test demonstrated no statistically significant association between BMI category and spirometric pattern.

Variable	Obstructive (n = 125)	Non-obstructive (n = 875)	p-value
BMI, kg/m²	22.83 ± 3.87	23.14 ± 4.15	0.506

TABLE 8: Relation between BMI and obstructive pattern
The mean BMI was 22.83 ± 3.87 kg/m² among participants with an obstructive pattern and 23.14 ± 4.15 kg/m² among those with a non-obstructive pattern. The reported difference was not statistically significant (p = 0.506).

Biomass exposure

Among participants with an obstructive spirometric pattern, 18 (14.4%) reported biomass exposure, while 107 (85.6%) did not.

Discussion

This prospective observational study evaluated spirometric airflow obstruction among 1,000 apparently asymptomatic male smokers in Northern India. The principal finding was that 125 participants (12.5%) had an obstructive spirometric pattern despite the absence of significant respiratory symptoms, as assessed using the modified Medical Research Council (mMRC) questionnaire and the COPD Assessment Test (CAT). Importantly, nearly all participants with airflow obstruction had mild disease according to the GOLD spirometric grading.

The finding that 12.5% of apparently asymptomatic smokers had airflow obstruction highlights the potential discrepancy between respiratory symptoms and physiological impairment. Smokers may develop measurable reductions in pulmonary function before symptoms become sufficiently prominent to prompt medical consultation. Consequently, relying exclusively on symptoms may delay the identification of individuals with early airflow limitation.

These findings are consistent with the broader epidemiological literature demonstrating a substantial burden of undiagnosed or unrecognized airflow limitation. The BOLD study reported considerable international variation in COPD prevalence and highlighted the importance of standardized post-bronchodilator spirometry in epidemiological studies [5]. Similarly, the BOLD study conducted in Kashmir demonstrated a substantial prevalence of chronic airflow limitation among adults in the region [6].

The present study focused specifically on male smokers without significant respiratory symptoms, distinguishing its population from the general populations assessed in the BOLD studies. Nevertheless, the findings support the possibility that spirometric abnormalities may be present in individuals who have not sought medical attention because of respiratory symptoms.

A particularly notable finding was the association between smoking exposure and airflow obstruction. Among the 263 participants with a smoking index >200, 115 (43.7%) had airflow obstruction, compared with 10 (1.4%) of the 737 participants with a smoking index <200. The estimated OR of 56.49 indicates a strong association between the higher smoking-index category and airflow obstruction in this study population.

The biological plausibility of this association is supported by extensive evidence identifying cumulative tobacco exposure as a major determinant of COPD risk. However, the magnitude of the observed OR should be interpreted in the context of the observational study design and the categorization of smoking exposure.

It should not be interpreted as evidence of a causal effect.

The mean smoking index was substantially higher among participants with airflow obstruction than among those without obstruction. Participants with obstruction also had a longer mean smoking duration. Together, these findings further support an association between cumulative tobacco exposure and physiological airflow limitation.

Another important observation was the predominance of mild airflow obstruction. Of the 125 participants with obstruction, 121 were classified as GOLD stage 1 and only 4 as GOLD stage 2; no participants had severe or very severe obstruction. This distribution is consistent with the study's focus on apparently asymptomatic smokers and suggests that airflow limitation was generally mild in this cohort.

Nevertheless, mild airflow obstruction should not automatically be equated with symptomatic or clinically established COPD in every individual. Diagnosis requires consideration of the clinical context, exposure history, alternative causes of airflow limitation, and appropriate interpretation of spirometric findings.

BMI was not significantly associated with spirometric pattern in this cohort, and mean BMI values were similar between participants with and without airflow obstruction. Although low BMI and nutritional depletion may occur in advanced COPD, this cohort predominantly comprised individuals with mild airflow limitation and no significant respiratory symptoms. The absence of a significant association may therefore reflect the characteristics of the study population and the predominance of mild disease [11].

Similarly, biomass exposure was not significantly associated with spirometric pattern in the reported analysis. This finding should be interpreted cautiously because biomass smoke is a recognized respiratory risk factor, particularly among populations with prolonged household exposure. The relatively small number of participants with airflow obstruction who reported biomass exposure may have limited the study's ability to detect an association [12].

The clinical importance of identifying airflow obstruction early lies primarily in the opportunity to modify risk factors. Smoking cessation remains the most important intervention for smokers at risk of COPD. The Lung Health Study demonstrated that smoking cessation was associated with an initial improvement in FEV1 and a slower subsequent decline in lung function compared with continued smoking [9]. Identifying airflow obstruction in smokers may therefore provide an opportunity to reinforce smoking-cessation counselling and other preventive measures.

The findings also suggest a potential role for spirometry in the targeted respiratory assessment of smokers. However, universal spirometric screening of completely asymptomatic populations remains controversial, and these results do not establish that every asymptomatic smoker should undergo spirometry. Rather, the findings suggest that individuals with substantial cumulative tobacco exposure may be an important group for targeted assessment, particularly when clinical evaluation indicates an increased likelihood of airflow limitation.

Limitations

The study also has important limitations. First, its observational design limits the ability to establish causal relationships. Second, the study included only male smokers aged ≥ 30 years, limiting the generalizability of the findings to women, never-smokers, former smokers, and younger individuals. Third, the study was conducted at a single medical institution and within its associated community catchment area, which may limit the generalizability of the findings to other regions of India. Fourth, airflow obstruction was defined using a fixed post-bronchodilator FEV₁/FVC ratio of <0.70 was used to define airflow obstruction. Although this criterion is consistent with the GOLD recommendations, the fixed ratio may result in age-related misclassification, particularly among older adults. Finally, the available data did not provide detailed information on the distribution of participants between hospital-based and community-based recruitment sites. Consequently, separate prevalence estimates for these two settings could not be calculated.

Conclusions

In this cohort of 1,000 apparently asymptomatic male smokers from Northern India, 12.5% demonstrated spirometric airflow obstruction, with the majority having mild airflow limitation. Higher cumulative smoking exposure and longer smoking duration were associated with the presence of airflow obstruction, whereas BMI and biomass exposure were not significantly associated with spirometric pattern in the available analysis.

The findings demonstrate that clinically relevant physiological airflow abnormalities may be present in smokers before the development of prominent respiratory symptoms. Targeted spirometric assessment of smokers with substantial cumulative tobacco exposure may therefore facilitate earlier identification of airflow limitation and provide an opportunity for smoking cessation and other preventive interventions. Longitudinal studies are required to determine whether individuals with asymptomatic mild airflow

obstruction progress to clinically significant COPD and to establish the long-term clinical implications of early spirometric abnormalities in this population.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Abir Aijaz, Judat Tasawoor, Elena Khalid, Manzoor Wani, Shuhaab Shah

Acquisition, analysis, or interpretation of data: Abir Aijaz, Judat Tasawoor, Maryam Pervez, Mariya Manzoor, Nadia Islam, Hajra Khanan

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Supervision: Abir Aijaz, Judat Tasawoor, Elena Khalid, Shuhaab Shah

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Government Medical College (GMC) SRINAGAR issued approval N/A. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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Judat Tasawoor, Elena Khalid, and Maryam Pervez contributed equally and should be considered joint first authors alongside Abir Aijaz.

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