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Diagnosis And Management Of Pleural Effusion In Adults

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Abstract

Pleural effusion reflects either systemic disease or local pleural pathology. Treating the effusion as a final diagnosis can delay recognition of infection or malignancy. To present a cause-specific diagnostic and management framework for adult pleural effusion. This narrative review selected 30 journal articles published from December 2023 through March 2026, identified through PubMed and journal or publisher websites up to September 15, 2026. Records were checked against DOI metadata; neither meta-analysis nor formal risk-of-bias assessment was undertaken. Initial evaluation combines clinical assessment, thoracic ultrasound and a decision on diagnostic thoracentesis. Paired pleural-fluid and serum studies, fluid pH and glucose, cultures, cytology and focused investigations guide subsequent management. Pleural infection calls for antibiotics and drainage when indicated; symptomatic malignant effusion requires an individualized choice of pleurodesis or an indwelling catheter, whereas systemic transudates require treatment of their underlying disease. A staged, cause-directed approach supports timely drainage of high-risk effusions and avoids unnecessary procedures.

Keywords: Pleural Effusion; Thoracentesis; Thoracic Ultrasound; Pleural Infection; Malignant Pleural Effusion; Pleural Tuberculosis.

INTRODUCTION

Pleural effusion is a clinical manifestation rather than a disease in itself. Fluid accumulation occurs due to changes in hydrostatic or oncotic pressure, pleural permeability, or lymphatic obstruction. Heart failure, cirrhosis, pneumonia, tuberculosis, and malignancy require different diagnostic and therapeutic approaches. The European Respiratory Society has highlighted the lack of attention given to nonmalignant pleural effusions.

The distinction between transudative and exudative effusions remains useful as an initial step; however, the results should be interpreted together with symptoms, diuretic use, imaging findings, and the pretest probability of disease before further testing. Reviews of noninfectious and nonmalignant causes indicate that overly simplistic classification may overlook important etiologies. This article summarizes the diagnostic and management approach to pleural effusion in adults, with particular attention to clinical situations requiring immediate decision-making.

RESEARCH METHODS

A narrative search was conducted up to September 15, 2026, through PubMed and publisher or journal websites using a combination of the terms “pleural effusion,” “pleural infection,” “malignant pleural effusion,” “thoracic ultrasound,” “tuberculous pleural effusion,” “benign pleural effusion,” “thoracentesis,” and “pleural drainage.” English-language journal articles published within the three years preceding the search date were considered. Purposive selection prioritized scientific statements, clinical reviews, systematic reviews, clinical trials, and diagnostic studies relevant to adult patients. The 30 articles included had traceable DOIs, and duplicate articles were listed only once. As this was a narrative review, the number of articles identified and excluded was not reported using a PRISMA flow diagram, and findings from different study designs were not combined into a single pooled effect estimate.

RESULTS AND DISCUSSION

Clinical and Imaging Assessment

First, assess the severity of dyspnea, hypoxemia, blood pressure, fever, and suspected sepsis. Determine whether the effusion is unilateral or bilateral, new or recurrent, and whether there is a history of cancer, heart failure, cirrhosis, thromboembolism, or tuberculosis exposure. An unexplained unilateral effusion requires further evaluation, whereas a bilateral effusion with typical features of heart failure may be reassessed after treatment of the underlying condition if there are no atypical features.

Chest radiography demonstrates the presence and extent of the effusion; however, thoracic ultrasonography is more useful for identifying a safe fluid pocket for procedures, detecting septations, and assessing the pleura. Contrast-enhanced chest CT may be used when a mass, parenchymal abnormality, or unexplained pleural disease is suspected; its use depends on the clinical question and the patient's stability. Newer imaging techniques and artificial intelligence still require external validation before they can be used as the sole determinants of diagnosis.

Ultrasound-guided diagnostic thoracentesis should be considered when the cause of the effusion is unclear, the effusion is unilateral, the patient has fever, malignancy is suspected, or the response to treatment of the systemic disease is inconsistent with expectations. Pleural fluid analysis should be planned before the procedure to ensure that sufficient sample volume is obtained for biochemical, microbiological, and cytological examinations. In a prospective study, ultrasonography and CT demonstrated different diagnostic values in predicting malignant pleural effusion; neither modality replaces cytological or histopathological confirmation.

Clinical and Radiological Features of Pleural Effusion

Small effusions may be asymptomatic. As the volume of fluid increases, patients may develop dyspnea, dry cough, or pleuritic chest pain; the symptoms and severity of dyspnea are also influenced by the underlying disease. On physical examination, findings suggestive of pleural effusion include reduced chest movement on the affected side, dullness to percussion, and decreased breath sounds and tactile fremitus over the fluid-filled area. These findings help determine the site for further examination but do not establish the etiology.

On an upright chest radiograph, a free-flowing effusion typically appears as a basal opacity with blunting of the costophrenic angle and a curved upper border forming the meniscus sign. A large effusion may obscure most of the hemithorax, as shown in the chest radiograph of the patient presented in Figure 1. In the supine position, fluid may layer posteriorly behind the lung, making the meniscus sign less apparent. Thoracic ultrasonography demonstrates the fluid space between the chest wall and lung as an anechoic area in a simple effusion. Septations or debris may be visible in more complex effusions. Ultrasonography can assist in selecting the site for thoracentesis. However, ultrasonography alone is insufficient to distinguish all causes of pleural effusion without clinical information and pleural fluid analysis.

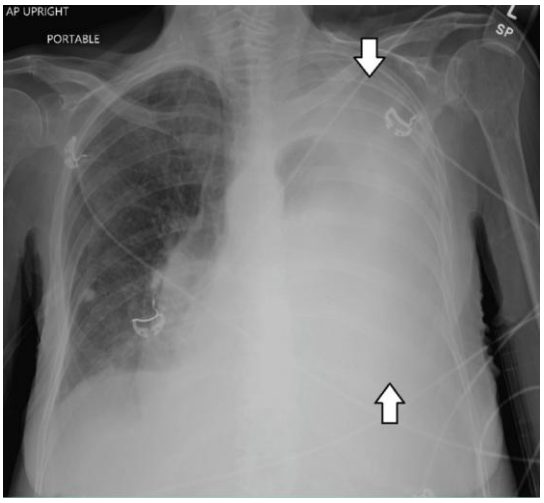

Figure 1. Portable upright AP chest radiograph of a patient with massive left pleural effusion due to hepatic hydrothorax before thoracentesis.

The left hemithorax appears almost completely opaque, with mediastinal shift to the right. Arrows indicate markers on the published image. Original radiograph from the case report by Assali DR, Richardson A, Kalnow A. *An Acute Hepatic Hydrothorax Causing Tension*. *Cureus*. 2024;16(10):e71543. doi:10.7759/cureus.71543, Figure 1; reproduced with attribution under the CC BY 4.0 license. This example illustrates a very large effusion and does not represent the full range of pleural effusion severity.

Pleural Fluid Analysis

Obtain a serum blood sample at approximately the same time as thoracentesis for measurement of protein and lactate dehydrogenase (LDH) [7]. An effusion is classified as an exudate according to Light's criteria if at least one of the following conditions is met: a pleural fluid-to-serum protein ratio greater than 0.5; a pleural fluid-to-serum LDH ratio greater than 0.6; or pleural fluid LDH greater than two-thirds the upper limit of normal serum LDH. Following diuretic therapy, some effusions caused by heart failure may appear to be pseudoexudates; findings that are inconsistent with the clinical condition require additional assessment, such as the serum–pleural fluid albumin gradient or natriuretic peptides. The relationship between pleural effusion and hemodynamics in advanced heart failure has been studied, making assessment of volume status still relevant.

Measure pleural fluid pH using an appropriate technique when infection is suspected, followed by glucose measurement, differential cell count, Gram staining, and culture. A neutrophil-predominant fluid supports an acute process such as infection, whereas lymphocyte predominance prompts evaluation for tuberculosis or malignancy, although neither finding is diagnostic on its own. Purulent fluid establishes the diagnosis of empyema. Hepatic hydrothorax usually occurs in the setting of portal hypertension and should be distinguished from infection and other causes in patients with cirrhosis.

Table 1. Pleural Fluid Analysis According to the Clinical Question

Question	Priority Assessment	Follow-up if Unclear
Transudate or exudate	Fluid and serum protein and LDH; Light's criteria	Review diuretic use, albumin gradient, and the context of systemic disease [7].
Infection	pH, glucose, Gram stain, culture; assess for septations on ultrasound	Consider drainage if infection is confirmed [14]. Assess the need for surgery if drainage fails [18].
Tuberculosis	Differential cell count, ADA; sputum and culture/NAAT as available	Proceed with pleural biopsy or thoracoscopy if evidence remains insufficient [11].
Malignancy	Cytology with an adequate sample; CT if indicated	Consider pleural biopsy if cytology is negative [23]. Thoracoscopy can provide tissue for diagnosis [25].

Pleural Tuberculosis

In regions with a high tuberculosis burden, a lymphocyte-predominant exudative effusion increases suspicion of pleural tuberculosis, but adenosine deaminase (ADA) levels do not constitute microbiological evidence. Sputum analysis remains necessary even when the lung parenchyma appears normal on imaging. Culture or molecular testing of pleural fluid or tissue can help identify the causative organism and detect drug resistance.

ADA levels of 40–70 IU/L may overlap between tuberculosis and malignancy. The diagnostic performance of ADA depends on the selected threshold and patient characteristics [13]. When pleural fluid analysis does not confirm tuberculosis despite a high clinical suspicion, pleural biopsy for histopathological examination and culture is required [11]. Antituberculosis treatment should follow relevant guidelines and drug-susceptibility testing results. Complicated effusions or empyema may require drainage.

Pleural Infection and Parapneumonic Effusion

In patients with pneumonia and pleural effusion, distinguishing between a simple parapneumonic effusion and pleural infection determines the need for drainage. Pus, positive Gram staining or culture, low pH, or complex fluid collections with septations are strong indications for prompt assessment for drainage. A pH below 7.2 is often used as a marker of high risk but should be interpreted in conjunction with the quality of sample collection and other findings. Recent reviews emphasize a combination of antibiotic therapy and fluid evacuation, as well as the importance of early reassessment when clinical improvement does not occur.

Initial antibiotic therapy should be tailored to the source of infection, risk of resistant organisms, and local guidelines, and subsequently narrowed according to culture results. Negative pleural fluid cultures do not exclude pleural infection, particularly when the patient has already received antibiotics. Recent reviews also emphasize ultrasonography and CT to identify undrained fluid collections. Patient assessment should include signs of sepsis, pain, renal function, and adequacy of drainage.

Initial drainage commonly involves a small-bore pleural catheter positioned under imaging guidance. The choice of catheter type should be adapted to the drainage objective and characteristics of the fluid. Treatment success is also determined by catheter positioning and monitoring, rather than catheter diameter alone. If residual loculated fluid persists, intrapleural tPA and DNase therapy or surgical referral may be discussed with the pleural and thoracic surgery teams based on bleeding risk, service availability, and the patient's clinical condition. The optimal sequence of interventions remains debated. A 2024 comparative meta-analysis found higher treatment success with surgery than with fibrinolysis in the available studies; however, differences in study design limit causal conclusions for all patients. The SPIRIT feasibility trial supports larger studies of medical thoracoscopy as an initial treatment without demonstrating that the procedure should be routinely performed.

Malignant Pleural Effusion

Malignant pleural effusion should be suspected in patients with cancer and recurrent effusion, pleural nodules, or unexplained pleural thickening. Pleural fluid cytology is a relatively minimally invasive initial investigation, but a negative result does not exclude malignancy. Image-guided pleural biopsy or thoracoscopy is required when tissue is needed for histological examination or molecular marker assessment. A 2024 review summarized the roles of imaging, cytology, and biopsy, as well as the need to integrate the diagnosis with the goals of cancer treatment. Medical thoracoscopy can obtain tissue while also assessing the feasibility of therapeutic intervention in selected patients.

Intervention decisions should consider symptoms, recurrence, lung expansion, patient preferences, and the burden of healthcare visits. Initial drainage helps assess improvement

in dyspnea and lung expansion. In patients with an expandable lung, talc pleurodesis or an indwelling pleural catheter may be selected. If the lung does not expand or the patient prefers outpatient management, an indwelling pleural catheter may be more appropriate. Repeated aspiration as the sole strategy may impose a burden on patients when the effusion rapidly recurs.

Table 2. Interventional Options for Symptomatic Malignant Pleural Effusion

Situation	Options Discussed	Considerations
Dyspnea and first episode of pleural effusion	Ultrasound-guided therapeutic thoracentesis	Assess improvement in dyspnea and lung re-expansion [26].
Recurrent, expandable lung	Talc pleurodesis or indwelling pleural catheter	Discuss inpatient care, home-based care, and patient preferences [26].
Recurrent, non-expandable lung	Indwelling pleural catheter when appropriate	Pleurodesis requires apposition of both pleural surfaces [26].
Limited prognosis or frailty	Least burdensome strategy that relieves symptoms	Align the goals of care with the patient [28].

A patient-centered approach considers the ability to manage a catheter at home, family support, and concerns regarding pain and repeated procedures. The LENT and PROMISE scores can provide prognostic estimates but should not be used as the sole reason to withhold an intervention that may provide symptomatic benefit. Validation of the LENT score in other populations has demonstrated its ability to stratify patients. External validation of both scores in 2025 showed limitations in the precision of median survival estimates, although predictions at specific time points were reasonably accurate.

Nonmalignant Pleural Effusion Due to Systemic Disease

In heart failure, management of congestion and the underlying cardiac disease is the primary approach. Thoracentesis is not routinely required for a small bilateral effusion with a typical presentation, but it should be considered when the effusion is unilateral, highly symptomatic, accompanied by fever, or does not improve after adequate therapy. In cirrhosis with hepatic hydrothorax, management focuses on the underlying liver disease and portal hypertension; repeated interventions require consideration of protein loss, infection, and advanced treatment options. Kidney disease, pulmonary embolism, medications, and less common causes should be evaluated when the clinical pattern is inconsistent with heart failure or cirrhosis.

Discussion and Limitations

Ultrasonography links the assessment of pleural effusion with the selection of a safer site for intervention. Advanced imaging techniques may increase suspicion of pleural disease but do not always establish its etiology. In suspected tuberculosis, microbiological testing or biopsy remains necessary according to the level of clinical suspicion. In suspected malignancy, negative cytology may necessitate tissue examination. In pleural infection, pleural fluid biochemical findings and the clinical condition should be assessed together when deciding whether drainage is required. Septations can help identify fluid that may not be adequately drained. Drainage adequacy and clinical improvement should be reassessed throughout treatment.

This review used purposive selection of 30 articles rather than a systematic search conducted by two independent reviewers. The strength of evidence varies among expert statements, reviews, retrospective studies, feasibility trials, and systematic reviews; therefore, the recommendations should not be interpreted as treatment effects established across all populations. Local antibiotic and antituberculosis guidelines, availability of thoracoscopy, and local laboratory standards remain important determinants of implementation. The optimal sequence of intrapleural therapy and surgery requires further investigation. Available comparative reviews have methodological limitations and have not

established the optimal treatment sequence for every patient. Larger studies are also needed to evaluate medical thoracoscopy as an initial intervention for pleural infection.

CONCLUSION

The evaluation of pleural effusion in adults begins with an assessment of the acute clinical condition, underlying disease context, and thoracic ultrasonography. Image-guided thoracentesis with paired serum samples and pleural fluid analysis selected according to the suspected etiology helps determine subsequent investigations. Pleural infection requires prompt assessment for antibiotic therapy and drainage. When suspicion of tuberculosis remains high despite negative pleural fluid testing, further evaluation should focus on microbiological evidence or pleural biopsy. Suspected malignancy with negative cytology may likewise require pleural biopsy. In recurrent pleural effusions, the choice of intervention should be guided by symptoms, lung expandability, the patient's clinical condition, and patient preferences.

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