Section: Respiratory Medicine

Original Research Article

UTILITY OF DIFFUSING LUNG CAPACITY FOR CARBON MONOXIDE IN COPD PATIENTS

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is characterized by persistent airflow limitation, but spirometry alone may not adequately reflect alveolar–capillary dysfunction or overall disease severity. Diffusing capacity of the lung for carbon monoxide (DLCO) provides additional information regarding gas transfer and may complement conventional spirometric assessment. The aim is to evaluate the utility of DLCO in assessing pulmonary function and grading disease severity among patients with COPD.

Materials and Methods: An observational cross-sectional study was conducted in the Department of Respiratory Medicine, Heritage Institute of Medical Sciences, Varanasi, from August 2024 to January 2026. A total of 110 patients aged >40 years with COPD diagnosed according to GOLD 2024 criteria were included. Patients with other respiratory diseases, acute exacerbation, or inability to perform pulmonary function testing were excluded. All participants underwent clinical assessment, chest radiography, spirometry, and single-breath DLCO measurement according to ATS/ERS recommendations. DLCO was expressed as percentage predicted and categorized as normal, mildly reduced, moderately reduced, or severely reduced. Data were analyzed using SPSS version 25, with $p<0.05$ considered statistically significant.

Results: The mean age of participants was 62.4 ± 10.81 years. Mean FEV_1 was 58.9 ± 16.76% predicted, while mean DLCO was 63.07 ± 18.04% predicted, indicating impaired diffusion capacity in a substantial proportion of patients. Significant differences were observed among DLCO, alveolar volume (VA), and KCO ($F=852.22$, $p<0.001$; partial $\eta^2=0.89$). Chest radiographic changes suggestive of COPD were present in 74.5% of patients.

Conclusion: DLCO demonstrates clinically important impairment among patients with COPD and provides additional physiological information beyond conventional spirometry and chest radiography. Incorporation of DLCO, together with VA and KCO, may improve characterization and assessment of COPD severity, particularly when clinical symptoms and spirometric findings are disproportionate.

Keywords: COPD; DLCO; pulmonary function; spirometry; FEV_1; alveolar volume; KCO; disease severity.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common chronic respiratory disorder characterized by persistent airflow limitation and respiratory symptoms resulting from abnormalities of the airways and/or alveoli. The disease is associated with progressive impairment of pulmonary function and considerable morbidity and mortality. Although cigarette smoking remains an important risk factor, COPD may also occur among non-smokers because of exposure to biomass smoke, environmental air pollution, occupational hazards and previous respiratory infections, particularly in developing countries such as India.[1,2]

Spirometry, particularly forced expiratory volume in one second (FEV_1), is routinely used for the diagnosis and assessment of airflow limitation in COPD. However, the degree of airflow obstruction does not always reflect the extent of structural and functional abnormalities within the lung. Patients with similar spirometric impairment may have substantially different abnormalities in gas exchange, emphysema and pulmonary vascular involvement. Consequently, assessment based solely on spirometric parameters may not provide a complete picture of disease severity.[3–5]

The diffusing capacity of the lung for carbon monoxide (DLCO) is a pulmonary function parameter that reflects the ability of the lungs to transfer gas from the alveolar space into the pulmonary capillary blood. Impairment of DLCO may result from loss of alveolar-capillary surface area, destruction of pulmonary capillary beds and abnormalities in pulmonary vascular blood volume. Thus, DLCO may provide information regarding physiological impairment that is not captured by conventional spirometry.[5,6]

Reduced DLCO has been reported across different stages of COPD and has been associated with greater disease severity and adverse clinical outcomes.[3–5,7,8]. In addition, DLCO-related indices have been investigated for their ability to identify pulmonary hypertension and predict mortality in patients with COPD.[9–11] These observations suggest that diffusion capacity may have an important role not only in characterizing pulmonary impairment but also in assessing the clinical and prognostic burden of COPD.

Despite its potential clinical value, DLCO is not routinely incorporated into the assessment of disease severity in all patients with COPD. Furthermore, the relationship between DLCO and conventional measures of airflow limitation may vary because COPD is a heterogeneous disease involving different combinations of airway, alveolar and vascular abnormalities. Therefore, evaluating DLCO along with spirometric parameters may provide a more comprehensive assessment of functional impairment. The present study was undertaken to assess the utility of DLCO in evaluating disease severity among patients with COPD and to examine its relationship with conventional pulmonary function parameters, including FEV_1 and FVC. The study also evaluated alveolar volume (VA) and the transfer coefficient for carbon monoxide (KCO) to provide further insight into the components contributing to impaired pulmonary gas transfer.

MATERIALS AND METHODS

Study Design and Setting: This observational cross-sectional study was conducted in the Department of Respiratory Medicine, Heritage Institute of Medical Sciences (HIMS), Varanasi, Uttar Pradesh. The study was carried out over a period of 18 months, from August 2024 to January 2026. Institutional Ethical Committee approval was obtained before initiation of the study.

Study Population and Sample Size: The study included patients with COPD attending the Respiratory Medicine outpatient department during the study period. Consecutive eligible patients were approached using a convenience sampling method. A total of 110 patients were enrolled. The sample size was calculated using the formula:

$n = Z^2 \times P \times (1 - P) / d^2$

with a Z value of 1.96 for a 95% confidence interval; the minimum calculated sample size was 110.

Inclusion Criteria

Patients were included if they:

1. >40 years of age.
2. Had a confirmed diagnosis of COPD according to GOLD 2024 criteria.
3. Provided written informed consent for participation.

Exclusion Criteria

Patients were excluded if they had:

1. Co-existing respiratory diseases other than COPD, including asthma, interstitial lung disease, bronchiectasis, or other chronic pulmonary disorders.
2. Acute exacerbation of COPD at the time of evaluation.
3. Inability or unwillingness to cooperate with the study procedures, including bedridden patients.
4. Inability to perform adequate spirometry or DLCO testing because of clinical limitations.

Data Collection and Clinical Assessment: After obtaining informed written consent, eligible participants underwent a structured clinical assessment. Information regarding age, symptoms, smoking status and comorbidities was recorded. General and respiratory examinations were performed, and baseline measurements including height, weight, pulse rate, blood pressure, respiratory rate, temperature and resting oxygen saturation (SpO_2) were documented.

Pulmonary Function and Radiological Assessment:

All participants underwent posterior–anterior chest radiography, spirometry and DLCO measurement. Spirometry was used to assess FEV_1, FVC and FEV_1/FVC. DLCO was measured using the single-breath technique according to ATS/ERS recommendations. The pulmonary function tests were performed with the assistance of trained respiratory technicians, and the equipment was calibrated daily. Participants unable to perform acceptable maneuvers despite repeated attempts were excluded.

The pulmonary function variables recorded included FEV_1, FVC, FEV_1/FVC ratio, DLCO, alveolar volume (VA), and KCO where applicable.

DLCO was expressed as percentage of the predicted value and categorized as follows:

DLCO (% predicted)	Classification
>80%	Normal
60–80%	Mild reduction
40–60%	Moderate reduction
<40%	Severe reduction

These DLCO categories were compared with spirometric parameters to assess their utility in grading COPD severity.

Data Management and Statistical Analysis: Data were recorded using a structured proforma containing demographic characteristics, clinical findings, physical examination findings and investigation results. Spirometry and DLCO results were recorded from digitally generated machine outputs.

Statistical analysis was performed using SPSS. Continuous variables were summarized using mean and standard deviation, while categorical variables were expressed as frequencies and percentages.

Ethical Considerations: The study was initiated only after obtaining Institutional Ethical Committee clearance. Eligible participants were informed about the study objectives and procedures in their preferred language, and written informed consent was obtained before enrolment.

RESULTS

A total of 110 COPD patients were included. Most patients were aged ≥50 years, and 70.9% were smokers. Hypertension was the most common comorbidity (59.1%). Based on FEV_1, 47.3% had moderate, 26.4% severe, 14.5% very severe, and 11.8% mild airflow limitation (p = 0.007). DLCO was severely reduced in 30.0%, moderately reduced in 22.7%, mildly reduced in 25.5%, and normal in 21.8% of patients (p < 0.001). The mean DLCO was 57.61 ± 22.44% predicted, while mean VA was 4.96 ± 0.91 L and mean KCO was 82.50 ± 12.49% predicted. Overall, the findings indicate that reduced DLCO was common among COPD patients and may provide additional information for assessment of disease severity.

Table 1: Baseline demographic and clinical characteristics of COPD patients (N = 110)

Variable	Category	n	%
Age (years)	<40	0	0.0
	40–49	12	10.9
	50–59	27	24.5
	60–69	28	25.5
	70–79	24	21.8
	≥80	19	17.3
BMI (kg/m²)	Underweight	17	15.5
	Normal	30	27.3
	Overweight	30	27.3
	Obese	33	30.0
Smoking status	Smoker	78	70.9
	Non-smoker	32	29.1
Comorbidity	Hypertension	65	59.1
	Diabetes mellitus	23	20.9
	Hypertension + diabetes	22	20.0

Table 2: Distribution of spirometric parameters according to severity (N = 110)

Parameter	Category	n	%	Statistical finding
FEV_1 (% predicted)	<30% (Very severe)	16	14.5	Mean FEV_1: 58.9 ± 16.76% predicted
	30–49% (Severe)	29	26.4	
	50–79% (Moderate)	52	47.3	
	≥80% (Mild)	13	11.8	
	Overall	110	100.0	p = 0.007*
FVC (% predicted)	<50%	26	23.6	
	50–79%	58	52.7	
	≥80%	26	23.6	

Table 3: Distribution of DLCO according to degree of impairment (N = 110)

DLCO (% predicted)	Degree of impairment	n	%	
<40%	Severe reduction	33	30.0	p <0.001*
40–59%	Moderate reduction	25	22.7	
60–79%	Mild reduction	28	25.5	
≥80%	Normal	24	21.8	
Total		110	100.0	

Table 4: Distribution of alveolar volume (VA) (N = 110)

VA (L)	n	%
<3.0	0	0.0
3.0–3.9	27	24.5
4.0–4.9	29	26.4
≥5.0	54	49.1
Total	110	100.0

Mean VA: 4.96 ± 0.91 L

Table 5: Distribution of KCO (% predicted) (N = 110)

KCO (% predicted)	n	%
<40%	0	0.0
40–59%	0	0.0
60–79%	46	41.8
≥80%	64	58.2
Total	110	100

Mean: 82.50 ± 12.49%

Table 6: Relationship between chest X-ray findings and COPD severity (N = 110)

COPD severity	X-ray changes present, n (%)	X-ray changes absent, n (%)	Total
Severe	19 (57.6)	14 (42.4)	33
Moderate	20 (80.0)	5 (20.0)	25
Mild	24 (85.7)	4 (14.3)	28
Normal	19 (79.2)	5 (20.8)	24
Total	82 (74.5)	28 (25.5)	110

Table 7: Comparison of DLCO, VA and KCO with repeated-measures ANOVA

Parameter	Mean ± SD	Median	Range
DLCO (% predicted)	57.61 ± 22.44	55.5	20–95
VA (L)	4.96 ± 0.91	4.97	3.53–6.47
KCO (% predicted)	82.50 ± 12.49	83.35	60.5–100

DISCUSSION

In the present study, most patients were older than 50 years, with the largest proportion in the 60–69-year age group (25.5%). COPD is commonly seen in older individuals because of cumulative exposure to risk factors and progressive changes in lung function with age. The majority of patients were smokers (70.9%), supporting the important role of tobacco exposure in COPD. However, the presence of COPD among non-smokers also suggests a possible contribution of other factors such as biomass smoke, environmental pollution and previous respiratory infections, particularly in the Indian setting.[1,2]

Regarding spirometry, 47.3% of patients had moderate airflow limitation, followed by severe (26.4%), very severe (14.5%) and mild (11.8%) obstruction. The mean FEV_1 was 58.9 ± 16.76% predicted, indicating moderate airflow obstruction overall. These findings show that the study population had a wide range of spirometric severity. However, spirometry mainly reflects airflow obstruction and may not adequately represent abnormalities in gas exchange or alveolar-capillary function. Previous studies have similarly reported that DLCO can provide additional information beyond FEV_1 in COPD.[3–5]

A major finding of the present study was the high frequency of DLCO impairment. Severe reduction in DLCO was observed in 33 patients (30.0%), moderate reduction in 25 (22.7%), mild reduction in 28 (25.5%), while only 24 (21.8%) had normal DLCO. The mean DLCO was 57.61 ± 22.44% predicted, indicating substantial impairment of gas-transfer capacity. This finding supports the importance of DLCO in COPD assessment, as reduced DLCO reflects abnormalities at the alveolar-capillary level that may not be completely explained by airflow obstruction. Previous studies have also reported that lower DLCO is associated with greater COPD severity and adverse clinical outcomes.[5,7,8]

The VA findings showed that almost half of the patients (49.1%) had VA ≥5.0 L, with a mean VA of 4.96 ± 0.91 L. In contrast, KCO was relatively preserved, with 58.2% of patients having KCO ≥80% predicted and a mean KCO of 82.50 ± 12.49% predicted. The difference between DLCO, VA and KCO was highly significant ($F = 852.22$, $p < 0.001$; partial $\eta^2 = 0.89$). This suggests that the reduction in overall DLCO may not be explained only by reduced alveolar volume. Loss of alveolar surface area and pulmonary capillary blood volume may also contribute to impaired diffusion in COPD.[5,6]

Chest X-ray abnormalities suggestive of COPD were present in 74.5% of patients. However, there was no statistically significant association between chest X-ray findings and COPD severity ($\chi^2 = 7.51$, $p = 0.057$). Interestingly, the thesis also found that the absence of chest X-ray changes was associated with higher odds of severe COPD (OR = 3.49, $p = 0.008$). This finding suggests that radiographic changes on plain chest X-ray may not accurately reflect the extent of physiological impairment. Similar observations have emphasized the limitations of plain

radiography compared with physiological assessment and HRCT.[5,12]

The clinical importance of reduced DLCO is further supported by previous studies. Lower DLCO has been associated with increased mortality and poorer outcomes in COPD, even after adjustment for conventional spirometric measures.[7,8]. Studies have also shown that DLCO-related indices such as FVC/DLCO and FEV_1/DLCO may help identify pulmonary hypertension and predict mortality.[9,10] Although pulmonary hypertension was not directly assessed in the present study, these findings support the possibility that reduced DLCO may reflect both alveolar and pulmonary vascular abnormalities in COPD.

Overall, the present findings indicate that DLCO provides additional information beyond conventional spirometry and chest radiography. A considerable proportion of patients had significant diffusion impairment despite predominantly moderate airflow obstruction, highlighting the heterogeneous nature of COPD. Therefore, incorporating DLCO into pulmonary function assessment may help provide a more complete evaluation of disease severity and gas-exchange impairment.

CONCLUSION

DLCO impairment was common among COPD patients and provided important information beyond spirometry. DLCO may therefore be a useful complementary parameter for assessing disease severity and gas-exchange impairment in COPD, particularly when spirometric findings do not fully reflect the extent of functional impairment.

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