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Impact Of Tobacco Smoking On Lung Morphology: A Comparative Analysis Of Chest Radiography And Ct Scan Findings In Smokers

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ABSTRACT

Tobacco smoke is a major contributor to respiratory diseases such as chronic bronchitis, bronchial cancer, emphysema, and respiratory bronchiolitis-associated interstitial lung disease (RB-ILD). This study aimed to evaluate the correlation between smoking and lung changes using chest radiographs and CT scans. A prospective cohort of 200 clinically stable smokers from PSP Medical College and Hospital, Chennai, was analyzed over a 3-month period. Chest radiographs and CT scans were performed simultaneously, and patients with pneumonia, sarcoidosis, extrinsic allergic alveolitis, lymphangiosis carcinomatosa, or silicosis were excluded. The revised ILO classification system was applied to evaluate lung markings. The results revealed that 63% of patients exhibited bronchial wall thickening, and 22% had an increase in linear patterns on chest radiographs. Moderate and severe emphysema were observed in 30% and 21% of patients, respectively. CT scans revealed bronchial opacities in 62%, emphysema in 64%, and thickened bronchial walls in 64%. Intriguingly, small airway disease and the resulting intralobular opacities were identified as significant contributors to increased lung markings. The study found a significant relationship between tobacco consumption and lung changes, particularly emphysema and intralobular opacities, highlighting the effectiveness of chest radiographs and CT scans in early detection. Despite the small sample size, these preliminary results underscore the impact of smoking on lung morphology and emphasize the need for further research with larger sample sizes and more refined methodologies.

Keywords: *Tobacco smoke, chronic bronchitis, emphysema, RB-ILD, chest radiograph, CT scan, smoking, lung markings, ILO classification, small airway disease*

1. INTRODUCTION

Tobacco smoke is known to contribute to a variety of respiratory issues, including chronic bronchitis, bronchial cancer, and emphysema. Specifically, respiratory bronchiolitis-associated interstitial lung disease (RB-ILD), caused by smoking, affects the alveoli and walls of the respiratory bronchioles. Patients with this condition often exhibit a "dirty chest" on chest radiographs, characterized by a proliferation of non-specific lung markings. A similar radiographic pattern, linked to cigarette smoking, was observed in a study of coal miners with anthracosilicosis [1,2]. Consequently, the ILO classification system could be useful in quantifying smoking-induced lung changes. This study further explores the correlation between increased lung markings on chest radiographs and cigarette smoking, as well as the relationship between chest radiograph scores and CT scan findings. To our knowledge, this analysis has not been previously documented in clinical research.

Over a 3-month period, a prospective cohort of smokers was analyzed in the Radiology Department at PSP Medical College and Hospital, Chennai. Chest radiography and CT scans were performed simultaneously within one week of each other to establish a diagnosis. The study included all clinically stable patients, with those suffering from pneumonia excluded to avoid misinterpretation of parenchymal changes due to acute infectious processes. In addition, patients with sarcoidosis, extrinsic allergic alveolitis, lymphangiosis carcinomatosa, and silicosis were also excluded. The study was approved by a local ethics committee, and informed consent was obtained from all participants. A total of 200 patients were enrolled during the observation period, and their demographic data and clinical features are provided in Table 1.

Table 1: Demographic data, indication, and smoking habit of the 200 enrolled patients

Age (years)	30			
Age (years), range	28–44			
Gender				
Male, *n* (%)	122			
Female, *n* (%)	78			
Indication, *n* (%)	Suspected malignancy: 42 (21%)	Pulmonary embolism: 44 (22%)	Staging: 82 (41%)	Others: 44 (22%)
Cigarette consumption, *n*	<40 py:88 (44%)	40–<80 py: 72 (36%)	80–<120 py: 26 (13%)	≥120 py: 14 (7%)

Assessment of Chest Radiograph and CT

Bronchial walls exhibited thickening, along with linear or nodular opacities. Using semi-quantitative techniques, emphysema was classified as mild, moderate, or severe. The study focused on evaluating the overall increase in lung markings based on the revised ILO classification of chest radiographs. A profusion score of 0/1 was categorized as 0, a profusion score of 1/1 as 1, and a profusion score of 2/1 as 3. CT scans were reviewed by chest radiologists and radiology residents, with analyses performed to detect lung opacification, lung attenuation, and bronchial malformations. Airways with thick walls were defined as having diameters greater than 2 mm or being visible as 1 cm from the pleura. Based on high-resolution CT (HRCT) images, as published in a related study, two readers categorized chronic bronchitis as moderate or severe, with severity determined by the thickness of the bronchial walls and airway walls.

Emphysema signs were identified by a reduction and thinning of pulmonary vessels. Areas with attenuation and approximately 1 cm in diameter were surrounded by homogeneous lung parenchyma, typical of circulating emphysema. Panlobular emphysema, characterized by uniform low attenuation levels within panlobules, was also identified during this period. Increased lung opacification was characterized by attenuation, consolidation, or reticular opacities. Consolidations obscured the pulmonary vessels, unlike ground-glass opacification. The extent of thickening influenced whether reticular opacities appeared intralobularly or interlobularly. Interlobular septal thickening, extending to the pleural surface, was identified as a linear opacity in the lung periphery. The thickened interlobular septa created 12 polygonal lobules in diameter.

Intralobular septal thickenings were classified as interlobular septal thickenings when they did not conform to reticulation patterns. The alveolar walls were thickened, showing respiratory bronchial abnormalities along with other irregularities. Fine, irregular lines in intralobular tissues were visible to the naked eye. Additionally, a micronodule of approximately 5 mm in diameter, with a sharp, ill-defined, centrilobular or subpleural appearance, was recognized. This feature, previously categorized as intralobular lines, was renamed as intralobular opacities.

Statistical Evaluation

This study investigated the relationship between smoking habits and the increase in lung markings on chest radiographs using a linear regression model. The correlation between smoking status and the presence of emphysema, thickened bronchial walls, and increased linear patterns on both chest radiographs and CT scans was analyzed. A significance level of $p<0.05$ was considered statistically significant.

2. RESULTS

Chest Radiography

In our study, 126 out of 200 (63%) patients exhibited bronchial wall thickening due to cigarette consumption, with a statistically significant association ($p < 0.05$). Additionally, 44 of the 200 patients (22%) had an increase in linear structures. A significant difference was observed between smokers with and without 20 pack-years ($\chi^2 = 5.4$, $p < 0.01$). Among the study participants, 60 out of 200 (30%) had moderate emphysema, while 42 out of 200 (21%) exhibited severe emphysema. The odds of developing severe emphysema were significantly higher for heavy smokers with ≥60 pack-years, with 12 out of 18 (67%) affected. This group showed a marked difference from moderate smokers with 20 pack-years ($\chi^2 = 9.7$, $p < 0.05$) and smokers with 20–40 pack-years ($\chi^2 = 7.0$, $p < 0.05$).

Of the 200 patients, 126 (63%) showed an increase in lung markings, while 74 patients (37%) had normal lung parenchyma. Among the smokers, 32 patients (37%) had increased lung markings, with most smoking between 10–20 pack-years (n = 32), and 24 patients (28%) smoked more than 40 pack-years. Among heavy smokers (≥40 pack-years), only 8 patients had a profusion score of 1/100 or higher. The ILO scores of 62 patients (31%) ranged from 1/1 to 1/1. Among these, 56 (28%) had smoked 20 or more pack-years, while three (1.5%) had smoked more than 20 pack-years. The highest profusion score observed was 2/2, seen in heavy smokers with more than 60 pack-years (89%). Chest radiography findings are summarized in **Table 2.**

CT Findings

In the CT scans, bronchial opacities were the most common finding, observed in 124 of 200 patients (62%), followed by emphysema (128 patients, 64%) and thickened bronchial walls (128 patients, 64%). Approximately 39% of patients exhibited smooth nodules and thickened septa in their lobes, often accompanied by a prominent interlobular septum. Only 6% of patients had thickened interlobular septa without thickened intralobular septa. Among smokers with moderate and heavy pack years, bronchial wall thickening was not significantly different. There was a high rate of intralobular opacities (44%) in smokers with 40–60 pack-years. The group smoking over 20 pack-years showed a statistically significant difference in the presence of intralobular opacities ($\chi^2 = 5.6$, $p < 0.01$). Ground-glass opacity and subpleural micronodules did not exhibit significant associations with smoking habits. **CT findings are presented in Table 3.**

Table 2: Findings in chest radiography correlated with cigarette consumption

Findings in Chest Radiography	**Cigarette Consumption (Pack-Years)**
	<40
Bronchial Wall Thickening	56 (28%)
Linear Pattern	8 (4%)
Overall Marking Score	
0	0 (0%)
1	1 (0.5%)
2	9 (4.5%)
3	10 (5%)
8	48 (24%)
10	8 (4%)
12	8 (4%)
Emphysema	
Moderate	52 (26%)
Severe	20 (10%)
Total	72 (36%)

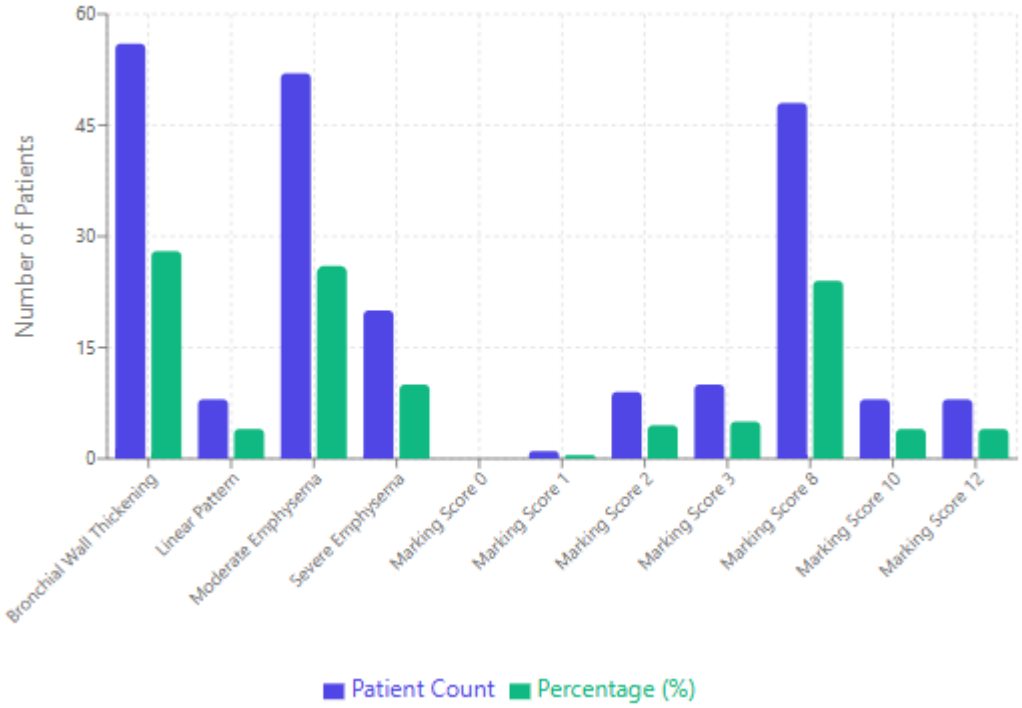

Figure 1. Chest radiography Findings in cigarette smokers

CT findings

In CT scans, bronchialogenic opacities were most common (62%), followed by emphysema (64%), and thickened bronchial walls (64%). Approximately 39% of patients exhibit smooth nodules and thickened septa in their lobes. This was often accompanied by a prominent interlobular septum. Patients with thickened interlobular septums but not thickened intralobular septums accounted for only 6% of the cases. In smokers with moderate and heavy pack years, bronchial wall thickening was not significantly different. There is a high rate of intralobular opacities among smokers who consume 40 to 60 packs per year. Patients who smoked over 20 packs of cigarettes a year were found to have intralobular opacities on nearly half of their CT scans. The 20 year group showed statistically significant differences ($\chi 2=5.6$, $p<0.01$). Ground-glass opacity and subpleural micronodules were not associated with significant differences in smoking habits.

Table 3: Findings in CT correlated with the cigarette consumption

CT Findings	**Cigarette Consumption (Pack-Years)**
	<40
Intralobular	68 (34%)
Interlobular	120 (60%)
Micronodule	8 (4%)
Gravel	4 (2%)
Thickness of the Respiratory Tract Wall	40 (20%)
Asthma	26 (13%)

3. DISCUSSION

The health risks associated with cigarette smoke remain prevalent in Western countries, even with the decline of industries like coal and steel [5]. Numerous studies have linked tobacco smoke exposure to respiratory diseases and cancer [5,6]. Smoking-induced respiratory conditions, such as "smokers' bronchiolitis," predominantly affect smokers, and altered CT findings due to emphysema or bronchial wall changes have received less attention compared to chronic bronchitis or chronic

RB-ILD [7,8]. As a result of smoking, a greater number of lung markings appear on chest radiographs, a phenomenon that has been well-documented in previous literature [9,10]. The presence of minimal lung parenchyma in smokers has been confirmed in several studies, with abnormal chest radiographs observed in 75% of cases of RB-ILD [11,12]. Chest radiographs often show thickened bronchial walls in approximately 75% of RB-ILD patients [13], and reticulonodular patterns are present in two out of ten patients with RB-ILD [22]. Our study found that among smokers with more than 20 pack-years of consumption, only eight (15%) had a reticular pattern with ILO score 0/1.

Tobacco smoke's effects on lung health are often underestimated, and the growth of lung tissue has never been demonstrated through chest radiographs. Furthermore, chest radiographs and HRCT scans do not aid in diagnosing or managing chronic obstructive pulmonary disease (COPD) [13-16]. However, CT scans are instrumental in distinguishing between different COPD phenotypes, such as airway disease and emphysema, and can guide appropriate treatment plans. A study of 98 asymptomatic smokers using HRCT detected micronodules and mild emphysema, with follow-up of 57 smokers over 5.5 years revealing emphysematous changes and ground-glass opacities in 40% of the cases. Micronodules with poor definition were common in many cases. Numerous CT findings have been associated with RB-ILD, including atelectasis, ground-glass opacities, and distortions of linear and reticular structures, as described by Holt et al. Their research found that smokers and ex-smokers presented with thickened bronchial walls in 76% of cases and ground-glass opacities in 57% [7]. Furthermore, a significant 90% of patients had thickened central and peripheral bronchial walls, while 71% exhibited nodules and 67% showed opacities. Centrilobular opacities were observed in 61% of patients, while ground-glass opacities were found in only 7%.Our results are consistent with these findings, with nearly 90% of chest radiographs and 95% of CT scans revealing emphysema, despite a high prevalence of heavy smoking. Studies have demonstrated that both chest radiographs and CT scans are effective in detecting emphysema early. Among these modalities, HRCT offers superior sensitivity and specificity in identifying emphysema when compared to functional tests. However, our study suggests that chest radiography may be just as reliable as CT in detecting emphysema in certain cases. The study sample in our research exhibited a relatively low rate of early emphysema, which may have influenced the results.

4. CONCLUSION

In conclusion, the findings from our study indicate a significant association between tobacco consumption and the presence of emphysema and intralobular opacities on CT scans. Small airway disease is likely a key underlying cause of the increased intralobular opacities and lung markings seen on chest radiographs. Although the sample size was small, which limits the generalizability of the results, these preliminary findings provide valuable insights into the effects of smoking on lung morphology. Additionally, the study design did not allow for comparison between smokers and non-smokers of the same age, due to the nonspecific nature of lung markings on chest radiographs. Moreover, the results were not verified through a gold-standard histological examination, and invasive investigations were not warranted. Interpretation bias in CT scans, especially in diagnosing interstitial lung disease, may also have impacted the findings. The ability to detect subtle abnormalities could be improved by enhancing the definition of inspiration conditions in future studies. Given the preliminary nature of these results, further research with larger sample sizes and refined methodologies is necessary to confirm these findings.

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