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Original Research Article

The spectrum of exudative pleural effusion: clinical and etiological insight

Tamanna Bagal, Vinu Jamwal*, Anil Gupta, Abhinav Gupta

Department of Medicine, ASCOMS, Jammu, Jammu and Kashmir, India

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***Correspondence:**
Dr. Vinu Jamwal,
E-mail: vinujamwal@yahoo.co.in

ABSTRACT

Background: Pleural effusion, an abnormal accumulation of fluid in the pleural space, is classified as transudative or exudative using Light's criteria. This study aimed to evaluate the clinical and etiological profile of exudative pleural effusion in a tertiary care center in a high-tuberculosis-prevalence region.
Methods: This prospective study at Acharya Shri Chander college of medical sciences, Jammu (February 2024–January 2025), included 70 patients (14-85 years) with exudative pleural effusion. Demographics, clinical history, and investigations (X-ray, pleural/sputum analysis, CT) were recorded. Data were analyzed using excel and SPSS v20.0 with chi-square and Fisher's exact tests.
Results: The cohort was predominantly male (94.3%, $p<0.001$) with a mean age of 71.6±5.6 years. Common symptoms included cough (87.1%), dyspnea (77.1%), and fever (75.7%), with cough significantly associated with tuberculosis ($p=0.02$). Mean symptom duration was 2.7±1.2 weeks. Right-sided pleural effusion was most frequent (47.1%), followed by left-sided (27.1%) and bilateral (25.7%). Consolidation (22.9%) was significantly associated with pneumonia ($p=0.01$). Pleural fluid was exudative in 98.57% of cases, with malignant cells in 1.4%. Sputum analysis ($n=53$) showed AFB growth (35.84%) or CBNAAT positivity (50.94%), strongly associated with tuberculosis ($p<0.001$). Pulmonary tuberculosis was the leading etiology (74.3%), followed by pneumonia (8.6%), lung malignancy (1.4%), and undetermined causes (15.7%).
Conclusions: Pulmonary tuberculosis is the leading cause of exudative pleural effusion in this cohort, with symptoms and imaging consistent with infection. The low malignancy rate, unlike Western data, highlights the need for region-specific diagnostics.

Keywords: Exudative pleural effusion, Pulmonary tuberculosis, Sputum analysis

INTRODUCTION

Pleural effusion is the abnormal accumulation of fluid in the pleural cavity. To keep the lungs lubricated and facilitate smooth movement during breathing, small amounts of fluid are continuously produced. However, this balance is disrupted by various pathological processes, leading to excessive fluid buildup.[1] There is 0.1 to 0.3 mL/kg of pleural fluid in the pleural space. The blood vessels of the parietal pleural surfaces produce pleural fluid, which is reabsorbed through the lymphatic vessels located in the dependent parts of the pleural cavity. Fluid accumulation can happen either from overproduction or decreased absorption.[2]

Pleural effusion is classified by Light's criteria as either a transudate or exudate, which helps in understanding the pathophysiology and establishing a diagnosis. If none of the given criteria is met, it is called Transudative effusion and if one or more of the following criteria are met, it is termed exudative effusion. The criteria includes-Pleural fluid protein to serum protein ratio of more than 0.5,

pleural fluid LDH to serum LDH ratio of more than 0.6 and pleural fluid LDH is more than two-thirds of the upper limit of the normal serum LDH value.[3]

Change in hydrostatic and oncotic pressure leads to transudative pleural effusion. Conditions such as congestive heart failure, nephrotic syndrome, liver cirrhosis, and low serum albumin levels are common causes. In contrast, exudative pleural effusions are more often associated with localized inflammation or injury. These can arise from infections like pneumonia or tuberculosis, cancers, and autoimmune diseases such as lupus, rheumatoid arthritis, and pancreatitis. Other common causes include chylothorax, hemothorax, post-cardiac injury syndrome, pleural reactions following coronary artery bypass surgery, and non-malignant asbestos-related pleural diseases.

Pulmonary embolism can lead to either transudative or exudative effusion. Certain medications-such as methotrexate, phenytoin, dasatinib, and amiodarone-can provoke exudative effusions. Additional causes include radiation therapy, esophageal perforation, and ovarian hyperstimulation syndrome.[4,5]

Chest radiography is an important and readily available method to detect pleural effusion. When taken in an upright posteroanterior position, the presence of a meniscus sign typically suggests a moderate to large fluid accumulation usually more than 200 mL and is often associated with the blunting of the costophrenic angle. In cases where the fluid volume is smaller, subtle blunting of the costophrenic angles on an upright posteroanterior chest X-ray may prompt further diagnostic evaluation. A lateral decubitus view is more sensitive and can identify even minimal fluid collections, sometimes as little as 50 mL.[6]

Thoracentesis is recommended for any patient suspected of having an exudative pleural effusion when the fluid layer measures more than 10 mm on a lateral chest X-ray, ultrasound, or CT scan. Firstly, we need to distinguish between transudative and exudative effusions. In cases confirmed as exudative, the pleural fluid should be evaluated for its appearance and odor. Laboratory analysis typically includes total and differential white blood cell counts, along with biochemical tests such as protein, glucose, LDH, and amylase levels. Microbiological testing may involve acid-fast bacillus (AFB) staining, Gram staining, culture and sensitivity, ADA (adenosine deaminase) levels, and cytological evaluation. Depending on the clinical scenario, tests for triglycerides and chylomicrons might also be necessary. A closed pleural biopsy is advised if tuberculosis is suspected but ADA levels are not elevated. For cases where the cause of an exudative effusion remains unclear, thoracoscopy offers a highly accurate diagnostic option.[7]

This is a prospective study to look for the etiology and clinical profile of exudative pleural effusion in a tertiary care center.

METHODS

This is a Prospective study performed in the department of medicine, Acharya Shri Chander College of Medical Sciences, a tertiary care center in Jammu. This is a 500 bedded tertiary care hospital in province of Jammu and Kashmir, India. The main aim of this study was to assess the clinical and etiological profile of exudative pleural effusions. This study included all in-patients admitted with exudative pleural effusion from February 2024 to January 2025. A Total of 70 patients were included in the study as per the following inclusion and exclusion criteria:

Inclusion criteria

Male and female aged 14-85 years old and patients with exudative pleural effusion were included.

Exclusion criteria

Patients with transudative pleural effusion were excluded.

The demographic data of the patients was collected, which included age, sex, and address. A detailed history of patients was taken, which included chief complaints, history of presenting illness, and comorbidities. Basic investigations including complete blood count, kidney function tests, liver function tests, thyroid function tests, serum proteins, chest x-ray, pleural fluid analysis, ultrasonography chest and abdomen, Computed tomography chest were done.

Statistical analysis

Data were analyzed using Microsoft excel and SPSS version 20.0. Descriptive statistics (counts, percentages, means, and standard deviations) were calculated. Chi-square and Fisher's exact tests were used to assess associations.

RESULTS

Table 1 represents the demographic characteristics of the study population. The cohort was predominantly male, with 66 male patients accounting for 94.3% of the total, while only 4 female patients were included, comprising a mere 5.7%. This marked male predominance was statistically significant, as determined by a chi-square test ($p<0.001$).

In terms of age distribution, the patients were overwhelmingly elderly, with 68 individuals (97.1%) being 60 years or older, while only 2 patients (2.9%) were younger than 60 years. The mean age of the study population was 71.6 years, with a standard deviation of 5.6 years, and the age range spanned from 62 to 84 years.

Table 2 presents the clinical presentation of the 70 patients with exudative pleural effusion. Cough was the most frequently reported symptom, affecting 61 patients (87.1% of the cohort). This was further categorized into productive

cough, noted in 44 patients (62.9%), and dry cough, observed in 17 patients (24.3%), indicating that productive cough was the predominant type. Dyspnea was the second most common symptom, reported by 54 patients (77.1%), underscoring its significance as a hallmark of pleural effusion in this population. Fever was also highly prevalent, affecting 53 patients (75.7%), suggesting an infectious or inflammatory etiology in a substantial proportion of cases.

Less frequent symptoms included chest pain, reported by 13 patients (18.6%), and hemoptysis, noted in 10 patients (14.3%), which may point to specific underlying conditions such as tuberculosis or malignancy. Weight loss and loss of appetite were each reported by 6 patients (8.6%), indicating systemic involvement in a smaller subset of the cohort. Altered sensorium was the least common symptom, observed in only 1 patient (1.4%), suggesting it is a rare presentation in this context. The high prevalence of cough, dyspnea, and fever, combined with the significant association of cough with tuberculosis (p=0.02, Fisher's exact test), emphasizes the importance of these symptoms in directing clinical suspicion toward infectious etiologies, particularly pulmonary tuberculosis, in patients with exudative pleural effusion.

Table 3 represents the distribution of symptom duration among the 70 patients with exudative pleural effusion. The majority of patients, 37 individuals (52.9%), experienced symptoms for 2-4 weeks before seeking medical attention, indicating that this duration is the most common timeframe for presentation. A notable portion, 17 patients (24.3%), reported symptoms lasting 1-2 weeks, while 11 patients (15.7%) had symptoms for less than 1 week, suggesting a subset of cases with more acute onset. Only 5 patients (7.1%) had symptoms persisting beyond 4 weeks, indicating that prolonged symptom duration was less common. The mean duration of symptoms was calculated as 2.7±1.2 weeks, reflecting a relatively short to moderate timeframe for symptom progression prior to hospital evaluation. A significant statistical association was found between cough and tuberculosis (p=0.02, Fisher's exact test), with 95.2% of patients diagnosed with pulmonary tuberculosis reporting cough compared to 68.4% of patients with non-tuberculous etiologies, highlighting cough as a key clinical feature in identifying tuberculous pleural effusion in this cohort.

Table 4 represents the radiological findings. Right-sided pleural effusion was the most common, observed in 33 patients (47.1%), followed by left-sided effusion in 19 patients (27.1%) and bilateral effusion in 18 patients (25.7%), indicating a slight predominance of unilateral right-sided involvement. Regarding the extent of effusion, 22 patients (31.4%) had minimal pleural effusion, while 10 patients (14.3%) presented with massive effusion, suggesting variability in the severity of fluid accumulation. Consolidation was noted in 16 patients (22.9%), with the right upper lobe (RUL) being the most frequent site (6 patients, 8.6%), followed by the right middle lobe (RML) and right lower lobe (RLL) (3 patients each, 4.3%), and the left upper lobe (LUL) and left lower lobe (2 patients each, 2.9%). Additional findings included fibrotic patches in 4 patients (5.7%), cavities in 3 patients (4.3%), bulky hilar regions in 2 patients (2.9%), and an RML mass in 1 patient (1.4%). A significant statistical association was identified between consolidation and pneumonia (p=0.01, Fisher's exact test), with all 6 patients diagnosed with pneumonia exhibiting consolidation compared to only 16.1% of non-pneumonia patients, underscoring consolidation as a key radiological marker for pneumonia in this cohort.

Table 5 represents the pleural fluid and sputum analysis results. All 70 patients underwent pleural fluid analysis, with 69 cases (98.57%) confirmed as exudative based on Light's criteria, indicating that nearly all effusions were inflammatory in nature. Malignant cells were identified in the pleural fluid of only 1 patient (1.4%), pointing to a rare instance of malignancy, specifically lung malignancy confirmed by biopsy. Sputum analysis was performed in 53 patients, with 19 samples (35.84%) showing acid-fast bacilli (AFB) growth and 27 samples (50.94%) testing positive for *Mycobacterium tuberculosis* via cartridge-based nucleic acid amplification test (CBNAAT), collectively indicating a high prevalence of tuberculosis among those tested. Seven samples (13.2%) showed no growth, consistent with non-tuberculous etiologies such as pneumonia. The strong association between positive sputum analysis (AFB growth or CBNAAT positive) and tuberculous etiology (p<0.001, Fisher's exact test) underscores the diagnostic utility of sputum testing in identifying pulmonary tuberculosis as a primary cause of exudative pleural effusion in this cohort.

Table 6 represents the etiological profile of the 70 patients with exudative pleural effusion. Pulmonary tuberculosis was the predominant etiology, diagnosed in 52 patients (74.3%), highlighting its significant burden in this cohort. Pneumonia was identified in 6 patients (8.6%), while lung malignancy was confirmed in only 1 patient (1.4%), supported by the presence of malignant cells in pleural fluid and biopsy findings. The etiology remained undetermined in 11 patients (15.7%), likely due to incomplete diagnostic workup, such as missing sputum analysis or other confirmatory tests. Statistical associations further elucidated these findings: tuberculosis was strongly associated with positive sputum analysis (AFB growth or CBNAAT positive, p<0.001, Fisher's exact test), reinforcing the diagnostic importance of sputum testing. Pneumonia showed a significant association with consolidation on chest X-ray (p=0.01, Fisher's exact test), with all pneumonia cases exhibiting this radiological feature. The single case of malignant pleural effusion was significantly associated with the presence of malignant cells in pleural fluid (p=0.04, Fisher's exact test), underscoring the specificity of cytological analysis for malignancy in this context. These findings emphasize tuberculosis as the leading cause of exudative pleural effusion in this population, with pneumonia and malignancy as less frequent contributors.

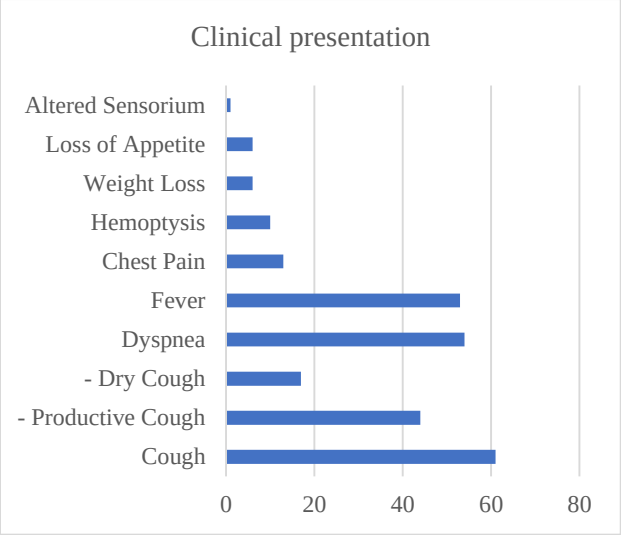

Figure 1: Clinical presentation.

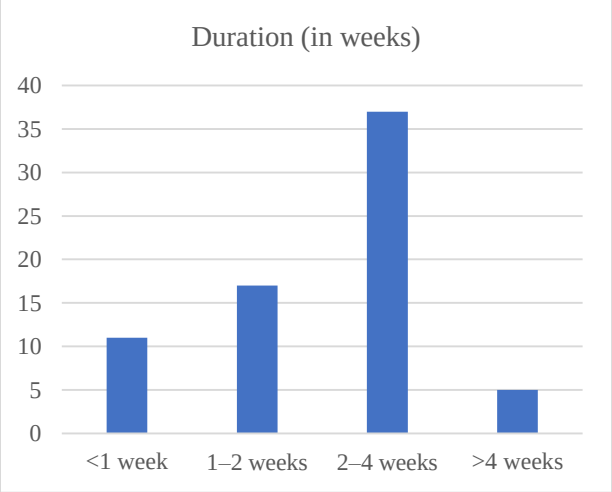

Figure 2: Duration (in weeks).

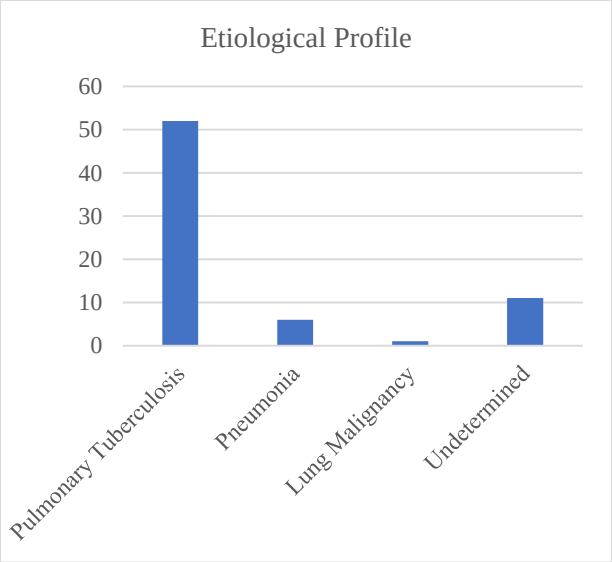

Figure 3: Etiological profile.

Table 1: Demographic characteristics.

Variables	N	Percentage (%)
Sex		
Male	66	94.3
Female	4	5.7
Age group (in years)		
<60	2	2.9
≥60	68	97.1

Table 2: Clinical presentation.

Symptoms	N	Percentage (%)
Cough	61	87.1
Productive cough	44	62.9
Dry cough	17	24.3
Dyspnea	54	77.1
Fever	53	75.7
Chest pain	13	18.6
Hemoptysis	10	14.3
Weight loss	6	8.6
Loss of the appetite	6	8.6
Altered sensorium	1	1.4

Table 3: Distribution of symptom duration.

Duration (in weeks)	N	Percentage (%)
<1	11	15.7
1-2	17	24.3
2-4	37	52.9
>4	5	7.1
Total	70	100

Table 4: Radiological findings.

Findings	N	Percentage (%)
Side of pleural effusion		
Right-sided	33	47.1
Left-sided	19	27.1
Bilateral	18	25.7
Extent of pleural effusion		
Massive	10	14.3
Minimal	22	31.4
Other findings		
Consolidation	16	22.9
RUL	6	8.6
RML	3	4.3
RLL	3	4.3
LUL	2	2.9
Left lower lobe	2	2.9
Fibrotic patch	4	5.7
Cavity	3	4.3
Bulky hilar region	2	2.9
RML mass	1	1.4

Table 5: Pleural fluid and sputum analysis.

Analysis	N	Percentage (%)
Pleural fluid characteristics		
Exudative	69	98.57
Malignant cells present	1	1.4
Sputum analysis (n=53)		
AFB growth	19	35.84
CBNAAT positive	27	50.94
No growth	07	13.2

Table 6: Etiological profile.

Etiology	N	Percentage (%)
Pulmonary tuberculosis	52	74.3
Pneumonia	6	8.6
Lung malignancy	1	1.4
Undetermined	11	15.7

DISCUSSION

This study conducted at a tertiary care center investigated the clinical and etiological profile of 70 patients with exudative pleural effusion, revealing a predominant burden of pulmonary tuberculosis (74.3%), followed by pneumonia (8.6%), lung malignancy (1.4%), and undetermined etiologies (15.7%). The demographic characteristics, clinical presentations, symptom duration, radiological findings, and pleural fluid and sputum analysis were analyzed to provide a comprehensive understanding of this condition in a high-tuberculosis-prevalence setting. These findings align with and diverge from previous studies, offering insights into regional variations and diagnostic challenges associated with exudative pleural effusions.

The demographic profile of our cohort, with a marked male predominance (94.3%) and a mean age of 71.6±5.6 years, contrasts with some prior studies. A prospective cohort study by Hussein et al reported a male predominance of 76.1% and a younger mean age of 42.49±13.8 years, with tuberculous effusions occurring in younger patients (37.7±10.9 years) compared to non-tuberculous effusions (49.1±14.9 years).[8] This age discrepancy may reflect regional differences in tuberculosis epidemiology, as our study population was predominantly elderly, potentially due to age-related comorbidities or delayed presentation in our setting. Similarly, a study by Porcel et al on over 3,000 thoracenteses found tuberculosis to be the leading cause of exudative effusions in younger adults (<34 years, 52%), while older patients had higher rates of malignancy and heart failure.[9] The male predominance in our study ($p<0.001$) is consistent with global trends, possibly attributable to higher exposure to risk factors such as smoking or occupational hazards in males.

The clinical presentation in our study showed cough (87.1%), dyspnea (77.1%), and fever (75.7%) as the most common symptoms, with cough significantly associated with tuberculosis ($p=0.02$). These findings are comparable to those reported by Reddy et al who noted dyspnea (84%), cough (80%), and fever (65%) as leading symptoms in a tertiary care setting in India, with tuberculosis accounting for 38% of cases.[10] The high prevalence of productive cough (62.9%) in our study aligns with the infectious etiology, particularly tuberculosis, which often presents with productive cough due to parenchymal involvement. The mean symptom duration of 2.7±1.2 weeks, with most patients (52.9%) presenting within 2-4 weeks, suggests a subacute course, consistent with the delayed hypersensitivity reaction typical of tuberculous pleural effusion, as described by Shaw et al.[11]

Radiologically, right-sided pleural effusion (47.1%) was more common than left-sided (27.1%) or bilateral (25.7%), aligning with Ferreiro et al who reported that tuberculous pleural effusions are predominantly unilateral and right-sided. Consolidation was observed in 22.9% of our patients, significantly associated with pneumonia ($p=0.01$), consistent with findings by Porcel et al where pneumonia accounted for 14% of massive effusions and was frequently associated with consolidation.[12] The presence of fibrotic patches (5.7%) and cavities (4.3%) in our study further supports a tuberculous etiology, as these are common radiological features of pulmonary tuberculosis.

Pleural fluid analysis confirmed exudative effusions in 98.57% of cases, consistent with Light's criteria, and sputum analysis revealed a high tuberculosis burden, with 86.78% of tested samples positive for AFB growth (35.84%) or CBNAAT (50.94%). The strong association between positive sputum analysis and tuberculosis ($p<0.001$) corroborates the findings of Lo Cascio et al who emphasized the diagnostic utility of sputum analysis and pleural fluid adenosine deaminase (ADA) levels (>40 IU/L) in high-prevalence settings.[13] However, our study's limitation in not reporting ADA levels due to incomplete data mirrors challenges noted in other studies, where low ADA levels necessitate invasive procedures like thoracoscopy for diagnosis. The single case of malignant pleural effusion (1.4%) with cytological confirmation aligns with Hussein et al who reported malignancy in 22.2% of cases, suggesting a lower malignancy burden in our setting, possibly due to the overwhelming prevalence of tuberculosis.[8]

The etiological profile, with pulmonary tuberculosis dominating (74.3%), is higher than reported in other studies from developing countries. For instance, a study in Qatar by Khan et al found tuberculosis in 41% of exudative effusions, followed by parapneumonic effusions (24%) and malignancy (19.6%).[14] Similarly, a 2016 study from India reported tuberculosis in 62% of cases, with malignancy at 18%. The higher tuberculosis prevalence in our study may reflect regional epidemiology, as India remains a high-burden country for tuberculosis. The low incidence of malignancy (1.4%) contrasts with Western studies, such as Porcel et al where malignancy accounted

for 18% of effusions in older populations.[9] The undetermined etiology in 15.7% of our cases highlights diagnostic challenges, consistent with global estimates that 20-25% of exudative effusions remain undiagnosed despite extensive workup.

CONCLUSION

In conclusion, our study underscores pulmonary tuberculosis as the leading cause of exudative pleural effusion in a tertiary care setting in India, with a clinical and radiological profile consistent with infectious etiologies. The findings align with previous studies in high-tuberculosis-prevalence regions but show a lower malignancy rate compared to Western cohorts.

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