Section: Miscellaneous

Original Research Article

ASSESSMENT OF PLEURAL EFFUSION AND PULMONARY EDEMA IN PATIENTS WITH CHRONIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Chronic kidney disease (CKD) is a progressive condition associated with significant systemic complications, including respiratory manifestations. Among these, pleural effusion and pulmonary edema are commonly observed but often underdiagnosed, particularly in resource-limited settings. **Objective:** This study aimed to evaluate the prevalence, clinical characteristics, and biochemical associations of pleural effusion and pulmonary edema in CKD patients.

Materials and Methods: A hospital-based cross-sectional observational study was conducted over 10 months at two tertiary care centers in Maharashtra and Chhattisgarh. A total of 150 adult patients with CKD stages 3 to 5 were enrolled. Clinical examination, radiological imaging, and relevant biochemical investigations were performed to assess the presence and type of respiratory complications. Data were analyzed using SPSS version 25.0.

Results: The mean age of participants was 52.7 years, with 63.3% males. Pleural effusion was observed in 25.3% and pulmonary edema in 10.0% of patients. Most pleural effusions were bilateral (63.2%) and transudative (78.9%). Pulmonary edema was significantly associated with higher ultrafiltration volumes and maintenance hemodialysis. Biochemically, patients with complications had elevated serum creatinine and lower serum albumin, hemoglobin, and sodium levels ($p<0.05$ for all). Comorbidities such as hypertension (78%) and diabetes (54.7%) were prevalent.

Conclusion: Respiratory complications are common in advanced CKD, particularly among hemodialysis patients. Pleural effusions are typically transudative and bilateral, while pulmonary edema is linked to fluid overload. Routine screening and optimized fluid management are crucial for early identification and intervention.

Keywords: Chronic Kidney Disease, Pleural Effusion, Pulmonary Edema, Hemodialysis, Respiratory Complications.

INTRODUCTION

Chronic kidney disease (CKD) affects an estimated 11–13% of the global population, making it a major contributor to morbidity and mortality worldwide.[1] The burden is particularly high in developing countries like India, where delayed diagnosis and limited access to nephrology care exacerbate outcomes.[2]

Among the various complications of CKD, respiratory complications, especially pleural effusion and pulmonary edema, are frequently encountered and significantly impact prognosis.[3] Pleural effusion refers to the accumulation of fluid in the pleural space, which can impair lung function and cause dyspnea. In CKD, it is often transudative due to hypoalbuminemia and volume overload. Pulmonary edema, on the other hand, is the accumulation of fluid in the lung parenchyma and

alveoli, often resulting from increased hydrostatic pressure, as in left ventricular dysfunction, or fluid overload in dialysis patients.

In a prospective Indian study involving 100 CKD patients, 24% had pleural effusion, and 9% developed pulmonary edema, with fluid overload and hypoalbuminemia being key contributing factors.[3] Pleural effusion refers to the accumulation of fluid in the pleural space, which can impair lung function and cause dyspnea. In CKD, it is often transudative due to hypoalbuminemia and volume overload. Pleural effusion in CKD is usually transudative, due to volume overload, low oncotic pressure, or congestive heart failure.[4] In a Nepalese study, pleural effusion was found in 10.9% of CKD patients, most commonly bilateral and transudative in nature.[5] Pulmonary edema, on the other hand, is commonly related to rapid fluid shifts, particularly in patients undergoing dialysis.[6] In a prospective multicentric Indian study involving 250 ESRD patients undergoing maintenance hemodialysis in Solapur, pulmonary edema was observed in 20.58% of patients as one of the common pulmonary complications, following pleural effusion (33.8%) and pneumonia (25%).[7]

The pathophysiology involves fluid retention, reduced plasma oncotic pressure due to hypoalbuminemia, and increased capillary permeability due to uremic toxins.[8-10] Additionally, left ventricular diastolic dysfunction in CKD contributes to increased pulmonary venous pressure, exacerbating pulmonary edema.[9]

Given their high prevalence and impact on prognosis, yet limited documentation in the Indian context, this study evaluates the clinical profile, prevalence, and mechanistic basis of pleural effusion and pulmonary edema among CKD patients to guide better preventive and therapeutic strategies.

MATERIALS AND METHODS

Study design and setting

This hospital-based, cross-sectional observational study was conducted over a period of 10 months in two tertiary care hospitals: one located in Maharashtra and the other in Chhattisgarh. The study aimed to evaluate the prevalence and underlying pathophysiological mechanisms of respiratory complications specifically pleural effusion and pulmonary edema in patients diagnosed with chronic kidney disease (CKD).

Study population and selection criteria

The study included adult patients (aged ≥18 years) diagnosed with CKD stages 3 to 5, who were either undergoing conservative management or on maintenance hemodialysis. Patients were enrolled primarily from the Nephrology and General Medicine departments of both participating institutions. The Department of Respiratory Medicine played a key role in the evaluation and confirmation of respiratory complications through clinical assessment, interpretation of radiological findings, and involvement in differential diagnosis and management planning for pleural and pulmonary conditions.

Informed written consent was obtained from all participants prior to inclusion in the study. Multidisciplinary collaboration ensured accurate diagnosis, data collection, and holistic assessment of the respiratory manifestations in CKD patients.

The study included patients aged 18 years and above who were diagnosed with chronic kidney disease (CKD) stages 3 to 5, based on the estimated glomerular filtration rate (eGFR) criteria as per the KDIGO guidelines. Only those who were willing to provide informed written consent were enrolled in the study. Patients were excluded if they had pre-existing chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD), bronchiectasis, or interstitial lung disease. Other exclusion criteria included a history of pulmonary tuberculosis or active pulmonary infections, recent thoracic trauma or thoracic surgery, and pregnancy.

Sample Size

The sample size was determined using the prevalence data of pleural effusion and pulmonary edema in CKD patients from previous Indian studies. Based on an estimated 20% prevalence of tuberculous pleural effusion (TPE) among CKD patients,[12] with a 7% allowable error and 95% confidence interval, the minimum sample size calculated was 126. Accounting for potential data attrition, a total of 150 patients were enrolled, 75 from each center.

Data Collection

Data were collected through a structured case record form that captured comprehensive information across several domains. Demographic details such as age, sex, address, and occupation were recorded. Clinical data included the duration and stage of chronic kidney disease (CKD), along with presenting symptoms like dyspnea, orthopnea, and pedal edema. The presence of comorbid conditions such as diabetes mellitus, hypertension, and ischemic heart disease was also documented. Laboratory investigations encompassed hemoglobin levels, serum creatinine, blood urea, serum albumin, and serum electrolytes. For patients undergoing dialysis, details including frequency, duration, and ultrafiltration volume were noted. Radiological evaluation involved the use of chest X-rays and/or ultrasonography to identify pleural effusion and pulmonary edema. In selected cases, high-resolution computed tomography (HRCT) of the chest or echocardiography was performed to assess cardiac function and fluid overload status. Pleural effusion was classified as transudative or exudative based on Light's criteria when thoracocentesis was indicated. Pulmonary edema was diagnosed radiologically and clinically, based on classical features such as bilateral perihilar opacities, Kerley B lines, and basal crepitations, along with correlation to clinical findings and dialysis history.

Statistical Analysis

The collected data were entered in Microsoft Excel and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and median (interquartile range) for skewed data. Categorical variables were summarized as frequency and percentages. When comparing continuous variables across more than two groups, one-way analysis of variance (ANOVA) was applied for normally distributed data, and the Kruskal Wallis test was used when data were non-normally distributed.

RESULTS

Table 1: Demographic Profile of CKD Patients (N = 150)

Variable	Maharashtra (n=75)	Chhattisgarh (n=75)	Total (N=150)
Mean Age (years)	53.8 ± 11.4	51.6 ± 10.9	52.7 ± 11.2
Male (%)	49 (65.3%)	46 (61.3%)	95 (63.3%)
Female (%)	26 (34.7%)	29 (38.7%)	55 (36.7%)
Rural residence (%)	40 (53.3%)	47 (62.7%)	87 (58%)
Urban residence (%)	35 (46.7%)	28 (37.3%)	63 (42%)

The mean age of the study population was 52.7 years, with a slightly higher mean in Maharashtra (53.8 years) compared to Chhattisgarh (51.6 years). Males constituted 63.3% of the participants, while 36.7% were females. A higher proportion of patients were from rural areas (58%) as compared to urban areas (42%).

Table 2: Distribution of CKD Stages Among Patients

CKD Stage	Maharashtra (n=75)	Chhattisgarh (n=75)	Total (N=150)
Stage 3	12 (16.0%)	14 (18.7%)	26 (17.3%)
Stage 4	25 (33.3%)	23 (30.7%)	48 (32.0%)
Stage 5 (ESRD)	38 (50.7%)	38 (50.7%)	76 (50.7%)

Among the 150 CKD patients, 50.7% were in stage 5 (ESRD), while 32.0% and 17.3% were in stages 4 and 3, respectively. Both centers showed a similar distribution of CKD stages, with stage 5 being the most common.

Table 3: Comorbidities Among CKD Patients

Comorbidity	Maharashtra (n=75)	Chhattisgarh (n=75)	Total (N=150)
Hypertension	60 (80.0%)	57 (76.0%)	117 (78.0%)
Diabetes Mellitus	42 (56.0%)	40 (53.3%)	82 (54.7%)
Ischemic Heart Disease	14 (18.7%)	11 (14.7%)	25 (16.7%)

Hypertension was the most common comorbidity, seen in 78% of patients, followed by diabetes mellitus (54.7%) and ischemic heart disease (16.7%). The distribution of comorbidities was comparable between the two centers.

Table 4: Prevalence of Respiratory Complications in CKD Patients

Complication	Maharashtra (n=75)	Chhattisgarh (n=75)	Total (N=150)
Pleural Effusion	18 (24.0%)	20 (26.7%)	38 (25.3%)
Pulmonary Edema	7 (9.3%)	8 (10.7%)	15 (10.0%)
Pneumonia	5 (6.7%)	7 (9.3%)	12 (8.0%)

Pleural effusion was observed in 25.3% of the patients, while pulmonary edema was present in 10.0%. Pneumonia was reported in 8.0% of cases. Chhattisgarh had a slightly higher proportion of all three complications compared to Maharashtra.

Table 5: Type and Distribution of Pleural Effusion

Type of Effusion	Maharashtra (n=18)	Chhattisgarh (n=20)	Total (N=38)
Transudative	14 (77.8%)	16 (80.0%)	30 (78.9%)
Exudative	4 (22.2%)	4 (20.0%)	8 (21.1%)
Bilateral Presentation	11 (61.1%)	13 (65.0%)	24 (63.2%)
Unilateral Right	5 (27.8%)	4 (20.0%)	9 (23.7%)
Unilateral Left	2 (11.1%)	3 (15.0%)	5 (13.1%)

Among the 38 patients with pleural effusion, 78.9% had transudative effusion and 21.1% had exudative effusion. Bilateral effusion was present in 63.2% of cases, while unilateral involvement was more often right-sided (23.7%) than left-sided (13.1%).

Table 6: Dialysis and Respiratory Complications

Parameter	Pleural Effusion (n=38)	Pulmonary Edema (n=15)	No Complications (n=97)
On Maintenance Hemodialysis (%)	30 (78.9%)	14 (93.3%)	59 (60.8%)
Mean Ultrafiltration Volume (mL)	1850 ± 420	2100 ± 370	1620 ± 400
Dialysis Frequency ≥ 2/week	32 (84.2%)	15 (100.0%)	66 (68.0%)

Most patients with pleural effusion (78.9%) and pulmonary edema (93.3%) were on maintenance hemodialysis. The mean ultrafiltration volume was higher in patients with pulmonary edema (2100 mL) than in those with pleural effusion (1850 mL) or without complications (1620 mL). Frequent dialysis (≥2 times/week) was more common in patients with respiratory complications.

Table 7: Laboratory Parameters by Respiratory Complication Status

Parameter	No Complications (n=97)	Pleural Effusion (n=38)	Pulmonary Edema (n=15)	p-value
Serum Creatinine (mg/dL)	6.1 ± 1.4	7.4 ± 1.6	7.8 ± 1.8	0.01*
Serum Albumin (g/dL)	3.4 ± 0.5	2.9 ± 0.4	2.7 ± 0.3	0.002*
Hemoglobin (g/dL)	9.8 ± 1.1	9.1 ± 1.0	8.8 ± 1.2	0.03*
Serum Sodium (mmol/L)	137.5 ± 4.2	134.8 ± 4.5	133.6 ± 5.0	0.04*

Patients with pulmonary edema and pleural effusion had significantly higher serum creatinine levels (7.8 and 7.4 mg/dL respectively) compared to those without complications (6.1 mg/dL). Serum albumin was lower in patients with complications (2.7–2.9 g/dL) than in those without (3.4 g/dL). Similarly, lower hemoglobin and serum sodium levels were observed in patients with respiratory complications, with all differences being statistically significant ($p < 0.05$).

DISCUSSION

This cross-sectional study highlights that pleural effusion is more commonly observed in CKD patients (25.3%) compared to pulmonary edema (10%). The majority of pleural effusions were transudative (78.9%) and bilateral (63.2%), strongly pointing towards volume overload and hypoalbuminemia as the principal pathophysiological factors. Respiratory complications were common, especially in those undergoing maintenance hemodialysis, with distinct clinical and biochemical profiles.

Pleural Effusion

Pleural effusion was noted in 25.3% of the study population, most commonly bilateral (63.2%) and transudative (78.9%). These findings are in agreement with a prospective observational study by Jabbar et al., which found transudative effusions in 75.7% of CKD patients, primarily due to volume overload and cardiac dysfunction.[3] Gadkari et al. also reported that 75% of pleural effusions in CKD were transudative in nature, with congestive heart failure and fluid overload as key contributors.[12]

Bilateral pleural effusion is commonly associated with systemic causes such as nephrotic syndrome, ESRD, and heart failure, all of which can occur concurrently in CKD patients. A Nepalese cross-sectional study reported a pleural effusion prevalence of 10.9%, most of which were bilateral and transudative, further corroborating our findings.[5]

Pulmonary Edema

Pulmonary edema was seen in 10% of patients, especially in those on maintenance hemodialysis (93.3%). The average ultrafiltration volume was significantly higher in this group (2100 mL), supporting the role of rapid fluid shifts and volume overload in pulmonary edema pathogenesis.

These results are consistent with Widiastuti et al., who found a positive correlation between CKD stage and pulmonary edema on chest X-ray, emphasizing the contribution of fluid overload and cardiac dysfunction in ESRD.[9] Shaik et al., in a multicentric study involving 250 hemodialysis patients, reported pulmonary edema in 20.6%, ranking it among the most common pulmonary complications following pleural effusion and pneumonia.[7]

Additionally, Patel et al. reported that persistent fluid overload in ESRD leads to impaired pulmonary compliance and gas exchange, particularly in poorly dialyzed individuals, reinforcing the need for precise volume control.[6]

Laboratory Correlates

Patients with respiratory complications had significantly higher serum creatinine and lower serum albumin levels than those without. Hypoalbuminemia is well recognized as a key driver of transudative fluid shifts, decreasing oncotic pressure and exacerbating pleural and pulmonary effusions.[3,12] Anemia and hyponatremia, both common in advanced CKD, were also more pronounced in those with respiratory complications, consistent with the literature.[7]

Clinical Implications

This study highlights the importance of vigilant monitoring for respiratory complications in advanced CKD, particularly among those receiving frequent dialysis. Clinicians should consider chest imaging in symptomatic patients and optimize fluid management to avoid pulmonary congestion. Addressing hypoalbuminemia, improving dialysis adequacy, and evaluating cardiac function are essential components of a multidisciplinary approach.

CONCLUSION

This study demonstrates that respiratory complications, particularly pleural effusion and pulmonary edema, are common in patients with advanced CKD, especially those on maintenance hemodialysis. Pleural effusions were mostly transudative and bilateral, while pulmonary edema was linked to higher ultrafiltration volumes and fluid overload. Patients with these complications had significantly worse biochemical profiles.

These findings underscore the need for regular respiratory monitoring and optimized dialysis management to prevent and manage pulmonary complications in CKD. Further studies are needed to assess long-term outcomes and intervention strategies.

Limitations

This study has certain limitations. Being cross-sectional in design, it cannot establish causality between CKD and respiratory complications. The hospital-based setting may limit the generalizability of findings to the broader CKD population. Not all patients underwent advanced imaging or pleural fluid analysis, which may have affected diagnostic precision. Additionally, the lack of follow-up prevents assessment of long-term outcomes, and potential confounding factors like nutritional status and cardiac function were not fully evaluated.

Conflict of interest

The authors declare no conflict of interest related to this study.

REFERENCES

1. Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, et al. Global prevalence of chronic kidney disease – a systematic review and meta-analysis. PLoS One. 2016;11(7):e0158765.https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0158765
2. Rajapurkar MM, John GT, Kirpalani AL, et al. What do we know about chronic kidney disease in India: first report of the Indian CKD registry. Indian J Nephrol. 2012;22(4):243–246. https://www.indianjnephrol.org/text.asp?2012/22/4/243/101011
3. Jabbar A, Ahmed M, Hussain T, et al. Transudative and exudative pleural effusion in chronic kidney disease patients: a prospective observational study. Cureus. 2021;13(11):e19577. doi:10.7759/cureus.19577
4. Krishna R, Antoine MH, Alahmadi MH, Rudrappa M. Pleural Effusion. [Updated 2024 Aug 31]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448189/
5. Pant P, Baniya S, Jha A. Prevalence of Respiratory Manifestations in Chronic Kidney Diseases: A Descriptive Cross-sectional Study in a Tertiary Care Hospital of Nepal. JNMA J Nepal Med Assoc. 2019;57(216):80-83. doi:10.31729/jnma.4284
6. Patel S, Al-Mahmeed W, Mousa A, et al. Fluid overload in end-stage renal disease: implications for pulmonary complications. BMC Nephrol. 2018;19(1):123.
7. https://bmcnephrol.biomedcentral.com/articles/10.1186/s12882-018-0928-2
8. Shaik L, Thotamgari S, Kowtha P, et al. A Spectrum of Pulmonary Complications Occurring in End-Stage Renal Disease Patients on Maintenance Hemodialysis. Cureus. 2021;13(6):e15426. doi:10.7759/cureus.15426
9. Rackow EC, Fein IA, Sprung C, Grodman RS. Uremic pulmonary edema. Am J Med. 1978 Jun;64(6):1084-8. doi: 10.1016/0002-9343(78)90466-7. PMID: 655190.
10. Widiastuti DRTK, Murti B, Raharjo SS, Prasetyo B. The correlation between disease stage and pulmonary edema assessed with chest X-ray in chronic kidney disease patients. Imaging Med. 2021;13(1):1–6.
11. Kattula SRST, Avula A, Baradhi KM. Anasarca. [Updated 2023 Oct 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK519013
12. Cho GY. Diastolic dysfunction and chronic kidney disease. Korean J Intern Med. 2013 Jan;28(1):22–4. doi:10.3904/kjim.2013.28.1.22. Available from: https://www.kjim.org/upload/kjim-28-1-22.pdf
13. Gadkari N, Patel R, Shet T, Patil A, Mahajan S. Study of Pleural Effusion in Chronic Kidney Disease. J Med Sci Clin Res. 2019;7(5):383–388. DOI: 10.18535/jmscr/v7i5.62.