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Original Article

Assessment of Renal Function in Chronic Obstructive Pulmonary Disease Using Estimated Glomerular Filtration Rate and Urine Protein Analysis: A Cross-Sectional Study

Dr Neha Sharma[1], Dr Shubham Sharma[2], Dr Prashant Sharma[3], Dr Diksha Taneja[4], Dr Jatin Prajapati[5], Dr Nandini Verma[6]

[1] Senior Resident, Department of General Medicine, J.L.N. Medical College, Ajmer, Rajasthan, India.
[2] Medical Officer (MD General Medicine), Government of Rajasthan, Ramsar, Ajmer, Rajasthan, India.
[3] Post Graduate Resident, Department of Radiation Oncology, RNT Medical College, Udaipur, Rajasthan, India.
[4] Post Graduate Resident, Department of Obstetrics and Gynaecology, RNT Medical College, Udaipur, Rajasthan, India.
[5] Senior Resident, Department of Community Medicine, World College of Medical Sciences & Research, Jhajjar, Haryana, India. (ORCID: https://orcid.org/0009-0004-7298-4499)
[6] Post Graduate Student, Department of Obstetrics and Gynaecology, Maulana Azad Medical College, New Delhi, Delhi, India. (ORCID: https://orcid.org/0009-0009-6017-8402)

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Corresponding Author:

Dr Neha Sharma

Senior Resident, Department of General Medicine, J.L.N. Medical College, Ajmer, Rajasthan, India.

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is a major global health problem and is increasingly recognized as a systemic disorder with multiple extrapulmonary manifestations, including renal dysfunction. The coexistence of renal impairment in COPD patients often remains underdiagnosed due to the limitations of conventional markers such as serum creatinine.

Objectives: To assess renal function in patients with COPD using estimated glomerular filtration rate (eGFR) and urine protein analysis, and to evaluate its association with disease severity.

Methods: This hospital-based cross-sectional observational study was conducted over a period of 12 months at a tertiary care center. A total of 150 patients diagnosed with COPD as per Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria were included. Patients with known chronic kidney disease or other conditions affecting renal function were excluded. Detailed clinical evaluation, spirometry, and laboratory investigations including renal function tests and urine protein analysis were performed. eGFR was calculated using the Cockcroft–Gault equation. Statistical analysis was conducted using SPSS version 16.0, with $p < 0.05$ considered statistically significant.

Results: A substantial proportion of patients demonstrated renal impairment, with reduced eGFR and presence of proteinuria. Increasing severity of COPD was significantly associated with higher age, longer duration of illness, elevated serum creatinine levels, and greater prevalence of proteinuria. A progressive decline in eGFR was observed with increasing disease severity. Pearson correlation analysis revealed a strong negative correlation between eGFR and serum creatinine, and moderate negative correlations with age and duration of illness. No statistically significant association was found between COPD severity and comorbidities such as diabetes mellitus and hypertension.

Conclusion: Renal dysfunction is highly prevalent in COPD patients and is strongly associated with disease severity. eGFR and urine protein analysis are more reliable indicators than serum creatinine alone for early detection of renal impairment. Routine renal function assessment should be incorporated into the management of COPD patients to improve outcomes.

Keywords: *COPD; Renal dysfunction; eGFR; Proteinuria; Creatinine clearance; Chronic kidney disease.*

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a common, preventable, and treatable disease characterized by persistent respiratory symptoms and airflow limitation resulting from airway and/or alveolar abnormalities, usually caused by significant exposure to harmful particles or gases [1,2]. It represents a major global health burden and is associated with substantial morbidity and mortality. According to the World Health Organization (WHO), approximately 65 million people worldwide suffer from moderate to severe COPD, and the disease accounts for nearly 3 million deaths annually, representing about 5% of all global deaths [3]. Furthermore, COPD has been projected to become the third leading cause of death globally, highlighting its increasing public health importance [4].

COPD is now recognized not only as a pulmonary disorder but also as a systemic inflammatory disease with multiple extrapulmonary manifestations. The pathogenesis of COPD involves a complex interaction between genetic susceptibility and environmental exposures, particularly tobacco smoke and air pollution [5]. In developing countries such as India, additional risk factors such as indoor air pollution from biomass fuel and occupational exposure to dust and chemicals significantly contribute to disease burden [6]. The systemic inflammatory response associated with COPD leads to a wide range of comorbid conditions, including cardiovascular disease, metabolic syndrome, and renal dysfunction [7].

Renal impairment is an increasingly recognized comorbidity in patients with COPD. Several studies have demonstrated a higher prevalence of chronic kidney disease (CKD) among COPD patients compared to the general population, often based on reduced estimated glomerular filtration rate (eGFR) [8,9]. The underlying mechanisms linking COPD and renal dysfunction include chronic hypoxia, hypercapnia, systemic inflammation, oxidative stress, and increased sympathetic activity, all of which may adversely affect renal perfusion and function [7]. Additionally, acute kidney injury (AKI) has been shown to be an independent predictor of in-hospital mortality among patients admitted with acute exacerbations of COPD, further emphasizing the clinical significance of renal involvement in this population [10,11].

Assessment of renal function in COPD patients is therefore crucial for early detection and management of renal impairment. Renal function tests, including serum creatinine, creatinine clearance, and urine protein analysis, are commonly used in clinical practice [12]. However, serum creatinine alone may not accurately reflect renal function in COPD patients due to variations in muscle mass, especially in individuals with cachexia or sarcopenia [9]. Consequently, creatinine-based eGFR may underestimate the true prevalence of renal dysfunction in this population.

Creatinine clearance, estimated using formulas such as the Cockcroft-Gault equation, provides a more reliable assessment of glomerular filtration rate and kidney function [13]. Early identification of reduced creatinine clearance allows timely interventions to prevent progression to chronic kidney disease and facilitates appropriate dose adjustments of medications, thereby reducing the risk of drug-related toxicity [14]. In recent years, alternative biomarkers such as cystatin C have been explored to improve the accuracy of renal function assessment, particularly in patients with reduced muscle mass [15,16]. Additionally, the creatinine-to-cystatin C ratio has emerged as a potential marker reflecting both renal function and muscle mass [17].

Urine protein analysis is another important tool for detecting renal involvement. The presence of proteinuria indicates glomerular or tubular damage and serves as an early marker of kidney disease [18]. In COPD patients, proteinuria may result from systemic inflammation, endothelial dysfunction, and chronic hypoxia, all of which contribute to renal injury [19]. Regular monitoring of urinary protein excretion can therefore aid in early detection and management of renal dysfunction.

Given the significant burden of COPD and its systemic complications, it is essential to evaluate renal function comprehensively in affected patients. Despite growing evidence of the association between COPD and renal impairment, data from Indian populations remain limited. Therefore, the present study aims to assess renal function in COPD patients using creatinine clearance and urine protein analysis and to evaluate its relationship with disease severity.

METHODS

Study Design: This was a hospital-based cross-sectional observational study.

Study Setting: The study was carried out in the Department of General Medicine at RNT Medical College and its associated Maharana Bhupal Government Hospital, a tertiary care center. The study duration was 12 months following approval from the Institutional Ethics Committee.

Participants

Inclusion Criteria

Patients were eligible for inclusion if they met the following criteria:

- Diagnosed cases of COPD (previously known or newly diagnosed) based on Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines
- Age ≥18 years
- Provided written informed consent

Exclusion Criteria
Patients were excluded if they had:
- Known chronic kidney disease
- History of long-term use of nephrotoxic drugs (e.g., aminoglycosides, amphotericin B, cisplatin)
- Comorbid conditions likely to affect renal function, including diabetic nephropathy, hypertensive nephropathy, chronic liver disease, obstructive uropathy, or malignancy

Sample Size: The sample size was calculated using a previously reported prevalence of renal dysfunction of 40% among COPD patients. With a confidence level of 95% (Z = 1.96) and an allowable error of 10%, the calculated sample size was 93.58, which was rounded up to 150 patients to enhance statistical robustness.

Variables
Independent Variables
- Age
- Gender
- Duration of illness
- Severity of COPD (GOLD classification)

Dependent Variables
- Serum creatinine
- Creatinine clearance (eGFR)
- Urine protein levels

Data Sources and Measurement

Clinical Assessment: All patients underwent detailed history taking (including symptoms, smoking history, and occupational exposure) and comprehensive general and systemic examination.

Pulmonary Function Testing: Spirometry was performed before and after bronchodilator administration (200 µg salbutamol via metered-dose inhaler with spacer). COPD was confirmed by a post-bronchodilator FEV1/FVC ratio <0.7. Severity was classified as per GOLD criteria:
- Mild (GOLD 1): FEV1 ≥80% predicted
- Moderate (GOLD 2): FEV1 50–79% predicted
- Severe (GOLD 3): FEV1 30–49% predicted
- Very severe (GOLD 4): FEV1 <30% predicted

Assessment of Renal Function

Creatinine Clearance (eGFR): Creatinine clearance was estimated using the Cockcroft–Gault equation:

$$CrCl = \frac{(140 - age) \times weight(kg) \times (0.85 if female)}{72 \times serumcreatinine(mg/dL)}$$

Renal function was categorized into standard eGFR ranges.

Urine Protein Analysis
A spot morning urine sample was collected and analyzed for protein content. Proteinuria was classified as:
- Normal: <30 mg/dL
- Microalbuminuria: 30–300 mg/dL
- Clinical albuminuria: >300 mg/dL

Other Investigations: Routine investigations included complete blood count, renal function tests, liver function tests, arterial blood gas analysis, chest X-ray, and electrocardiography where indicated.

Bias: Selection bias was minimized by including consecutive eligible patients attending the outpatient department and admitted to wards and ICU. Patients with known causes of renal impairment were excluded to reduce confounding.

Statistical Methods: Data were entered into Microsoft Excel and analyzed using SPSS version 16.0. Continuous variables were expressed as mean ±standard deviation, while categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the Chi-square test. Pearson correlation analysis was performed to evaluate the relationship between eGFR and continuous variables such as age, serum creatinine, and duration of illness. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrollment. Confidentiality of patient data was maintained throughout the study.

RESULTS

A total of 150 patients with COPD were included in the study. The baseline demographic characteristics of the study population are summarized in **Table 1**. The majority of patients belonged to the middle to older age groups, with a predominance of male participants.

Table 1: Baseline Demographic Characteristics of Study Participants (n = 150)

Variable	Category	n (%)
Age (years)	40–50	24 (16.0)
	51–60	57 (38.0)
	61–70	49 (32.7)
	71–80	14 (9.3)
	>80	6 (4.0)
	Mean ± SD	**60.98 ± 10.26**
Gender	Male	113 (75.3)
	Female	37 (24.7)
Weight (kg)	30–45	77 (51.3)
	46–60	53 (35.3)
	61–75	20 (13.3)
	Mean ± SD	**48.18 ± 10.81**

The clinical profile of the patients, including duration of illness and severity of airflow obstruction, is presented in **Table 2**. Most patients had a disease duration of more than five years, and mild obstruction constituted the largest proportion, followed by moderate and severe categories.

Table 2: Clinical Profile and Severity of COPD Patients

Variable	Category	n (%)
Duration of Illness (years)	≤5	27 (18.0)
	6–10	45 (30.0)
	11–15	42 (28.0)
	16–20	33 (22.0)
	>20	3 (2.0)
	Mean ± SD	**11.5 ± 5.46**
Severity of COPD (GOLD Classification)	Mild	80 (53.3)
	Moderate	35 (23.3)
	Severe	35 (23.3)

The renal function parameters of the study population are depicted in **Table 3**. A substantial proportion of patients demonstrated evidence of renal impairment, as indicated by reduced eGFR values and the presence of proteinuria.

Table 3: Renal Function Parameters among Study Participants

Parameter	Category	n (%)
Serum Creatinine (mg/dL)	0.6–1.2	142 (94.7)
	>1.2	8 (5.3)
Urine Protein (mg/dL)	<30	55 (36.7)
	30–300	95 (63.3)
eGFR / Creatinine Clearance (mL/min)	15–30	7 (4.7)
	31–60	69 (46.0)
	61–89	49 (32.7)
	≥90	25 (16.7)

	Mean ± SD	**64.98 ± 25.80**

A significant association was observed between the severity of COPD and various clinical as well as renal parameters (**Table 4**). Increasing severity of airflow obstruction was associated with higher age, longer duration of illness, elevated serum creatinine levels, and a higher prevalence of proteinuria. In addition, a progressive decline in eGFR was noted with increasing severity of COPD.

Table 4: Association of COPD Severity with Clinical and Renal Parameters

Variable	Mild (n=80)	Moderate (n=35)	Severe (n=35)	P-value
Age (years)	57.93 ± 8.57	61.82 ± 9.87	67.08 ± 11.52	<0.0001*
Duration of illness (years)	9.96 ± 4.70	12.00 ± 5.95	14.54 ± 5.34	<0.0001*
Serum Creatinine >1.2 mg/dL	2 (2.5%)	1 (2.9%)	5 (14.3%)	<0.0001*
Proteinuria (30–300 mg/dL)	25 (31.3%)	35 (100%)	35 (100%)	<0.001*
eGFR (mL/min)	77.8 ± 25.43	60.10 ± 14.35	40.54 ± 13.51	<0.0001*

*p<0.05 considered statistically significant

The relationship between comorbid conditions and COPD severity is shown in **Table 5**. No statistically significant association was observed between the presence of diabetes mellitus or hypertension and the severity of airflow obstruction.

Table 5: Association of Comorbidities with Severity of COPD

Variable	Mild (n=80)	Moderate (n=35)	Severe (n=35)	P-value
Diabetes Mellitus	9 (11.3%)	7 (20.0%)	0 (0%)	0.21
Hypertension	8 (10.0%)	3 (8.6%)	1 (2.9%)	0.42

Pearson correlation analysis demonstrated significant relationships between renal function and clinical variables (**Table 6**). eGFR showed a strong negative correlation with serum creatinine levels and moderate negative correlations with age and duration of illness, indicating a decline in renal function with increasing age and longer disease duration.

Table 6: Pearson Correlation between eGFR and Clinical Variables

Variable	Correlation Coefficient (r)	P-value
Serum Creatinine	-0.70	<0.001*
Age	-0.56	<0.001*
Duration of Illness	-0.52	<0.001*

*p<0.05 considered statistically significant

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is increasingly recognized as a systemic disorder with significant extrapulmonary manifestations, including renal dysfunction. The present study demonstrates a substantial burden of renal impairment among COPD patients and highlights a strong association between disease severity and declining renal function. These findings reinforce the concept that COPD is not confined to the respiratory system but involves multisystem pathophysiological processes.

In this study, the mean age of the study population was 60.98 years, with the majority of patients belonging to the 51–60 years age group. These findings are consistent with previous studies by Saravanan et al. [20] and Pelaia et al. [21], which reported similar age distributions among COPD patients. The higher prevalence of COPD in older age groups may be attributed to cumulative exposure to risk factors such as smoking, environmental pollutants, and age-related physiological decline in lung function. Furthermore, increasing age was associated with greater disease severity, indicating the progressive nature of COPD.

A marked male predominance was observed in the present study, which is in agreement with earlier studies [20,22,23]. This may be explained by higher rates of tobacco use and occupational exposure among males. However, emerging evidence suggests a rising prevalence of COPD among females, particularly in developing countries, likely due to increased exposure to biomass fuel and indoor air pollution.

The duration of illness showed a significant association with the severity of airflow obstruction, indicating that prolonged disease leads to progressive deterioration in pulmonary function. Most patients had a disease duration between 6–15 years, with fewer patients in longer duration categories. These findings are consistent with Saravanan et al. [20], who also reported a significant relationship between disease duration and worsening clinical outcomes, including renal dysfunction. This emphasizes the importance of early diagnosis and long-term monitoring of COPD patients.

A key finding of the present study is the significant association between COPD severity and renal dysfunction. A progressive decline in eGFR was observed with increasing severity of airflow obstruction, with patients in the severe category demonstrating markedly reduced renal function compared to those with mild and moderate disease. These findings are in concordance with previous studies [21,24,25], which have reported impaired renal function and increased risk of chronic kidney disease among COPD patients. The underlying mechanisms may include chronic hypoxia, hypercapnia, systemic inflammation, oxidative stress, and increased sympathetic activity, leading to renal vasoconstriction and reduced renal perfusion [26].

Proteinuria was found to be strongly associated with disease severity, with all patients in the moderate and severe categories demonstrating elevated urine protein levels. This supports the hypothesis that endothelial dysfunction and microvascular injury play a significant role in COPD-related renal impairment. Similar findings have been reported by Bozkus et al. [23], who demonstrated a strong association between microalbuminuria and disease severity, suggesting that proteinuria may serve as an early marker of systemic vascular damage and increased cardiovascular risk.

Although serum creatinine levels showed an increasing trend with disease severity, the majority of patients had values within the normal range. This highlights the limitation of serum creatinine as a sole marker of renal function in COPD patients, particularly in those with reduced muscle mass. Previous studies have also emphasized that creatinine-based assessment may underestimate renal dysfunction in this population [9,27]. Therefore, the use of eGFR, calculated using the Cockcroft–Gault equation, provides a more reliable assessment of renal function.

In the present study, no statistically significant association was observed between COPD severity and comorbidities such as diabetes mellitus and hypertension. This finding differs from some previous studies [21,28], which reported a higher prevalence of these comorbidities among patients with renal dysfunction. This discrepancy may be attributed to the exclusion of patients with conditions known to independently affect renal function, thereby reducing confounding in the present analysis.

Pearson correlation analysis demonstrated a strong negative correlation between eGFR and serum creatinine levels, along with moderate negative correlations with age and duration of illness. These findings indicate that renal function declines progressively with advancing age and longer disease duration. Similar associations have been reported in previous studies [24,27], supporting the robustness of these observations.

Overall, the present study highlights the significant burden of renal dysfunction in COPD patients and underscores the importance of routine renal function assessment in this population. Early identification of renal impairment using parameters such as eGFR and urine protein analysis can facilitate timely intervention, optimize therapeutic strategies, and potentially improve clinical outcomes.

CONCLUSION

Renal dysfunction is a significant and underrecognized comorbidity in patients with chronic obstructive pulmonary disease (COPD). The present study demonstrates a strong association between the severity of COPD and declining renal function, as evidenced by reduced estimated glomerular filtration rate (eGFR) and increased prevalence of proteinuria. Patients with advanced disease exhibited more pronounced renal impairment, suggesting the impact of chronic hypoxia, systemic inflammation, and disease progression on renal physiology. Although serum creatinine showed an increasing trend with severity, it was not sufficiently sensitive to detect early renal dysfunction, highlighting the importance of using eGFR and urine protein analysis for accurate assessment. The absence of significant association with comorbidities such as diabetes and hypertension underscores the independent effect of COPD on renal function. Routine screening for renal dysfunction in COPD patients is recommended to enable early detection, optimize management, and potentially improve clinical outcomes and quality of life.

DECLARATIONS

Ethical Approval: The study was conducted after obtaining approval from the Institutional Ethics Committee of RNT Medical College, Udaipur.

Informed Consent: Written informed consent was obtained from all participants prior to their inclusion in the study.
Conflict of Interest: The authors declare that there is no conflict of interest.
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Author Contributions: All authors contributed to the conception, design, data collection, analysis, and manuscript preparation. All authors have read and approved the final manuscript.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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