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Original Research Article

Diffusing Capacity of the Lung for Carbon Monoxide and Its Clinical Correlates in Chronic Obstructive Pulmonary Disease

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Abstract

Background: Diffusing capacity for carbon monoxide (DLco) of lung, is a important index of gas exchange as it provides physiological severity which is distinct from spirometry. DLCO is not routinely included for COPD assessment. dlco itself is an important prognostic marker for assessment of disease severity, treatment response, clinical follow up.

Objective: To study diffusion capacity of lung for carbon monoxide in patients with COPD and to assess severity of these diseases.

Methods: This hospital-based cross-sectional study included 33 treatment-naive adults with COPD from March 2025 to February 2026.After a thorough history, general examination and systemic examination subjects were evaluated by Blood test, CXR, HRCT, spirometry, DLCO and 6MWT.

Results: Among 33 COPD patients, 27 were diagnosed as emphysema and 6 chronic bronchitis cases. males were 25(75.7%) 8 (24.2%) were females.79% smokers while 6% non-smokers, and 15% were former smokers. Mean pack years was 36.39 ± 7.7. The predominant symptom was cough and SOB observed in 100%, 60.4% had wheeze, 42.4% had chest pain, and 72.7% had fever. Mean DLCO level for 20-30 pack yrs group was 72.88 ± 25.17, while for 30-40 pack yrs was 56.07 ± 15.77 and for 40-50 pack yrs was 45.00 ± 7.27.9% had mild, 42% had moderate, 18% had normal and 30% had severe DLCO. 6% mild obstruction, while 58% moderate and 33% severe obstruction. 1(3%) patient has normal spirometry. Mean FEV1/FVC was 53.52 ± 6.71, mean FEV1(%) was 55.42 ± 11.56, while mean FVC was 74.15 ± 8.61. Mean DLCO for mild division was 85.71 ± 29.12 while for moderate division was 58.50 ± 15.28 and for severe mean DLCO was 41.13 ± 12.02. One COPD patient with normal spirometry has DLCO value of 56.

Conclusion: D_{LCO} can be indicated in morbidity assessment, a low D_{LCO} is seen in cases with increased symptomatology and low exercise capacity. DLCO below 40% predicted may qualify a patient for total disability and as an indication to assess if the patient needs oxygen therapy. DLCO integration into the clinical workup provides a more comprehensive assessment in patients with COPD and will help plan strategies for disease management.

Keywords: Diffusing capacity for carbon monoxide (DLco), Chronic Obstructive Pulmonary Disease (COPD), Spiromerty.

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Introduction

Spirometry gives the information about airflow, lung volumes, response to bronchodiators widely included for diagnosing and monitoring of respiratory dieases. Spirometry cannot give information about gas exchange where DLCO plays a key role to calculate the gas exchange at alveolar & capillary level. [1] Carbon monoxide (CO) binds strongly to hemoglobin (Hb) making diffusion the sole limiting factor for CO uptake [2]. The rate of CO transfer from alveoli to pulmonary capillaries can be assessed & used as a robust indicator for oxygen transfer.[3] Single-breath lung diffusing capacity for carbon monoxide (DLCO) measurement provide an integrated information of the complex mechanisms involved in the transfer of oxygen from atmospheric air to lung capillaries. [4] COPD is a heterogeneous lung disease characterized by chronic respiratory symptoms due

to abnormalities of the alveoli (emphysema) or airways (bronchitis) which that causes progressive persistent airflow obstruction.[5] Tobacco smoking and the inhalation of toxic particles, gases from household or occupation and outdoor air pollution are The main environmental exposures leading to COPD. [6]

Worldwide Chronic obstructive pulmonary disease (COPD) is the third leading cause of death which affects nearly 328 million people. [7] To evaluate the severity of COPD, a number of measurements are required. Spirometry is widely used for COPD assessment, including forced expiratory volume during the first second (FEV1), forced vital capacity (FVC), and the ratio (FEV1/FVC). For multidimensional evaluation, of copd - spirometry measures are added upon by assessment of symptoms, risk of exacerbations, CT imaging of emphysema as a quantitative assessment. [8,9] However, the measurement of diffusing capacity of the lung for carbon monoxide (DLCO) a noninvasive and widely available tool is not included in commonly used prognostic models of COPD assessment.

Aim & Objective: To asses diffusion capacity of lung for carbon monoxide in patients with COPD and to assess severity of the disease.

Patients and Methods: The present study was cross sectional prospective observational study conducted in the department of pulmonary medicine, Kakatiya Medical College, Warangal, Telngana from March 2025 to february 2026. A total of 33 subjects with chronic respiratory diseases like COPD. Who were fulfilling the inclusion criteria were taken in the study. Approval of ethics committee of the institute was taken prior to the study. Subjects were explained about the study and procedures in their native language and a well-informed, written consent was obtained. After a thorough history, general examination and systemic examination subjects were evaluated by Blood test, CXR, HRCT, spirometry, DLCO and 6MWT.

Inclusion Criteria

1. Diagnosed and presumptive cases of COPD
2. Age more than 18 years
3. Patients who could hold their breath for 8-10 seconds for DLCO procedure

Exclusion Criteria

1. Age less than 18 years
2. Patients unable to perform PFT
3. Patients in whom PFT is contraindicted like sputum positive Pulmonary Tuberculosis, HIV positive, recent Myocardial infarction, and arrythmias. (<1month).

Spirometry: The procedure was done according to ATS guidelines. Smoking was stopped 12 hours prior to the procedure and inhalers on the day of procedure. The procedure was explained piror to performance. After sitting comfortably a Nose clip was attached and mouthpiece was kept in mouth with closed lips around the mouth piece. Then patient was asked to inhale completely and rapidly with a pause of one second at TLC and exhale maximally until no more air can be expelled while maintaining an upright posture. Instructions were repeated as necessary. A minimum of three manoeuvres were done.

D_{LCO} Procedure: The manoeuvres were demonstrated prior to procedure. After comfortable sitting test was performed at a stable, comfortable temperature within the manufacturer's equipment specifications.smoking was refrained on the day of the test. Once the mouthpiece and nose clip are in place, tidal breathing must be carried out for a sufficient time with no leaks.The D_{LCO} manoeuvre begins with unforced exhalation to Residual Volume (RV). At RV, the subject's mouthpiece was connected to a source of test gas, and the subject inhales rapidly to TLC. After inspiring to TLC patients were asked to breathe hold for 10±2 secs. Valsalva and Muller's manouveres were not encouraged during breath hold. Subjects were asked to exhale to RV, with a maximum exhalation time of 12 s, which provides improved measurement of VA (Rapid Gas Analyser system). The tracer gas must be relatively insoluble and relatively chemically and biologically inert. Commonly used tracer gases include helium and methane. Our study had methane as tracer gas.At least 4 min was allowed between manoeuvres to allow for adequate elimination of test gas from the lungs. D_{LCO} manoeuvre was conducted following pre- and post-bronchodilator spirometry testing.

Criteria for acceptability:

1. A VI(inspired volume) ⩾90% of the largest VC(vital capacity) in the same test session; alternatively a VI ⩾85% of the largest VC in the same test session and VA (alveolar volume)within 200 mL or 5% (whichever is greater) of the largest VA from other acceptable manoeuvre.
2. 85% of test gas VI inhaled in <4 s
3. A stable calculated breath-hold for 10±2 s with no evidence of leaks or Valsalva/Müller manoeuvres during this time
4. Sample collection completed within 4 s of the start of exhalation.

Criteria for Repeatability: At least two acceptable D_{LCO} measurements within 2 mL/min/mm Hg of each other.

Six Minute Walk Distance: The six minute walk test is the most frequently used exercise capacity

assessment for patients with chronic respiratory diseases. The six minute walk test was performed according to the ATS guidelines. The subjects were asked to walk at their own pace to as much distance as possible for six minutes. The course was a 30 meters long and straight hospital outpatient department hallway marked at two meters intervals. Subjects were instructed to stop and if required sit if they developed any symptom like dyspnea, fatigue, chest pain, cramps etc. The subjects were allowed to resume the walk and the resting time was also included in the given six minutes .Any subject who did not want to continue the test was allowed to stop and their walked distance was .After the six minute walk test, the distance walked was duly noted to the last meter .The following parameters were noted before and after the test: pulse rate, systolic and diastolic blood pressure, saturation of oxygen and respiratory rate. Oxygen desaturation was defined according to the royal college of physicians guidelines as >4% reduction between arterial oxygen saturation measured by pulseoximetry pre and post-test and post spo2 <90%.

Observation and Results

Among 33 COPD patients, 27 were diagnosed as emphysema and 6 chronic bronchitis cases. Males were 25(75.7%) 8 (24.2%) were females.

Mean Age of the study population was 56.78±12.97 years, among which 63.6 %(n=21) were in between 40 to 60 years. It was observed that 79% of the patients had the habit of smoking while 6% of the patients didn't have the habit of smoking and 15% were former smokers. It was observed that mean pack years was 36.39±7.7. The predominant symptom among the study population was cough and SOB observed in 100%, 60.4% (n=20) had wheeze, 42.4% (n=14) had chest pain, and 72.7% (n=24) had fever.[Table 1]

It was observed that for the group COPD, mean DLCO level for 20-30 pack yrs group was 72.88 ± 25.17, while for 30-40 pack yrs was 56.07 ± 15.77 and for 40-50 pack yrs was 45.00 ± 7.27.[Table 2] this suggests that as pack years of smoking increases the diffusion capacity of lung decreases.

It was observed that for the group COPD, mean DLCO level for non-smokers was 75.00 ± 22.633 while for smokers mean DLCO level was 57.55 ± 19.54. Suggests that DLCO is low in smokers compared to non-smokers.[Table 3]. 6% had mild, while 58% had moderate and 33% had severe obstruction. 1(3%) patient has normal spirometry.[Table 4]. Patients with chronic bronchitis (n=6), showed normal DLCO values with obstructive pattern on spirometry. Mean FEV1/FVC was 53.52 ± 6.71, mean FEV1(%) was 55.42 ± 11.56, while mean FVC was 74.15 ± 8.61.[Table 5]

It was observed that 9% of the patients had mild DLCO while 42% of the patients had moderate DLCO, 18% had normal DLCO and 30% had severe DLCO [Table 6]. The mean DLCO % predicted was 58.61 ± 19.8 with a minimum of 36 and a maximum of 121. Mean DLCO correction (for Hb) was 54.287 ± 18.3 with a minimum of 33.76 and a maximum of 106.3 while mean VA was 78.48 ± 11.18. Mean KCO was 66.91 ± 13.27. Mean TLC was 131.03 ± 13.54.[Table 7]. The mean DLCO level for COPD patients across the three division of cases by spirometry (FEV1). It was observed that mean DLCO for mild division was 85.71 ± 29.12 while for moderate division was 58.50 ± 15.28 and for severe mean DLCO was 41.13 ± 12.02. One COPD patient with normal spirometry has DLCO value of 56.[Table 8] The mean 6MWT distance covered in COPD patients was 365.45 ± 79.26m [Table 9]. For COPD patients, pre 6MWT SpO2 was 95.64 ± 1.87 and post 6MWT SpO2 was 93.18 ± 2.83. Mean DLCO level for patients with 6MWT distance of <400 mtr was 51.10 ± 14.41 while for patients with normal 6MWT distance of 400-700 mtrs mean DLCO level was 71.75 ± 21.59. [Table 10].

Table 1: Descriptive data of study population

1.	**GENDER**	**No.of patients**	**% of patients**
	male	25	75.7.%
	female	8	24.2%
	total	33	100%
2	**Age groups**		
	20-40yrs	4	12.1%
	41-60yrs	21	63.6%
	61-80yrs	7	21.2%
	>80 yrs	1	3.03%
3	**symptoms**		
	fever	24	72.7%
	cough	33	100.0%
	Shortness of breath	33	100.0%
	Chest pain	14	42.4%

	Wheeze	20	60.4%
4	**Smoking status**		
	yes	26	79%
	no	3	6%
	Former smoker	5	15%

Table 2: Mean DLCO according to pack years

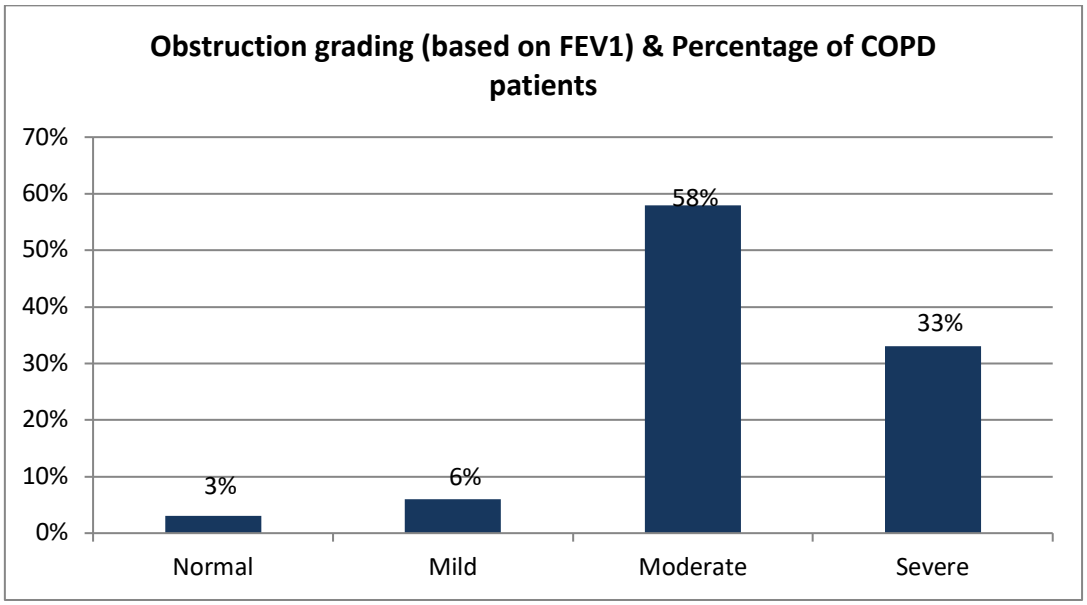
Pack Years	**COPD**	
	n	**Mean ± SD**
20-30 yrs	8	72.88 ± 25.17
30-40 yrs	15	56.07 ± 15.77
40-50 yrs	8	45.00 ± 7.27

Table 3: Mean DLCO according smoking status.

Smoking	**COPD**	
	n	**Mean ± SD (DLCO)**
No	2	75.00 ± 22.633
Yes	31	57.55 ± 19.54

Table 4: Obstruction grading of COPD patients (based on FEV_1).

Obst Grading	**COPD**	
	Frequency	**%**
Normal	1	3%
Mild	2	6%
Moderate	19	58%
Severe	11	33%
Total	33	100%



Graph 1: Obstruction grading of COPD patients (based on FEV_1).

Table 5: Mean Spirometry values.

Spirometry	**COPD**		
	Mean ± SD	**Median**	**Min-Max**
FEV1/FVC	53.52 ± 6.71	54 (47.5-58)	39-65
FEV1 (%)	55.42 ± 11.56	56 (47.5-60.5)	39-83
FVC	74.15 ± 8.61	72 (66.5-80.5)	61-93
FEF 25 - 75 %	55.33 ± 12.94	59 (43-65.5)	26-76

Table 6: Grading of DLCO.

Grading of DLCO	COPD	
	Frequency	%
Normal	6	18%
Mild	3	9%
Moderate	14	42%
Severe	10	30%
Total	33	100%

Table 7: Mean DLCO values

DLCO			
	Mean ± SD	Median (IQR)	Min-Max
DLCO % predicted	58.61 ± 19.8	56 (43-65.5)	36-121
DLCO correction (for Hb)	54.287 ± 18.3	51.99 (37.71-63.32)	33.76-106.3
VA	78.48 ± 11.18	78 (71.5-86)	58-102
KCO	66.91 ± 13.27	68 (52.5-78)	43-84
TLC	131.03 ± 13.54	131 (121-142)	104-157

Table 8: Mean DLCO according to Division of cases by spirometry (FEV1) in COPD

Division of cases by spirometry (FEV1)	COPD		p value
	n	Mean DLCO ± SD	
Normal	1	56 ± 0.00	<0.001
Mild	2	85.71 ± 29.12	
Moderate	19	58.50 ± 15.28	
Severe	11	41.13 ± 12.02	

Table 9: minute walk test

6 minute walk test	COPD	
	Mean ± SD	Min-Max
Distance (metres)	365.45 ± 79.26	220-500
pre 6MWT spo2	95.64 ± 1.87	91-99
post 6MWT spo2	93.18 ± 2.83	88-98

Table 10: mean DLCO and 6 MWT

6 MWT (metres)	DLCO		P value
	n	Mean ± SD	
<400 m	21	51.10 ± 14.41	>0.05
Normal (400-700m)	12	71.75 ± 21.59	>0.05

Discussion

Diffusing capacity of the lungs for carbon monoxide (DLCO), is termed as transfer factor for carbon monoxide (TLco) clinically valuable test of lung function. This test is easy and convenient for the patient to perform with an added advantage of being noninvasive.

The mean age of our study population was 56.78±12.97 years and 75.7 percent (N=25) of the study group were males and 24.2 percent (N=8) were females, which was similar to Guleria et al. [10] In present study, 29(79%) out of the 33 were current smokers, 3 (6%) were non-smokers, and 5(15%) were former smokers. More than 70% of were smokers, DLCO values were decreased this reflects the causative underlying disease is smoking. Bhakti P et al [11] observed in their study of middle aged asymptomatic male smokers the transfer factor values were declined and it had shown an inverse relation with severity and duration of smoking. The predominant symptom in the present study population was cough & sob followed by fever and wheeze in the present study which are consistent with a study done by Javier F Aduen et al [12] Amir Farkhooy et al [13] observed in their study that the diffusing capacity was the strongest predictor of exercise capacity in all subjects. In addition to FEV1, DLCO and Inspiratory capacity (IC) provided significantly higher predictive value regarding exercise capacity in COPD patients. Sahin H et al [14] in their study of 68 patients compared the effects between pulmonary rehabilitation (PR) and six-minute walk test (6mWT) in COPD patients with moderate or severe DLCO grade. They observed that pulmonary rehabilitation may improve DLCO and FEV1 values in COPD patients with severe diffusion defects, although the MMRC and BORG scores were higher in the patients with severe diffusion

defects. In present study, 33 of the 50 subjects (66%) were COPD patients. Of them, 2(6%) were having mild obstruction, 19(58%) were having moderate obstruction and 11(33%) had severe obstruction defect in spirometry study. It was observed that mean DLCO for mild division was 85.71 ± 29.12 while for moderate division was 58.50 ± 15.28 and for severe mean DLCO was 41.13 ± 12.02. One COPD patient with normal spirometry has DLCO value of 56 ± 0.00. Further it was observed that there was a significant difference in mean DLCO level when compared between the three Division of cases by spirometry (FEV1) (p value <0.001).

Forced expiratory volume in the first second was associated with health status in COPD and whereas, FVC and DLCO showed significant correlation with quality of life in interstitial lung disease. [15]

B. A. Sin et al. [16], studied 51 patients above 60 years of age group and found that 27 had late onset asthma and 24 were diagnosed as COPD. Mean DLCO among asthmatics was 69.70 ± 25.43 and among COPD was 49.16 ± 22.47 and concluded that patients with COPD demonstrated significantly decreased diffusing capacity for carbon monoxide when compared to asthmatic patients (p<0.005). In a study by D. Rosenberg et al. [17] Low diffusion capacity was more likely in COPD (68% vs 8%, P <0.0001), a receiver operating characteristic (ROC) curve for discriminating between COPD and asthma was most accurate at a DLCO < 70% predicted (LR=14.7, sensitivity 63%, specificity=96%).

Conclusion:

Impairment in DLCO was associated with increased COPD symptoms, reduced exercise performance, after accounting for spirometry and CT evidence of emphysema. These findings suggest that DLCO should be considered for inclusion in future multidimensional tools assessing COPD. DLCO can be indicated in morbidity assessment, a low DLCOis seen in cases with increased symptomatology and low exercise capacity. DLCO below 40% predicted may qualify a patient for total disability and as an indication to assess if the patient needs oxygen therapy. Inclusion of DLCO and FEV1 measurements will give a more comprehensive assessment of patients with COPD. This measurement also predicts a better outcome for pulmonary rehabilitation.

Limitations

1. The sample size of study population was low.
2. The present study did not take into consider other causes of chronic lung diseases.
3. The present study did not take into consider the post covid fibrosis cases. DLCO also varies with age, sex, height and possible ethnicity, PIO2, exercise tobacco smoking, changes with Hb, high altitude and body position.

Recommendations

Follow up studies should be done for chronic lung diseases to further evaluate that progressive decline in D_{LCO} values have poor prognostic implications, especially in connective tissue disease associated ILDs, where the disease is progressive in nature.

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