



ETIOLOGY AND PROFILE OF PLEURAL EFFUSION AMONG CHRONIC KIDNEY DISEASE PATIENTS ATTENDING A TERTIARY CARE CENTRE: AN OBSERVATIONAL STUDY

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ABSTRACT

Introduction

Chronic kidney disease (CKD) represents a major public health burden and is commonly associated with systemic complications, including cardiovascular disease, infections, and fluid accumulation in serous cavities. Pleural effusion is a frequent finding in CKD patients and may arise from multiple etiologies such as fluid overload related to renal or cardiac dysfunction, uremic pleuritis, infections, or malignancy. Identifying the underlying cause of pleural effusion is essential for appropriate clinical management. This study was conducted to evaluate the etiological profile and characteristics of pleural effusion among CKD patients attending a tertiary care centre in Kerala.

Objectives

To evaluate the etiologies of pleural effusion in patients with CKD and determine the proportion of transudative and exudative effusions. The study also aimed to analyze pleural fluid biochemical, pathological, and microbiological characteristics, as well as assess the nature and size of pleural effusions in the study population.

Methods

This cross-sectional study included CKD patients diagnosed with pleural effusion at a tertiary healthcare facility in Kerala, irrespective of dialysis status. A comprehensive evaluation was performed, including clinical history, physical examination, and relevant investigations.

Pleural fluid analysis comprised biochemical, cytological, and microbiological assessment. Effusions were classified as transudative or exudative based on Light's criteria. The distribution of etiologies and demographic characteristics of the study population were analyzed.

Results

Transudative pleural effusions were the most common, observed in 60.6% of patients, predominantly due to fluid overload associated with CKD (33.8%) and congestive heart failure (28.2%). Exudative

effusions accounted for 39.4% of cases, with parapneumonic effusions being the most frequent (16.9%), followed by tuberculosis (14.1%). Exudative effusions were more commonly unilateral. Pleural fluid analysis was instrumental in differentiating infectious and malignant effusions from transudative causes.

Conclusion

Transudative pleural effusions due to volume overload related to CKD and congestive heart failure constitute the majority of pleural effusions in CKD patients. Among exudative effusions, parapneumonic effusion is the most common etiology, followed by tuberculosis. Early identification of the underlying cause of pleural effusion is essential for optimizing management and improving outcomes in CKD patients. Further studies are needed to refine diagnostic and therapeutic strategies in this population.

Key words: Chronic kidney disease, pleural effusion, exudative effusion, transudative effusion, parapneumonic effusion, tubercular effusion, Light's criteria.

INTRODUCTION

Chronic kidney disease (CKD) is a global health issue, often leading to serious consequences such as renal failure, heart disease, and early mortality. Pleural effusion is frequently encountered in clinical practice and can arise from a variety of underlying conditions.

The most commonly observed causes include congestive heart failure, malignancies, pneumonia, and pulmonary embolism. Pleural fluid aspiration (thoracentesis) plays a key role in distinguishing between transudative and exudative effusions, forming the basis of further diagnostic evaluation [1]. Effective treatment can only be determined after thorough diagnostic evaluation. In recent years, therapeutic options have expanded significantly, and ongoing research is expected to provide further advancements in diagnostic techniques, improved pleurodesis agents, minimally invasive interventions, and insights into the genetic predisposition of affected patients [2]. The prognosis of individuals with effusion is influenced by its underlying cause, severity, and associated comorbidities. In general, individuals who do not receive appropriate treatment have worse outcomes compared to those who undergo timely management [3]. If pleural effusions are not adequately treated, complications such as empyema, sepsis, and trapped lung may develop [4].

Chronic kidney disease is associated with multiple pathological mechanisms caused by reduced kidney function and a progressive decrease in glomerular filtration rate (GFR). Most pleural effusions occurring in CKD are attributed to renal failure and heart failure and are left alone [5]. Other causes responsible for effusions in CKD patients include Para pneumonic effusion, tuberculosis, and other infections and malignancies due to immunosuppression; hence, the presence of pleural effusion in CKD patients needs further evaluation. Inadequate dialysis is another contributing factor to effusion formation. Uremic pleurisy remains a diagnosis of exclusion, characterized by persistent or recurrent effusion despite intensive dialysis treatment.

Accurate differentiation of its etiology is crucial, as both the management and prognosis depend on the underlying cause. This study aims to determine the various etiologies of pleural effusion among chronic kidney patients and to raise awareness about the importance of early interventions in CKD individuals with pleural effusion. The primary objective of this research is to identify the etiology of pleural effusion in CKD patients, while the secondary objectives include classifying the pleural effusion and studying the overall profile of these patients.

Materials & Methods

Study design and setting

This was a hospital-based observational (cross-sectional) study. The study was conducted among patients attending the Respiratory Medicine, Nephrology, Cardiology, and General Medicine departments at Travancore Medical College, Kollam, Kerala.

Study population and selection

The study population included all chronic kidney disease (CKD) patients with pleural effusion aged over eighteen years who met the inclusion criteria. Inclusion criteria consisted of patients with an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73 m² for more than three months (CKD stages G3, G4, and G5) or markers of kidney damage, including albuminuria. Additionally, patients with CKD and pleural effusion in whom pleural fluid analysis was clinically indicated were included. Exclusion criteria included patients with bleeding disorders, chronic liver disease, or hypothyroidism

Sample size and sampling

The minimum sample size was calculated as seventy-one participants based on a formula using a ten percent absolute precision and a previous prevalence of tuberculosis (24.6%) among CKD patients with pleural effusion in a study conducted in Shimoga Institute of Medical Science. Initially, all patients attending the hospital with CKD underwent an eGFR calculation using the CKD-EPI creatinine equation[6].

Study procedure

Data were gathered after securing written informed consent through one-on-one interviews using a pre-designed, interviewer-administered, semi-structured questionnaire.

Confidentiality was strictly maintained. Patients clinically suspected of having pleural effusion were confirmed using chest X-ray and ultrasound. A detailed demographic and clinical assessment, including general and systemic examination, was conducted. Laboratory investigations included complete blood count, erythrocyte sedimentation rate, renal function tests, and liver function tests.

Radiological assessment

Pleural effusion size was assessed using chest radiographs and categorized based on the British Thoracic Society 2010 guidelines[7]. Mild effusion was defined as fluid blunting the costophrenic angle without extending beyond the lower one-third of the hemithorax.

Moderate effusion referred to cases where the fluid occupied up to two-thirds of the hemithorax. Massive effusion included cases where the fluid occupied more than two-thirds of the hemithorax, often leading to significant lung compression and mediastinal shift[7]. Ultrasound screening was used to quantify and characterize the effusion. The Balik formula was used for bedridden or mechanically ventilated patients in a supine position[8]:

Pleural fluid volume (mL) = 20 times {pleural separation (mm)} The Goecke formula was used for normally breathing patients in a sitting or semi-recumbent position[8]:

Pleural fluid volume (mL)} = 16 times {pleural separation (mm)}

Pleural fluid characterization and analysis

Based on ultrasonographic characteristics, pleural effusions were categorized as anechoic (simple), complex non-septated, complex septated, echogenic, or mass-like lesions [9].

Thoracentesis was performed under aseptic precautions using a 20-gauge intravenous cannula. Pleural fluid samples were evaluated for gross appearance and subjected to biochemical analysis, including protein, glucose, and lactate dehydrogenase levels. Cellular analysis, adenosine deaminase estimation, cytological examination, and microbiological investigations comprising Gram staining, bacterial culture, acid-fast bacilli staining and culture, and fungal studies were also performed.

Pleural effusions were classified as exudative or transudative according to Light's criteria [10]. Patients with exudative effusions underwent further evaluation with pleural fluid ADA estimation, cytological analysis, microbiological studies, and histopathological examination of pleural biopsy specimens to determine the underlying etiology. In cases of transudative effusions, the etiology was established by identifying the underlying systemic cause through appropriate clinical assessment and relevant investigations.

Statistical methods

Data collected were entered into Microsoft Excel and analyzed using IBM SPSS Statistics (IBM Corp., Armonk, NY). Categorical variables were expressed as frequencies and percentages. Continuous variables were summarized using mean $\pm$ standard deviation or median with interquartile range.

Results

Demographics and clinical characteristics

A total of seventy-one participants with chronic kidney disease (CKD) and pleural effusion who met the inclusion criteria were included in the study. The mean age of the participants was 62.24 ± 12.57 years, with a majority (53.5%) being over sixty years of age. The study showed a significant male predominance, with fifty (70.4%) male subjects and twenty-one (29.6%) female subjects, resulting in a male-to-female ratio of 2.4:1. Regarding the severity of renal impairment, sixty-one (86.0%) cases were in stage G5 (end-stage renal disease), while seven (9.8%) and three (4.2%) were in stages G4 and G3, respectively. Furthermore, sixty-one (85.9%) patients were undergoing haemodialysis

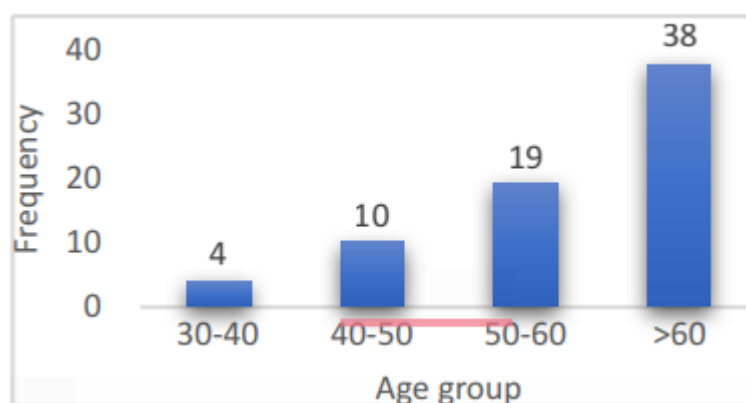


Figure 1 : Represents the age distribution of study participants Majority (53.5%) of the participants were above 60 years.

Patient Comorbidities and Laboratory Characteristics

Diabetes mellitus (76.1%) and hypertension (73.2%) were the most prevalent comorbid conditions. Coronary artery disease was observed in 45.1% of cases, and chronic obstructive pulmonary disease was present in 15.5%. Laboratory investigations revealed significant anaemia with a mean haemoglobin level of 8 g/dL. Mean serum creatinine levels were 5.7 mg/dL, indicating advanced renal impairment. Additionally, 33.8% of patients presented with low serum protein levels (<6 g/dL), suggesting hypoalbuminemia as a contributing factor to fluid imbalance.

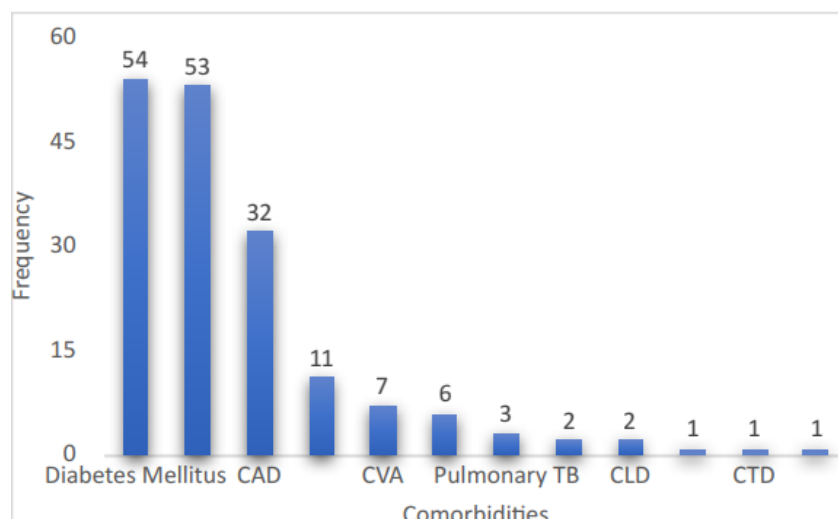


Figure 2: showing co-morbidities and associated diseases, Most frequently seen comorbidities were diabetes mellitus (76.1%) and hypertension (73.2%), which are leading causes of CKD.

Pleural Effusion Characteristics, Distribution, and Etiology

Following diagnostic thoracentesis, the initial evaluation using Light's criteria revealed that forty-three (60.6%) subjects had transudative effusions, while twenty-eight (39.4%) had exudative effusions. Bilateral effusions were more prevalent (59.2%) than unilateral ones (40.8%). Notably, bilateral involvement was predominant in transudative cases (81.4%), whereas exudative effusions were more frequently unilateral (75.0%).

Figure 3: Showing Frequency distribution of Transudative and Exudative effusion

The most common overall cause of effusion was volume overload related to CKD (33.8%), followed by congestive heart failure (28.2%). Among exudative causes, parapneumonic effusion was the most frequent (16.9%), followed by tubercular effusion (14.1%) and uremic effusion (5.6%).

Table 1. Etiological Spectrum of Pleural Effusion in the Study Population

Cause of Effusion	Frequency (n=71)	Percentage
CKD related fluid overload	24	33.8
CHF	20	28.2
Parapneumonic effusion	12	16.9
Tubercular	10	14.1
Uremic	4	5.6
CLD with portal hypertension	10	14.1
Myelomatous effusion	1	1.4

Discussion

In this observational study, we analyzed the causes and characteristics of pleural effusion in chronic kidney disease (CKD) patients. Pleural effusions in CKD can result from multiple underlying conditions, including volume overload, infections, systemic diseases, and malignancies. Identifying the precise etiology is important for ensuring effective management and improving patient outcomes.

Demographic Characteristics and Comorbidities

More than half of the participants (53.5%) were aged 60 years or older, with a mean age of years. A clear male predominance was observed (70.4%), reflecting the greater prevalence of chronic kidney disease (CKD) among men, which may be attributed to higher exposure to risk factors such as hypertension, diabetes mellitus, and tobacco use. Dyspnea was the most frequently reported presenting complaint, affecting all patients (100%), followed by chest pain (42.2%) and cough (35.2%). The prominence of dyspnea in CKD patients with pleural effusion is likely due to multiple contributing mechanisms, including fluid overload, coexisting cardiovascular disease, and diminished cardiopulmonary reserve. Diabetes mellitus (76.1%) and hypertension (73.2%) were the most common associated comorbid conditions, highlighting their significant role in CKD pathogenesis and progression. Cardiovascular disease also played a substantial role in the development of pleural effusion in this cohort, primarily through heart failure-related volume overload.

Radiological Findings and Pleural Fluid Characteristics Chest radiography demonstrated bilateral pleural effusions in 59.2% of patients, while 40.8% had unilateral involvement. Bilateral effusions were predominantly transudative in nature (81.4%), whereas exudative effusions were more commonly unilateral (75.0%). Thoracic ultrasonography was instrumental in further characterization, with the majority of effusions (91.6%) identified as simple.

Overall, transudative effusions constituted the larger proportion (60.6%), with volume overload secondary to chronic kidney disease (33.8%) and congestive heart failure (28.2%) emerging as the leading etiologies. Among exudative effusions, parapneumonic effusion was the most frequently identified cause (16.9%), followed by tubercular pleural effusion (14.1%) and uremic pleurisy (5.6%). A neutrophil-predominant cellular profile was observed in 60.7% of exudative effusions, predominantly in cases related to bacterial infections. Elevated pleural fluid adenosine deaminase levels were detected in 53.6% of exudative cases, supporting a tubercular etiology in a substantial proportion of patients.

Etiological Spectrum and Diagnostic Approach

Congestive heart failure represented a major etiological factor for bilateral pleural effusion among patients with chronic kidney disease. In the current cohort, 20 cases were attributed to cardiac

dysfunction, all demonstrating bilateral effusions accompanied by echocardiographic evidence of left ventricular impairment. In contrast, pleural effusions related to volume overload ($n = 24$) were differentiated from cardiac etiologies by the presence of preserved cardiac function on echocardiography. Parapneumonic effusions were observed in 12 patients, with *Klebsiella pneumoniae* emerging as the most commonly identified pathogen on sputum culture. Advanced diagnostic procedures, including thoracoscopy and pleural biopsy, were undertaken in approximately 7% of cases to evaluate unexplained exudative pleural effusions. These interventions yielded a diagnosis of tuberculosis in three patients, based on histopathological evidence of granulomatous inflammation.

Strengths and limitations

The strength of this research lies in its comprehensive diagnostic approach, incorporating pleural fluid analysis and advanced imaging across multiple specialties. However, the study is limited by its cross-sectional design, which prevents the establishment of causal relationships. Additionally, being a single-center study, the findings may not be entirely representative of the broader CKD population. The lack of long-term follow-up also limited the ability to assess disease progression over time.

Conclusion

Pleural effusion is a frequently encountered clinical manifestation in patients with chronic kidney disease and encompasses a broad etiological spectrum. Transudative effusions resulting from volume overload and congestive heart failure constitute the predominant causes; however, exudative etiologies, particularly parapneumonic and tubercular effusions, represent a clinically important proportion and warrant meticulous evaluation. Bilateral pleural effusions are more commonly associated with transudative mechanisms, whereas unilateral involvement should prompt consideration of exudative processes.

Timely diagnostic thoracentesis, complemented by thoracic ultrasonography, plays a pivotal role in guiding appropriate management strategies. Given the heightened susceptibility to infection in patients with advanced kidney disease, clinicians should maintain a low threshold for investigating infectious causes, including tuberculosis, particularly in regions where the disease remains endemic.

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DECLARATIONS

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